UNIVERSITY "UNION - NIKOLA TESLA"

Nikola Tesla

THE FIRST INTERNATIONAL CONFERENCE ON SUSTAINABLE ENVIRONMENT AND TECHNOLOGIES

PROCEEDINGS

24-25 SEPTEMBER 2021
CARA DUŠANA 62-64, BELGRADE, SERBIA

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SERBIAN WATER PROTECTION SOCIETY

The First International Conference on Sustainable Environment and Technologies

"Creating sustainable commUNiTy"

Organizer of the Conference: University „Union Nikola Tesla”, Belgrad, Serbia

Editors:

Ph.D Ljiljana Nikoluć Bujanović

Ph.D Sanja Mrazovac Kurilić

Publisher: University „Union Nikola Tesla”, Belgrad, Serbia

For publisher:

Ph.D Nebojša Zakić

Design:

MSc. Arh. Dunja Bujanović

Mateja Đurić, student

Printed in: Dobrotoljublje, Beograd

ISBN 978-86-89529-33-3

Conference is financially supported by
The Ministry of Education, Science and Technological
Development of the Republic of Serbia

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LECTURES

DESIGNING THE CONTEMPORARY CITY BY INTEGRATING DIFFERENT FORMS OF SUSTAINABLE DEVELOPMENT.

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INTRODUCTION

There is no contemporary city, there is a diachronic development of the different presents of the urban dimensions. It is as if there was a time zone of urban development, that is at the same time different cities of the world live a different phase of their evolutionary path.

A general discourse on the contemporaneity of cities can start from general concepts such as that of sustainable development, or it can be based on technological or cultural trends that are assumed at the level of diffusion or global debate, but the contemporaneity of cities defines different scenarios, more or less sustainable or desirable and some even critical.

The local dimension, the territorial capital of a specific place, are still the determining aspects that define the consistency of an urban planning approach aimed at proposing indications on the strategies and tools that should guide a proper and coherent development.

The present-day nature of the cities defines a diversified scenario where the concept of sustainable development always makes sense, but is characterized in a unique sense according to the territorial context of reference

The historical context we are experiencing holds together words and methods still anchored to a modernistic idea of growth and progress, think, for example, of the oxymorons, typical of political compromises, which have defined the strategy of the European Union in the last ten years such as "sustainable growth". It tries to hold together economic models based on growth, a strictly modernistic concept, with an adjective that instead accompanies the development that should instead characterize the management models of post-industrial societies.

The need to govern this diversity pushes politics to seek "compromised concepts" which, however, often only have the function of increasing the friction

that opposes those forces that push the transformation of the contemporary city to face commonly recognized challenges.

This article aims, through a generalistic examination of the main challenges faced by the cities to highlight how the concept of sustainable development is a valid reference for organizing the various innovative impulses that characterize the debate on the contemporary city and how this "container of ideas" has been enriched in recent years by further dimensions that can help urban planning practices and tools.

The challenges of contemporary cities

To start a dialogue about the challenges of the contemporary city, a great effort of abstraction and generalization must be made. Because, in fact, these challenges are different as, at least

- the size of the city,
- its history,
- its social, political, geographical and economic context,
- its demography,
- its territorial capital.[1]

It is necessary to frame challenges and problems in categories loose enough to be compared on a global scale. Three loose categories to be used to understand the challenges contemporary city are:

1. The growing phenomenon of **urbanization.**
2. The rapid progress of information **technology** and telecommunications.
3. The acceleration of trade and financial relations on a planetary scale, in the face of the absence of a global (political) **governance.**

These three phenomena can be used as picks to contextualize and understand the drivers of transformation in the contemporary city as they manifest their impact globally and go beyond the differences listed above.

A separate discussion must be made for a fourth category that influences, and it is influenced by, urban dimensions, and clearly refers to **climate change**.

1 Territorial capital is meant as defined in the Handbook for Policy Planners: TERRITORIAL ATTRACTIVENESS MONITORING PLATFORM, https://www.researchgate.net/publication/342870658_TERRITORIAL_ATTRACTIVENESS_MONITORING_PLATFORM_A_HANDBOOK_FOR_POLICY_PLANNERS

The climate change is a phenomenon on a global scale that has also led to the birth of the debated development versus growth, but which cannot be strictly linked to contemporaneity, since, in the terms in which we currently understand it, it has already been at the centre of the political debate for many years both on a local and global scale. This phenomenon should also be contextualized within the definition of a new geological era, namely the Anthropocene (Stoermer, E., F., 1980), which is a proposed geological epoch dating from the commencement of significant human impact on Earth's geology and ecosystems.

The mad rush to urbanization

When dealing with the issue of urbanization, a distinction must be made between "Urbanization" and "Growth of Cities". A common mistake is to think urbanization as simply the growth of cities (Davis, K., 1965): cities can grow without any urbanization.

The type of urbanization we are experiencing now is characterized in economically advanced countries, referring again to Europe, through migratory flows of people who leave small and medium-sized cities to reach the capitals or cities that present the greatest opportunities for socio-economic and cultural development. In this sense, the internal European migrations (in-migrations), which often occur within the same state, define a sort of loss of urban life resources, the loss of a balanced polycentric pattern, an imbalance not between urban and rural, but an imbalance between a marginal urban and a main urban. The graph below (Average Annual Population Development in European LAUs) shows very well how many small and medium European cities, especially in the Mediterranean and Balkan areas, are becoming shrinking cities, while few capital cities, on a regional, national or macro-regional are becoming growth poles.

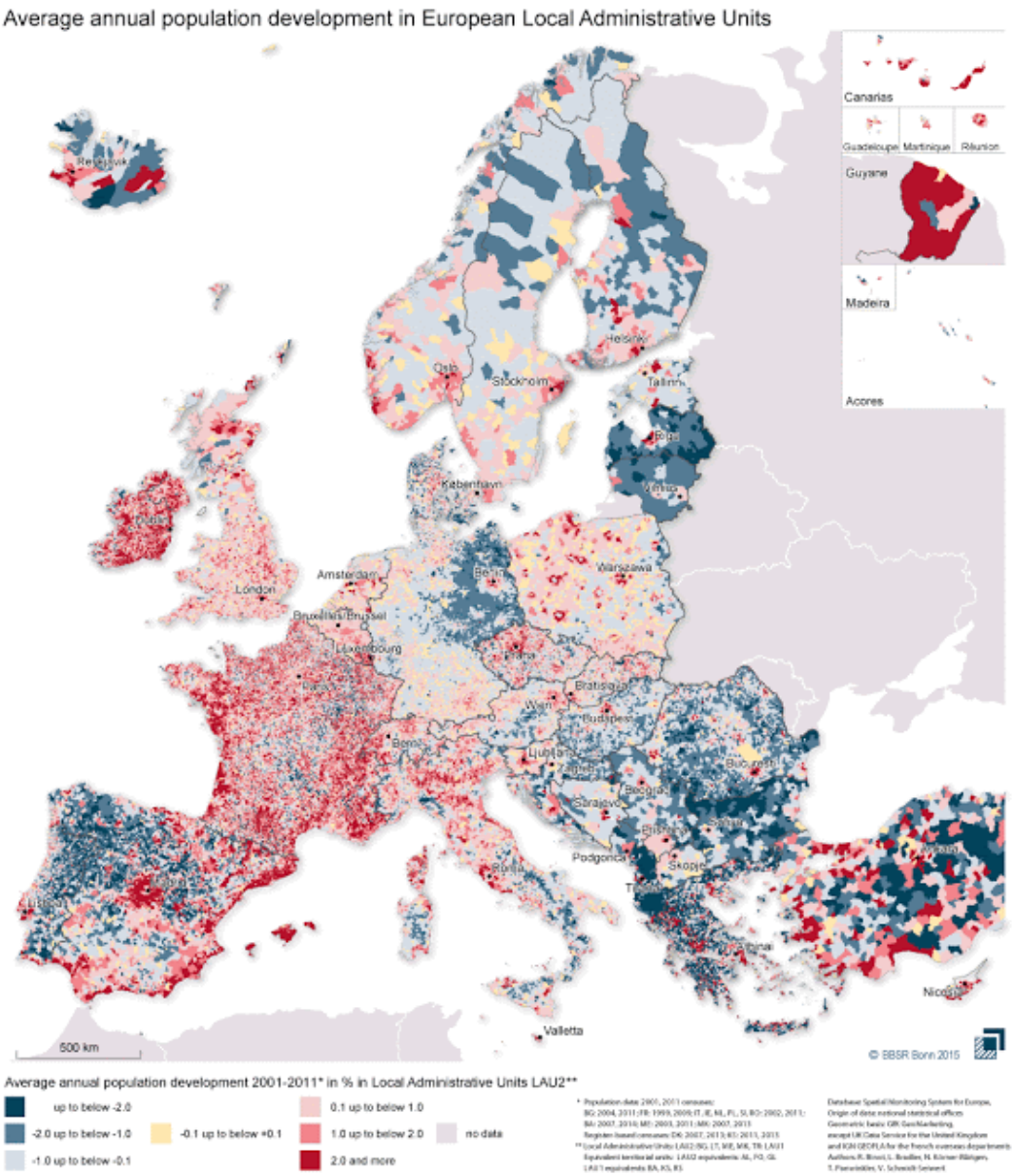

Figure 1 Shrinking cities in Europe, SOURCE BBSR, https://www.bbsr.bund.de/BBSR/DE/startseite/_node.html , 2015

It is evident from these migratory movements that many areas, especially in the south and east of Europe, are losing their characteristic polycentric fabric and many small and medium-sized cities are experiencing a demographic and economic crisis. It means, therefore, loss of knowledge, territorial diversity and competitiveness, which is reflected and aggregated at the regional and macro-regional level.

In the less developed continents, we consider, for example, the critical macro-regions of Asia, Africa and Latin America, the phenomenon is characterized more as abandonment of the rural area due to endemic poverty. A mass of population pouring into megacities to try their luck at a better life, the current urbanization in these areas is clearly linked to the search for better economic conditions. Lastly, the global urban population is expected to grow approximately 1.84% per year between 2015 and 2020, 1.63% per year between 2020 and 2025, and 1.44% per year between 2025 and 2030. However, this means that, considering the urbanization rate, a significant migratory flow towards urban areas will have to be managed: the annual growth rate of people migrating to urban areas is projected to be 1.63% between 2020 and 2025 and 1.44% between 2025 and 2030. By doing some simple arithmetic calculations we realize that the urbanization of around 720 million people will have to be managed between 2020 and 2030, it means:

• Around 20 new megacities growing up

• or, if we consider equipping every person who will urbanize with a minimum standard of a single room, it will be necessary to build more or less an area equal to 9 times that of greater London.

Much of the definition of sustainable development for the years to come passes from the ability to govern this phenomenon of migration to cities, this strong trend towards urbanization.

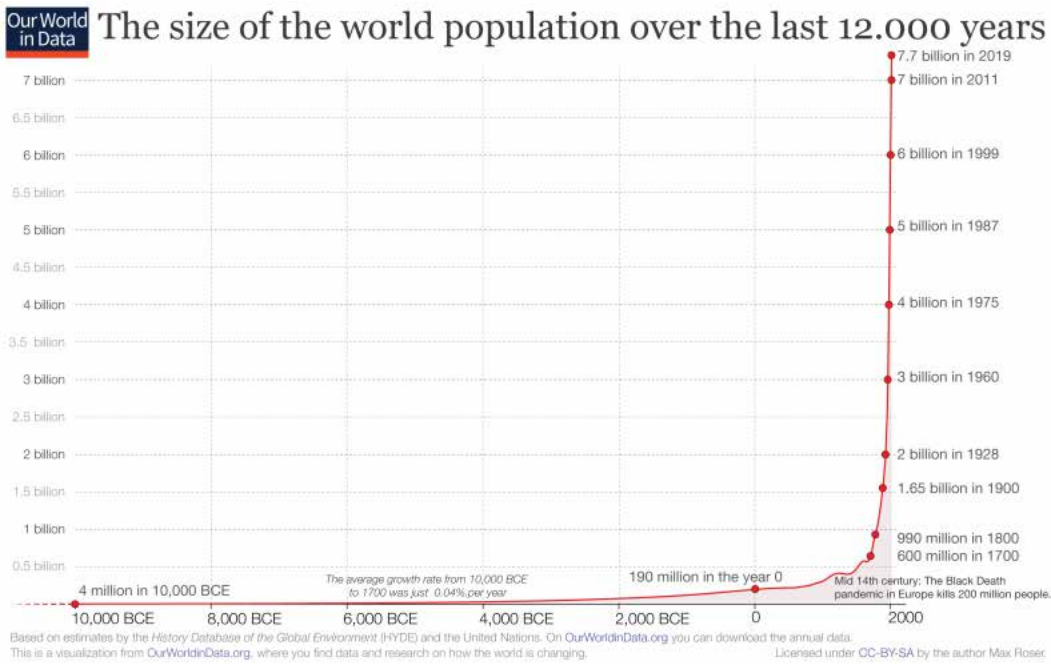

Figure 2 Measuring the world population. Source: https://ourworldindata.org/world-population-growth

The flood of data through the expansion of ICT technologies: many actions for sustainable development are connected to this context.

Alongside the issues related to urbanization, another important impact on contemporary cities is certainly that determined by information and communication technologies, better known under the acronym ICT. In the 90s' these technologies, both in their hard and soft components, begin to become popular and their markets to expand significantly. Promptly, the debate on the impact of these new technologies on the city becomes an important topic of discussion among professionals: cities enter the era of digital change, in other words, the digital revolution changes our way of living and communicating.

Many theories related to the network society (van Dijk, 1991) and its constant rise (Castells, 2000) take on practical consistency thanks to the small daily revolutions introduced by hard and soft technologies (mobile phones, the Internet, the GIS applications). Precisely, these evolving and rapid changes linked to technologies make it possible to look at urban space from another perspective, and Castells, at the beginning of the century, comes to our aid by talking about

space of flows: *"the space of flows [...] links up distant locales around shared functions and meanings on the basis of electronic circuits and fast transportation corridors, while isolating and subduing the logic of experience embodied in the space of places "*.

Beyond the enthusiasm for these innovations that take place in the material organization of social practices, we also immediately notice some risks, which perhaps have further exacerbated over time, and we refer to extraordinarily rapid (but highly uneven) application of digital information and communications technologies (ICTs). Contradictions coexist in this space of flows: hyper-connected people co-located with people who have limited or no access to the internet or new technologies (Graham, 2002).

At first the engines of this technological acceleration were confined within specific niches of users and above all they were not perfectly integrated with each other, I am referring above all to three great ICT drivers:

1. The Internet
2. The Geographical Information Systems (GIS)
3. The Mobile Phones

The Internet arrives in our homes at the turn of the century, it did not have the current gift of obliquity, it was slow and costly. Geographic information systems were used at the end of the 1990s in research centres, university departments and in advanced and competitive planners' companies, while mobile phones were not very smart, not very pocketable and very expensive. Simplifying, the first decade of this century increases the qualities of these drivers:

- The speed of the internet increases, costs are lowered, more and more wifi spots are born.
- Geographic information systems become competitive and widely used, plus open-source experiences that make this sector of urban and territorial data representation very competitive.
- The technology of mobile phones travels at a very high speed, within a few years we move to touch screens, keyboards are eliminated, phones become the place of integration of different services, in other words they become smart: from mobile phones to smart phone.

What happens in the first decade of the 21st century is the integration of these drivers, see the image below:

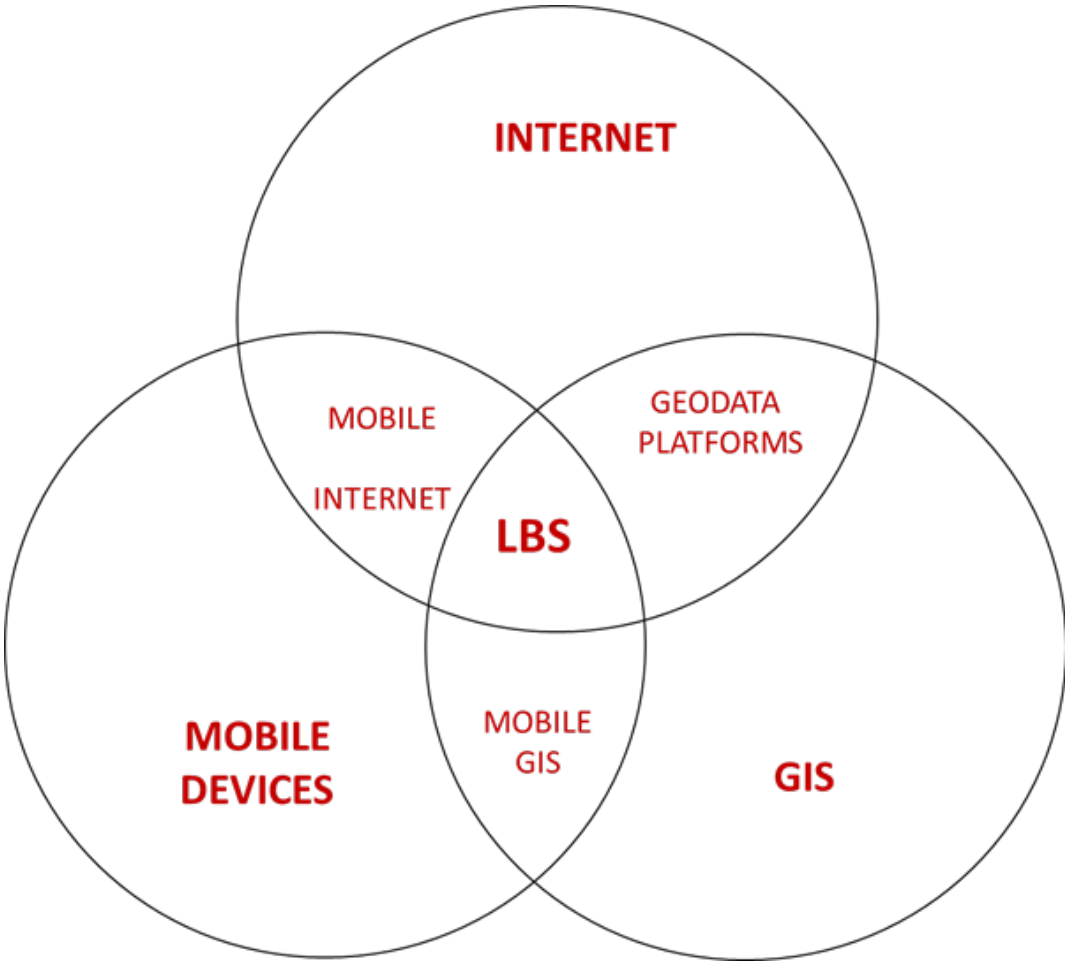

Figure 3 Diagram elaborated by the author

The reciprocal contaminations of these drivers allow us to define the so-called Location Based Services. The space of flows identified by Castells at the end of the 80's begins to conform in the contexts of everyday life and therefore of urban transformations. Electronic devices, more and more performing and intelligent, move with people who are no longer connected occasionally from home, but are always online. These transformations induced by technology impact on the very nature of urban spaces, changing the way of defining, designing and living places. In the last ten years, urban spaces have become hyperspaces:

- The medium of technology being more and more present in the space.
- Time sensitive and continuous data that flows across the space.

- People gathering into a continuous real time space.
- A finally realized space of flows enhances the dynamicity of places. Public and private spaces are becoming a mix of practices related both to human and objects behaviors (the internet of things). As urban planners we have to realize that there are new and innovative inputs to consider in designing the urban space, in making the contemporary places. In fact, in mixing the concept of place with the technological drivers, a new set of opportunities for thinking the contemporary city is generated (see the image below). These new domains need to be explored and developed to understand what problems they entail and what potentials can be developed in a sustainable way to improve the quality of life and local economies.

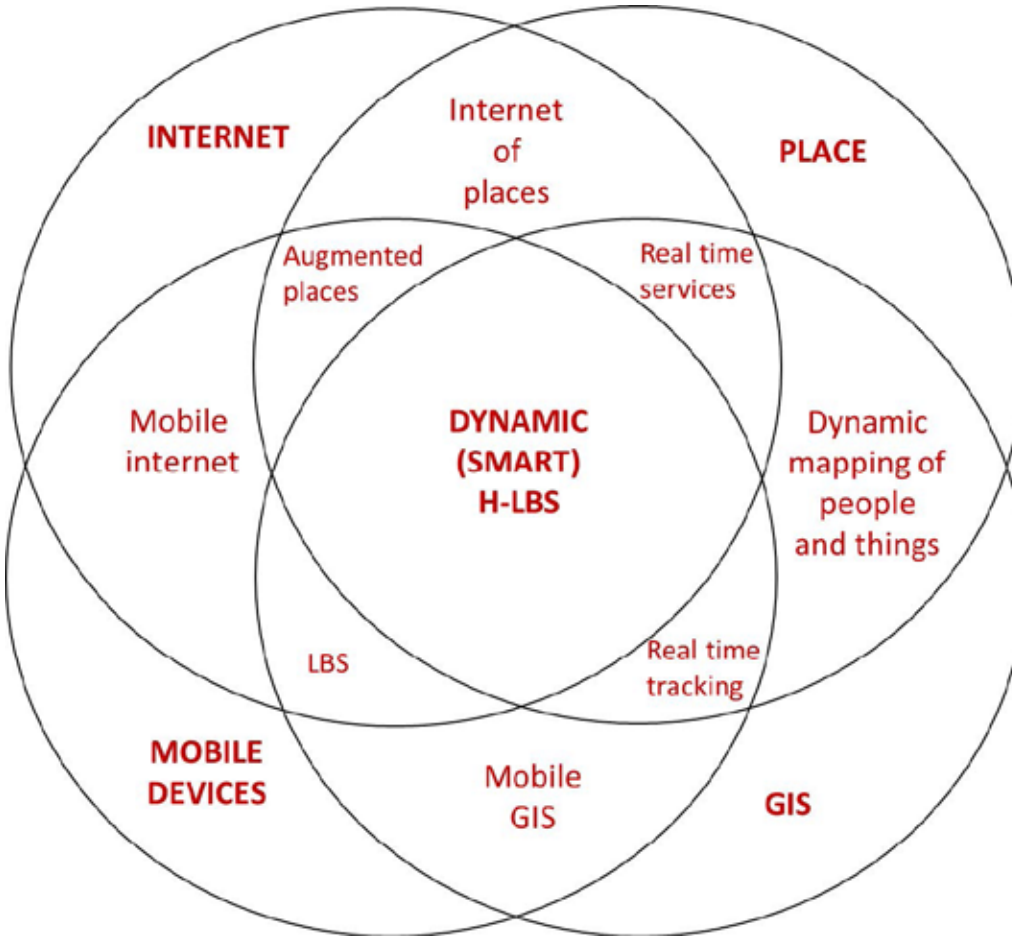

Figure 4 Diagram elaborated by the author

Also, in this context of technological and conceptual advancement we are faced with an increase in disparities on the urban scale, both in terms of accessibility to data and services:

- Extraordinarily rapid (but highly uneven) application of digital information and communications technologies (ICTs), (Castells 1999).
- Hyper-connected people co-located with people who have limited or no access to the internet or new technologies (The digital divide, Graham, 2002).
- Systems and databases are not integrated, often due to competition among vendors, but the cost of replacing those items is so high that cities cannot afford to change them (Zhou, 2018)
- Infrastructures for smart cities are expensive both in realization and in maintenance (especially after an economic crisis and a pandemic): How will they be powered?

This resilience of the digital divide leads us to consider likewise with criticality the transformations induced by investments triggered by the trend of smart cities, but without a doubt this movement has been, and still is, a harbinger of innovation.

However, most of the investments related to smart cities have been nothing more than an infrastructural upgrading (lighting, security and control systems, improvement of urban mobility management software) that has not changed the approach to planning and management of the city. The good of smart cities is still completely embryonic and needs to be valued within an integrated and holistic development vision of the city (the services that can be generated and managed by public administrations through the development of digital twin cities, the new ways of planning and designing the city through the dissemination of tools for 3D survey, start-ups and new economies linked to these 3D environments integrated with IGIS…). Unfortunately, even in a theoretically innovative concept such as that of smart city there are many archaic and despicable approaches to planning, for example based on:

- Big Picture: Old style top-down planning
- Data owned by ICT multinational companies
- Citizen as a data provider, but not data owner

On the other hand, the concepts, the standards developed, the technologies developed in the context of the debate and experiments related to smart cities can greatly help sustainable development if:

- Interoperability and standards are relevant
- There is not a big picture, but an incremental path built bottom up together with main stakeholders
- Open data and open content city's data ownership, Community-led decision making

The multiplicity of situations reported above are already changing, the way of thinking and designing the city. Urban planning workspaces have become hybrids, the objects and people that populate the spaces produce data and are perpetually interactive. The contemporary challenge is not to transform spaces into places, but to understand how these hybrid spaces (internet of people + internet of things) made up of people, objects and data flows can be designed as hyper-locations, how to create new local economies through the LBS (Location Based Services).

Figure 5 A creative representation for the Internet of Things, Source: https://e-estonia.com/tag/iot/

A big challenge will be to understand how to manage a growing datasphere. In fact, between 2013 and 2015 (Marr, B.) we produced more data than in the entire history of humanity until then. It's easy to assume that now that amount of data is being generated in even a single year, if not less. In fact, the race to invent new, ever greater units of measurement for the quantity of data is starting.

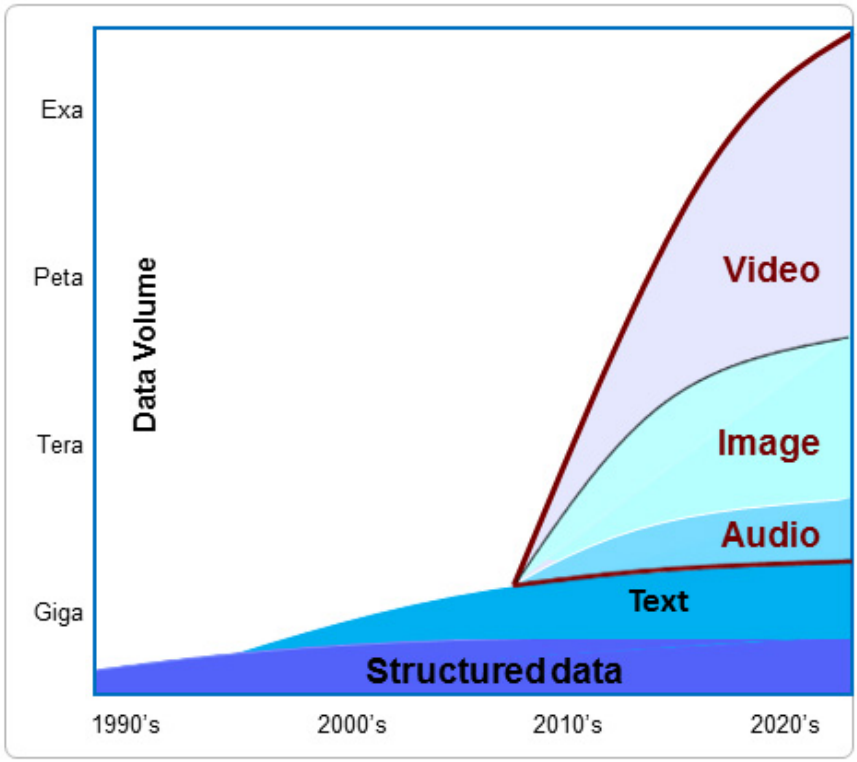

Figure 6 Data generated by people in the last years. SOURCE: https://www.nur.it/ma-quanti-dati-generiamo/

Urban planners, but also other professions that deal with promoting sustainable development, must absolutely take into account this remarkable production of data and understand how to transform and aggregate this flow of information in such a way that it can become operational knowledge that actually helps to trigger virtuous processes of an economic, socio-cultural nature and which can serve to reduce environmental impacts.

Finally, remaining in the field of innovative technologies, one cannot fail to consider the potential associated with the development of blockchain technology. Blockchain was invented to create bitcoin but can now store computer code and "smart contracts". The technology offers the possibility to innovate in

virtually any area, but the top uses are currently for cryptocurrencies and decentralized finance (DeFi) applications, which use blockchain-based smart contracts to implement financial instruments (UNCTAD, 2021).

Just to give an example, in the present European context, the many funds that will be made available for the various post-COVID recovery plans (the so-called resilience and recovery plans promoted at EU and member states scale), but also the simple mainstreaming funds linked to the classic structural funds could be managed with public procurements based on blockchain technology, this would guarantee:

- Greater participation
- Greater transparency
- Greater diversification and effectiveness in investments (avoiding misuse of funds and expanding the arena of the protagonists of urban and territorial development policies, going beyond the usual suspects).

Investing in urban governance on a global scale: planning matters!

Humanity, with Coronavirus, is simply becoming aware that its push for globalization must simply be managed, we must take the good and leave the bad of this push. The global governance was an easy victim of covid, supranational coordination. The supranational coordination of the pandemic was non-existent.

In January, many experts were already talking about an ongoing pandemic, but only in March 2020 the WHO declares it. By the time COVID was declared a pandemic in March 2020, there were more than 118,000 confirmed cases of the virus in 114 countries and more than 4,000 deaths.

From this moment on we can clearly see the paradox of a globalized world still governed by premodern instruments: The states.[2] Obviously, each state immediately thought of closing its boundaries and distrusting other countries initiatives.

We live in a postmodern (or late modern) system, increasingly open to the logic of global exchange, but we rule it through pre-modernistic tools (at the end of the day, we have centralistic actions led by states to fight the pandemic and a

2 The modern state was established in Europe between the fifteenth and nineteenth centuries. Its formation takes place through a progressive centralization of the power and territoriality of the political obligation.

competition among states to get the necessary assets to protect the own people, that is poor, weak instruments for transnational, global cooperation).

Furthermore, the pandemic immediately highlighted the disparity of conditions in the various macro-regions of our globe and highlighted the value of the disparities. The regions of the global south have suffered greatly from the impact of the pandemic, and in this phase of vaccination they suffer from the delay in the distribution of vaccines.

This episode of COVID19 has made many people aware of how many phenomena now travel on networks that go beyond our local contexts, but above all of the decision-making processes that can be taken at the local level. We realized through COVID why it has induced a sudden change in our ways of living and has put our own lives at risk, but many and different phenomena, which are not necessarily related to the domain of health, but to the economic and cultural sectors. now they follow the same diffusive logic.

Global cities and megacities are increasingly the generators and vectors of these "generators of change", the places where the catalysts of urban transformations are more and more active. These transformations can be positive, open to innovation, but they can also, as in the case of COVID, generate planetary risks. Other cities, in general, suffer the effects of globalization and can only respond through defense strategies, for simple questions of available critical mass.

For this simple reason it would be necessary to define global governance bodies that hold together, through a cooperative and non-competitive dialogue, these cities that play urbanization games at a higher level.

Today's globalization, as the last 20 years have shown, is bringing with it many risky challenges:

- ethnic conflicts,
- infectious diseases,
- terrorism
- climate change,
- energy security,
- food and water scarcity,
- international migration flows

Nevertheless, this same globalization is, at the same time, a source of wealth and emancipation, above all for the role played by cities: *Cities are productive*

engines of growth. They bring economies of scale, develop markets, create jobs and encourage new economic activities to flourish. As economies move from primary activities such as farming, fishing and mining to industrial production and then on to services, the role of cities in the global economy increases with each transition (Clos, J.)

Alongside the sectoral globalization that puts the interests of economic growth first, we must begin to structure networks, in which cities must play a primary role, which focus on values and actions that can balance risk factors, often existential, which globalization brings with it. Existential risks generally can't be solved by fragmented initiatives, success will almost certainly require deep cooperation among all countries. In fact, existential risks can be categorized according to how much cooperation is needed to avoid them. Mass cooperation without an explicit structure might work for some types of risk mitigation, but not for all (Harack, B.).

Many of the risks listed can have significant impacts on our very existence. Some risks, such as those related to the effects of climate change, have almost reached points of no return, in this sector, for example, coordinated action by urban realities is very necessary and urgent (70 per cent of greenhouse gas emissions come from cities, which account for 55 per cent of the world's population who consume more energy per head than people living in rural areas).

The world metropolises have grown within transnational networks (Sassen, S.) and now have more characteristics in common with each other than with their respective regional or national contexts. The response to current global risks must go through greater cooperation of the cities that drive global development.

This cooperation should act on at least three levels:

- Proper and careful planning of cities (governing urbanization through an investment in innovative urban planning tools and practices)
- Promote the networking of the major territorial actors that revolve around the transformation of global cities but create and strengthen moments of cooperation between the cities themselves.
- Campaign for territorial rebalancing actions (favour rural economies, invest in small and medium-sized cities, favour a polycentric structure of the territories)

Large urban areas define the main lines of global development, making this development sustainable means investing in each of these three lines of action listed above and understanding that, even if the economies of these urban reali-

ties go beyond their specific territorial contexts, it is important to re-establish a balance with the local dimension of origin and seek, as far as possible, a dialogue with the local context that can rebalance the consumption of resources and keep under control the ecological, social, cultural and economic impact of large metropolises.

Final remarks: Applying sustainable development in the planning and design practices of the contemporary city

To design the contemporary city, both at the level of strategic planning, be they plans or policies, but also at the level of urban design or even at the scale of the object, the three categories set out in the previous paragraphs must be kept together (an urbanization out of control , the unstoppable rise of new information and communication technologies, the weakness in governing various economic, socio-cultural and health phenomena now on a global level) and understanding what challenges they determine in the local context that is being faced. The absolute priority remains that of decreasing the impact of cities on ecosystem balances and reducing greenhouse gas emissions, and therefore addressing climate change, both in terms of mitigation and adaptation: Mitigation focuses to the causes of climate change, while adaptation tackles its impacts. From the reflections emerging in the previous paragraphs, we can see how:

- Cities are booming in countries with emerging economies, while are shrinking in Europe and other countries with more mature economies.
- On a side, it is evident and pressing the demand for the creation of urban dimension (cities with growing urbanization).
- On the other, there is the need to reinvent a post-industrial economy (EU cities) that is less space consuming, but even less dependent on existing productive infrastructures and facilities.
- In between these extremes, there is a relevant grey zone of economies in transitions.

An approach to city planning that focuses on the search for sustainable development is more necessary than ever at this historic moment. However, sustainability must be understood in a broader sense, as a function that holds together various variables and in a more operational sense, linking it to the solution of real problems. Sustainability is not only a conceptual reference but can be made practical by linking it more and more to local contexts, their diversity and con-

sidering it as a living matter in continuous evolution. Continuing to link sustainable development to the three great containers of society, the economy and the environment means reciting a mantra that is now without a proper meaning. The table below tries to contextualize sustainable development in an operational way:

	ECONOMIC DIMENSION	SOCIAL/EQUITY DIMENSION	ENVIRONMENTAL DIMENSION	GOVERNANCE DIMENSION	LOGISTICS DIMENSION
SUSTAINABLE PLANNING CHOICES	COSTS BENEFITS ECONOMIC RETURN OF PROJECTS STABLE JOBS CRETAED TEMPORARY JOBS CREATED [...]	STAKEHOLDERS INVOLVED GUARANTEED EQUITABLE ACCESS TO BENEFITS LOCAL DIVERSITY UNDERSTOOD AND CONSIDERED INDIVIDUAL/COMMUNITIES EMPOWERMENT IS PURSUED INCLUSIVE ACTIONS ARE PROMOTED QUALITY OF LIFE [...]	NEGATIVE IMPACTS ON ENVIRONMENT ARE AVOIDED OR MITIGATED PROJECTS FAVORS THE USE OF RENEWABLE SOURCES/RESOURCES PROJECTS ARE CONFORM TO EU DIRECTIVE ON: • WASTE MANAGEMENT • WATER MANAGEMENT • SOIL CONSUPTION • AIR POLLUTION • NOISE POLLUTION ADAPTATION/MITIGATION CLIMATE CHANGE [...]	LOCAL CLARIFICATION: ALL COMPETENT ADMINISTRATIVE AUTHORITIES SUPPORT THE SOLUTION AND DEFINE THEIR ROLE IN FACILITATING THE IMPLEMENTATION POLICY TOOLS ARE AVAILABLE TO MANAGE THE DEVELOPMENT OF PROPOSED SOLUTIONS PROJECTS ARE CONFORM TO TECHNICAL NORMS AND NORMATIVE PLANNING TOOLS [...]	BUDGETARY SUPPORT TO THE PROJECTS INSTITUTIONAL SUPPORT TO THE PROJECTS RIGHT SCALE OF PROPOSED SOLUTIONS (PROJECTS CAN BE MANAGED AT THE SCALE OF THE TOWN AND OF AVAILABLE RESOURCES AND CAPABILITIES) [...]

Table 1 designed by the author

We must, as planners, strive to make sustainable development operational. This operational step requires a design effort that must take us beyond traditional regulatory instruments and think more and more in terms of flexible, complex policies based on the involvement of various stakeholders. In terms of strategic planning this could mean:

- To Switch from a project's logic to a logic of process
- To move from the mere technical management of interventions to one putting at the centre the process of urban / metropolitan / territorial governance

- To promote planning instruments that are facilitating the private investments (providing clear strategic business plans), but under precise conditions in respect of general and public interest.
- To support pluralistic decision-making planning processes (multi-stakeholders / horizontal governance).
- To sustain multidisciplinary planning process (professionals with different backgrounds to be involved, not just architects and engineers).
- Replacing the logic of business plans with the logic of business strategy (a long-term plan of action designed to achieve a particular goal or set of goals or objectives).
- In terms of more tactical level actions, when intervening on the city: Multi-level governance activation on/in the intervention areas (activating multi-scalar competence and facilitating cross-sectorial policies coordination).
- Area based approach (commitment to community empowerment, and community capacity, limiting and precisely identifying the intervention area).
- Time based approach (setting clear and realistic timeframes for the regeneration/development planning processes).
- Clearly define the intervention areas responding to priorities put in evidence in the strategic plan process (housing, productive areas, public spaces…)
- A clear design of/for critical infrastructure (green, blue, mobility, services networks)
- Define a clear frame of action for the normative plans (Land Use and strictly technical plans) and link them to new IGIS and 3D applications.

Other important aspects to consider are related to promoting investments in innovative processes, training and research (strengthening aspects related to creative and knowledge led economies), for example:

- Foster integration by supporting balanced capacities for cooperation at all institutional and stakeholders' levels, and to merge results into a unique tool of governance promoting innovative services and products.

- Implement joint actions, supporting the participation of local groups in the urban spaces planning, through valorisation and exploitation of the ICT use and Knowledge Economy related products and services.
- Improve knowledge and skills within the involved city/ies with regard to the topic of the project and also to learn from the transnational network valuable information for future projects.
- Attain valuable experience and know-how in supporting participatory projects through e-platforms and setting up the cities' database in a way accessible to the public and mainly to city users and tourists.
- Develop experimental zones with a focus on public spaces and services and on hybrid participation, and replicate/upscale the methodology and innovations locally in other public spaces or at a larger scale, through knowledge transfer to urban planners and e-city specialists.
- For stakeholders, developers, investors, institutions, to "think outside the box" on various urban development topics and to adopt new methods and tools for improving their local activities and development.
- Implement public policies necessary to cover the identified planning aim them and its two fundamental challenges: Create knowledge and innovative tools that generate sustainable and efficient management models.
- Access to finance schemes, new business models in the field of R&D and innovation.

In conclusion and in synthesis, cities are faced with the enormous challenges of contemporaneity, of which they are protagonists, or as main actors or as those who have to manage the consequences of transformative phenomena that impact on a global scale, planners, policy and decision makers cannot only have an attitude of response on the emergency, but we must return to planning in a structured way and with a clear perception of what are the sustainable choices, and what are the choices to avoid:

- Projects that do not give a guarantee on economic and environmental sustainability and that do not come from an enlarged participatory process cannot be prioritized, the projects to be promoted must be those carried out through participatory paths, which implement an integrated approach and which have a low impact in terms of climate change.
- In managing the Urbanization processes, one cannot only think of planning and improving the spaces of the cities that will continue to grow

and of the new ones that will be created, but of rebalancing the rural urban relationship and maintaining a polycentric configuration of the territories.

- In tackling the rise of new ICT technologies, one must look at safeguarding the role of citizens and keeping the data generated within a public sphere (open data, open-source software, smart cities dashboards owned by the cities) and not leaving them managed by purely private actors.
- In addressing global challenges defining and promoting dialogue between cities, at this time global networks of cities would be much more useful in identifying and addressing priority issues than other structures (both national and supranational) that represent government apparatuses now obsolete and responding to the logic of an industrial and modernistic era that no longer exists.

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TECHNOLOGICAL CITY OR URBAN SCIENCE?

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Abstract

Very often technological innovation and urban planning had few points of contact, on one side computer scientists often adopted top-down approach of high-tech centralized control systems capable of resolving all the urban issues completely forgetting the essence of a city with its connected problems, on the other side urban planners were refractory in adopting technologies in urban phenomena monitoring. This paper, after summarizing the main experiences in the use of technologies applied to the city, develops some considerations on these aspects, trying to insert the technological issues within a framework closer to planning and with attention to the social and environmental impact. To this aim is fundamental consider a new approach in managing cities moving from a paradigm focused on bureaucracy and negotiation to an approach based on urban scientists.

Keywords: Urban Planning, Open data, Citizens as sensors, Governance, Smart city, Urban Science

1. Technologies for cities: Virtual Cities, Computable City and Ubiquitus City

Since the late '90s, with the growing diffusion of the internet, the experience of Virtual Cities (Smith,1998) has focused on construction and representation of urban scenarios. The use of Virtual Reality Modeling Language (VRML) allowed the creation of virtual environments and three-dimensional models of cities usability on the internet. This experience is not only restricted to simulation fields, but, using the large internet diffusion, it has been used to create

online participatory experiences, allowing part of the population to take part in urban policies creation. In other cases, citizens were allowed to contribute to a neighbourhood renewal project choice (Levy, 1995; Batty and Doyle, 1998; Hudson-Smith, 1998; Batty et al., 1998) simply by means of electronic vote.

Batty (1995) considered the huge possibilities deriving from a massive convergence of computer and communications through various forms of media.

Initially computers were used as a deeper support in city planning and programming. In subsequent years, interest has been moved on how computers and information technologies are changing cities. The result is the concept of Computable City (Batty, 1995), focused on the simultaneous analysis of both aspects. This concept examined both the ways in which computers were changing methods for city understanding and changes in city structure and dynamics. Later on, other types of computing with strong impact on the city have been adopted, such as ubiquitous computing, pervasive computing, physical computing, tangible media, each as facet of an interaction coherent paradigm, which Greenfield (2006) defines "everyware". At the end of 1990s, Openshaw (1998; 2000) coined the term Geocomputation, considering two main issues: intensity of the process and increase of knowledge and intelligence. This expression has been interpreted according to several meanings. Ehlen et al. (2002) analyzed four aspects of Geocomputation: from a high performance computing point of view, as a set of spatial analysis methods, as the essential aspects of Geocomputation and as their relationship with GIS (Murgante et al., 2009; 2011). In some cases there is a transition from a vision based on a computing power to a distributed environment where computers, seen in their traditional sense, disappear.

Consequently, the concept of computable city assumed increasing importance with the growth of electronic devices in our physical environment (Hudson-Smith et al., 2007).

The transition towards a not only virtual environment, i.e. an environment with a deep human and social interaction through computers, characterizes urban computing (Shepard and Greenfield, 2007). These theories take into account the social dimension of human environments, placing computers at the background. Shepard and Greenfield's (2007) theories on urban computing coupled with ubiquitous computing research developed at the Xerox Palo Alto Research Centre (Weiser, 1993) promoted the first experiences of ubiquitous cities (Jang and Suh, 2010), mainly concentrated in Asia. The objective of an ubiquitous city (U-city) is to create an integrated environment, where citizens can get any type of services, in all places, at any time and with all kinds of ICT devices (Lee et

al. 2008). These applications are based on infrastructures with the aim to support local needs by improving daily life of local communities.

The possibility of using real time acquired data, allowing continuous monitoring of main urban phenomena, can substantially improve the effectiveness of spatial planning and urban management. There is a transition from a traditional approach, based on the sequence real city, computer, virtual representation, to the sequence, computer, real city, ubiquitous city.

The traditional sequence considered many people working on one or on a few computers, while in U-city sequence only one person handles much computers and electronic devices (Lee et al. 2005).

2. Open Government and Gov. 2.0

A large amount of information produced by human activities and automated systems Information-Explosion Era (Kitsuregawa et al., 2007) is available, not only in Asia, where experiences of U-city are mostly concentrated.

In the last five years, acceleration occurred, supported by the diffusion of GPS devices and 3G connections in mobile phones, which has led to a large production of geo-localized or social networks based applications. This has led to a huge activity of Crowdsourcing (Howe, 2008), where suggestions services, ideas and any decision support can be achieved by online communities' actions. Population directly provides certain services that government is not interested to develop and private sector does not con- sider convenient to realize.

There are more and more initiatives (OpenStreetMap, WikiMapia, Google Map, Geo-Wiki) of Volunteered Geographic Information (Goodchild, 2007a), based on mass collaboration to create, manage and disseminate geographic data where citizens are voluntary sensors (Goodchild, 2007b). The huge production of data on the web has led to "Neo-geography" (Turner, 2006), defined as a new approach to geography without geographers (Goodchild, 2009) which describes the bottom-up production of maps with geo-tagged photos, videos, blogs, Wikipedia, etc. (Hudson-Smith et al., 2009).

Another important tendency in progress in recent years is open government. Such an approach is based on a more participative method of government and it starts from the assumption that ideas of citizens have always to be collected, not only before elections. Consequently, public involvement, getting ideas and

suggestions, is a daily activity, aiming to have a wider inspiration in managing and to collect feedback in already started actions. Obama's administration has given a great impetus to this approach, implementing such a policy and enlarging the possibility to capture public imagination by means of social networks, blogs and all possible solutions to directly interact with citizens.

This new approach is often called Gov. 2.0. Open government without a 2.0 approach is still based on a direct action. "Providers" are a sort of Right to Information, where the administration tries to inform people, but interacting just with main stake- holders. Gov. 2.0 is a more open approach, which "enables" citizens to have an important role in defining policies. Social media and all 2.0 platforms are a key element in generating a direct contact with citizens. Extensions of 2.0 philosophy changed completely the relationship between citizens and administration (Murgante et al., 2011).

It is a type of governance where aspects related to participatory decision-making are central and the transition from Government to Governance is combined with visioning techniques.

Since early '90s a transition occurred from an approach where local authorities directly provide to problem solutions (Government), to another approach, where local authorities tend to accompany the process (Governance). In the latter one, administrations enable and facilitate the search of different solutions, in collaboration and agreement with other public and private stakeholders (Balducci, 1999, Gibelli, 1996). In the same years visioning methods were adopted in order to develop bottom-up contributions, fundamental in planning process. contribution to the definition of a scenario of desirable actions in planning process (Gibelli, 1992).

3. Participation, e-participation, planning 2.0

In recent decades, the typical hierarchical relationships adopted in planning process have been modified moving toward a convergence of planning models, combining top-down policies, promoting functional principles of a plan and bottom-up initiatives, increasing the value of local specificities.

Envisioning methods have been adopted in numerous cases to develop bottom-up contributions, considered essential planning inputs. Unfortunately, in several cases this approach has been applied in contexts where decision makers

did not wish to share decisions with the community. The weak application of such a planning model generates a sort of suspicion towards planning activities, due to a poor attention to citizen needs coupled with an inadequate opposition to main transformation demands of the most influential stakeholders. Very often, a decision concerns only the actors who are directly involved in the process, excluding all people affected by the consequences of that decision (Simon, 1947) and whose needs should be taken into account. Consequently, in a decision-making process it is important to identify all the subjects to involve.

Three types of subjects can be identified, related to the different decision making levels: public sphere, interest groups and ordinary citizens.

Public sphere is responsible for stimulating and coordinating the planning process with the aim to ensure general interests. This category includes politicians, managers, municipal employees, planners, sectoral consultants. It represents the level at which the decision is taken.

An individual or a group of individuals is an actor of a decision if it directly or indirectly influences the decision itself. A group of individuals can be identified as a single actor, if they have the same value and information systems and relational networks (Roy and Bouyssou, 1993).

Interest groups often are privileged interlocutors of the decision-making level. This category includes both organised (e.g., organisations, associations) and spontaneous forms (e.g., protest groups) of interests. The aim of these groups is to influence choices for their economic interests, for general interests of the community or interests of specific sectors (environment, trade, etc.).

Citizens belong to the level that is directly affected by decisions. In a system based on a representative democracy, the lowest level of participation is realised voting at municipal or district elections. It is a theoretically perfect model that could lead to a democracy without citizens because of the low level of participation. A citizen can have a more active role in decision-making by participating in associations or organisations.

Friedmann (1993) uses the term Transactive Planning describing possible negotiations and interactions between planners, experts and citizens.

In traditional planning processes, there is a negotiation among all actors involved. On one side, the plan defines what are unnegotiable uses, specifying constraints that should intercept safeguarding instances; on the other side, interest groups propose possible transformations. Land use demand may be allowed only in areas defined by plans as suitable for transformations. The Plan has to

pursue the need of preservation and transformation, safeguarding collective interests and avoiding, at the same time, the possibility to lose any private investment (Pazienti, 2002). It is important that a plan receives and transmits impulses to its community. Generally, participation process in planning is strongly related to interest groups. In order to involve more people in planning process, it is fundamental to distinguish between not organised citizens, organisations and associations. Interest groups are influential subjects for an initiative, while in the great part of cases citizens' opinions, ideas, claims remain unheard (Murgante, 2012). This distinction is important because, in traditional planning forms, only organised groups of citizens are able to send impulses to planners in terms of needs, claims, demands, imagination, ideas, projects, which can be accepted or not. The plan has to identify rules defining constraints, in the case of unnegotiable transformations or in terms of negotiation, if transformation is possible. A plan, which does not accept impulses, is a self-referenced plan. If a plan does not produce effective and efficient rules, it is a plan that does not pursue public interest (Figure 1).

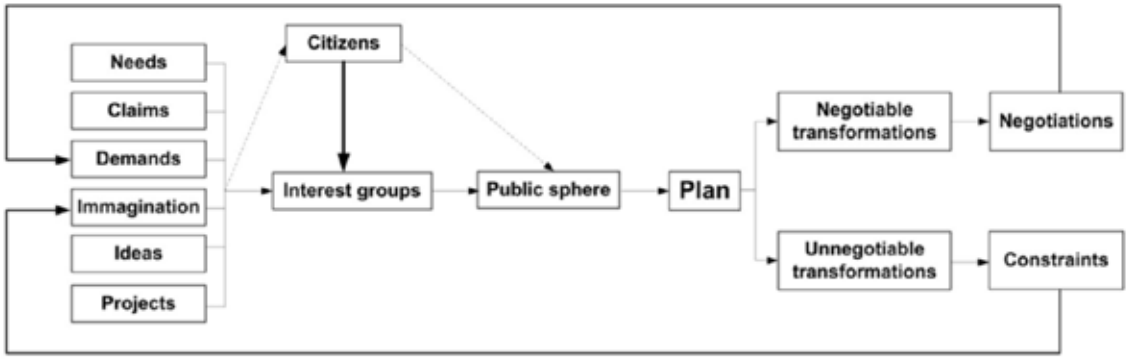

Figure 1 Relationships between citizens, organisations and plan (Murgante 2012).

Consequently, only organised actions can have a good level of influence. Generally, instances produced by citizens have been 'filtered' by organisations (i.e., parties, trade unions, associations of industrialists and entrepreneurs, associations of craftsmen and trades, environmentalist groups, etc.) and delivered to decision makers (Figures 1 and 3). The filtering phase was based on wide discussions and great debates inside single associations.

More than 40 years ago, Arnstein (1969) defined eight different levels of citizens' involvement in a planning process, using the metaphor of the ladder (Figure 2). Unfortunately, very often, traditional participatory approaches based on public meetings do not represent a significant sample due to multiple aspects:

- economically active population does not have enough time to attend meetings, consequently only children and elderly people's opinions are collected
- people consider physical participation as a waste of time, because the final decision will be taken by technicians and politicians
- often the participatory phase begins when decisions have already been taken, just to build consensus about the choice
- people may be inhibited when speaking in public
- in a public meeting citizens not always have an immediate idea or a ready answer
- often the person who screams is right
- screams are often functional to boycott new ideas.

Electronic participation goes beyond space and time dimension, allowing all citizens, who are working during the meeting time, who live in a distant place, who are embarrassed of public speaking, to express their opinions and produce a significant contribution in improving ideas.

In the last two decades, many experiences have been tested on the use of technologies to increase citizens' involvement in planning process (Laurini, 2001; Jones, 2000). Technologies are mainly based on the internet and geographical information system.

The first experiences were mainly based on putting images on a website, containing plan schemes or projects simulations. It was just a communicative approach in order to attract consensus. Subsequently, citizens' feedbacks have been collected using emails and newsgroups; in several experiences, electronic vote has been adopted asking citizens to choose which was the best project. This phase represented the transition from a one-way approach where citizens are simply informed on what are the contents of a plan, to a two-way approach where citizens' opinions have been collected and perhaps used by the administration. Peng (2001) provided a classification of levels and procedures of electronic participation, developing a taxonomy of a web-based public participation

system. He realised a matrix that correlates tool functions, interfaces, and gives general information concerning the plan. In this matrix for the first time, internet tools and GIS functionality have been analysed at the same time, in order to have scenario development tools. In this period, many systems based on web-mapping have been developed, in order to visualise possible scenarios and collect citizens' opinions.

Several years ago, Kingston (2002) adapted Arnstein ladder to the electronic era, defining an E-participation Ladder, establishing several levels from a simple website to online decision-making (Figure 2).

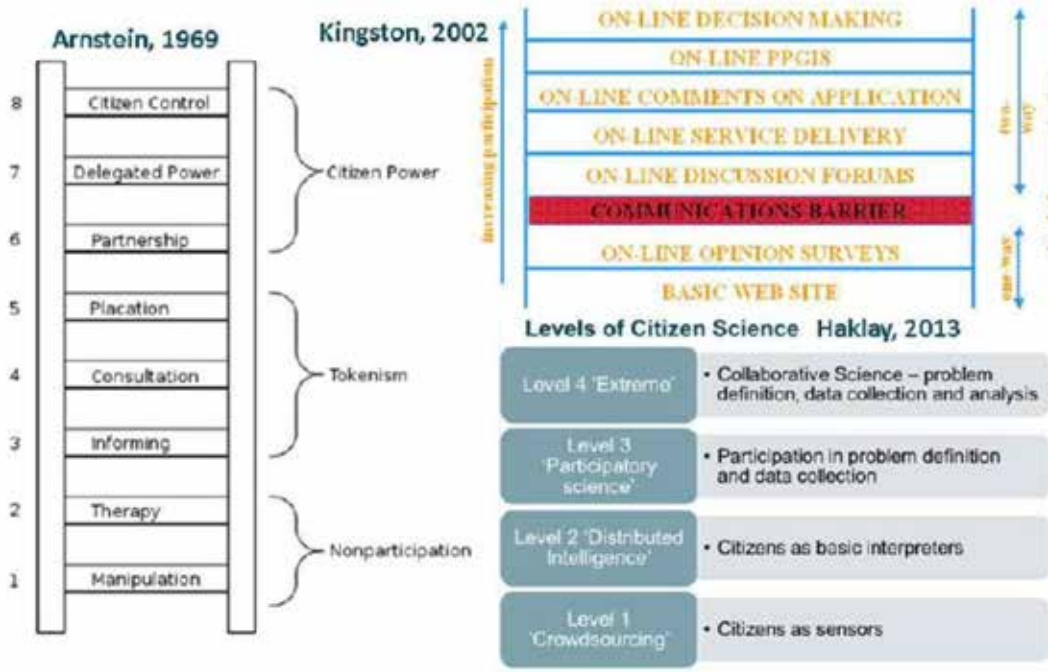

Figure 2 Public participation ladder (Arnstein, 1969), E-participation ladder (Kingston, 2002) citizens science ladder (Haklay, 2013)

The lesson learned by experiences of this period is that adopted electronic tools are expensive and not very effective, because they are not easy to use and possible users are not familiar with them. The typical conclusion of papers describing experiences of this period is "citizen participation was very poor".

After a few years, the situation is completely different. In 2004, Zuckerberg launched Facebook social network, a platform where people can discuss, share

documents, create events, etc., establishing closer relationships. Facebook has achieved a great popularity and, in short time, 50% of population of developed countries has a Facebook account.

Following Facebook, other social networks with different features and in several cases concentrated in particular domains received a good success (i.e., Twitter, LinkedIn, Myspace, Academia.edu, ResearchGate, Foursquare, etc.). Today, also the cheapest mobile phones have freely downloadable applications to allow people to be always connected to social networks. Consequently, in last period the popularity of social networks growth in an impressive way involving not only Millennials, but also Gen X, and Baby Boomers. Several reports describe statistics about the use of social networks classifying the typology by age (Nanji, 2017; Murnane, 2018; Smith and Anderson, 2018). The results highlight that Facebook is the most popular social media for every age, but at the same time younger generations are substantially more likely to use platforms such as Snapchat (78%) and Instagram (71%), Pinterest is widely used by women and LinkedIn is prevalently adopted in business sector.

The increase in connection capabilities and collaborative approaches has been coupled with the decrease in credibility by several organisations, completely self- referenced and disconnected from citizens' problems and needs.

Figure 3 Transition from typical social mediator to direct connection between decision makers and citizens using social network (Murgante 2012).

This situation creates a great gap in the upper part of the scheme of Figure 3, leaving the decision maker totally at the mercy of interest groups and decreasing transparency level. Consequently, a balance is lacking in planning process,

because decision makers have a strong connection only with people with great interests, losing a great source of ideas produced by common citizens.

It may seem a paradox, but great part of planning choices, which effectively have evident implications on citizens quality of life do not directly involve community; they are only the result of technical and political activities.

The connection between decision makers and citizens has been newly found by means of social networks (Figure 3). On these platforms, it is possible to discuss, comparing opinions and suggesting ideas. The decision maker, in this case, can participate to a debate having clearer indications on which are the problems and proposals of a community.

If 'planning through debate' (Healey, 1992) represents a collaborative approach that brings an enrichment of points of view, when analysing problems, it is also important to consider the 'rational ignorance' (Krek, 2005). Citizens often trivialise concepts or manifest inertia in understanding technical issues.

In 2.0 planning approaches, citizens, probably unconsciously, face many of the typical steps adopted in planning process, reaching the highest level of levels of Arnstein, Kingston and Haklay Ladders. Generally, a group of citizens denounces the most critical aspects occurring in an area (analysis of problems), another group defines a set of objectives, another group prepares a list of alternatives and after many discussions a huge part of a community proposes an idea, a project with the great support of public opinion. Social platforms become the main place where producing and developing ideas. In addition, newspapers, which generally are more influenced by economic lobbies than by individual ideas, can support a project, if an important opinion movement supports it. In terms of planning theory, 2.0 planning can be seen as a renewed approach to Advocacy Planning (Davidoff, 1965), where the collector of instances is a virtual environment. Advocacy Planning was a movement mainly concentrated on the solution of social and human problems. Advocacy Planning has played a central role in 'making people aware' of local communities or single action groups for balancing the power of big public and private agencies. The advocacy planner represents all people generally unheard in decision process and the needs of marginalised neighbourhoods, generally absent at decision-making tables. 2.0 planning is rooted on advocacy planning. These actions are mainly developed on virtual environment and cloud services.

While in advocacy organisations, a sort of hierarchy remains between the mass of people and their representatives, in 2.0 planning all people have the same position on a scale of responsibility.

The development of 2.0 planning is strictly related to social media growth. Facebook, twitter and the other social networks were born to look for old classmates, military service friends and university colleagues; today these are powerful media and places where it is possible to exchange ideas and opinions (Rocha et al., 2015; Murgante, 2012; Rocha et al., 2016; Resch et al., 2016).

The use of Social networks has enabled a significant expansion of participatory basis, beyond the constraints of space and time (Salvini, 2005). Social scanning (Soojung-Kim Pang, 2010) is a fundamental instrument in collecting ideas, opinions, etc. from citizens. Social platforms can lead from a closed model of decision-making based on professionals' government and representative democracy, where participation is mainly relegated to election (Noveck, 2009), to an integration of representative democracy and collaborative approaches, where a decision maker has the possibility to directly consult citizens in order to take a particular decision. If, on one side, it is important to avoid pitfalls highlighted by Michael Bloomberg in an interview to the New York Times (Grynbaum, 2012), where Twitter has been defined as a source of everyday referendum leading activities only to short term actions because great part of people is not interested in future programming activities; on the other side social platforms can produce social mobilisation, claims and real changes in people quality of life (Healey, 2001).

4. City Sensing and Smart City

City sensing is based on electronic and human sensors or on the combination of both (Bergner et al., 2013), on voluntary or unconscious actions (Tagliolato et al., 2014), and it is a key component in Smart City.

It is central to correctly define the relationship between city sensing and smart city, because these are new concepts without a precise and unambiguous definition.

Considering also that the application domain is the city, whose elements are rooted in our daily lives, there is a risk, in analogy with what happened with the concept of sustainability, that after many years we have collected a lot of words and few results. The correct relationship between city and sensing Smart city must be based on equal dignity of all aspects. It could happen to forget the city, focusing the attention only on technology. The main risk would be represented by

a fall of electronic devices on the city, which does not have a direct relationship with its main problems.

In analogy with the beginnings of geographic information systems, when the market was mainly determined by supply more than by demand, the risk is to invest significant resources in purchasing hardware and software without having a clear idea of administration needs and their possible use in city management.

The European experience differs from U-city in giving less importance to computational aspects and in paying more attention to the potential of technologies for the improvement of city quality. Great attention has been paid to digital citizenship that leads to new forms of social organization related to information technology.

A shared definition identifies smart cities in a synthesis of physical and social infrastructures (Caragliu et al., 2009), where the first one can represent a catalyst for knowledge communication, increasing social and intellectual capital. A superficial approach combined with a rush to be included under "smart umbrella", can lead to ignore these aspects, mainly focusing on improving devices and technological systems which quickly get old. A city can be considered smart if it can quickly integrate and synthesize data produced by each type of sensor, to improve efficiency, equity, sustainability and quality of life (Batty et al., 2012). It is important to consider the big impact of technologies on new forms of policy and planning. In analysing smart cities, Batty et al. (2012) identify seven points on which the attention should be focused, analysing key problems of cities, using information and communication technologies:

1. a new understanding of urban problems;
2. effective and feasible ways to coordinate urban technologies;
3. models and methods to use urban data across spatial and temporal scales;
4. developing new technologies for communication and dissemination;
5. new forms of urban governance and organisation;
6. defining critical problems about cities, transport, and energy;
7. risk, uncertainty and hazard in the smart city.

It is important to give priority to the construction of cognitive frameworks and to a wider knowledge in supporting decisions in urban planning, compared to approaches based on procedural efficacy. Today, especially in Europe, compliance

with procedures is mainly considered the production of a bureaucratic truth, in most cases very far from reality, when analyzing urban phenomena. Recently, a lot of reports have been published in order to define variables to classify smartness level of municipalities in a hypothetical path to smarter cities. Table 1 is an attempt to synthesize the main variables adopted in reports which analyse smart cities.

Dimension	Variables
Smart Economy	Employment rate; presence of innovative enterprises, presence and quality of universities and research institutes; infrastructures (roads, railways, airports, electronic infrastructures, etc.).
Smart Environment	Air quality, percentage of separate collection of municipal waste (also electrical and electronic equipment waste), presence of green spaces in the city, efficiency and quality of water supply (water leakage and water treatment).
Smart Governance	Not only related to e-government, percentage of ecological cars, use of recycled paper, energy saving, adoption of ecological policies for city planning and development, ability to network with other municipalities.
Smart Living	Investments in culture and welfare providing several services, from childcare facilities to community libraries, from counselling structures for old people to cinemas, number of people below poverty level, hospital emigration rate, immigrants social integration, criminality rate.
Smart Mobility	Extensive and efficient public transportation network, park and ride, great diffusion of ecological cars, limited traffic areas, cycle paths, bike and car sharing.
Smart People	Education and early school leaving level, number of women working and holds positions within the administration, presence of foreign students, political participation, involvement in voluntary associations, newspapers diffusion and level of participation to cultural events.

Table 1. Synthesis of the main variables adopted in reports analysing smart cities

In a smart city the technological infrastructure related to ICT is central, in the same way as in the past the realization of new buildings, roads, railways, telephone and energy distribution lines and networks was. Such infrastructures both supported population needs and influenced how such population interacted with the urban space.

The city should therefore set as an "enabling platform for the activities that citizens are able to develop, linking those inherited from the past to those that can be realized in the future, so it is not focused on just applications but on the possibility that citizens realize them" (De Biase, 2012).

A smart city should therefore be passed on different pillars, elements to be organized and linked together. These can be summarized (Murgante and Borruso, 2014) in three main elements (Figure 4):

1. connections - as networks and technological infrastructures;
2. data – open and public or public interest data to allow the development of innovative solutions and the interaction between users/citizens and the city;
3. sensors - these including citizens (Goodchild, 2007a, 2007b, 2009) able to actively participate in a bottom up way to city activities.

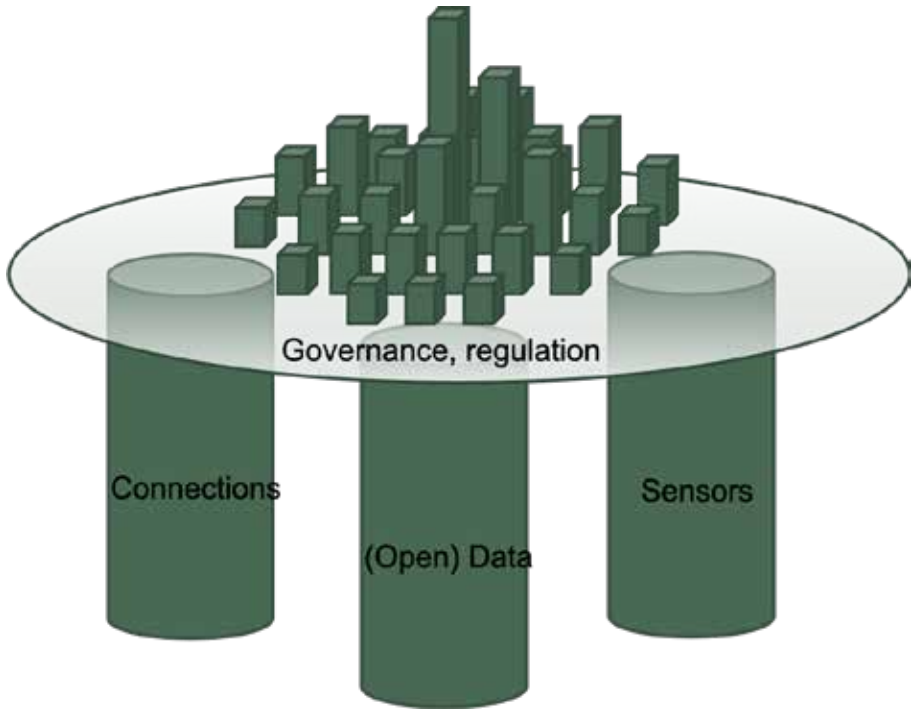

Fig. 4. The Pillars sustaining the Smart City and its Governance (Murgante and Borruso, 2015)

These pillars must be coupled with a governance capable of linking them together, giving a direction and a vision to the city. Such governance should regulate the smart city in a neutral way, without entering into the details for applications and contents.

A Smart city therefore appears as an urban project, as a big infrastructure and as a metaphor of the net in an urban context. In a sentence, a smart city becomes an environment where a definite set of elements, as the ones above reported – sensors, data and connections – harmonized by a limited set of basic rules, gives public bodies, citizens, enterprises the possibility of developing applications and solutions able to improve life of the city itself, leaving actually the initiative of doing that to people, groups, firms, etc., allowing also to create new markets and solutions also where the public sector is not able to move.

5. Towards a science for cities

The traditional approach to planning and managing cities, and the consequent legislative apparatus, generated a concept of plan suitable for less dynamic cities. The main purpose was to control the physical shape of the city in smallest detail, controlling construction activities, defining the new areas where it was possible to build and the amount of new constructions. This approach was suitable for cities that changed slowly and by adding new parts and the purpose of the plan was simply to make the new additions coherent with the existing structure of the city.

As the years passed an increase of cities complexity occurred. Consequently it is no longer possible to manage and plan cities with a reductionist approach. Cities are complex systems and cannot be managed dividing them in smaller parts. A complex system is very different from the sum of its single parts (Anderson, 1972). Cities cannot be managed with traditional approaches mainly based on lows, norms, bureaucracy, privileging the procedural aspects compared to the cities knowledge.

Generally, plans are the results of long negotiations, which produce a long list of strict norms. Consequently, the main aim of this approach to planning is to enforce such rules. In several cases, plans are old, very far from the current reality, or based on old laws, which do not allow for the production of tools to solve current problems. The result is that the main planning goals are very far from providing a serious response to the transformation demands that arise daily.

Several authors describe these trend as "vintage planning" (Romano et al., 2018) or "ghost planning" (Scorza et al., 2020). This approach leads to leads to a situation synthetized on the left of figure 5:

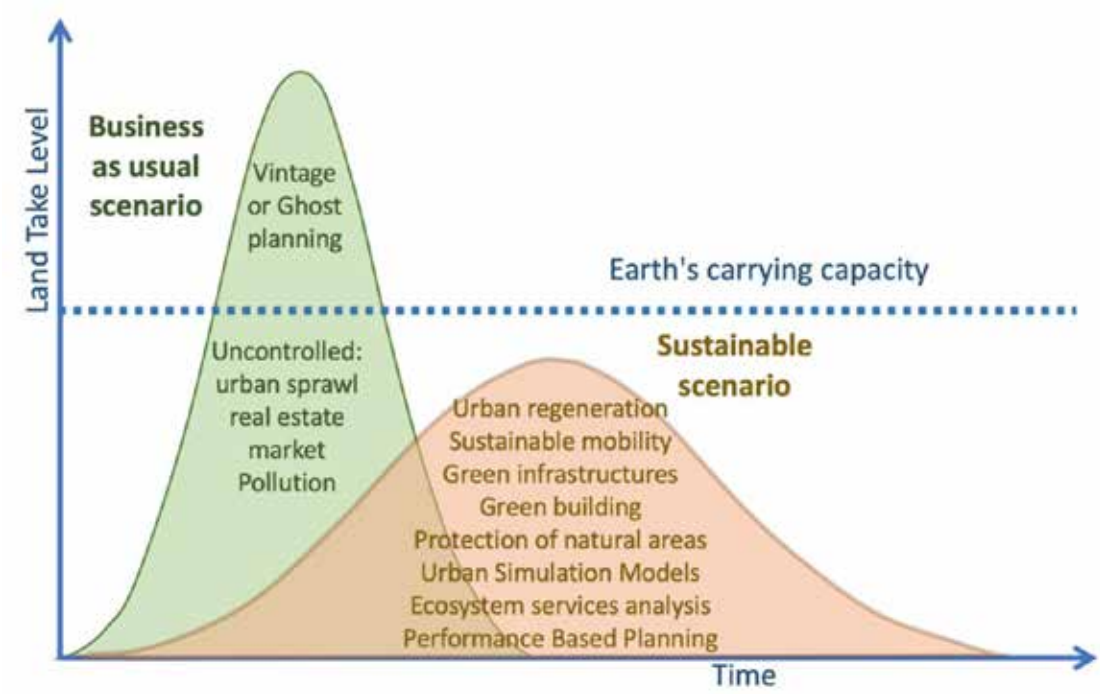

Fig. 5. Flattening curve of Earth's carrying capacity based on comparing two possible scenarios: business-as-usual and sustainable (Murgante et al., 2020).

The results are different: a city with an uncontrolled real estate market, which produces urban sprawl; several portions of the city inhabited only by tourists due to the effects of Airbnb; cities dominated by cars with serious pollution problems. This scenario leads to a consumption of resources greater than the capacity of the planet. In 2019, Overshoot Day occurred in late July. Consequently, for the following five months, humanity used resources that the planet could not provide. An alternative is an approach based on simulations in assessing transformation impacts, allowing planners to take into account several land use scenarios, choosing the more suitable solutions for the transformations. This approach to planning also considers possible losses of the ecosystem services in simulations (Geneletti, 2016; Gobattoni et al., 2016; Pelorosso et al., 2017; Picchi et al., 2019).

Several authors adopted the term performance-based planning (Botequilha-Leitão and Díaz-Varela, 2020; Baker et al., 2006; Frew et al., 2016; Marwedel, 1998; Janin Rivolin, 2008; Pappalardo, and La Rosa, 2020; Geneletti et al., 2017) to synthetize this approach. Consequently, this "umbrella" can contain

all simulation models and tools. Due to data availability, all models based on Cellular automata or Multiagent Systems, Space Syntax, Geodesign, etc. can take into account a lot of components in detailed simulations. Therefore, goals for the protection of natural areas will be pursued more easily. Furthermore, adopting urban policies based on urban regeneration, sustainable mobility and the creation of green infrastructures can create a more sustainable scenario able to flatten the curve under the earth's carrying capacity.

It is fundamental consider a new approach in managing cities, based on urban scientists, Giovanni Astengo (1996) in Encyclopedia of Arts defines Urban Planning as science able to study urban phenomena.

Also Batty (2013) considers cities not simply as places in space but as systems of networks and flows, consequently it is important to analyse cities with models a tools able to support decisions. "Complexity sciences, social physics, urban economics, transportation theory, regional science, and urban geography, can support theories and methods that reveal the deep structure of how cities function".

When I was student, several decades have passed, there was a parallelism between urban planners and orchestra directors. Today the "director" has to develop knowledge in a lot fields connected to technologies and cities.

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THE ROLE OF ANALYTICAL CHEMISTRY OF METAL IONS IN MONITORING THE QUALITY OF THE ENVIRONMENT

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Abstract:

There is no doubt analytical laboratories have an essential role to play in environmental protection through monitoring of pollutants in air, water or soil. Research on trace elements and the effects of their ingestion on human health is also often seen in scientific literature. The term heavy metal is often used to refer to the group of metals and semimetals (metalloids) that have been associated with contamination and potential toxicity or ecotoxicity. Environmental medium is exposed to a number of pollutants including toxic heavy metals by various natural and anthropogenic activities. Consequently, heavy metal contaminated environmental has the potential to pose severe health risks and hazards to humans as well as other living creatures of the ecosystem through various routes of exposure such as direct ingestion, contaminated drinking ground water, food crops, contact with contaminated soil and through food chain. Therefore, it is mandatory to explore various techniques that could efficiently determine the occurrence of heavy metals in different environmental samples. A number of methods have been developed for the quantification and monitoring of analyzed matrices. In this work summarized development and application of different analytical methods and techniques, from kinetic-UV-Vis spectrometry, ICP-OES to ICP-MS to analyze heavy metals, in different real samples, from an environmental point of view.

Keywords: metal ions, monitoring, environment

INTRODUCTION

Currently, environmental pollution by heavy metals is a global problem. Therefore, it is crucial to develop effective detection techniques to determine the levels of heavy metal contamination in various mediums. One of the most important global environmental problems is contamination of food products

throughout the food chain with a variety of toxicants. Heavy metals cause a lot of ecological damage and danger to living organisms due to their characteristics such as chemical stability, low degradability, long half-life, high toxicity, carcinogenic and neurotoxic effects, even in very small amounts, and biological accumulation at different levels. Therefore, the contamination of soils, water, air and agricultural products with potentially toxic elements, especially through water, soil and during the production process is one of the serious threats to the health of consumers. The most important toxic elements that have harmful effects on humans health include Pb, Ni, Cd and As. Some of these elements are carcinogenic and others cause damage to various parts of the body. As a result, quality control and safety of water, air, soil and agriculture products as a valuable export product and human risk assessment for the consumer should be considered. According to the complexity of food matrices, different analytical techniques have been applied for the determination of trace elements in the different real samples such as spectrophotometric, kinetic-spectrophotometric methods, the inductively coupled plasma-optical emission spectrometry (ICP-OES), inductively coupled plasma-mass spectrometry (ICP-MS) graphite furnace atomic absorption spectrometry (GFAAS) and flame atomic absorption spectrometry (GFAAS), voltammetry, (Lu, 2017).

EXPERIMENTAL

Spectrophotometric measurements were performed on a Perkin-Elmer Lambda 15 UV-vis spectrophotometer, using a cylindrical cell thermostated at 25.0±0.1 C°. A Julabo MP-5A model thermostatic bath was used to maintain the reaction temperature at 25.0_0.1_C. The pH measurements were carried out using a Hanna Instruments pH meter. Sigma buffers, pH of 7.00_0.01 and pH of 4.00_0.01, were used to calibrate the pH meter. The solutions were thermostated at 25.0_0.1_C before the beginning of the reaction. All analyses were carried out in an iCAP 6300 Duo inductively coupled plasma optical emission spectrometer (Thermo Scientific Cambridge, UK) which used an Echelle optical design (52.92 grooves per mm, 63.5_blaze angle) and a change injection device solid-state detector (RACID86). The nebulizer was ultrasonic (CETAC U-6000). An Ultra-Scientific (North Kingstown, RI) ICP multi-element standard solution of about 20.00 ± 0.01 mg/L was used as a stock solution for calibration. The PVC containers were treated with 20% nitric acid and washed with ultra-pure water 0.05 mS/cm (MicroMed high purity water system, TKA Wasseraufbereitungssysteme GMBH, Stockland, Niederelbert, Germany). Both nitric acid (65%) (Merck, Darmstadt,

Germany) and hydrogen peroxide (30%) (Fluka, Buchs, Switzerland) were of analytical grade. All reagents used were of analytical grade.

RESULTS AND DISSCUSSION

Kinetic-spectrophotometric determination of traces of metal ions in permanganate indicator system

At the beginning of this kinetic-spectrophotometric research, we used the already known indicator system kinetic-spectrophotometric system, which have some disadvantages, from the point of view of chemical stability and economy. It is the reaction oxidation of 4-hydroxycoumarine by KMnO4 at the different pH. In these papers new kinetic procedures have been developed for the sensitive determination of metal ions such as Mn(II), Mo(VI), Th(IV), V(V) and Au(III). The proposed kinetic methods were validated, and applied to real samples. All research was published in scientific international journals whose areas of publication were the focus of the analytical improvements and applications. A group of these papers shows development, optimisation and validation with analytical application from environmental point of view.

The first of these works (Micic, 2006) describes a simple, selective and sensitive kinetic method for the determination of trace amounts of molybdenum(VI) based on its inhibitory effect on the reaction oxidation of 4-hydroxycoumarine by KMnO4 in the presence of hydrochloric acid, at pH 1.75 at 25°C. The rate of the indicator reaction was followed spectrophotometricallyby measuring the decrease in the absorbance of KMnO4 at 525 nm. The development method includes optimization of the reagent concentration and temperature. The calibration graph was linear in the range of concentrations from 20 to 200ng/cm3 of molybdenum(VI). The probable relative error was in the interval 3.10 – 10.52% for the concentration range of 200 – 20 ng/cm^3 molybdenum(VI), respectively. The interference effects of the foreign ions were determined to assess the selectivity of the method. The developed method was found to have relatively good selectivity, sensitivity, simplicity and rapidity.

Further reported paper (Micic, 2006) presents a new kinetic method for determination of traces of manganese(II) based on its catalytic effect on the oxidation of 4-hydroxycoumarine with KMnO4 at pH of 1.35 and at a temperature

of 25°C was proposed. The reaction also, followed spectrophotometrically by measuring the decrease in the absorbance of the dye at 525 nm. The calibration graph is linear in the range 20–200 ng/cm3. The effects of certain foreign ions upon the reaction rate were determined for assessment by the selectivity of the method. The proposed method has been applied for determination of manganese(II) in river water samples with satisfactory results.

Moreover (Micic, 2015) a new kinetic method has been developed for simple, fast and selective determination of trace amounts of vanadium (V) (0.5–5 μg/cm3) based on its inhibiting effect on the oxidizing reaction of 4-hydroxicumarine by means of $KMnO_4$ in acid media. The proposed kinetic method was used for determination of vanadium (V) in different samples of water without its preliminary separation. Thus, the developed kinetic method for determination of trace amounts of vanadium (V) without its preliminary isolation, which greatly reduces the time of analysis. The use of proposed method substantially improves at adding of masking ligands for removing components creating interferences. Other advantages of the proposed method are simplicity of operation, low costs, low consumption of reagents and samples and also a very important fact: decreased losses of the trace level of vanadium (V) and reduction of the pollution danger. In addition, the method is distinguished with high precision, correctness and selectivity in analysis of vanadium at the level of trace amounts.

An very practical analytic kinetic-catalytic method (Micic, 2011) based on catalytic effect of traces of Th(IV) on the reaction oxidation of 4-hydroxycoumarin by KMnO4 were developed and validated. The linearity of the method was obtained in the range of concentrations of Th(IV) from 0.2 to2 μg mL^{-1} . The probable relative error is in the interval from 7.88 to 3.50 % for the range of concentration of Th(IV) from 0.5 to 2 μg mL^{-1}. Proposed kinetic method was directly applied in environmental water samples. Th(IV) was spiked and determined in the natural water samples by using proposed kinetic method and comparable atomic absorption spectrophotometry (AAS) method. Application of masking agents in acidic media (0.1 M NaF) significantly improved selectivity of the method and also, simplified application of the proposed kinetic method in real samples, regard interfering ions.

An simple and fast kinetic method based on the oxidation of 4-OH coumarine using $KMnO_4$ for the determination of ultramicroamounts of Au(III) by its catalytic effect on this reaction, was also reported (Petkovic, 2008). The sensitivity of the method is 25 ng/mL. The relative error ranges between 9.20–3.90% for the concentration interval $5 \cdot 10^{-8}$–$2 \cdot 10^{-7}$ g/mL. The selectivity of the

method is very good, and the effect of foreign ions is investigated. The proposed approach has been applied to the determination of traces of Au(III) in copper ore.

Kinetic research with simpler, available and more stable spectrophotometric reagents

Having in mind the instability of permanganate as well as the synthesis of coumarin, with all the adverse reactions, kinetic research determination of traces of metal ions was continued with other indicator reagents, in order to simplify but also improve the analytical performance of the proposed methods. An indicator system as the reaction oxidation of disodium-6-hydroxy-5-[(4-sulfophenyl) azo]-2-naphtalenesulfonic acid (artificial color, Sunset Yellow FCF, E110 in text selected as SY by H_2O_2 in borate buffer was used for this purpose. Also, artificial azo-dye: tartrazine (tri-sodium – 5 – Hydroxy – 1 - (4-sulfophenyl) -4- [(4-sulfophenyl) azo]pyrazole-3-carboxylate), in further text labeled as TZ with H_2O_2 was used as an indicator system. Sunset Yellow and Tartrazine are water-soluble synthetic colorants, widely used as additives in the food industry. A number of methods have been available for their analysis individually or simultaneously in mixtures. Food dyes may be natural or synthetic, and they have been widely used to optimize food color, because freshness, ripeness, and flavour are all associated with the color of food [1]. However, the synthetic colorants may be toxic, especially if consumed in large amounts.

Thus, in this group of papers kinetic methods for the determination of Cu, Co, Pb, Au, but also SCN anions based on the inhibitory effect on the kinetic-catalytic reaction were developed, validated and applied in different real samples.

Reported paper (Micic, 2009) shown high sensitive, accurate and simple kinetic method for determination of trace of Co(II) ions, based on its strongly catalytic effect in the reaction oxidation of disodium-6-hydroxy-5-[(4-sulfophenyl)azo]-2-naphtalenesulfonic acid (artificial color, Sunset Yellow FCF, E110, SY) by hydrogen peroxide in borate buffer at pH of 9.5, by monitoring the rate of disappearance of SY. Reaction rate was monitored spectrophotometrically, at λmax of the SY at 478.4 nm. The optimum operating conditions regarding reagents concentration and temperature were established. The tangent method was adopted for constructing the calibration curve, which was found to be linear over the concentration range 1.18–17.67 ng /ml and 17.67-58.90 ng/ml of Co(II).

The limit of detection (3σ) is 0.15 ng /ml, and limit of quantification (10σ) is 0.5 ng/ ml. The effects of the other ions on the reaction rate were determined for an assessment of the selectivity of the method. This method is one of the most sensitive kinetic methods for determining ultra traces of cobalt.

Further (Micic, 2009) a sensitive and rapid kinetic method for trace determination of Cu(II) was developed and validated, based on its catalytic effect on the oxidation of disodium-6-hydroxy-5-[(4-sulphophenyl)azo]-2-naphtalenesulphonicacid (''SY, FCF", E110) by hydrogen peroxidein borate buffer at pH 10.5. The reaction was monitored spectrophotometrically by measuring the decrease in the absorbance of SY at 478.4 nm. The optimum operating conditions regarding concentration of reagents, pH and temperature were established. The calibration curve was linear up to 318 ng/ mL of Cu(II) and the limit of detection (3σ/S) is 5.0 ng/ mL, and limit of quantification (10σ/S) is 16.67 ng/ mL. The proposed kinetic procedure was successfully applied to monitoring of the concentration of Cu(II) in fruit, wine and milk samples from different areas. The results obtained by the proposed kinetic procedure were compared by those obtained by ICP-OES method, and shown good agreement. The proposed kinetic method useful for monitoring of quality of drinks or fruit depending on Cu(II) concentration, because of its important role as nutritional element.

Futher reported paper (Micic, 2014), shown an efficient, high sensitive, fast and selective kinetic method for determination of traces of Cu(II) which developed and applied for its quantification in different kind of real samples. This simple method was based on catalytic effect of traces of Cu(II) on the redox reaction of artificial azo-dye tartrazine (tri-sodium-5-Hydroxy-1-(4-sulfophenyl)-4-[(4-sulfophenyl)azo]pyrazole-3-carboxylate), with H_2O_2. The optimum operating conditions regarding reagent concentration and temperature were established, and the linearity of the method was obtained in the concentration range from13 to 318 ng/ml of Cu(II), with a detection limit (LOD) (3σ) of 2.05 ng/ml, and limit of quantification (LOQ) (10σ) of 6.85 ng/ml.

A simple, fast, green analytical kinetic method for the determination of micro-amounts of gold(III) ions, were also established and reported (Micic, 2016) in same indicator kinetic system. The method was based on the inhibitory effect of traces of Au(III) ions on the redox reaction between disodium-6-hydroxy-*5*-[(4-sulfophenyl)azo]-*2*-naphtalenesulfo-nate (artificial azo-dye "Sunset Yellow

FCF", E110) and hydrogen-peroxide, in alkaline media of borate buffer. All experimental parameters affecting to the determination: reagent concentrations, pH and temperature were investigated and optimised. Working experimental conditions are set according to the highest sensitivity of the proposed kinetic method for the determination of Au(III) ions. The linearity of the method was obtained within the range 1.97-59.07 μg/mL of Au(III) ions with relative standard deviation of 3.66 - 0.43 %, respectively. The influence by possible interference effects by major ions on the determination of Au(III) and their limits are investigated, at the constant Au(III) concentration of 39.39 μg/mL. The results of Au(III) determination in samples obtained by proposed kinetic method and comparative ICP-OES method were statistically agreeable. this kinetic method was applied to the determination of Au(III) ions in pharmacological samples, ampoules *Tauredon* ® with Au(III) ions concentration of 50 mg/0.5 mL, (Na_2SAuO_4).

All these kinetic methods were statistically comparable with the high sensitive and selective ICP-OES method.

Further research was aimed at analyzing a larger number of samples for the presence of toxic ions in samples of water, soil and food, through which toxic metals enter the food chain, especially from the territory of Kosovo and Metohija (Micic,2015).

The concentrations of selected elements in vegetables (radish, onion, garlic and spinach) from Kosovo were determined using ICP-OES method. Oral intake of metals and health risk index were calculated. Statistical analysis indicated numerous positive correlations between concentrations of selected elements in vegetables. As a result of principal component analysis, 15 new variables were obtained which were characterized by eigenvalues.

Performed statistical analyses indicated large number of positive and negative correlations between concentrations of selected elements (23) in vegetables. As a result of principal component analysis, 15 new variables were obtained which were characterized by eigenvalues. The sequence of health quotients for the heavy metals followed the decreasing order Zn=Mn>Pb>Cu>Ni>Fe>Cd>Co>Cr. The health quotients for all investigated toxic metals were below 1 (one), which is considered safe.

The idea of a broader examination and comparison of the results is based on the fact that Kosovo has a specific geo-morphological composition, under the

strong anthropogenic influence of mining and metallurgical activity. This was the first research of this type which includes the wider area of Kosovo taking into account the mineral wealth. The concentrations of 20 elements: Al, As, Ba, Ca, Cd, Co, Cr, Cu, Fe, K, Mg,Mn, Na, Ni, P, Pb, Se, Si, V, and Zn were determined using ICP-OES. The ranges of concentrations of toxic elements are lead (Pb) 0.044–14.98 g/kg, arsenic (As) 0.007–0.33 g/kg, cadmium (Cd) 0.004–0.044 g/kg, and chromium (Cr) 0.053–0.245 g/kg. The spatial distribution of toxic elements was described using distribution maps. Principal component and cluster analyses were performed to reveal grouping of samples (Simonovic, 2018). The results of the study highlighted the influence of industrial and mining activities on elemental content of the soil on a wider area of Kosovo, as well as geological characteristics, in particular taking into account toxic element quantities. Also, the statistical analysis performed gave us the minimum number of factors four that can be traced to monitor the pollution of the area caused by the elements, thus saving time and money.

It should be emphasized that the research went in the direction of applying the proposed kinetic spectrophotometric methods for measuring the concentration of metal ions before and after the treatment of electrochemically synthesized ferrates, in order to remove them from ecological samples (Micic, 2019). In this paper reported the application of electrochemically generated Na_2FeO_4, for the purpose of the elimination of Th(IV) ions from water samples as coagulating agent. Th is a radioactive element often used as a fuel for nuclear reactors. Analyzed natural water samples spiked with Th(IV) were treated with solution of ferrates (VI) under recommended conditions of electrochemically synthesized ferrates solution and Th(IV) was quantified by previously established kinetic method. Removal of Th(IV) ions by ferrates (VI) was successfully confirmed by comparison of the concentration of Th(IV) before and after ferrates (VI) treatment of spiked analyzed water samples. A simple kinetic-spectrophotometric method was successfully applied to determine Th(IV) concentration, indicating the decrease in the concentration of Th(IV) in water samples applying ferrate (VI).

CONCLUSIONS

The paper presents research concerning the analytical determination of the content of ion traces using simple kinetic spectrophotometric methods. The second group of papers presents elemental analysis through the ICP-OES method in various environmental samples, as well as products that can be a health risk through the food chain. Principal component analysis was used as a statistical tool. It is used with the aim to evaluate the dataset,reducing its dimension and conserving most of the statistical information. Principal component analysis(PCA) permits establishing the relationships among examined variables.

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SPECIFICITIES AND DETERMINANTS OF ECO-INNOVATION PROJECTS

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Abstract

Eco-innovations have aroused great interest among researchers and decision-makers in business and governments as they enable the reduction of environmental impact, increase competitiveness, and actively contribute to the goals of sustainable development. In this context, the paper analyzes the concept of eco-innovation, the specifics of eco-innovation projects and the main drivers for their implementation. Eco-innovations are more complex compared to conventional innovations; eco-innovation projects need to meet economic, environmental and social goals simultaniously. Various external and internal factors trigger eco-innovation projects. Among the external determinants in the paper there is the focus on political and regulatory determinants, economic-market determinants, as well as cooperation and networking with other organizations. Regarding internal determinants, the focus is on resources, competencies, abilities and strategy. The findings are general. Therefore, in order to determine the relevant determinants in a country, researchers should take into account the specifics and local conditions.

Key words: eco-innovation, external determinants, firm-level determinants, project management

INTRODUCTION

The concept of eco-innovations is being developed in response to the connection between innovations and environmental protection, preservation of natural resources and life quality improvement and is in line with the philosophy of sustainable development. According to Kemp & Foxon (2007) eco-innovations imply the production, assimilation or exploitation of a product, production pro-

cess, service or management or business method that is new to the organization (it is being developed or adopted) and which, during its life cycle, results in environmental risk reduction, the reduction of pollution and other negative impacts of resource and energy use compared to relevant alternatives.

In the literature, the authors mostly focus on three types of eco-innovation: eco-product, eco-process and eco-organizational innovation (Liao, 2018; Triguero et al., 2013). Eco-product innovations present the improvement of existing or the introduction of new products in terms of their characteristics, which aim to reduce their impact on the environment throughout the product life cycle. Eco-process innovations represent the adoption of new or the improvement of existing processes that cause positive (or less negative) effects on the environment compared to alternative processes. Eco-organizational innovations relate to the introduction of organizational methods and management systems to address environmental issues in manufacturing and products (Kemp & Foxon, 2007).

Eco-innovations have many benefits for the national economy and society by significantly increasing competitiveness and economic development, generating new sources of value for productivity growth, reducing environmental risks and helping to achieve sustainable development goals (UNEP, 2017). The benefits of eco-innovation for enterprises include, among other things, reducing costs in the long run (reducing materials or energy per unit of output), increasing market share, creating business opportunities, contributing to image, improving prospects for long-term survival (Beltramello et al., 2013; Yao, et al., 2019). Eco-innovations enable companies to meet environmental imperatives and are a factor of competitive advantage (Nidumolu, et al., 2009). Dominantly research records highlight the positive impact of eco-innovations on enterprise performance. On the other hand, some research suggests that eco-innovations can incur high investment costs and harm financial performance (Madaleno et al., 2020).

Eco-innovations are indispensable in the development of an ecologically healthier and more prosperous society. Governments should play an active role in fostering environmental technologies and innovation (Beltramello et al. 2013). Managers and entrepreneurs need to be environmentally conscious and companies need to constantly look for innovative ways to contribute to the environment. According to Scarpellini et al. (2016), in many European countries, eco-innovation projects, despite numerous potential benefits, are not common. Researchers point out that eco-innovations are more complex compared to conventional innovations (Wicki & Hansen, 2019). Eco-innovations are associated with improvements in environmental, economic and social performances simul-

taniously, which is not easy for companies to achieve. Numerous factors influence eco-innovations that decision-makers in governments and business need to understand in order to support the implementation of eco-innovation projects.

SPECIFICITIES OF ECO-INNOVATION PROJECTS

An innovation project is defined as a non-recurrent process aimed at formalizing a new idea and turning it into an innovation that will be diffused and accepted (or not) by its users (Walch-Fernez, 2017). The input of an innovation project is always an idea (invention, discovery, market observation, etc.) and the outcome is an innovation (new or improved product, process, organizational method, etc.). Innovation is never a goal in itself; it is the means for a company to achieve strategic goals, therefore the launch of an innovation project is always the result of a strategic decision (Walch-Fernez, 2017).

Eco-innovation projects have their own specifics in relation to other innovation and other projects. Eco-innovation projects reduce the overall negative impact on the environment, combining business and innovation to create sustainable solutions (Stošić, et al., 2016). Companies that implement eco-innovation projects (independently or in a network) deal with the challenges of achieving environmental, economic and social goals simultaniously. The implementation of eco-innovations is a coherent set of actions taken to implement an eco-innovation project and these actions usually fall under product, process or organizational aspects where each company can put a different degree of emphasis on these aspects when implementing an eco-innovation project (Cheng & Shiu, 2012). For instance, eco-organizational innovations can foster eco-process and eco-product innovations; eco-product innovations can affect eco-process innovations and these further affect eco-organizational innovations, etc.

In addition to the nature of the project output, one of the dimensions of eco-innovations is the intensity of newness, where we distinguish between eco--innovation projects that are incremental or radical in nature. The environmental impact dimension refers to the effect of eco-innovation projects on the environment (OECD, 2009). Eco-innovations that bring radical and systemic improvements to environmental performance offer significantly higher environmental contributions, but also carry higher economic risks.

Many methods for evaluation and selection of innovation projects have crystallized in theory and practice. If we look at the methods of multicriteria decision-making, eco-innovation projects require a wider set of criteria compared

to other innovation projects (Stošić et al, 2016). In the application of the AHP method for the evaluation of eco-innovation, projects provide the following criteria for the AHP hierarchy: project criteria, economic criteria, environmental and technological criteria, as well as social criteria. Each of these criteria consists of several sub-criteria. Thus, the project criteria contain: approach structure, project management elements and risk; environmental and technological criteria are: environmental benefits, technical progress and applicability of the solution; economic criteria include: market and financial outcomes and social criteria include social acceptability and social well-being (Stošić et al., 2016).

The project management literature emphasizes that there must be a clear link between project outputs and business strategy requirements for an organization to achieve optimal value from investing in projects (Scarpellini et al., 2016; Too & Weaver, 2014). Research shows (Portillo-Tarragona et al., 2018; Scarpellini et al., 2016) that eco-innovation projects can be both profitable and achieve environmental benefits, do not require a necessarily high level of investment and that external sources of funding are more represented, and for each specific case, the organizational characteristics, resources and capabilities, as well as the characteristics of the eco-innovation project itself (project type, objectives, level of investment, time, etc.) should be taken into account.

DETERMINANTS OF ECO-INNOVATION PROJECTS

The decision of a company's management to embark on the implementation of eco-innovation projects is influenced by various factors. Researchers have started from a general innovative theory in identifying factors. Later, a number of theories were considered and the most widely used were neoinstitutional theory, evolutionary economics theory, and resource-based theory (Keshminder & del Rio, 2019).

Different classifications of eco-innovation determinants can be found in the literature. Rennings (2000) identifies three groups of factors: technology push factors: material and energy efficiency, product quality; market pull factors: market participation, conquering new markets, customer requirements, image and competition; and regulatory push/pull factors: laws, regulations and standards. Horbach et al. (2013) list the following three groups: determinants of regulation and policy, institutional infrastructure, and regulatory design; supply side determinants: technological capabilities, resources, patents and market characteristics; and demand side determinants: environmental awareness and consumer

preferences for environmentally friendly products, as well as increased market share and penetration of new segments.

The determinants of eco-innovation are most often categorized in the literature as internal and external (del Rio Gonzales, 2009; Galliano & Nadel, 2013; Kiefer et al., 2018). Firm-level factors are mainly related to the existence of internal preconditions and characteristics that enable the company to engage in environmental technological changes (del Rio Gonzales, 2009). These factors include: tangible and intangible resources, technological and organizational capabilities and strategy, as well as company characteristics (Bernauer et al., 2006; Horbach et al., 2012; Keshminder & del Rio, 2019). Economic-market and administrative-warrant factors stand out as external factors: customer demands for ecological products, competitive pressures, high material and energy costs, and policies and regulations (Bernauer et al., 2006; Kesidou & Demirel, 2012; Kijek, 2013). Collaboration and networking have also attracted the attention of researchers (de Marchi et al., 2012).

From the company's point of view, the goal is to select projects that can most effectively contribute to the achievement of strategic goals, taking into account external and internal factors. The determinants identified in the literature, regardless of the different classifications, are basically similar: the authors mainly focus on external determinants: policies and regulations - command-control and market-based instruments; economic-market determinants - customer requirements, competitive pressures and cost savings; cooperation with other organizations and networking; as well as on firm-level determinants: resources, competencies, capabilities, and strategy including enterprise characteristics.

External determinants

Political and regulatory determinants. The main factors that fall into this group are market-based instruments (environmental taxes and fees, subsidies, tradable permits, etc.) and command and control instruments (laws, standards, technical requirements, specifications, etc.). It is prevalent in the literature that market-based instruments are superior to command and control instruments (Bitat, 2016; Cai & Li, 2018). According to Liao (2018), market-based instruments stimulate companies to implement eco-innovation projects to compensate for the loss of profits due to taxes, lower the cost of abatement pollution and increase the benefits of abatement pollution. Economists favor market-based instruments due to their economic efficiency because they lead to cost-effective decisions on abatement measures related to static efficiency, and also encourage technological

advances in efforts to prevent environmental degradation in terms of dynamic efficiency (Pereira-Sanchez & Vence -Deza, 2015).

Economic and market determinants. Studies find that consumer demands and demand for eco-friendly products present an important factor in opting for eco-product innovation (Horbach et al, 2012; Aibar-Guzman, 2021). It is generally considered that customers are now more aware of the environmental impacts and are willing to pay more for eco-products. Placing innovative eco-products on the market, and the awareness that the company also contributes to the environment through process eco-innovations, creates a positive impression among consumers about the company and the company's products, which leads to increased market share. However, the situations differ among the payment strata of the population, as well as between developed and developing countries. According to research by Biswas & Roy (2015), price sensitivity among consumers in the markets of developing countries may present a limitation in the expansion of the organic products market. In countries with low environmental awareness and low willingness to pay more for eco-products, a stronger impact of this factor cannot be expected.

Competition impact is another variable that is the subject of research. Studies show that competitive pressures have a significant impact on companies' commitment to eco-innovation projects (Li, 2014; Cai & Li, 2018). Competitors' environmental strategies and practices can persuade top management to introduce eco-innovation projects to help the company improve its market position. Boutry et al. (2021) find that the mimetic effects of competitor behavior in a sector strongly favor the development of eco-innovation. Li (2014) argue that enterprises today use eco-innovation as a tool for differentiation in order to improve efficiency, product quality, green image, etc. in order to gain a competitive advantage in an increasingly dynamic competitive market.

Cost saving has been identified in several papers as a significant driver of eco-innovation and is largely market-driven (Rave et al., 2011; Horbach et al., 2012). According to Kijek (2013), high prices of energy and materials on the market influence companies to apply eco-innovation. This driver has a greater impact on eco-process innovation projects compared to eco-product innovation projects. According to Horbach (2016), cost saving is more important for eco-innovation than other types of innovation because they are often related to reducing material and energy consumption (which also means reducing environmental impact). Cost saving increases profitability and leads to a competitive advantage, provided that certain investments are required (e.g. in technology, R&D) and that potential profits are not visible in the short term.

Cooperation and networking. In the literature, collaboration and networking have been identified as an important determinant of eco-innovation (de Marchi, 2012; Melander, 2018). Eco-innovators rely more on the capabilities and competencies of external partners than conventional innovators. According to de Marchi et al. (2012), cooperation with external partners is more intensive for eco-innovation due to their systemic and complex characteristics. Network partners can be different. Suppliers provide technology and innovative material and customers contribute knowledge about the market, products and services (Melander, 2018). Companies can cooperate in the network with other organizations, including competitors. Universities and other scientific research organizations provide knowledge and technological capabilities. External consultants and experts may also be involved. For SMEs, compared to large enterprises, it is even more important to connect to networks as they have fewer resources, smaller R&D capacities, and face more uncertainty and obstacles.

Firm-level determinants

Resource-based view (or RBV) theory is most commonly used to investigate internal factors. According to RBV, the competitiveness of companies depends on the quantity and quality of their resources and the ability of companies to optimize them (Testa et al., 2011). A company must practically have the resources, capabilities and competencies (RCC) to be able to implement eco-innovation projects or to acquire them through cooperation and networks from other companies.

Technological and organizational capabilities are significant drivers of eco--innovation (Horbach et al., 2012; Kesidou & Demirel, 2012). Technological capabilities consist of tangible technology, intangible experience and specialized knowledge required for the development of environmental products and processes (Cai & Li, 2018). In order to build such capabilities, it is necessary to invest in new technology, R&D activities, knowledge and skills of employees, etc. Companies that are more involved in R&D activities have greater potential for the implementation of eco-innovation projects. In addition, companies that build environmental organizational capabilities are more likely to invest more in eco-innovation (Kesidou & Demirel, 2012). According to Melander (2018), organizational skills and practices include clear goals and support for top management, organizing for eco-projects, environmental education, knowledge management, and an environmental organizational culture. The literature particularly emphasizes the importance of the environmental management system (EMS) in

stimulating eco-innovation (Rave, 2011; Cai & Li, 2018). EMS builds organizational capabilities and practices that help the organization achieve the intended outcomes that, in line with the organization's policy, include improving environmental performance, regulatory compliance, and achieving environmental goals. In addition, companies' ability to innovate increases when it is a part of a larger group due to access to knowledge and resources (de Marchi, 2012).

Kiefer et al. (2018) cite physical RCCs, inclusion in environmental supply chains, environmental organizational culture, organization motivation for eco--innovation (based on technology push and market pull) and internal financial resources as internal determinants of eco-innovation. Keshminder & Del Rio (2019) emphasize the importance of environmental strategy as a determinant of eco-innovation as a part of a company's strategy aimed at achieving and maintaining the alignment of organizational resources, competencies and capabilities with stakeholders' environmental expectations.

In terms of enterprise characteristics, researchers are mostly focused on size, and in the literature it is generally agreed that size has an effect on eco-innovation (Rave et al., 2011; Triguero et al., 2013). Large companies have more technological, financial and human resources, as well as the expertise to develop SME eco-innovation (Galliano & Nadel, 2013). SMEs face more difficulties in implementing eco-innovation, but they also implement eco-innovation projects, independently or in a network. Andries & Stephan (2019) find that SME motivation for eco-innovation is more based on user requirements than regulations, SMEs benefit from consumers who are willing to pay more for eco-friendly products, also SMEs are more dependent on local customers so that the benefits of adapting to their needs outweigh the resource disadvantages.

CONCLUSION

Eco-innovations have numerous benefits for national economies and society and support the implementation of sustainable development goals. Companies have gradually begun to recognize the value of eco-innovations, as an important factor of competitive advantage, long-term survival, and a favorable image. As organizations have increasingly implemented eco-innovation projects, independently or in cooperation with other organizations, the research base is increasing, generating a large number of studies. Researchers have focused their attention mostly on eco-product, eco-process and eco-organizational innovations. It has been observed that eco-innovations are more complex compared to conventional innovations. Eco-innovation projects should meet economic, environmental and

social goals simultaneously. Multiple criteria are used to evaluate eco-innovation projects, including project-related criteria, economic, technological, environmental and social criteria.

Management should select the projects that most effectively contribute to the realization of the company's strategic goals, taking into account the relevant external and internal determinants. Studies indicate that among the most important external determinants are: policies and regulations - market-based instruments and command and control instruments; economic and market determinants - environmental customer requirements, competitive pressures and cost savings; also cooperation and networking with external partners. Internal determinants are: resources, competencies, capabilities and strategy of a company. Eco-innovation projects require governmental support, developed environmental awareness, well-informed managers and entrepreneurs, and appropriate resources and capabilities.

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SATELLITE VALIDATION OF TROPOMI-SO_2 OVER THE BALKAN REGION BY AIRBORNE SO_2 MEASUREMENTS OF COAL-FIRED POWER PLANTS

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Abstract

The first airborne in situ measurements of sulphur dioxide (SO_2) emissions (plumes) from two coal-fired power plants in Bosnia-Herzegovina (Tuzla) and Serbia (Nikola Tesla) were carried out with the German research aircraft *Falcon-20* in cooperation with local partners during the METHANE-To-Go field experiment in autumn 2020. Downwind of the power plants, SO_2 mixing ratios exceeding 100 ppb were measured in a distance ~20-40 km from the sources. The plumes were trapped in well-defined inversion layers between ~500-1000 m altitude. Our airborne measurements can be used to validate synchronously, spaceborne SO_2 measurements from the TROPOspheric Monitoring Instrument (TROPOMI) onboard the Sentinel-5P satellite. A first intercomparison indicates some problems with dense smoke clouds frequently covering these countries

in winter. However, one part of the Nikola Tesla flight is well suited for TROPOMI-SO_2 validation, since it was obtained during cloud-free conditions with a well-defined vertical extension of the probed SO_2 plume (needed to estimate the Vertical Column Density, VCD). These airborne measurements and model simulations can also be used to determine the SO_2 emission strength of the power plants. First estimates (mass balance approach) show that the SO_2 mass flux from Tuzla is about twice as high as indicated by common emission inventories.

Keywords: sulphur dioxide emissions, power plants, airborne measurements, satellite validation, Balkans

INTRODUCTION

Recent results from spaceborne measurements indicate that the Balkans is a hot spot region for anthropogenic SO_2 emissions in Europe (Theys et al., 2015; Fioletov et al., 2017, 2020; Liu et al., 2018). These emissions mainly originate from a few coal-fired power plants located in Bosnia-Herzegovina and Serbia. The Serbian power plants, Nikola Tesla, are ranked on position number 18 of the world´s strongest sources of SO_2 pollution according to Dahiya and Myllyvirta (2019), whereas the Bosnia-Herzegovina power plant Tuzla ranks on position number 25.

Here we report on the first airborne in situ measurements in this region carried out by the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt, DLR).

FIELD CAMPAIGN AND DATA

The DLR-funded field experiment METHANE-To-Go-Europe, with the objective to investigate anthropogenic methane (CH_4) and sulfur dioxide sources (SO_2), was carried out in October and November 2020 together with local partners in the Balkans (https://www.dlr.de/pa/en/desktopdefault.aspx/tabid-2342/6725_read-70275/). The focus of the CH_4 measurements was on emissions from off-shore gas facilities in the Adriatic Sea, whereas the focus of the SO_2 measurements was on emissions from coal-fired power plants in the Balkans. Here we only report on results from the latter objective.

Airborne in situ measurements were carried out with the German research aircraft *Falcon-20* of the DLR, which was equipped with a Chemical Ionization Ion-Trap Mass Spectrometer (CI-ITMS) (accuracy: ~15%; detection limit ~50 ppt; temporal resolution: ~3 s; Speidel et al., 2007) and meteorological instru-

mentation (Huntrieser et al., 2016). Two flights were dedicated to power plant emissions, a flight to Bosnia-Herzegovina (Tuzla) on 2nd November and a flight to Serbia (Nikola Tesla near Belgrade) on 7th November 2020. Here we mainly concentrate on the latter flight, however in the oral presentation also results from the first flight will be shown. **Figure 1** gives a first glance of the flight to the Nikola Tesla power plants on a typical autumn day with a strong inversion layer trapping the emissions from the power plant in a thin layer.

One of the main objectives of this study is to validate spaceborne SO_2-measurements by the TROPOMI/S5P instrument with our airborne measurements, which is the first study of its kind in the Balkans. TROPOMI/S5P is a novel passive imaging spectrometer which combines different methods/algorithms to retrieve SO_2 concentrations and cloud properties with a daily passage around local noon time (Theys et al., 2017; Loyola et al., 2018). In this work, we use two different sets of TROPOMI-SO_2 products, the official operational product and the COBRA product (Theys et al., 2021), which will replace the current operational product in the future. The variables extracted from the TROPOMI products are i.a. the Vertical Column Density (VCD) SO_2, the quality assurance value (QA), and the Cloud Fraction (CF).

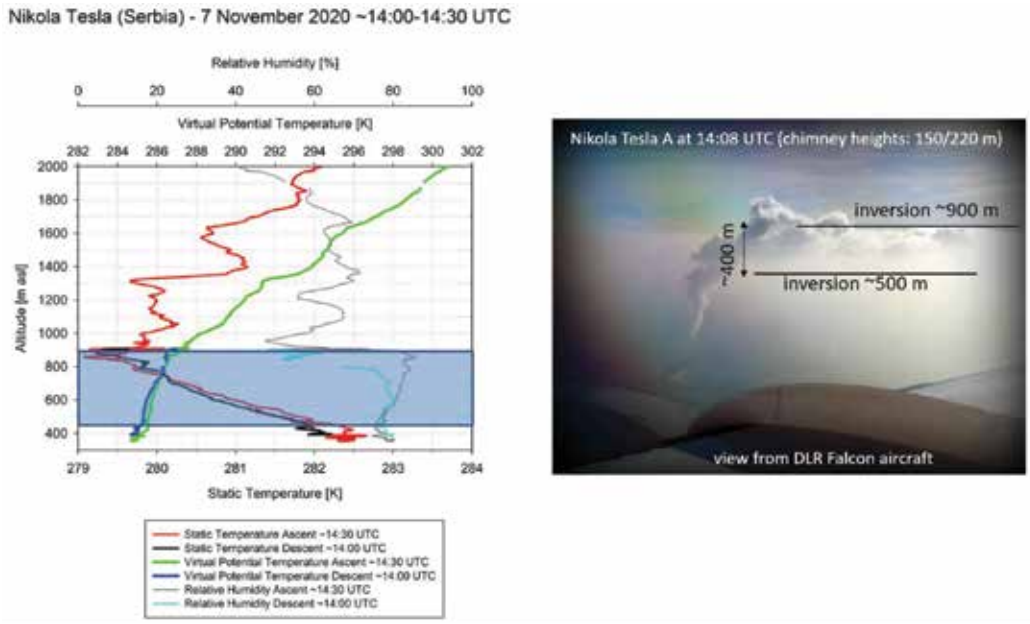

*Figure 1. Vertical temperature and humidity profiles from the DLR Falcon-20 flight to the Nikola Tesla A power plant on 7th November 2020 (**left**). The emissions from the coal-fired power plant were trapped in an inversion layer located between ~500 and ~900 m asl (**right**).*

METHODS

For the validation of the spaceborne measurements with airborne measurements, the first task is to select reliable TROPOMI/S5P pixels. However, this task turned out to be more difficult than expected. The inspection of daily TROPOMI-SO_2 images showed a very noisy situation on many days, especially at the end of the campaign in November. The TROPOMI measurements along the long light path at this time of the year were influenced by the low position of the sun in the winter months and the unexpected high frequency of dense smoke clouds over the Balkans. Aerosols in the smoke clouds have the capability to also absorb light in the same wave length range as SO_2 and therefore might disturb the SO_2 signal (Bergstrom et al., 2007). **Figure 2** shows one example of how the strong TROPOMI-SO_2 signals from the power plants in Bosnia-Herzegovina and Serbia deteriorate from October 2019 to November 2019 and simultaneously the noise from unspecified SO_2 sources in the surroundings increases. Similar noisy observations were made for the months December and January. First in February less disturbed TROPOMI-SO_2 signals are available as for the entire summer season.

The mission flights to Bosnia-Herzegovina on November 2nd and to Serbia on November 7th were influenced differently by the noise in the SO_2 retrieval. A number of nearby local fires affected the first flight (Tuzla power plant) significantly, it is questionable if a satellite validation will be possible. However, the second flight to the Nikola Tesla power plants in Serbia was less affected by noise in the SO_2 retrieval in the envisaged area and was found to be suitable for a validation.

To select reliable SO_2 pixel from the Serbian flight, the SO_2 data was combined with additional TROPOMI products (i.a. QA and CF) as mentioned in Section 2. Reliable SO_2 pixels were defined when QA≥50 and CF≤0.10. As will be shown later in Section 4, only one part of the Serbian flight is suitable for a validation.

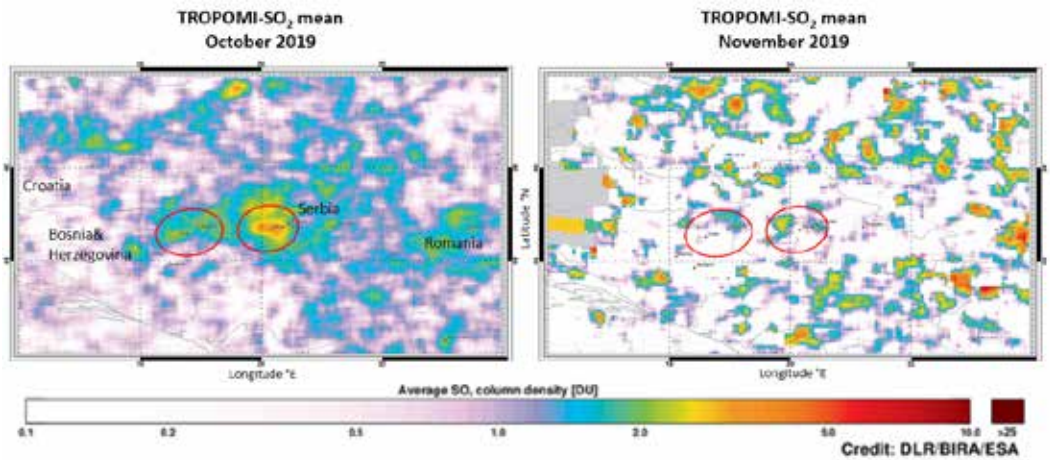

*Figure 2. Sulphur dioxide (SO_2) measurements from the Sentinel-5P satellite obtained with the TROPOspheric Monitoring Instrument (TROPOMI). Mean SO_2-values in Dobson Units (DU) for the Balkans are shown for October 2019 (**left**) and November 2019 (**right**). The red circles highlight the two SO_2 hot spot areas of the Balkans investigated in this study (power plants Tuzla in Bosnia-Herzegovina and Nikola Tesla in Serbia).*

Presently the TROPOMI/S5P pixel size is 3.6 x 5.6 km^2. For the selected validation area, our airborne SO_2 measurements were averaged over the area of each pixel. For the calculation of the VCD from the airborne measurements, also information about the vertical SO_2 distribution is necessary. For 7 selected pixels, measurements were performed at three different altitudes (~400, 540 and 900 m), just below, inside and at the top of the strong inversion layer (**Fig. 1)**.

From **Fig. 3** it is clear, that the main amount of SO_2 contributing to the VCD was located in this inversion layer between ~450 and 900 m (due to the elevated emission height from the tall chimneys). Therefore, our airborne measurements were vertically interpolated between these layers and then integrated over the inversion layer to receive VCD values comparable with satellite measurements. Both our airborne measurements and the ground-based measurements from the nearby site Obrenovac indicate that the contribution to the VCD from the layer below ~400 m was less important on this day (note the logarithmic scale).

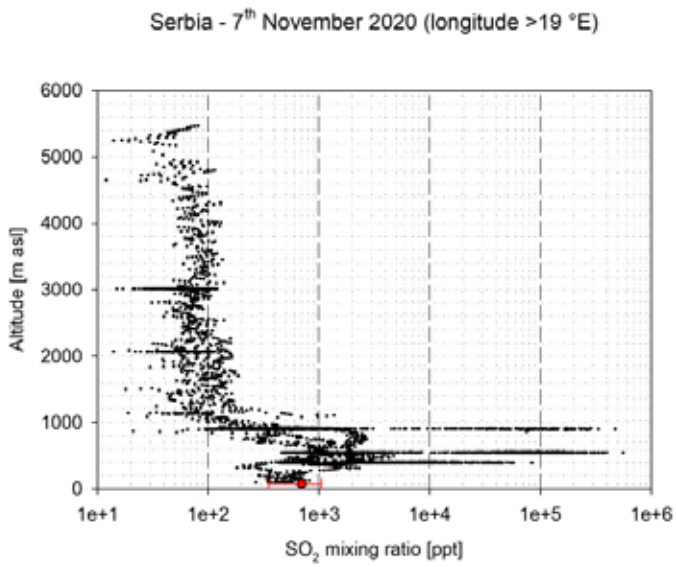

Figure 3. Vertical SO_2 profile from the DLR Falcon-20 flight over Serbia on 7th November 2020 (black dots). Superimposed is the daily mean value and standard deviation (red dot with bar) of the ground-based SO_2 measurements in Obrenovac (76 m asl), located near the Nikola Tesla power plants, on 7th November 2020. The SO_2 mixing ratios are given in parts per trillion (ppt).

RESULTS

The horizontal distribution of SO_2 mixing ratios along the flight path in vicinity of the Nikola Tesla A (NTA) and B (NTB) power plants is shown in **Fig. 4 (left)** in the unit parts per billion (ppb). Areas with highly elevated SO_2 mixing ratios are highlighted in green, yellow and red colors. It is clear, that the plumes from the NTA and NTB power plants are advected with the wind to the northwest and are distinguishable from each other, as also observed by the aircraft crew. Unfortunately, the CI-ITMS instrument had problems to measure the unexpectedly high SO_2 mixing ratios inflight and the uncertainty of the measurements could be in the range of several hundred percent, which still has to be determined by more laboratory tests.

In **Fig. 4 (right)**, several TROPOMI/S5P products have been added to the airborne measurements from **Fig. 4 (left)**. Color-coded in traffic light colors are the TROPOMI-SO_2 VCD values in Dobson Units (DU). Noticeable is the agreement of the location of the highest SO_2 values for the airborne and spaceborne

measurements in the westernmost part of the flight track capturing mainly the NTB plume. In comparison, the NTA plume is not well captured in TROPOMI--SO_2 signal compared to the airborne measurements. The reason is a nearby cloud remnant from the morning fog in the river valley, as indicated schematically in the figure according to the TROPOMI cloud product CF. This result shows that, as previously noticed, only the westernmost part of the flight (including the NTB, but not NTA plume) is suitable for a validation. Fortunately, this part of the flight was also flown at three different vertical levels as mentioned in Section 3 and the VCD-SO_2 can be determined from the airborne measurements and compared to the spaceborne TROPOMI-SO_2 measurements as discussed in the next section.

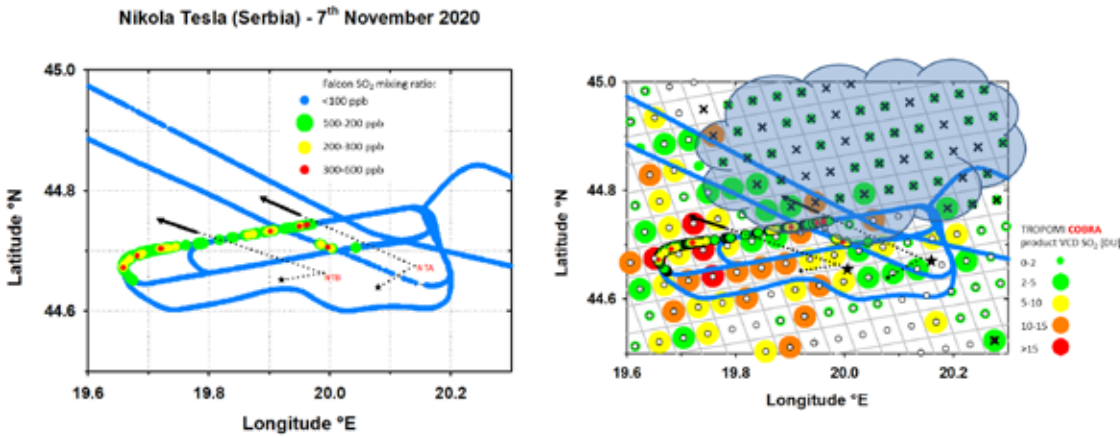

*Figure 4. SO_2 mixing ratios in ppb (color-coded) along the DLR Falcon-20 flight track in vicinity of the power plants Nikola Tesla A (NTA in red) and B (NTB also in red) on 7th November 2020 (**left**). The dotted lines with a star at the end indicate the measured wind direction at the height of the power plant chimneys (~150-300 m); varying between northeasterly to easterly direction. The dotted lines with an arrow at the end indicate the wind direction measured at the Falcon flight levels downwind of the power plants (~540-900 m); predominantly from southeasterly direction. Underlaid below the flight track is the corresponding TROPOMI-SO_2 COBRA product in DU (also color-coded) (**right**). In addition, the cloud fraction (CF) is superimposed as black crosses (CF ≥0.20) and as white circles (CF<0.20), and the position of a cloud remnant from the morning fog is schematically indicated.*

DISCUSSION

In **Fig. 5 (left)**, both VCD-SO_2 values obtained from airborne (*Falcon-20*) and spaceborne (TROPOMI) measurements (COBRA retrieval) are shown, indicating a positive correlation with a high correlation coefficient (r>0.9). However, the number of data points is unfortunately rather limited. In **Fig. 5 (right)** the SO_2 mean values of all 7 data points in **Fig. 5 (left)** were determined and in addition for the TROPOMI operational product. The TROPOMI COBRA product value is slightly lower (~10%) than the value of the operational TROPOMI product. The airborne measurements are presently a factor of 2.5-3 lower than the obtained TROPOMI values, which might be caused by the standard (instead of adjusted) averaging kernel used.

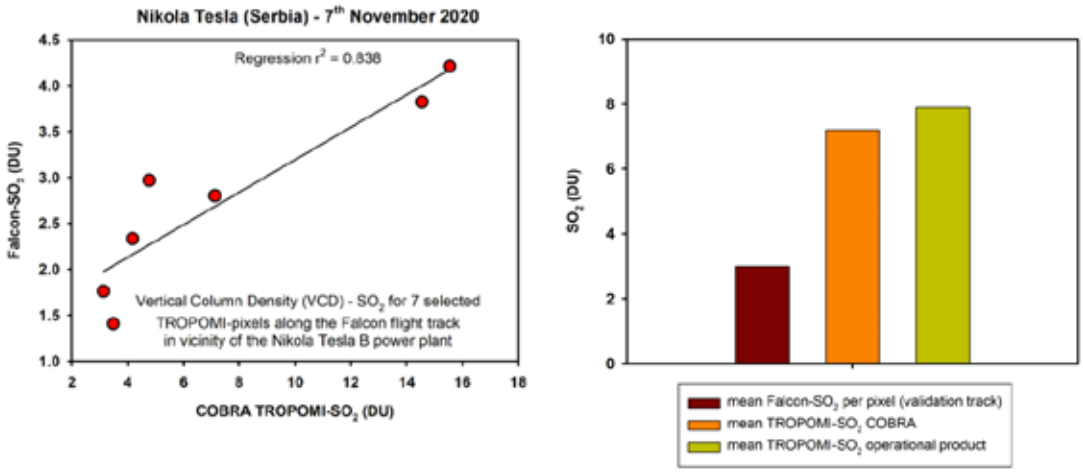

*Figure 5. Preliminary validation of the TROPOMI-SO_2 retrieval based on the COBRA algorithm with vertical column density (VCD) estimates in DU from airborne SO_2-measurements obtained from the DLR Falcon-20 in vicinity of the Nikola Tesla B power plant on 7th November 2020 (**left**). Preliminary comparison of mean VCD SO_2 values obtained from two different TROPOMI-SO_2 retrievals (COBRA and operational product) and from estimates based on the airborne SO_2-measurements (**right**).*

CONCLUSION

Our measurements during the METHANE-To-Go-Europe field experiment are:

- the first airborne in situ measurements of SO_2 plumes from coal-fired power plants in Serbia and Bosnia-Herzegovina,
- and the first try to conduct a TROPOMI-SO_2 validation with airborne measurements for this region (~2h time shift present between the two measurements).

We found that:

- a validation is difficult in the winter months due to the low sun position and the frequent and widespread occurrence of smoke clouds causing noise in the retrieval,
- however, a validation is partly simplified due to pronounced inversion layers,
- for the Serbian flight a validation of the SO_2 plume from the Nikola Tesla B power plant seems to be feasible, despite of a number of uncertainties and only few data points.

Outlook:

- tests with different averaging kernels are planned,
- CI-ITMS performance tests in the laboratory are planned → more airborne SO2 measurements of this kind are needed in the region to improve satellite algorithms.

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AVIATION ENVIRONMENTAL IMPACTS

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Abstract:

In this research we focused on understanding the influence of aircraft emissions on local air quality using air quality measurements and modeling results. One year of air quality data obtained at Zagreb Airport has been analyzed to assess the level of air pollution due to air traffic. Air transportation growth has rapidly increased over the years and notable influences of aviation emissions on local and regional air quality as well as on climate are identified. The environmental impacts of atmospheric emissions from aircraft have been addressed in two separate ways; aircraft pollutant emissions occurring during the landing and take-off (LTO) phase (local pollutant emissions), and the non-LTO phase (global/regional pollutant emissions). Aircraft pollutant emissions are an important source of pollution and directly or indirectly harmfully affect human health and ecosystems. The AIRMODE model was applied in order to calculate local concentrations of CO, PM10 and NO2 around the Zagreb airport in Croatia. Furhter on the WRF-Chem, EMEP and WRF-CAMx models were used to estimate the contributions of aviation emissions with several different emission scenarios.

Key words: Aircraft emissions, aircraft pollution assessment, WRF-Chem, AERMODE, LTO cycle

INTRODUCTION

Domestic and international aviation is one of the key components of Europe's mobility system. However there exist significant environmental pressure from aviation as a result of various sources, e.g. aircraft and transport vehicles on the airport. The aircraft is a source of noise pollution and CO_2, SO_2, NOx, VOCs, PM and greenhouse gases (GHG) emissions during flight, landing and cruising on airport. In addition, emissions from the numerous ground support services, such as ground vehicles operating at or around runways, airport heating, and transport to and from airports by passengers and freight services, significantly contribute to the emissions of air pollutants. From airport terminals, aircraft and airspace service operators main influence on environment are co-

ming from waste generation. The other environemntal problems are related to bird strikes from collision between aircrafts and airborne animals, exhaus gases from transporting goods and passangers, water pollution from use of e.g. deicing agents etc. (EEA, 2017). The total contribution of aircraft emissions to total global anthropogenic CO2 emissions is considered to be about 2 % (IPCC, 1999). This relatively small contribution to global emissions should be seen in relation to the fact that most aircraft emissions are injected almost directly into the upper free troposphere and lower stratosphere. IPCC has estimated that the contribution to radiative forcing is about 3.5 %. The importance of this source is growing as the volume of air traffic is steadily increasing. Within EU-28 emissions from aviation are accounted for around 13% of GHG emissions, which have only from international aviation doubled since 1990. In comparioson to year 2000 the GHG emissions from aviation were almost 25 % higher in the year 2015. By 2050 it is expected that global aviation and shipping together are anticipated to contribute almost 40 % of global carbon dioxide (CO_2) emissions unless further mitigation actions are taken (Cames et al., 2015).

In this work, we focused on assessment of local air quality in the vicinity of the Franjo Tuđman airport in Zagreb. The airport is situated at approximately 10 km south of the centre of Zagreb in the territory of the City of Velika Gorica and Zagreb County.

METHODOLOGY

The measurements were conducted from four measurements stations within the domain of research encompasing location of airport:

- MZLZ, monitoring station at airport (NOx, PM_{10}, PAH, O_3, meteo)
- ZG3, Urban station approximately 3.5 km NW from airport. (NOx, O_3, SO_2,CO, PM_{10}, meteo)
- ZG1 (Urban station, approximately 6 km NW from airport (NOx, PM_{10}, CO, SO_2, meteo)
- Velika Gorica (VG) ~ approximately 1.5 km S from airport ($PM_{2,5}$ daily gravimetric)

The aviation emissions are estimated thorugh Tier 1 methodology. It is the methodology based on an aggregate figure of fuel consumption for aviation to be multiplied with average emission factors. The emission factors have been averaged over all flying phases assuming 10 % of the fuel is used in the LTO (Landing and take off). The emissions produced by aviation come from the use of jet fuel (jet kerosene and jet gasoline) and aviation gasoline (small piston engine aircraft

only) the principal pollutants (common to other combustion activities) CO_2, CO, HC and NO, SO_2 (dependent of the level of sulphur in the fuel). Other important species, emitted at relatively low concentrations include PM , N_2O and CH_4. Landing and take off data, type of the aircraft and number of cycles are obtained from the Eurocontrol database.

Two different types of air quality modeling systems were used in air quality modeling assessment activities. Regional modeling activities were performed with WRF-Chem, WRF-CAMx and EMEP model while local assessment was done with AIRMODE model. Further analysis of measurements were done using conditional bivariate polar plots (CBPF) which are an advancement of conditional probability function, that shows how a concentration of a species varies jointly with wind speed and wind direction in polar coordinates.

RESULTS

From daily averaged time series of measured PM_{10} concentrations, a good agreement in temporal variability of urban (ZG3 station) and non-urban (but highly influenced by airport) concentrations at MZLZ stations is found (Figure 1). On the MZLZ station higher PM_{10} were observed during specific several episodes in summer, while on urban station higher PM_{10} concentrations were recorded in winter season. This is probably due to intense traffic in the city center and stable atmospheric conditions. Although the dominant wind direction and speed for MZLZ station is from SW-NE direction, the probability of occurrence of peak O_3 concentrations is the highest for low wind speed (up to 3 m/s) from SE direction. Measurements (bivariate polar plots) show that the highest concentrations ~ 35 $\mu g/m^3$ are transported from the W while minimum concentrations ~ 5 $\mu g/m^3$ are transported from E directions. High ozone concentrations are transported from E and NE while minimum concentrations are expected from W (Figure 2).

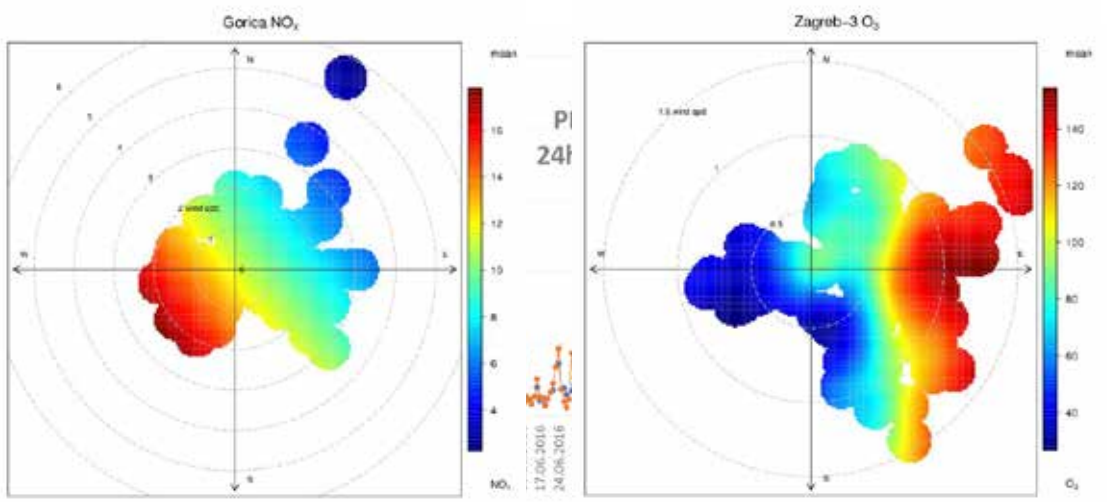

Figure 1. Time series of daily PM10 measurements from ZG3 (blue) and MZLZ (orange) stations during year 2016.

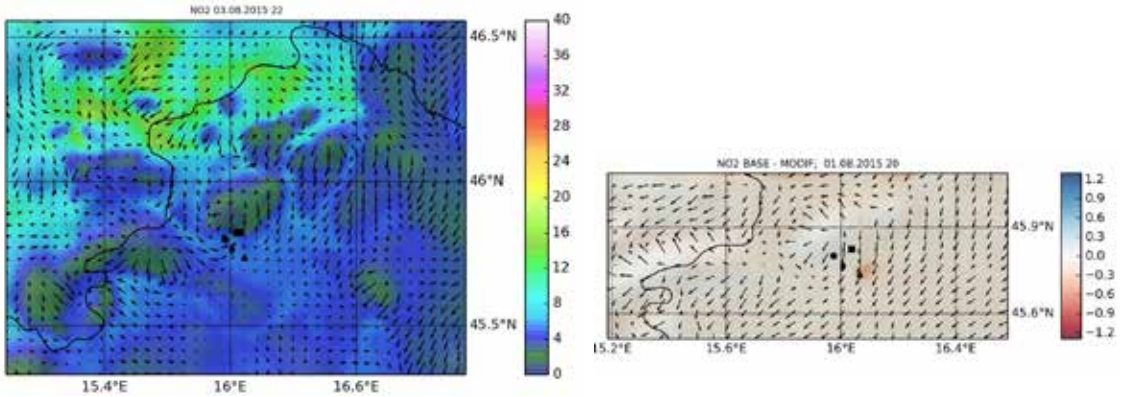

Figure 2. Conditional bivariate polar plots for NO_2 at VG station (left) and O_3 at ZG3 station.

From numerical modeling experiments it is concluded that WRF-Chem model simulates very well the wind direction but underestimates the measurements of NO_2 and O_3. Based on previous conducted research where overestimation of low wind speed was found (e.g. Gašparac et al., 2020) it can be expected that as well here bias of wind speed resulted in underestimation of gaseous pollutants and all fractions of PM. The results of simulations performed with CAMx simulation which included aviation emissions estimated for LTO cycles showed

that NOx contribution from aviation is approximately up to 30%. Numerical simulations of AIRMOD model with initial and boundary conditions from WRF model and emission estimations for LTO cycles showed an influence on local air quality mainly in the vicinity of the runaway (Figure 3).

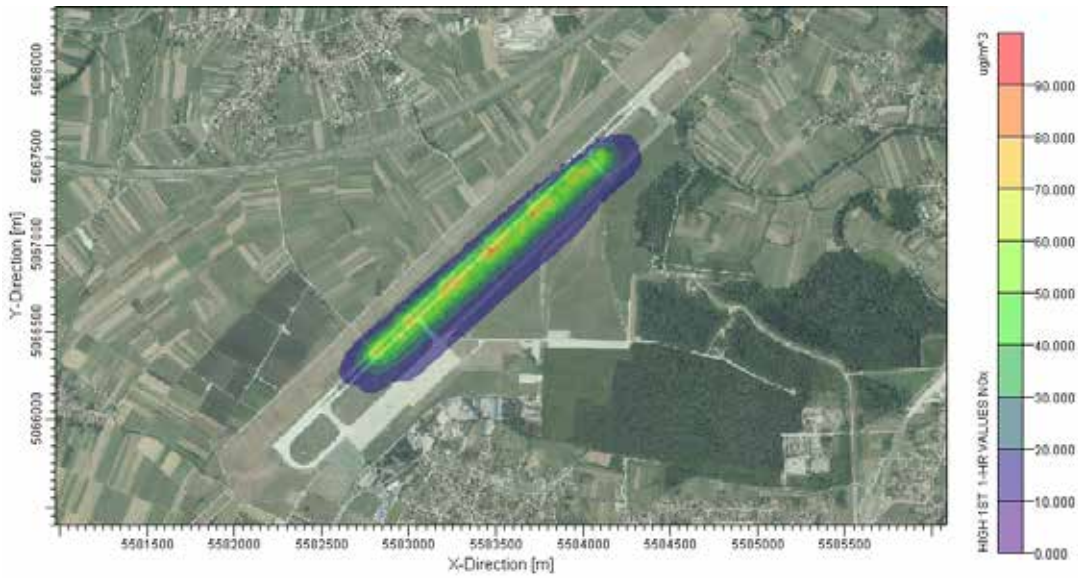

Figure 3. Hourly NO_2 concentrations with wind speed and direction barbs calculated with WRF-Chem model (upper left), hourly NO_2 concentrations with wind speed and directions barbs calculated with WRF-CAMx model (upper right) and daily NO_2 concentrations calculated with AERMOD model (bellow).

CONCLUSION

Aviation is challenging, as increasing demand is leading to increased pressures on the environment and climate. Measurements revealed high urban background and airport PM concentrations. Bivariate polar plot indicated high concentrations during low wind conditions with direction perpendicular to the runway. There is currently little information available to estimate emissions from start up of engines and these are not included in the LTO cycle. This is not of great importance for total national emissions, but they may have an impact on the air quality in the vicinity of airports. Bivariate polar plots of NO_2 measurements show high airport contributions. WRF-Chem simulates well the transport of NO_2 and O_3 concentrations, but underestimates the magnitude of concentrations. Influence of aviation traffic is recognized through many researches, however the

role of aviation is still not sufficiently included in the air quality management and the application and evaluation of models in this regard is needed to provide general recommendation to the scientific community.

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ENVIRONMENTAL MODELING AND ASSESSMENT OF ATMOSPHERIC PARTICULATE MATTER IN CENTRAL AND EASTERN EUROPE

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Abstract

The application of regional-scale air quality models is an important tool in air quality assessment and management. For this reason, the understanding of model abilities and performances is mandatory. The main objective of this research was to investigate the spatial and temporal variability of background particulate matter (PM) concentrations and to investigate processes that contribute to regionally increased PM concentrations. The domain of research encompassed almost entire Europe in order to include all sources in vicinity of Central and Eastern Europe that could contribute to possible transboundary pollution and to analyze model performance on significant amount of background air quality and meteorological stations. Two different regional air quality modelling systems (offline coupled EMEP and online coupled Weather Research and Forecast-Chem) were applied to simulate the transport of pollutants and to further investigate the processes that contributed to increased concentrations during identified high pollution episodes in Eastern Europe. Among the stations at altitudes up to 200 m, the best model performance, in terms of meteorology and chemistry, was found for both models. The underestimated modelled PM concentrations in some cases indicated the importance of accurate assessment of regional air pollution transport under statically stable atmospheric conditions and the necessity of further model improvements.

Key words: Regional models, WRF-Chem, EMEP, PM_{10}, air pollution, rural background stations, model evaluation, transboundary pollution, emission inventory.

INTRODUCTION

The increased concentration of particulate matter (PM) in the ambient environment is associated with a significant impact on human health and continuous exposure to PM is considered to be among the top 10 most significant risk factors for public health globally, including Europe (e.g., Heal et al., 2012; Pope et al., 2002). The elevated PM concentrations have also effects on entire ecosystem, visibility and has been recognised as a strong climate forcer that also has an influence on Earth's energy balance through the direct radiative effects and cloud processes.

Air quality models (AQM) play a significant role in the assessment and management of air quality. These are widely used in public health cohort studies given that the measurements are expensive and usually represent limited and small areas, e.g., rural areas, mountains (Ritter et al., 2013). Nowadays, numbers of AQMs are currently available for practical applications. These models can be broadly divided into two main groups: offline and online models. The offline models consider solving separately meteorological conditions prior to chemistry during the simulation runs while the online models were developed to include the more consistent description of processes such as atmospheric turbulence and to use a more frequent update of the meteorological variables within the chemistry part of the model. In this study, two widely used air quality modeling systems were used: WRF-Chem (online, Grell et al., 2015) and EMEP (offline, Simpson et al., 2012) model in order to test model performances on specific cases when periods of high PM concentrations occurred over hotspot areas in Europe. This work represents an overview of Gašparac et al., 2020 and is providing relevant results based on model evaluation on large amount of both air quality and meteorological stations.

METHODOLOGY

The measurements of PM_{10} from the rural background stations were taken from two available air quality databases. These were AirBase, the European air quality database maintained by the European Environmental Agency (http://acm.eionet.europa.eu/databases/airbase), and the database developed under the EU-funded PHARE 2006 project Establishment of Air Quality Monitoring and Management System, where 12 new rural stations were established in Croatia for PM measurements in 2011. In total there were 920 rural background stations and 310 meteorological stations used in this study. All monitoring stations were divided into three categories based on their elevation: (i) sea-level (altitude from 0 to 200 m), (ii) elevated (from 200 to 500 m), and (iii) mountain stations (>500 m) to examine the spatial variability of pollution and to test the model performance at different levels. As previously addressed, two modeling systems were used (EMEP and WRF-Chem) with non-harmonized emission and meteorological initial and boundary conditions. Each model was used with usual, default initial and boundary conditions related to the model used and available data over area of research. This work aims at filling the gaps in knowledge of regional modelling of PM over Eastern Europe in terms of less information about PM concentrations (e.g., low accuracy in the PM emission inventory, which is a typical case for the area of Croatia) and it fits in with the addressed problems in most of the air quality plans in Europe.

RESULTS

Available measurements of daily averaged rural background PM_{10} concentrations ($(\overline{PM_{10}})_d$) and meteorological parameters over Europe during the year 2011 and during periods of very high $(\overline{PM_{10}})_d$ concentrations in November 2011 were analysed. The underestimation of concentrations was found at sea-level (the median of -44% and -26% for the WRF-Chem and EMEP model, respectively, Fig 1) and for elevated stations (-55% and -29% for the WRF-Chem and EMEP model, respectively, Fig 1). At mountain stations, EMEP had good agreement of ~13%, while underestimation with respect to WRF-Chem was present ~ - 33%. Due to the coarser grid resolution, differences in terrain height could lead to a problem in station representativeness in regional models. Generally, from the given results (Fig 1), it can be concluded that the performance of both models varies with height. There is a moderate agreement in all of the analyzed meteorological parameters and $(\overline{PM_{10}})_d$, with the decrease in performance with height. The better model performance was found for daily averaged temperature

($\overline{(t_{2m})}_d$) using the WRF-Chem model, and for daily averaged wind speed ($\overline{(ws)}$) in the case of the EMEP model. Both systematic and unsystematic errors for $\overline{(PM_{10})}_d$ were the lowest for sea-level stations on comparable values between the models (Fig 1). Values of r ($\overline{(PM_{10})}_d$) and $RMSE$ ($\overline{(PM_{10})}_d$) decrease with height for both models (Fig 1). A substantial number of elevated stations is located in the vicinity of hotspot areas (south Poland, Czech Republic, etc.) and is therefore strongly influenced by high emissions sources. This can explain the relatively lower model performance (e.g., $NMSE_{sys}$ ($\overline{(PM_{10})}_d$) for the WRF-Chem model; $RMSE$ ($\overline{(PM_{10})}_d$) using both applied models) on a number of stations at an elevated level with respect to other altitudes. The distribution of $\overline{(t_{2m})}_d$ for both selected days when peak values occurred during the episodes (9 and 14 November) was generally equal over the entire domain for both models. The daily averaged PBLH ($\overline{(pblh)}_d$) tends to have lower values (< 100 m) in the WRF-Chem simulation and gradients in the pressure fields are much higher in comparison with the EMEP model. Values of $\overline{(ws)}_d$ were generally higher within the domain for the WRF-Chem simulation (not shown here). However, the results obtained with both models indicated the same areas with lowered wind speed, which is in accordance with the measurements. Generally, results obtained with both models correctly indicated areas affected by high pollution episodes (DF >100%; DF is a relative difference in percentage units). Over areas with $\overline{(pblh)}_d$ < 100 m, peaks of $\overline{(PM_{10})}_d$ were found, reaching measured $\overline{(PM_{10})}_d$ values. For both peak days the results of both models are consistent, showing prevailing high $\overline{(mslp)}_d$ fields, relatively cold areas with low $\overline{(pblh)}_d$ (more evident in the case of the WRF-Chem model) and low $\overline{(ws)}_d$ conditions (more evident in the results obtained with EMEP model) over the areas affected by increased $\overline{(PM_{10})}_d$ concentrations.

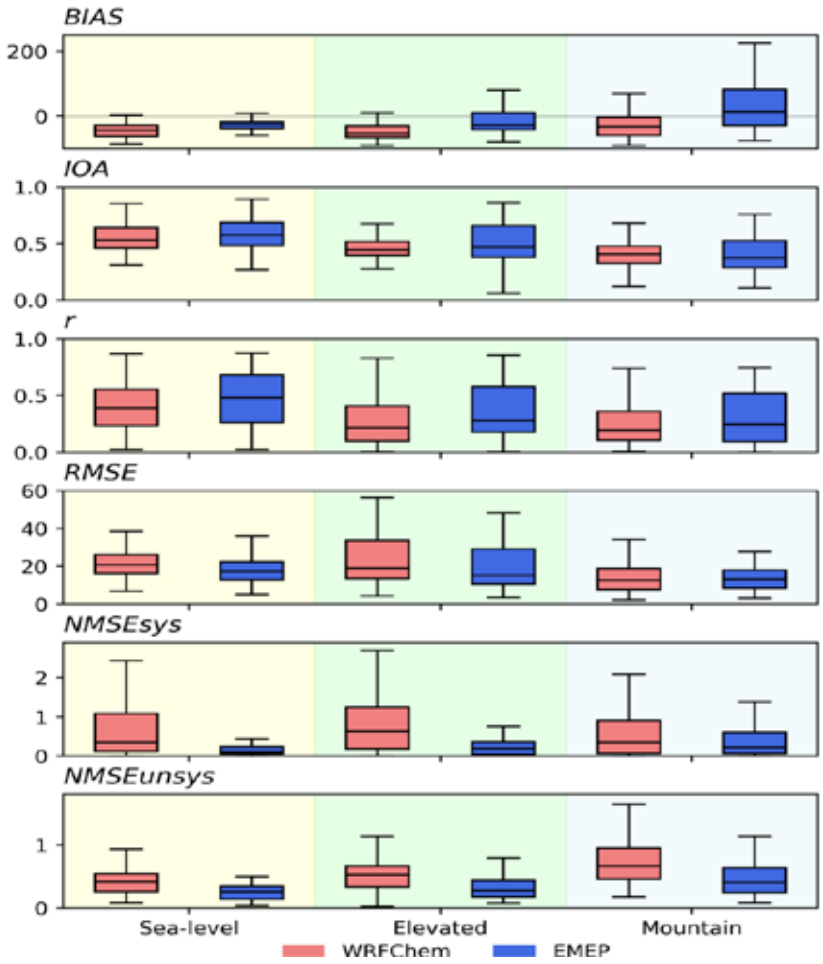

Fig 1. Intercomparison of the applied statistical measures (BIAS, IOA, r, RMSE, NMSEsys, NMSEunsys) between measured $(\overline{PM_{10}})_d$ *(310 rural background stations from AirBase, https://www.eea.europa.eu/data-and-maps/data/ airbase-the-european-air-quality-database-7, and the EU-PHARE project) and modelled* $(\overline{PM_{10}})_d$ *with the WRF-Chem (red boxes) and EMEP (blue boxes) models during November 2011 with respect to the station height.*

SUMMARY AND CONCLUSIONS

The added value here is in the individual statistical evaluation of modelling systems using data from the large number of meteorological and air quality stations in Eastern Europe. Those were less represented in other similar studies. The

analysed and modelled meteorological parameters were validated using surface measurements from 920 synoptic stations, soundings within the Pannonian region and mast-mounted instrument measurements. The $(\overline{PM_{10}})_d$ concentrations were validated against surface measurements from 320 rural background stations. During the colder part of the year, when usually higher PM concentrations are observed, following model features are recognized:

- According to the low systematic errors a very good performance is found for both models in simulating $(\overline{mslp})_d$ over sea-level and elevated stations, while there is a moderate performance due to the high spread of *BIAS* over mountain stations.
- Strong influence of meteorological conditions on increased background $(\overline{PM_{10}})_d$ is found and correct estimation of the $(\overline{ws})_d$ is recognised as one of the main factors in the dispersion of $(\overline{PM_{10}})_d$.
- General underestimation of background $(\overline{PM_{10}})_d$ concentrations by obtained with both models, except for EMEP for mountain stations (slight overestimation).,
- Statistical analysis with respect to the terrain type shows the best model performance of $(\overline{PM_{10}})_d$ and meteorology over sea-level stations (flat terrain). For both models the performance decreases with a height, indicating problems in application over complex terrain at regional scale.
- During the first high pollution episode, a high $(\overline{ws})_d$ obtained with WRF-Chem model resulted in a decrease in surface $(\overline{PM_{10}})_d$ while favourable conditions prevailed for the build-up of concentration in Central Europe over hotspot areas with a decrease in surface $(\overline{ws})_d$.
- Underestimation of background $(\overline{PM_{10}})_d$ concentrations with regional models is in accordance with other modelling studies.

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FUTURE CHANGES IN THE HEATING AND COOLING SEASON CHARACTERISTICS IN BOSNIA AND HERZEGOVINA, SERBIA AND HUNGARY

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Abstract

It is expected that future energy demand will significantly change due to global warming, but the exact magnitude is unknown due to the interaction of many sources of uncertainty. When it comes to future residential energy demand indicators, most studies focus only on climatic factors' impact without considering demographic and socioeconomic parameters. This study evaluates future residential heating and cooling season characteristics as indicators of the residential energy demand, considering changes in population, average housing insulation properties, and the usable floor area per person. Aladin regional climate model (RCM) is employed to project heating and cooling degree days (HDD and CDD) in the three European countries: Serbia, Bosnia and Herzegovina, and Hungary over the 21st century using RCP4.5 and RCP8.5 scenarios. The study results show an unequivocal reduction in both HDD and length of the heating season in all considered countries. On the other hand, this decrease is significantly lower in magnitude than the increase of CDD and cooling season length for Serbia and Hungary. The results for Bosnia and Herzegovina are not so unambiguous for interpretation.

Keywords: Climate change impact, heating degree days, cooling degree days, population projections, average housing insulation properties, forcing scenarios

INTRODUCTION

The concentration of carbon dioxide hits record levels not seen in the last three million years due to intensified anthropogenic emissions during the previous 150 years (IPCC 2014). Elevated levels disrupt the existing energy balance in

the atmosphere and most likely cause global warming, affecting humans' energy consumption. Therefore, it is expected that future energy consumption will be significantly affected by the projected changes in carbon dioxide levels and related global warming. However, the extent to which energy consumption will change is uncertain due to the interaction of many sources of uncertainty. Still, it is quite certain that projected global warming will lead to a decrease in energy demand for heating and an increase in electricity demand for cooling.

Many studies concerning future residential heating and cooling energy demand deal only with the climate indicators, such as heating and cooling degree days, assuming they are proportional to heating and cooling demand (Larsen et al. 2020). These researchers most often do not consider future changes in the thermal characteristics of buildings carved by the existing and forthcoming energy efficiency directives (Janković, Podraščanin, and Djurdjevic 2019). Moreover, threshold temperature for calculating HDD and CDD in the future will be shifted due to changes in building construction typology; e.g., more insulation will mean lower setpoint temperature for HDD and the shorter heating season. Furthermore, socioeconomic and demographic factors are not considered, such as changes in policies, population, and standard of living, as they significantly impact the average housing insulation properties and, consequently, heating and cooling season characteristics.

In this paper, we are trying to establish an approach that will overcome these shortcomings. More precisely, the method will use outputs from a high-resolution regional climate model and data on thermal and geometric characteristics of buildings as an input to calculate HDD, CDD, and length of the corresponding season. Current characteristics of buildings are taken from national building typologies, while future features are assumed based on the existing energy efficiency directives and demographic and socioeconomic factors. In this way, the heating and cooling season characteristics will not depend only on climate factors but also on the thermal insulation quality and the impact of the demographic and socioeconomic factors. The results of this study will be especially interesting to policymakers and energy management at the national level to gain insight into where climate changes and existing regulations lead and how they affect indicators of residential heating and cooling energy demand.

The remainder of this paper is organized as follows. In the following Section 2, we provide information on used methods with a schematic representation of the workflow. In section 3, the results are presented in the form of annual heating and cooling degree days, threshold temperature and length of the heating and cooling season for the referent (1981-2010), and the future period (2071-2100) under the

two forcing scenarios (RCP4.5 and RCP 8.5). For all quantities, average values are given at the regional (country) level, with the addition of spatial distribution of HDD and CDD. Finally, in the fourth section, the Conclusions, the main findings, and lessons from the paper are recalled.

METHODOLOGY

Three countries are chosen to investigate future residential heating and cooling energy demand indicators: Serbia, Bosnia and Herzegovina, and Hungary. The idea was to calculate the average thermal and geometrical characteristics of residential buildings normalized per person according to the current building census provided by the European project Tabula (Loga et al. 2010). The free online database contains information on the total number of typical buildings in considered countries and their thermal and geometrical characteristics (Figure 1). Based on the population data and Tabula online database, the usable floor area per person was calculated for the current period.

Three periods were chosen to calculate the average housing insulation properties in the future, consistent with the climatic thirty-year periods (2011 – 2040, 2041 – 2070, 2071 – 2100). It was assumed that future buildings would be built according to strict energy efficiency requirements representative for central Europe (U_{wall}<0.3, U_{roof}<0.2, U_{floor}<0.3, and U_{win}≤1.5 $Wm^{-2}K^{-1}$). Furthermore, we assumed that the lifespan of buildings is 100 years and that the usable floor area per person will increase to 45 m^2, which is the current average of the developed countries of the European Union. To see how many new buildings will need to be built, we used SSPs population projection [4], more precisely SSP2 projection that describes a world in which demographic outcomes are consistent with balanced expectations about population growth, urbanization, and spatial patterns of development.

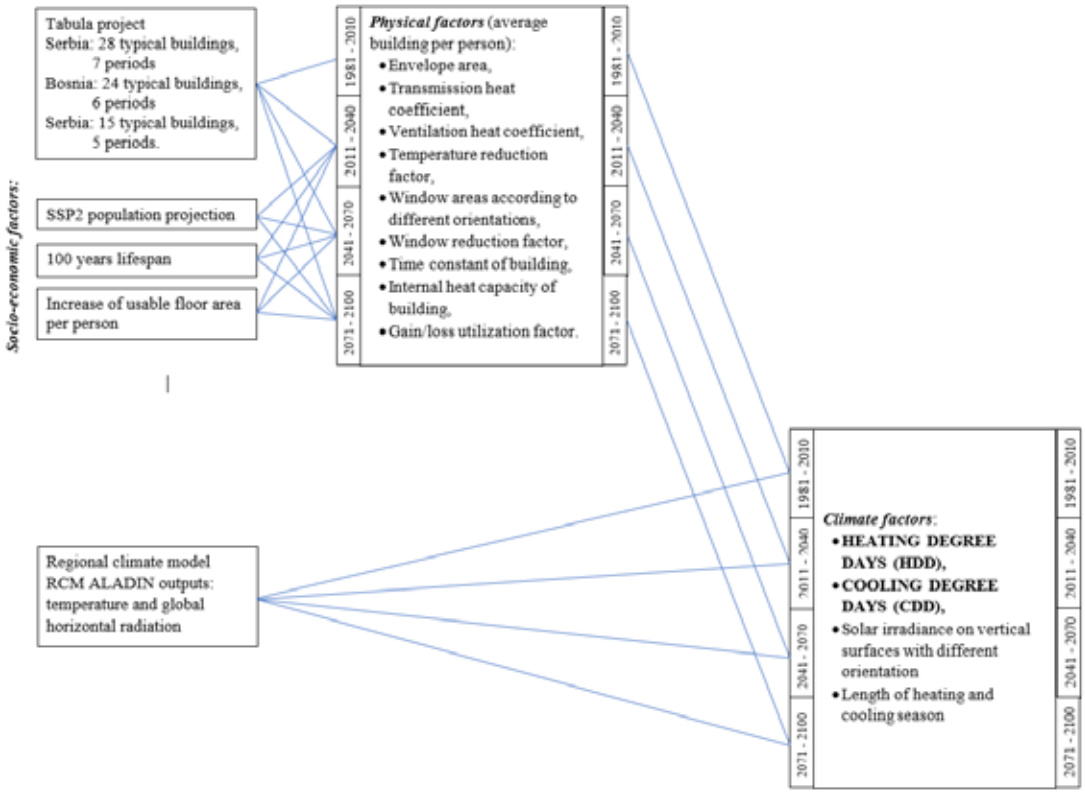
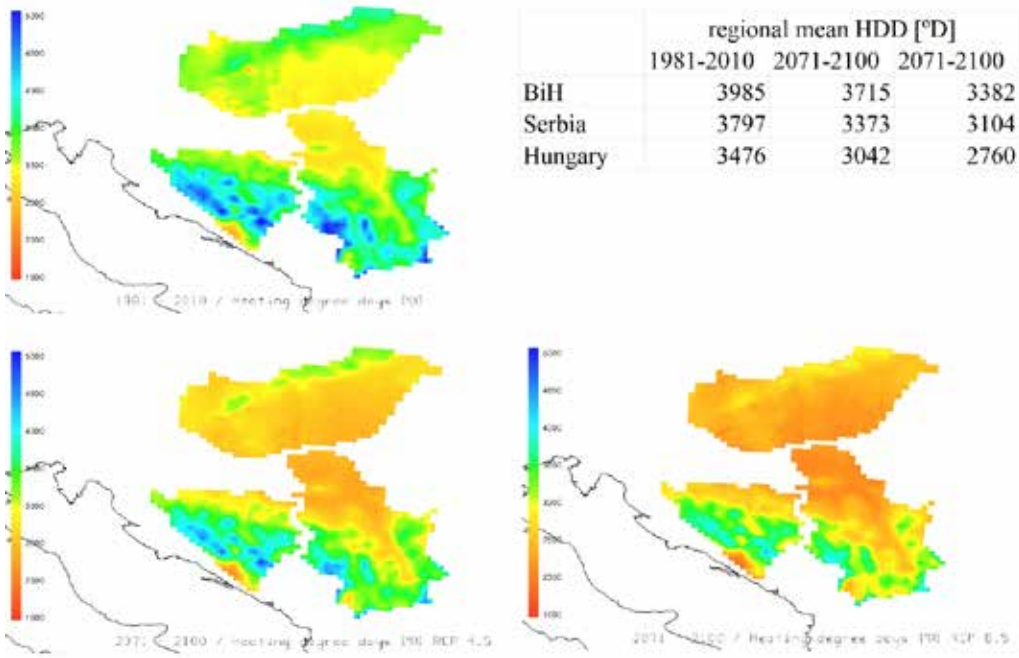


Figure 1 –Schematic representation of the research flow

Prevailing climatic conditions are determined from Aladin regional climate model (RCM) (Spiridonov, Déqué, and Somot 2005). Projection of temperature and global solar radiation on the horizontal surface was extracted for the Med-CORDEX domain with a resolution of 0.11º x 0.11º under intermediate and worst-case forcing scenarios (RCP4.5 and RCP 8.5). Four representative periods are chosen: referent (1981 – 2010) and three future periods (2011 - 2040, 2041 – 2070, and 2071 – 2100). Based on the average housing insulation properties and prevailing climatic conditions for these periods (see Table 1), threshold temperature for calculating HDD, CDD, and length of the heating and the cooling season is calculated. The calculation of threshold temperatures is done according to the ISO 13790 standard (EN ISO 13790, Energy Performance of Buildings, calculation of energy use for space heating and cooling 2008) and the quasi-state method.

RESULTS

Our analysis showed that regional mean annual HDD for Bosnia and Herzegovina decreases by -6.8 % and -15.1 %, according to the RCP4.5 and RCP 8.5 scenarios, respectively. The decrease of regional mean annual HDD for Serbia is even higher: -11.2 % for intermediate and -18.2 % for the worst-case scenario (Figure 2). Changes are more pronounced as one goes north, so Hungary experiences the most significant change of -12.5 % according to the RCP4.5 scenario and -20.6 % according to the RCP8.5 scenario.

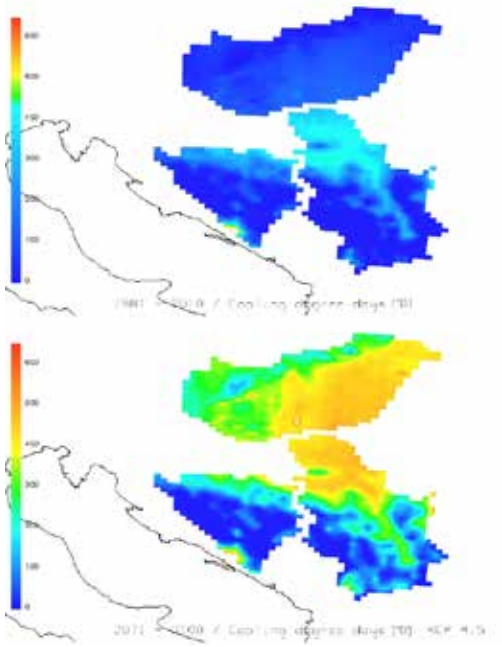


	regional mean HDD [°D]		
	1981-2010	2071-2100	2071-2100
BiH	3985	3715	3382
Serbia	3797	3373	3104
Hungary	3476	3042	2760

Figure 2 – Annual HDD for referent period (1981 – 2010) and future period (2071 – 2100) under RCP4.5 and RCP8.5 scenarios. The table in the upper right corner indicates regional mean values.

While the decrease of annual HDD and shortening of the heating season can be considered a positive thing from the energy demand perspective, an increase of annual CDD and prolongation of the cooling season is not. The relative change of annual CDD during this century will be much more pronounced than annual HDD (Figure 3). For example, in Serbia, the relative change of regional mean annual CDD will be 187 % according to the RCP4.5 scenario and 335 %

according to the worst-case scenario. For Hungary, that relative change will be even more noticeable, and it will amount to 349 % according to the intermediate scenario and 494 % according to the RCP8.5 scenario. However, for Bosnia, we have experienced discordance in results compared to the other two countries. More precisely, our analysis showed that according to the intermediate scenario, regional mean annual CDD should decrease by -12.5 %, while according to the worst-case scenario, there will be a relative increase of 45 %.



	regional mean CDD [°D]		
	1981-2010	2071-2100	2071-2100
BiH	128	112	186
Serbia	79	227	344
Hungary	81	364	481

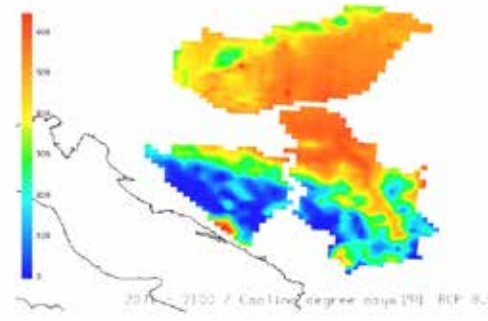


Figure 3 – Annual CDD for referent period (1981 – 2010) and future period (2071 – 2100) under RCP4.5 and RCP8.5 scenarios. The table in the upper right corner indicates regional mean values.

What may be the reason for such a projection? Let's take a look a Table 1 and threshold temperatures for the heating and cooling season. We see that Bosnia and Herzegovina have significantly different threshold temperatures for the referent period compared to two other countries. These values are calculated from the average housing insulation properties and outputs from the regional climate model. Given that the climatic conditions of the three countries are similar, this indicates that average housing insulation properties in Bosnia for the referent period (1981 - 2010) are significantly different than in Serbia and

Hungary. If we peek deeper, we can see that according to the current census (Tabula project), the share of transparent elements in the envelope of an average building in Bosnia is higher than in the envelope of average buildings of the other two countries. We can not claim with certainty if this is true or an error in a building census exists, as we are not experts in this field. However, we can argue that this most likely causes discrepancy in projections between Bosnia and the other two countries.

Table 1 – Threshold temperature for calculating HDD and CDD and length of the heating and cooling season

	1981 -2010		2071 – 2100 (RCP4.5)		2071 – 2100 (RCP8.5)	
	Heating	**Cooling**	**Heating**	**Cooling**	**Heating**	**Cooling**
Threshold temperature [^{O}C]						
BiH	**14.4**	**19**	**14.4**	**19.1**	**14.4**	**19.3**
Serbia	**16.9**	**22.2**	**14.5**	**19.5**	**14.6**	**19.6**
Hungary	**16.9**	**22.2**	**14.3**	**19.3**	**14.1**	**19.5**
The regional mean length of the season [D]						
BiH	**253**	**48**	**254**	**48**	**241**	**65**
Serbia	**263**	**38**	**237**	**71**	**228**	**85**
Hungary	**250**	**51**	**223**	**95**	**212**	**102**

When it comes to the length of the heating season, we can expect that in Bosnia and Herzegovina, the heating season will be shortened up to 12 days, in Serbia between 26 and 35 days, and in Hungary between 27 and 38 days, according to two forcing scenarios. On the other hand, the cooling season may be extended for 17 days in Bosnia, for 47 in Serbia, while in Hungary, it will be doubled according to the worst-case scenario. As expected, the RCP4.5 scenario gives somewhat milder projections, with no change in length for Bosnia and extensions of 33 and 44 days, for Serbia and Hungary, respectively.

CONCLUSIONS

Projected global warming and improvements in the thermal insulation quality of buildings, driven by the strict requirements of energy efficiency directives and changes in population and standard of living, will cause the decrease of annual HDD and shortening of the heating season. The worst-case scenario predicts

a drastic reduction in regional mean annual HDD of over 15 % for all three countries compared to the present climate period (1981 – 2010). According to the same scenario (RCP8.5), the heating season in Serbia and Hungary will decrease in average for more than a month at the end of this century. The intermediate and a much more likely RCP4.5 scenario sees somewhat less drastic reductions, both in annual HDD and in the length of the heating season.

As for the cooling season, the projections by both scenarios indicate extreme changes, potentially alarming for Serbia and Hungary. Both scenarios predict multiple magnifications of CDD and the length of the cooling season. The results of the analysis are not so apparent for Bosnia and Herzegovina. The intermediate scenario (RCP4.5) does not recognize significant changes in CDD and length of the cooling season, while the worst-case scenario (RCP8.5) predicts an increase in both parameters, however, to a considerably lesser extent than in Hungary and Serbia. A deeper analysis is needed to understand why projections of the cooling season for Bosnia and Herzegovina are discrepant to projections for the other two countries and whether the reason for this is a systematic error in input data from the building census.

Changes in the heating and cooling season characteristics will be felt the most at lower altitudes, i.e., the Pannonian basin encompassing Hungary and northern Serbia (Vojvodina). For instance, the cooling season in Hungary under both scenarios becomes longer than three months and almost as long as half of the heating season. That implies the use of air conditioners over ninety days a year, which can cause an enormous burden on the power grid. If changes in the heating season characteristics can be seen as positive from the perspective of the energy demand, predicted changes in the cooling season could have devastating consequences on the energy sector and the economic development of these countries.

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THE USE OF NUMERICAL WEATHER PREDICTION MODELS IN THE ENVIROMENTAL MODELLING

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Abstract

The outputs from the numerical weather prediction (NWP) models have been used in many environmental studies. In this paper the review of using NWP models in puff simulation and coupling NWP model with the chemical models for air pollutant concentration prediction was presented. For the prediction of the radionuclide spreading in nuclear plants during an accident in the first 10-20 min, the data from the local meteorology station are used as an input in a puff model. This is a good way for taking the first action for the evacuation, but for longer planning the use of the outputs from the NWP model in puff models for radionuclide spreading is necessary. For the prediction of the pollutant concentration in the air, the two types of coupled NWP and chemical models are used. One type is so-called "offline" coupled model where the outputs from the NWP model are used in chemical models without feedback between chemistry and meteorology. Another type is "online" coupled model where the influence of chemistry on meteorology is included. The "online" coupled models are "state of the art" models, but demand a lot of computation time.

Keywords: numerical weather prediction models, puff model, chemical transport model

INTRODUCTION

A lot of processes in environment depend on the meteorological conditions which should be included in their modelling. Use of the measured data would be the most optimal approach in gaining the best relationship between environmental processes and meteorological parameters. Unfortunately, the meteorological measurements are not available at every place on the Earth. To avoid the luck in the measured data, outputs from the Numerical Weather Prediction (NWP) models are used. The outputs from NWP model are usually provided by the

meteorological services in every country. Alternatively, such outputs could be provided using NWP models in almost all well equipped research centers.

Today there are NWP models which are publicly available and easy to use. Use of data from a NWP model has a lot of benefits, such as: choosing a model horizontal and vertical resolution, frequency of the model outputs and numerical schemes that describe the physical processes in the model, etc. For analyzing and prediction of the pollutant transport, different transport models are used, depending on needs in a given situation (Bai et al., 2018). Puff models are used in a situation when the influence of the specific source, mostly point source, on environment should be estimated. For the forecast of the pollutant concentration over some region, the chemical transport models are used. There are two ways the chemical transport model could be coupled with NWP model (Baklanov, 2010). In the so called "offline" coupled model, the output from the NWP model is used in chemical models without feedback between chemistry and meteorology. In the "online" coupled model, the two-way influence of chemistry and meteorology is included. Before running the "offline" coupled model, the NWP model must be run and the NWP outputs have to be prepared as an input for the transport model. When the model is "online" coupled, meteorological fields are utilized in the chemical transport model at each time step and feedbacks of pollution on meteorological processes and atmospheric chemical composition is determined. In this paper we used the WRF 3.6.1 (Weather Research and Forecasting Model) (Skamarock et al., 2008) outputs to drive puff model, CALPUFF (California Puff model) (Scire et al., 2000a) and SILAM (System for Integrated modeLing of Atmospheric coMposition) (Prank et al., 2013) model in the "offline" mode, and as online coupled, WRF-CHEM (Grell et al., 2005) model.

MATHERIALS AND METHODS

WRF model

The input meteorological data necessary for the CALPUFF and SILAM model runs were prepared using the **WRF model**. The WRF model is mesoscale numerical weather prediction model, designed for both atmospheric research and operational forecasting applications. In this paper the ARW (Advanced Research WRF) core of the model was used. The model domain with the centre at 45.25 N and 9.85 E covering 151x151 grid points was used in all simulations, with horizontal grid size of 10x10 km and 36 vertical levels. The simulations were initialized with GFS (Global Forecast System) forecast data.

CALPUFF model

The puff model, CALPUFF was used for the simulation of the radionuclide spreading. The model domain was 200x260 grid points with 10 vertical levels and horizontal resolution of 100m. The Cs-137 was the observed radionuclide with hypothetical point source at 80m height. In order to reduce meteorological grid space the CALMET (California Meteorological model) model (Scire et al., 2020b) was used. The CALMET model was run using the WRF outputs as the meteorological inputs.

SILAM model

The dispersion of airborne ragweed pollen has been simulated by atmospheric transport model SILAM. SILAM was run with the spatial resolution 0.1° x 0.1° and the domain covering area from 40° to 50° N and from 12° to 25° E. The ragweed map has been introduced to the SILAM model as input data (Prank et al., 2013).

WRF-CHEM MODEL

The online-couplet 3D air quality, WRF-Chem model (version 3.6.1) (Grell et al., 2005) was used for preparing the operational air quality forecast in Vojvodina region. The center of domain in all simulations was at 45.25 N and 19.85 E. The simulation was at 10x10 km grid with 151x151 grid points and 31 vertical levels. The global RETRO (REanalysis of the TROpospheric chemical composition over the past 40 yr) (0.5°x0.5°) (http://retro.enes.org) anthropogenic emissions were used in simulation. For the chemical initial and boundary conditions idealized chemical profile generated from the NALROM (NOAA-Aeronomy Laboratory Regional Oxidation Model) simulation was used.

RESULTS

CALPUFF model

In the nuclear plants, for the prediction of the radionuclide spreading during an accident in the first 10-20 min, the data from the local meteorology station could be used as inputs for a puff model. This is a good way for taking the first action for the evacuation, but for longer planning, the use of the outputs from the NWP model in puff models for radionuclide spreading is necessary. Such situation is illustrated in Fig.1. The distribution of the Cs-137 concentration was shown 1h (Figure 1a) and 2h (Figure 1b) after emission start using meteorology from the WRF model. The plume in Fig.1a covers different area than the plume

in Fig.1b. If the instant weather data from the local meteorology station were used, the concentration distribution would be similar to the one at Fig.1a. If the evacuation will be done only considering the temporal meteorological data only the area covered with high concentration shown in Figure 1a will be evacuated. The area that will be covered with, even higher concentration (Figure 2b) will not be evacuated.

SILAM model

The ragweed is an invasive plant widespread in the Pannonian Plain. Its pollen is a common allergen. The SILAM model was run with the aim to predict the concentration of ragweed pollen in the Vojvodina region. The early prediction of high ragweed pollen concentration is very important to take appropriate health protection measures. The forecasted ragweed concentration on 26.08.2018. is presented in Fig.2. Very high ragweed concentration covered the Vojvodina region, eastern part of Croatia, eastern part of Hungary and northeast part of Bosnia and Herzegovina. The people with allergy to ragweed pollen in those regions are in very high risk, and should be informed about high concentration to take unnecessary health measures.

a)

b)

Figure 1: 1) spreading of Cs-137 1h and b) spreading of Cs-137 2h after accident

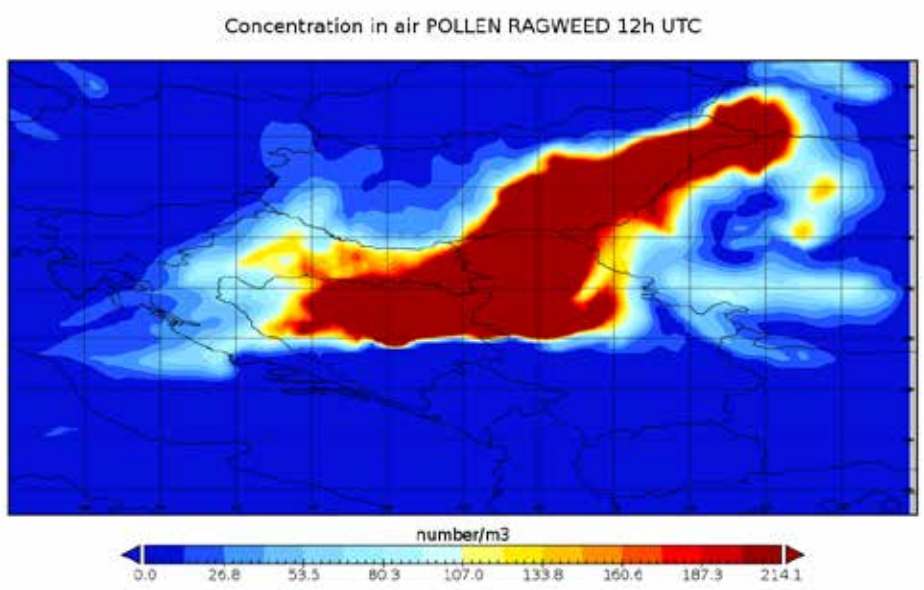

Figure 2. Forecasting ragweed concentration on 26.08.2018.

WRF-CHEM model

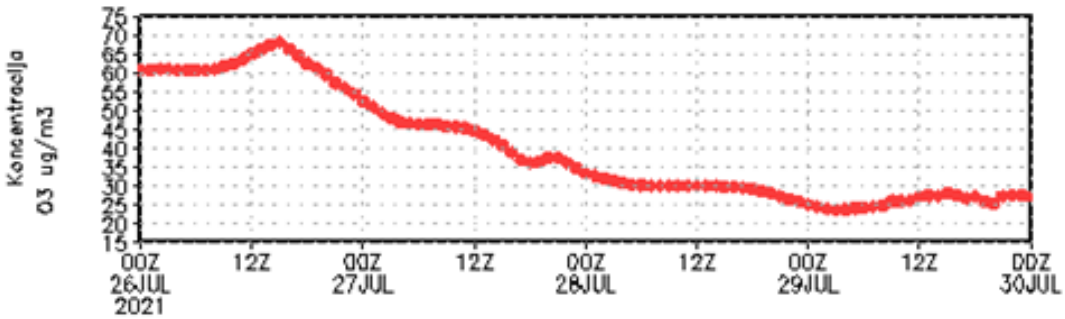

Figure 3. O_3 concentration forecast for Novi Sad four days ahead

The WRF-CHEM model was prepared for operational use in the Vojvodina region. The Air quality forecast is not in use operationally since the model outputs should be post processed and corrected before official use of this forecast. In Fig.3 the forecasted O_3 concentration for Novi Sad four days ahead is presented. The main goal is that all the bigger cities in the Vojvodina region have an air quality forecast.

CONCLUSION

In this paper the usage of the WRF model in environmental studies was shown. The WRF outputs were used as inputs in CALPUFF and SILAM model. The CALPUFF was used to simulate the spreading of Cs-137. The simulation shows the importance of the longer prediction of radionuclide speeding necessary for the evacuation decision making. The SILAM model with the meteorological inputs from WRF model was used for the ragweed concentration prediction. Such prediction is very important in situation where there are no ragweed concentration measurements or they are very sparsely distributed. The "online" coupled WRF-Chem model was used for air quality forecast in the Vojvodina region.

Acknowledgment

The authors acknowledge financial support of the Ministry of Education, Science and Technological Development of the Republic of Serbia (Grant No. 451-03-9/2021-14/ 200125)

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EFFECTS OF REDUCING AERO POLLUTION IN BELGRADE USING ELECTRIC BUSES ON THE LINE EKO 1

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Abstract

The electric bus (E-bus) is a new vehicle concept that is increasingly used in the passenger transport system and is the main alternative to conventional buses. The environmental performance of E-buses is reflected in zero emissions harmful gasses and lower noise emissions observed at the local level compared to diesel or CNG buses and depending on the method of electricity production, more favorable carbon dioxide emissions observed at the regional or national level. The paper will present the effects of the operation of the E-buses on the line EKO 1 (Vukov spomenik-Belvil) in Belgrade through the lower carbon dioxide emissions and elimination of emissions of harmful substances: carbon monoxide (CO), hydrocarbons (CxHy), nitrogen oxides (NOx), and microparticles (PM), which would happen using diesel or CNG-powered buses.

Keywords: E-bus, aero pollution, emission of CO_2

INTRODUCTION

The transport sector occupies an important place in meeting the needs of society in the transport of goods and passenger transport and is a significant generator of emissions of harmful gases and carbon dioxide, as significant causes of environmental damage. Emissions of harmful gases from road vehicles (passenger cars, buses, vans, trucks), is the main source of emitted harmful substances in urban areas (Ropkins, 2006). Combustion products in vehicles equipped with internal combustion engines, which are released into the atmosphere through the exhaust system, contain many harmful substances, the most common of which are: carbon monoxide CO, unburned hydrocarbon residues CxHy, nitrogen oxides NOx, suspended particles of different diameters $PM_{2.5}$, PM_5, $PM_{10,}$ sulfur compounds, aldehydes, benzene, etc. According to a report by the World Health Organization (WHO) from 2000, the presence of harmful substances in the air has been proven to be the cause of numerous chronic and acute diseases in humans (WHO, 2000). Especially children younger

than 5 years are endangered by the negative effects of harmful substances in the air (Schildcrout et al., 2006). In a 2012 report, the World Health Organization (WHO) announced that 3.7 million people worldwide die each year as a result of air pollution. According to the same report, more than 5600 people die prematurely in the Republic of Serbia as a result of air pollution (WHO, 2013; Kovačević, 2019).

Buses used in public city transport are mostly represented with diesel engines. Diesel engines emit large amounts of suspended particles and nitrogen oxides, especially during cold engine operation, at full load, and subsequent fuel injection into the engine. Numerous studies conducted worldwide have shown that the impact of suspended particles as a result of air pollution is directly related to the higher likelihood of lung cancer in humans (Kovačević, 2019; Weber, 2016) as well as the increased rate of morbidity and mortality due to cardiovascular and respiratory diseases (Kovačević, 2019; Weber, 2016; Xu et al., 2013). In addition to the negative impact of suspended particles on the human body, carbon monoxide and nitrogen oxides also have a negative impact. Clinical signs and symptoms of carbon monoxide poisoning are shortness of breath, rapid breathing, headache, dizziness, cardiac arrhythmias, pulmonary edema, and finally, loss of consciousness and death. Inhalation of large amounts of gas leads to acute bronchiolitis, alveolar damage, pulmonary edema, and death (Xu et al., 2013).

In Belgrade, the bus subsystem is the holder of the function of public city transport. Buses of the largest carrier JKP GSP "Belgrade" use about 31.29 million liters of Euro-diesel fuel for the realization of the planned annual transport work (ЈКП ГСП ''Београд'', 2019-2020). If analyze the most important and most frequent corridors in the city of Belgrade, where public transport buses operate every day, concluded that especially in peak load, buses that use diesel fuel significantly increase the concentration of harmful gas emissions.

Table 1.1 lists the traffic corridors in Belgrade with the highest frequencies of public transport buses at peak load (ЈКП ГСП ''Београд'', 2018).

Table 1.1 Traffic corridors with the higest frequencies of buses for public transport (ЈКП ГСП ''Београд'', 2018)

Street	Bus lines	frequency [buses/hour]
Brankova	**15,16,27E,35,43,65,67,71,72,75,77,84,95,704,706,707,EKO1**	**127.6**
Boulevard Despot Stefan	**16,27E,32E,35,43,58,95,96**	**63**
Kneza Milosa	**23,37,51,52,53,56,56Л,58,74**	**67**
Boulevard Z.Misica (Fair)	**23,37,51,52,53,55,56,56л,58,88,89,91,92,511,551,553**	**97**
Glavna (Zemun)	**17,45,73,83,84,704,705,706,706E,707**	**63**
Boulevard Oslobodjenja	**30,31,33,39,42,47,48,59,78**	**77**

The reduction of air pollution in Belgrade from the impact of traffic can be significantly improved by energy, environmental and technical-operational measures in the bus subsystem of public city transport, and as one of the most efficient ways is the substitution with electric buses. It is for these reasons that the bus subsystem of public transport has gained in importance as the main promoter of new technologies in the implementation of the city's sustainable development strategy.

LINE EKO 1 (Vukov spomenik-Belvil)

In Belgrade, the first line of public city transport EKO 1 (Vukov spomenik-Belvil), on which only fully electric buses operate, was put into operation on September 1, 2016. The introduction of five fully electric buses Higer KLQ6125GEV3 in regular traffic is a significant development project of the expert team of JKP GSP "Beograd" which is supported by the City of Belgrade and represents the beginning of using a new concept of environmentally and energy-efficient vehicles in public transport. City line EKO1 is a new line that is purposely designed and adapted for the operation of fully electric buses Higer KLQ6125GEV3, in order to maximize the energy and environmental benefits of E-buses in the central city area of Belgrade.Line EKO 1 is a diametrical city line that connects the old part of Belgrade with New Belgrade, passing through the central city zone. The spatial position of the route of the EKO 1 line is shown in Figure 1.1.

Figure 1.1 Spatial position of the line EKO 1

The average length of the EKO 1 line is 7.995 m. Observed by directions, the length of the route in the direction "A" is 7.477 m, where there are 15 stations with an average inter-station distance of 534 m. In the direction "B", the length of the route is 8.513 m, where 17 stations are positioned with an average inter-station distance of 532 m.

The fully electric bus Higer KLQ6125GEV3 is a modern low-floor standard city bus that meets all technical requirements in accordance with European Commission Directive 2007/46 (Directive EC / 2007/46) .The E-bus use a supercapacitor to store electricity with a capacity of 20 kWh. The E-bus charging system is with fast charging which is performed at the initial-final stops (terminals) where 150 kW chargers are installed (Figures 1.2, 1.3).

Figure 1.2 Cgarging the E-bus terminal ''Belvil''

Figure 1.3 Charging the E-bus, terminal ''Vukov spomenik''

ANALYSIS AND RESULTS OF TTW (Tank to Wheel) and WTW (Well to Wheel) ECOLOGICAL PERFORMANCE E-BUS COMPARED TO DIESEL AND CNG BUSES ON ECO LINE 1

Electric buses are classified in the category of zero-emission vehicles, since they use electricity for propulsion. In this sense, aspects of the environmental impact of the immediate environment can be analyzed, where vehicles are in operation (local level), which in the literature is called "tank to wheel", TTW (Tank to Wheel) and environmental impact on the wider environment that is a region or country known as a ''source to wheel'' analysis, WTW (Well to Wheel). In the case of TTW analysis, the electric bus propulsion system has no emissions: carbon monoxide, nitrogen oxides, hydrocarbons, and microparticles (Mišanović, 2021). The environmental impact at the local level is minimal, as the only negative impact on the environment comes from the formation of microparticles and dust due to contact of tires and roads, from the friction of brake linings and evaporation of working fluids (transmission lubricating oil, antifreeze, etc.). which can be ignored. The TTW analysis of electric buses can be viewed in the context of the environmental effect achieved by replacing buses using diesel fuel or CNG, by quantifying the amount of pollutants that will not be emitted into the atmosphere as a result of vehicle substitution. The method of production and transmission of electricity is essential when analyzing the impacts of the environmental performance of electric buses on a regional or national level, or WTW analysis. Analysis of WTW carbon dioxide emissions is important to consider and compare the emission levels emitted by buses with different propulsion systems, including purely electric buses. The aspect of carbon dioxide emissions that occur in the phase of electricity production is especially important here, considering that electricity is obtained from various sources. In the Republic of Serbia, most of the electricity is obtained from thermal power plants with a share of about 70% (Tomić et al., 2018).

The Higer KLQ6125GEV3 electric buses operate exclusively on the city line EKO 1. Measurement of fuel consumption for buses of standard length using diesel fuel and compressed natural gas (CNG) was done based on monitoring the results of diesel fuel consumption on buses IK-112N (EURO 4) and CNG on buses MAZ-203 CNG which are performed in the period 12.08.-5.10.2017. year, when due to infrastructural works in Roosevelt Street, the operation of electric buses was temporarily replaced with buses with diesel fuel and buses with CNG (Mišanović, 2021).

Example of comparison of estimated emissions of harmful gases and carbon dioxide from the point of view of TTW and WTW analysis on line EKO 1 of electric bus Higer KLQ6125GEV3, the bus with diesel fuel IK-112N (EURO 4) and bus with compressed natural gas MAZ-203 CNG , which meets the 2010 EPA/CARB and EURO 6 exhaust emission standards is shown in Table 1.2 on an annual basis (Mišanović, 2021).

Table 1.2 Summary analysis of the TTW and WTW for buses of different propulsion systems on line EKO 1 in Belgarde, (annual period of operation) (Mišanović, 2021)

Line EKO 1	Unit	E-bus Higer KLQ6125GEV3	IK-112N	MAZ-203 CNG
Number buses in operation		5	5	5
Mileage	km	62750	62750	62750
Average electricity consumption	$kWh \cdot km^{-1}$	1.493		
Average consumption of diesel	$L \cdot (100km)^{-1}$		47.05	
Average consumption of CNG	$kg \cdot (100km)^{-1}$			49.84
Emission CO	kg	-	2183.6	2347.1
Emission CxHy	kg	-	300.2	93.9
Emission CH_4	kg	-	-	293.4
Emission NO_x	kg	-	1910.6	158.5
Emission PM_{10}	kg	-	16.4	5.8
Emission CO_2, TTW	**t**	-	**388.2**	**397.1**
Emission CO_2, WTW	t	389.5	443.3	465.9

The UITP Environmental methodology was used to calculate CO, CxHy, CH_4, NOx, and PM_{10} emissions from diesel and CNG buses (UITP, 2020).

Carbon dioxide (CO_2) emissions for diesel-powered buses and CNG buses according to TTW analysis were obtained using equation 1.1 (Mišanović, 2021).

$$m_{CO_2} = m_{fg} \cdot g_c \cdot \frac{44}{12}, \quad (1.1)$$

m_{CO_2} - mass of formed carbon dioxide, g,
m_{fg} - mass of fosil fuel that burns, g,
g_c - carbon content in the fuel, %,
44 - molar mass of carbon dioxide, g·mol^{-1},
12 - molar mass of carbon, g·mol^{-1}.

The value of carbon dioxide (CO_2) emissions, if calculated according to the WTW analysis, was obtained by increasing the carbon dioxide emission value obtained by TTW analysis by an increase factor of 14.2% for diesel fuel and 17.3% for CNG, which are the most realistic for the Republic of Serbia.

In the case of electric buses, the calculation of CO_2 emissions according to the WTW analysis was obtained using equation 1.2 (Mišanović, 2021):

$$CO_{2_{WTW}} = \frac{E_{ebus_L}}{\eta_{ch}} \cdot LCA_{co_2} \cdot f_{gpee}, \quad (1.2)$$

$CO_{2_{WTW}}$ - carbon dioxide emissions acording to WTW analysis, g·km^{-1},
E_{ebus_L} - electricity consumption of E-bus, kWh·km^{-1},
η_{ch} - charger efficiency coefficient (~0.95),
LCA_{co_2} - emmision factor of the total cycle of electricity production in Republic Serbia,
f_{gpee} - coefficient of loses in electricity transmission

CONCLUSION

The ecological advantages of using electric buses have been proven by the example of estimating the amount of harmful exhaust emissions that would occur at the local level (TTW), the operation of five diesel buses equipped with EURO 4 engines or the operation of five CNG buses with EURO 6 engines, on the EKO 1 line in Belgrade. It is obvious that the mentioned emissions of harmful exhaust gases are not present during the operation of the electric buses on the EKO 1 line in Belgrade. Based on the analysis of WTW, it can be concluded

that electric buses Higer KLQ6125GEV3 operating on the line EKO 1 have an indirect impact on the environment observed at a wider level (Republic of Serbia) through the emission of 389.5 tons of carbon dioxide (CO_2) in electricity generation. Compared to the carbon dioxide emission from diesel buses, the annual level (WTW analysis) of 443.3 tons can be concluded to be 12.1% lower for electric buses. Compared to CNG-powered buses, the annual CO2 emission of electric buses is lower by 16.4%.

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THE PRINCIPLE OF OPERATION OF SOLAR CELLS AND THE POSSIBILITY OF INCREASING EFFICIENCY BY APPLYING QUANTUM DOTS

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Abstract

A solar or photovoltaic cell is a semiconductor device that converts the Sun's light energy into electricity, which occurs due to the photoelectric effect. The world market is dominated by silicon solar cells. The solar panel is only able to absorb the photons of a certain wavelength and this ability is directly impacted by the type of material from which the solar panel is made. This limitation results in certain shortcomings that are noticed during energy conversion and it is these shortcomings that represent opportunities for the improvement and application of quantum dots in solar systems.

This paper intends to review the theoretical explanation of the functioning of silicon solar cells and to present the possibilities of quantum dots application that arise from their unique properties. Due to their ability to absorb different wavelengths, quantum dots are capable of absorbing more photons from the solar spectrum, which theoretically increases their efficiency in relation to silicon solar cells.

In the case of quantum dots application, transmission and reflection are significantly reduced, so quantum dots can be used as a kind of coating for silicon solar cells.

The application of new quantum-dot-based tools provides broad scientific opportunities for the advancement and further development of nanotechnologies.

Keywords: *solar energy, photovoltaic cell, quantum dots, nanotechnology*

INTRODUCTION

The use of solar energy enables the gradual abandonment of the traditional use of fossil fuels in order to obtain an environmentally sustainable energy

system (Hassanien, Li, Dong Lin, 2016, pp. 989-1001). Further growth of the need for devices that generate clean energy is completely expected, as the energy needs of humanity are constantly growing (Filijović, 2015, pp. 304-306).

In the past few decades, the most commoN-type of solar cells has been silicon solar cells that can have a solar energy conversion efficiency of over 20% while at the same time maintaining more than 80% of the initial conversion rate even after long-term use of about 20 to 30 years (Savin et al., 2015, pp. 624-628).

When it comes to silicon solar panels, it is necessary to consider another important aspect, which is the possibility of recycling. Most solar panels that are currently in widespread use aim for performance, reliability and cost-effectiveness, but putting effort into the simplification of recycling is bypassed. This is an extremely important factor that makes it possible for the entire solar panel lifecycle to become a closed process that can be called a clean and renewable energy source in the true sense (Tao et al., 2020, pp. 1-12).

It was found that a material that has a band gap of 1.1 eV can absorb about 77% of sunlight. Silicon semiconductor materials have a band gap greater than 2 eV and can theoretically absorb approximately 30% of solar energy (Nunzi, 2002, pp. 523-542). Unlike silicon semiconductors, quantum dots have the ability to fine-tune the size of the band gap by changing size. Thanks to this characteristic, it is theoretically possible to absorb a larger number of photons of different wavelengths and thus increase the conversion efficiency.

SEMICONDUCTORS – SOLAR CELLS

Semiconductor materials are structures that under certain conditions can become conductors. Figure 1a shows the bands where electrons can be found.

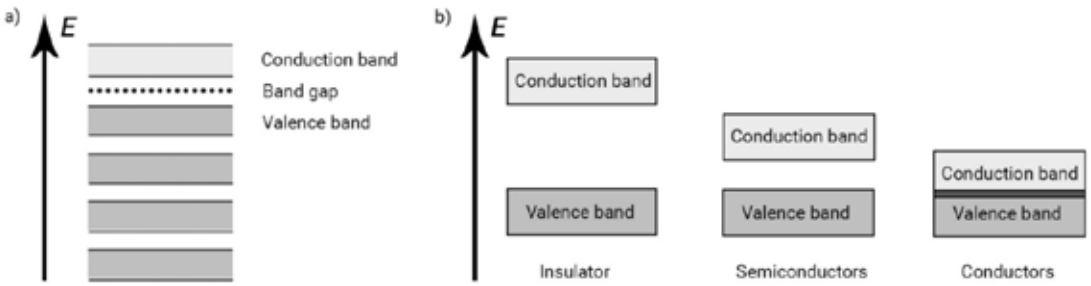

Figure 1. Schematic representation of a) energy bands layout, b) size of the forbidden zone in the case of insulators, semiconductors and conductors

The electrical conductivity depends on the possibility of electron flow from the valence level to the conduction band. In order for valence electrons to reach the conduction band, it is necessary for them to "jump over" the band gap (excited state) which occurs in cases when they absorb energy larger than the band gap size.

Figure 1b shows that the band gap size is large for insulators and small for semiconductors. In the case of conductors, the conductive and valence bands overlap. In the case of semiconductors, with relatively low energy absorption, it is possible to send a valence electron to the conduction band. A solar cell is essentially a semiconductor that has a small gap between the valence and conduction zones. This distance is short enough to cause the excited state of the electron by the mere action of sunlight. Figure 2 schematically shows a typical silicon solar cell composed of two types of semiconductors that differ only in the doping type.

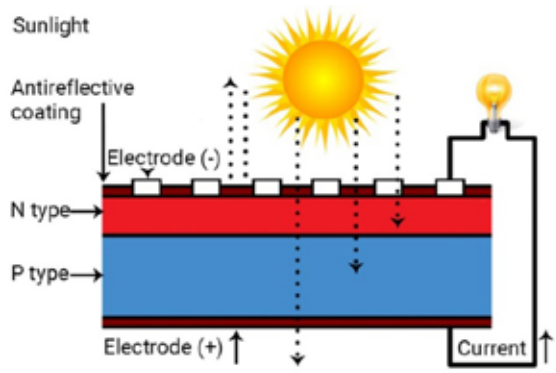

Figure 2. Schematic representation of a silicon solar cell

Since quantum dots will be discussed in the continuation of the paper, it should be pointed out that from a quantum point of view, light can be viewed in two ways - as a wave and as a particle. A photon is an elementary particle that represents a quantum of electromagnetic radiation. Sunlight photons hit the solar panel and then absorption, reflection or transmission occurs (Figure 2). The absorption of the photon causes the valence electrons to be excited by a quantum of energy that is large enough to let them jump over the band gap between the PN junctions of the semiconductor. The structure of the semiconductor significantly affects the performance characteristics which is why impurities such as boron and phosphorus are added to silicon. The addition of boron to silicon is called P-type doping while the addition of phosphorus is referred to as N-type doping.

Figure 3 shows that in the case of P-type semiconductors, the holes represent the majority of the electric charge carrier while the free electrons represent a minority - for the N-type, the reverse is true.

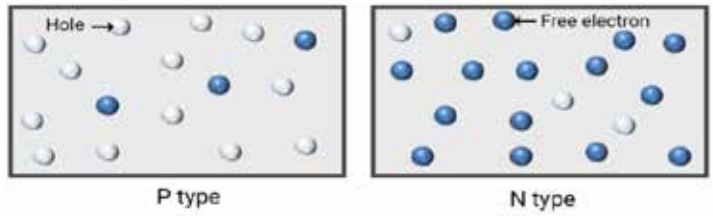

Figure 3. Schematic representation of N and P-type semiconductors

The N and P-type semiconductors are combined into a PN junction which is a semiconductor crystal structure with a preserved lattice at the junction between the P and N layers. By connecting P and N-type semiconductors (Figure 4), the exchange of charges in the contact zone occurs. Electrons from N-type semiconductors migrate to P-type semiconductors, while holes move in the opposite direction. When such electrons, moving from N to P-type semiconductors, merge with holes in P-type semiconductors, atoms in that zone have a higher number of electrons compared to the number of protons, so the charge is negative. An electron leaving an N-type semiconductor now makes its atom have more protons than electrons and we now have a case of a positive ion. A potential barrier (field) is created between the positive and negative contact charges, which prevents further movement of free electrons and holes so there is no movement of current through the semiconductor.

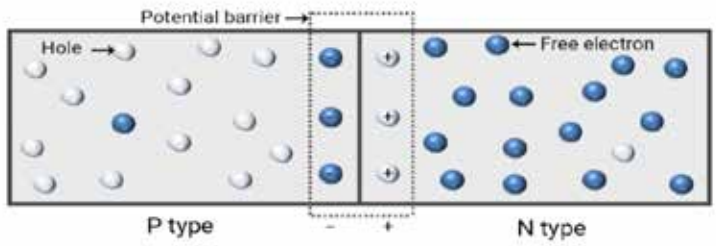

Figure 4. Schematic representation of N and P-type semiconductors

When sunlight reaches the contact band between the PN junction, energy absorption creates new electron-hole pairs. Due to the field action of the potential barrier, the free electrons start moving towards the N-type of semiconductor, while the holes move towards the P-type of the semiconductor. In this case, the accumulation of free electrons in the N-type and the accumulation of holes in the P-type of the semiconductor occur simultaneously. At some point, a large enough potential difference will be created between these two layers. By connecting a conductor, the electron charge will move from N-type to P-type of semiconductor. Once electrons reach type P semiconductors, the electron-hole recombination will occur.

APPLICATION OF QUANTUM POINTS IN SOLAR SYSTEMS

Nanotechnology is a branch of science that studies the characteristics of materials and phenomena that occur on a nanometer-scale - the size of atoms. The aim is to create new materials with unique characteristics that would be adapted for specific applications (Ouyang et al., 2004, p. 918).

In the early 1960s, the consideration of quantum dots as a new structure of semiconductor material began. In 1985, Louis Brus developed a quantum model of a spherical quantum dot (Brus, 1986, pp. 2555-2560). Work on the commercial production of quantum dots lasted for more than a decade, and in the late 1990s, this became possible. The work of Schaller and Klimov (2004, pp. 186601-186614) showed that quantum dots are able to emit up to three electrons for each absorbed photon (*multiple exciton generation*), which was revolutionary as standard semiconductors always emit one electron per each quantum of energy received.

By applying nanotechnologies, it is possible to improve silicon solar cells. Black silicon, or nanostructured silicon material, has promising properties to reduce the percentage of reflection of solar cells without the need to use the usual anti-reflection coating. In the work of Savin et al. it was assumed that the use of black silicon can simultaneously lead to cheaper production while increasing the efficiency of conversion (usability) of solar energy. The conversion efficiency was soon proven as black silicon led to an increase in the generated energy by 3% in relation to the reference cell (reference cell) (Savin et al., 2015, pp. 624-628). Moreover, according to Rasid et al (2020, pp. 105-113), it was found that at a wavelength of 600nm, black silicon, that is, its nanostructure, leads to reflection reduction from 9.9% to 6.5%, while the reduction becomes even more significant as we move towards larger wavelengths.

In addition, hybrid structures of silicon and aluminum nanocoating were observed. In the initial part of the infrared spectrum, in the range of 700-1600 nm, it was determined that the average absorption of the hybrid structure is 5 times higher in relation to the silicon cell (Zaman, Hossain, 2020, pp. 3082-3093).

As in the case of silicon solar panels, the safety aspect due to the use of toxic substances must not be left unmentioned. The most commonly used type of quantum dots in solar systems contains highly toxic elements such as cadmium (Cd), lead (Pb) and other harmful substances that can cause fatal consequences for human health and the environment (Fiandra et al., 2019, pp. 91 -101). However, success has been noted in this field due to the ability of quantum dots to adapt and overcome obstacles. The research of Meinardi et al. (2015, pp. 878-885) found that there is a way to produce solar panels based on quantum dots such that there is no need to use substances that are toxic and dangerous to the environment, while the group of authors led with You went a step further. Namely, not only was it established that there is a possibility for completely ecologically acceptable panels, but the use of such new technologies in semi-transparent panels that could replace windows on smart buildings in the future was considered (You et al., 2019, p. 1801967).

Quantum dots can be described as nanometer-sized crystals that have the ability to transport electrons. Such particles can be created to emit or absorb a specific wavelength of the light spectrum. Unlike silicon semiconductors, quantum dots have the ability to adjust the size of the band gap by changing the diameter which can be set precisely in the manufacturing process. If a photon that has less energy than the band gap of silicon comes to the silicon semiconductor, the photon will be transmitted through the material. In case the photon energy is higher than the band gap, an electron will be excited and it will "jump" over the band gap, but this excess energy (thermal loss) will be released immediately and the electron will go down to the lowest excited state. Only in the case that the wavelength of light is such that the energy of the photon exactly corresponds to the value of the band gap, the ideal excitation of the electron occurs without any losses.

Having all the above in mind, it should be pointed out that a quantum dot should be small enough so that quantum laws apply. Thanks to these laws, it is possible to establish a relationship between the diameter of a quantum dot and the size of the band gap for that quantum dot. If the diameter of the quantum dot increases, the band gap decreases, and vice versa (Figure 5a).

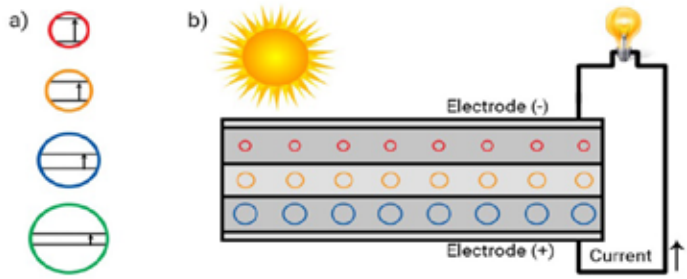

Figure 5. Schematic representation: a) dependence of the size of the band gap on the diameter of the quantum dot, b) quantum solar cells made of quantum dots of different sizes

A schematic representation of a solar cell based on quantum dots can be seen in Figure 5b where quantum dots of different diameters are placed in several different layers. The basic idea is to reduce the number of unused photons that the silicon cell cannot absorb (transmission and thermal loss). Each absorbed photon will excite an electron and generate an electron-hole pair.

Similar to traditional solar cells, by accumulating charges on the electrodes (electrons and holes), a potential difference will be created. Another interesting effect that is possible in such quantum systems is *multiple exciton generation* (MEG) (Beard, 2011, pp. 1282-1288). The basic characteristic of this effect is that one photon can excite two or more electron-hole pairs. This differs significantly from the classical silicon semiconductor where one photon always excites exactly one pair of electron-hole. This effect arouses great interest among scientists because if something like this were produced for commercial use, this discovery would be extremely important for humanity. That way, a significant reduction in the consumption of fossil fuels that harm the environment would be achieved.

CONCLUSION

With the use of solar energy, it is already possible to replace the traditional use of fossil fuels in order to obtain an energy system that is environmentally sustainable. Further growth in the need for devices that generate clean energy is completely expected, as the energy needs of humanity are constantly growing. The application of new technologies based on quantum dots provides ample

opportunity for the improvement and further development of solar systems. Quantum dots can still be considered young technology and it is expected that each new experiment may change previous knowledge and create new theories and principles on which future generations of solar systems can be developed.

In this regard, the essential task remains to increase the efficiency of solar energy conversion, but also to reduce the cost of the production process. The road to the commercialization of quantum dot solar panels is still thorny. However, having in mind the wide interest in this field as well as current research, the expectations that something like this will happen in the near future are quite realistic.

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INDOOR RADON MONITORING AS A USEFUL PREDICTOR OF EARTHQUAKE OCCURRENCES IN THE BALKAN REGION

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Abstract

This study deals with continuous radon monitoring conducted to estimate the relationship between indoor radon measurements and potential occurrences of earthquake in the Balkan region. Radon monitoring was performed with the detector Airthings Corentium Home placed in the basement office of faculty building in Kosovska Mitrovica (N 42.897°, E 20.867°) in winter period of the 2020/21 (four months in continuity). According to the European Seismic Hazard Map this region is classified as moderate hazard area. Radon daily variations were noted and analyzed with the earthquakes of magnitude M>2.0 which occurred in forthcoming days in the Balkan region. Anomalous emanation of geo-gases are connected with the ground shaking, and spike-like peaks in radon concentrations could be caused by seismic events in the wider area. In monitoring site it was reflected like a gradual increase in radon concentrations, then a sharp drop (e.g. from 865 Bq/m^3 to 73 Bq/m^3 within 48 hours). About seven days later an earthquake of magnitude M=2.2 occurred at the distance of 10 km from measuring site, and has been followed with a series of earthquakes in the region. The results seem to indicate that radon is a good indicator of crustal activity and seismic movements.

Keywords: radon, monitoring, earthquake

INTRODUCTION

Radon (^{222}Rn) is a natural radioactive gas with half-life of 3.824 days, produced in soil and rocks by the decay of the radium (^{226}Ra) in the series of uranium (^{238}U). Since radon is a gas, it leaves the rocks and soils more easily and has much greater mobility than uranium and radium. Radon travels (by diffusion or convection) a great distance before it decays escaping into fractures in rocks and into the pore spaces between grains of soil. Its mobility is related

to the permeability of the soil and to the degree of rock fracture. Radon moves more rapidly through permeable soils (coarse sand and gravel) than through impermeable soils (clays). It is moderately soluble in water. The behavior and distribution of radon in atmosphere is mainly governed by meteorological processes.

Radon is easily detectable and the most preferred as earthquake precursor in measurements of anomalous emanations of geo-gases (helium, hydrogen, carbon dioxide) in earthquake-prone regions. Abruptly emission the high concentrations of radon gas (along with releases of different gases: CO_2, CH_4, H_2S, SO_2, and H_2 suitable for radon transport to the earth's surface) through cracks could be attributed to strained rocks before the sudden slip. Spike-like peaks in the concentration of radon gas before a major earthquake appear due to pre-seismic stress or fracturing of the rock. Also, the short-term conspicuous changes of radon concentrations could be signed to a forthcoming earthquake. Radon measurements in soil and in groundwater have shown that spatial and temporal variations can provide information about geodynamical events usually performed at an active fault zone. The radon concentration in a spring increased constantly before an earthquake (M=5.2) on April 15, 1966 in Tashkent. This was the first evidence of radon in groundwater as precursor of earthquakes (Ulomov et al., 1967).

Anomalous radon concentrations were reported before the strong earthquakes. The strange behavior before an anomaly was reported like: a gradual increase in radon counts three months before the quake, then a remarkable increase two weeks and a sudden decrease one week before the shock, and after earthquake the radon levels returned to the pre-seismic events (Hatuda, 1953). There are also some of radon manifestations observed in studies: concentrations fluctuate around the mean value, showing some variations with peak values, about two or three times the mean value, preceding some seismic events; the anomalies are related to changes in crustal strain and indicated a probable relation with the local seismicity (Al-Hilal et al., 1998). On the other side, some authors reported quite significant radon anomaly, in particular over the fault line (Inceoz et al., 2006). Fifteen years continuous monitoring of geophysical events on Mt. Etna, which is characterized by tectonic and volcanic phenomena and by numerous earthquakes, showed that as well as the radon raises, the earthquake daily rate and strain release raise, correspondingly to the eruption beginning (Immè et al., 2005; Giammanco et al., 2009). Many studies were conducted to mark radon as a precursor of an earthquake and to prove the relationship of radon behavior and earthquake occurrence (Planinić et al., 2004; Ghosh et al., 2009; Kuo et al.,

2010; Sac et al, 2011; Gregorič et al., 2012; Hwa Oh and Kim, 2015; Kim et al., 2018).

This study deals with continuous radon monitoring conducted with aim to link indoor radon measurements and potential occurrences of earthquake in Balkan region.

MATERIAL AND METHODS

Geology of study area

The Balkan region has a diverse geological structure and diverse relief. There are rocks of Paleozoic age (shale and serpentine), limestone, sandstone and volcanic rocks (andensite, dacite, gabbro). The geology which includes measurement site is as follows. The mountains around the Kosovo and Metohija valleys are built of rocks of different ages and origins. Kopaonik has a diverse geological structure, which affects the appearance of various ores and minerals. There are also volcanic rocks east of the Kosovo valley. At the bottom of the Kosovo and Metohija valleys are lake deposits (sands and clays). The fluvial and alluvial plains are covered with river sediments from Quaternary. An intensive magmatic and tectonic activity in the past caused different vertical movements and forming a network of seismogenic faults. A deep fault stretches in NW-SE direction following the river valley; it is the one of the strike direction of young (neotectonic) faults (Dimitrijević, 1997). This region is classified from moderate hazard to high hazard area according to the European Seismic Hazard Map which displays the ground shaking (in terms of the unit gravitational acceleration, g) (Giardini et al., 2013).

In the Balkan region anomalies appear at distances sometime much greater than typical source dimensions. The earthquakes occur in the field of strain higher than 10^{-9}, some of them being in the field of strain higher than 10^{-8}, while slip rate of active faults is 0.1-0.5 mm/y (Giardini et al., 2013).

Methods

Radon monitoring was performed with the detector Airthings Corentium Home which was placed in basement office of faculty building in Kosovska Mitrovica (N 42.897°, E 20.867°) in winter period of the 2020/21 (four months in continuity). Radon detector Corentium Home measures in range from 0-9999 Bq/m^3. Detection method is alpha spectrometry. The accuracy of device at

typical concentration of 200 Bq/m^3 is 5-10% for measurement period from 7 days to two months, and uncertainty for one month measurement is less than 10%. Radon daily variations were noted and analyzed with any earthquake of magnitude M >2.5 which occurred in forthcoming days in the Balkan region. Besides meteorological parameters that influence radon fluctuations, these could also be connected with the ground shaking, since an active fault exists in this area.

The dilatancy model explained connection between the radon anomalies of chemical and physical parameters and seismic events (Scholz et al., 1973). Before an earthquake the cracks open, the diffusion of pore fluid increases, modified strength and pore pressure, and causes variations in the physical and chemical characteristics of the rocks. When the cracks start to form in the rocks the radon concentration increases. After that, the radon emission can be stable or decrease before the earthquake. The width of the zone involved by the stress loading is proportional to the magnitude and to the depth of the impending earthquakes. The pressure variations change the rocks characteristics creating the "precursor phenomena". According to an empirical relationship between earthquakes and indoor radon measurements proposed by Hauksson and Goddard (1981), the minimum magnitude M (the Richter scale) required for a radon anomaly at distance D (km) from the epicenter of an earthquake and the site of observed radon anomaly is:

$$M = 2.4\ log_{10}D - 0.43 \quad (1)$$

RESULTS AND DISCUSSION

The results of indoor radon monitoring are presented in Fig.1. The mean radon concentration within the four months was 210 Bq/m^3, while daily radon variations ranged from 58-865 Bq/m^3. The measurements were analyzed and related with any earthquake of magnitude M>2.0 which occurred in forthcoming days in the Balkan region. Anomalous emanation of geo-gases are connected with the ground shaking, and spike-like peaks in radon concentrations could be caused by seismic events in the wider area. In monitoring site it was reflected like a gradual increase in radon concentrations, then a sharp drop (e.g. from 865 Bq/m^3 to 73 Bq/m^3 within 48 hours). About seven days later an earthquake of magnitude M=2.2 occurred at the distance of 10 km from measuring site, and has been followed with a series of smaller earthquakes in the region. The results seem to indicate that radon is a good indicator of crustal activity and seismic movements.

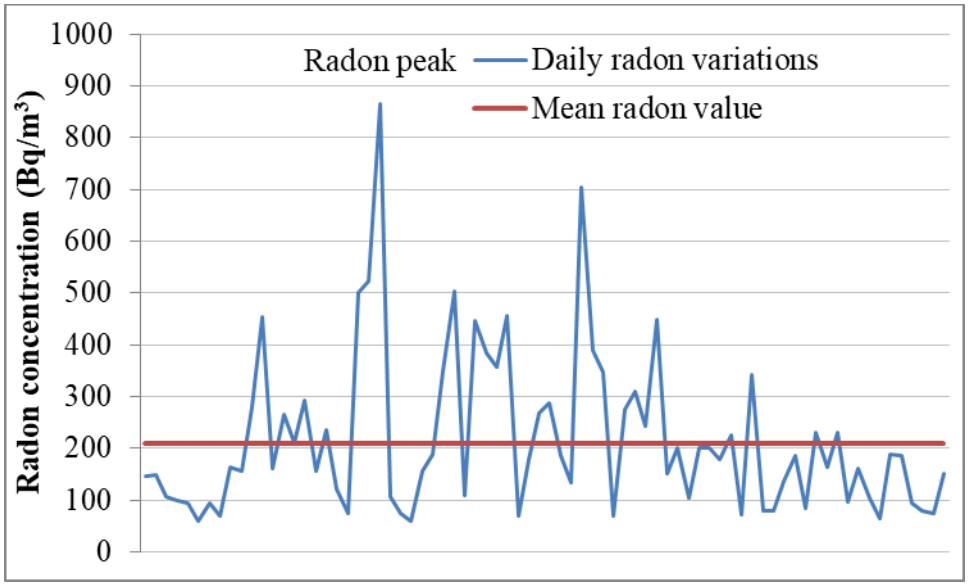

Figure1. Variation of indoor radon concentration

Anomalies which appear much faster are characterized as a short peak (duration: hours to days) in the radon concentration. These peaks can be either positive or negative and are often followed by an earthquake within about ten days. Any radon variation that can be considered "significant anomaly" must differ from the mean for ±2 standard deviations (Igarashi and Wakita, 1990).

CONCLUSION

Finally it could be concluded that continuous indoor radon measurements are a useful tool in investigations of geodynamical events connected with the ground shaking in the wider area. The results seem to indicate the radon as a good indicator of crustal activity such as earthquakes. However, more extended continuous data should be recorded, in particular near active faults, to find clear, causal relationship between radon and earthquake activity.

Acknowledgement

The work was supported by The Ministry of Education, Science and Technological Development of the Republic of Serbia (451-03-9/2021-14/200123).

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DOMESTIC MATERIAL MADE BY CALCIFICATION OF MODIFIED UF RESINS WITH INCORPORATED Fe-PARTICLES - A SENSITIVE PLATFORM FOR ELECTROANALYTICAL QUANTIFICATION OF GALLIC ACID

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Abstract

In this work, we present domestic high performance electrode material prepared by thermolysis of *in situ* synthesized urea-formaldehyde (UF) resins modified with Fe(III) nitrate. For comparison, material produced by thermolysis of physical mixture of synthesized UF resins and Fe(III) salt was also prepared, and produced materials were electrochemically characterized by cyclic voltammetry. The obtained results have shown that *in situ* synthesized Fe modified UF material (SynFe/UF-TP) prepared by thermolysis, incorporated in carbon paste electrode (CPE), possesses a better electrochemical response and conductivity than the other materials prepared by thermolysis and obtained by physical mixing of UF and Fe salt, and also commercially available classy carbon powder in pure CPE. The morphological and structural characteristics of produced materials were determined by SEM analysis. Then, SynFe/UF-TP incorporated in CPE was applied in sensing of gallic acid (GA), one of the most biologically active phenolic compounds of plant origin. Square wave voltammetry in Britton-Robinson buffer at pH 4 was used to quantify GA in the concentration range of 0.5-100 μM of GA. The limit of detection of developed analytical procedure at proposed electrode was 0.25 μM.

Keywords: Modified urea-formaldehyde resin, thermolysis, voltammetric sensor, gallic acid

INTRODUCTION

Urea-formaldehyde (UF) resin is a kind of amino resin obtained by the polycondensation reactions of formaldehyde with urea. UF resins have various applications and offer unique potential technical advantages, such as low price, non-toxicity, good bonding to wood products etc. Because of that, they are widely used as adhesives in the manufacturing of wood-based composite panels (Conner et al. 1996, p. 8497). Modification of UF resins by metal oxides and other compounds in order to reduce formaldehyde emission as a potential source of indoor air pollution and health problems (Lee et al. 2013, p. 7) is a top priority for this material in an ecological sense (Pizzi et al. 1994, p. 254, Fink 2013, p. 155). In our laboratory, UF resins were improved and modified with different fillers also for the same reasons (Samaržija-Jovanović et al. 2019, p. 161).

Nowadays, scientific interest focuses on materials made from natural or synthetic renewable resources, used for different purposes (Galembeck et al. 2019, e20181160). The goal of our work was to find other possible and effective applications for modified UF resins produced in our laboratory. It is known that UF resin serves for producing glassy carbon, one of the most used "green" electrode materials in electrochemistry. Iron and iron oxide particles also attract much attention due to their specific physical, especially magnetic and chemical properties, and they are, among other applications, used as sensors in electroanalysis (Šljukić et al. 2006, p. 1556). In this work, we present sensitive electrode materials obtained by thermolysis of Fe modified UF composites. The composites were produced by a) physical mixing of synthesized UF resins with an iron salt and b) by *in situ* synthesis of Fe salt and UF. The materials were examined morphologically and electrochemically. The best performance material was used as a voltammetric sensor to determine gallic acid, one of the most important phenols often used as a standard for determining the phenol content of various analytes. The measurement of "total phenols" is a good indication of the level of present antioxidants (Petković et al. 2015, p. 513).

MATERIAL AND METHODS

Materials

The following materials were employed in the study reported here: Urea, $(NH_2)_2CO$, (Alkaloid- Skopje, FYR of Macedonia); 35% Formaldehyde, CH_2O, (Unis-Goražde, Bosnia and Herzegovina); Fe(III) nitrate, $Fe(NO_3)_3 \times 9\ H_2O$;

Gallic acid, $C_6H_2(OH)_3CO_2H$, (Sigma-Aldrich). All the other materials and solvents used for analytical methods were of analytical grade.

Synthesis of modified UF composites

Two samples of iron-modified urea-formaldehyde (UF) composites with formaldehyde to urea (F/U) ratio (0.8) were synthesized. The first sample was a fiscal mixture of pure UF resin with 15% of iron (using Fe(III) nitrate) - hereinafter abbreviated as UF/Fe, and the second sample was prepared by adding the same amount of Fe(III) nitrate *in situ,* during the synthesis (abbreviated as SynUF/Fe). The synthesis of SynUF/Fe was done by the following procedure: 60 cm^3 of distilled water and 0.1 mol of urea are mixed into a reaction vessel with a magnetic stirrer. Then 4.36 g of $Fe(NO_3)_3 \times 9\ H_2O$, 0.12 mol of 35% formaldehyde and 0.6 cm^3 of concentrated sulfuric acid were added into the reaction mixture according to the following order. The reaction mixture is mixed for 3 hours. 0.22 mol of sodium hydroxide dissolved in 6 cm^3 of distilled water and added to the reaction mixture before the stirring was done. The iron-modified UF composite was cured at 110^{o}C for 2 h in a convective drying oven. For the first sample, UF/Fe, the synthesis procedure was the same, except the same amount of $Fe(NO_3)_3 \times 9H_2O$ was mixed and homogenized with pure UF after curing.

SEM measurements

The morphology of UF composites modified with Fe-particles, before and after thermolysis, was observed by TESCAN MIRA 3 XMU field emission scanning electron microscope (FE-SEM), operated at 20 keV. The samples were prepared for analysis by deposition of thin gold layer. The average particle size was determined by the image analysis, using the software ImageJ.

Electrode preparation and electrochemical measurements

Electrode material was prepared by calcination of Fe modified UF composites (UF/Fe and SynUF/Fe) at 950 C for 10 h and then cooled with the muffle furnace. Obtained materials were in 5% added to glassy carbon powder (Sigma-Aldrich) and mixed with paraffin oil to prepare carbon paste electrode. Three electrode systems in the working cell, attached to the PalmSence electrochemical system, consisted of this working electrode, an Ag/AgCl (saturated KCl) reference electrode and a Pt-wire counter electrode. The square wave frequency was varied from 10-100 Hz while pulse amplitude was changed from 10 to 100 mV, and potential step (scan increment) was changed in the range 2-20 mV.

RESULTS AND DISCUSSION

Surface morphology characterization

In order to determine the morphology of the obtained Fe modified composites, as well as the morphology and the particle size of Fe perticles prepared by thermolysis, SEM measurements were performed, and SEM micrographs of all samples are presented in Figure 1.

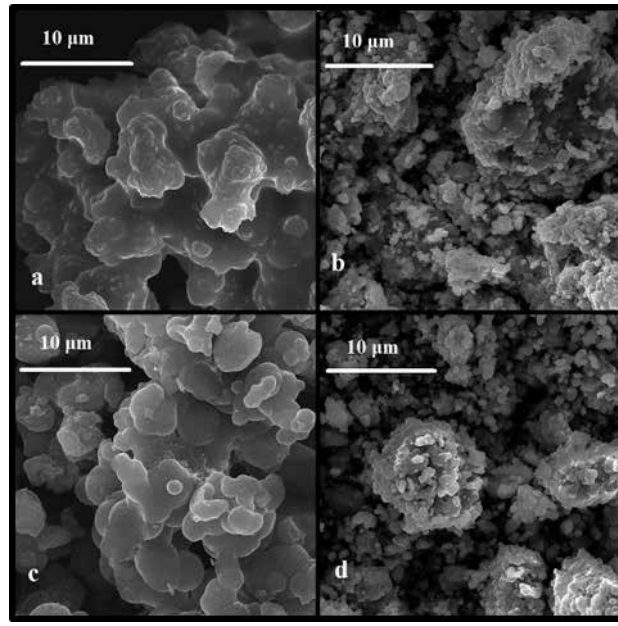

Figure 1. SEM micrograph of a)Physical mixture of UF resin and Fe salt (UF/Fe), b) Physical mixture of UF resin and Fe salt after thermolysis (UF/Fe-TP), c) In situ synthesized UF/Fe composite (SynUF/Fe), and d) In situ synthesized UF/Fe material after thermolysis (SynUF/Fe-TP).

From Fig. 1a, in the physical mixture of UF resin and Fe salt (UF/Fe), one part of the Fe-particles are on the surface of the UF composite covered with resin, and the second is immersed in the UF matrix. After thermolysis of UF/Fe, Fe-particles showed at Fig. 1b have defined shape; they are mostly spherical with the size of 445 ± 168 nm. From SEM micrograph of SynUF/Fe sample obtained by *in situ* synthesis of Fe salt and UF, only UF composite is observed (Fig. 1c). The Fe-particles potentially could be encapsulated with UF composite or incorporated in the structure. However, after thermolysis of SynUF/Fe, Fe-

particles are visible. In SynUF/Fe-TP, Fe-particles have a spherical shape, better defined than Fe-particles in UF/Fe-TP, with a smaller average diameter of 357 ± 113 nm.

Electrochemical characterization

In order to electrochemically characterize thermolysis prepared materials obtained from Fe modified UF composites, cyclic voltammetric measurements were performed in test solution of 5 mM $K_3[Fe(CN)]_6/K_4[Fe(CN)]_6$ (1:1) mixture as a redox probe in 0.1 M KCl, and in 100 μM of GA in BR buffer (Figure 2).

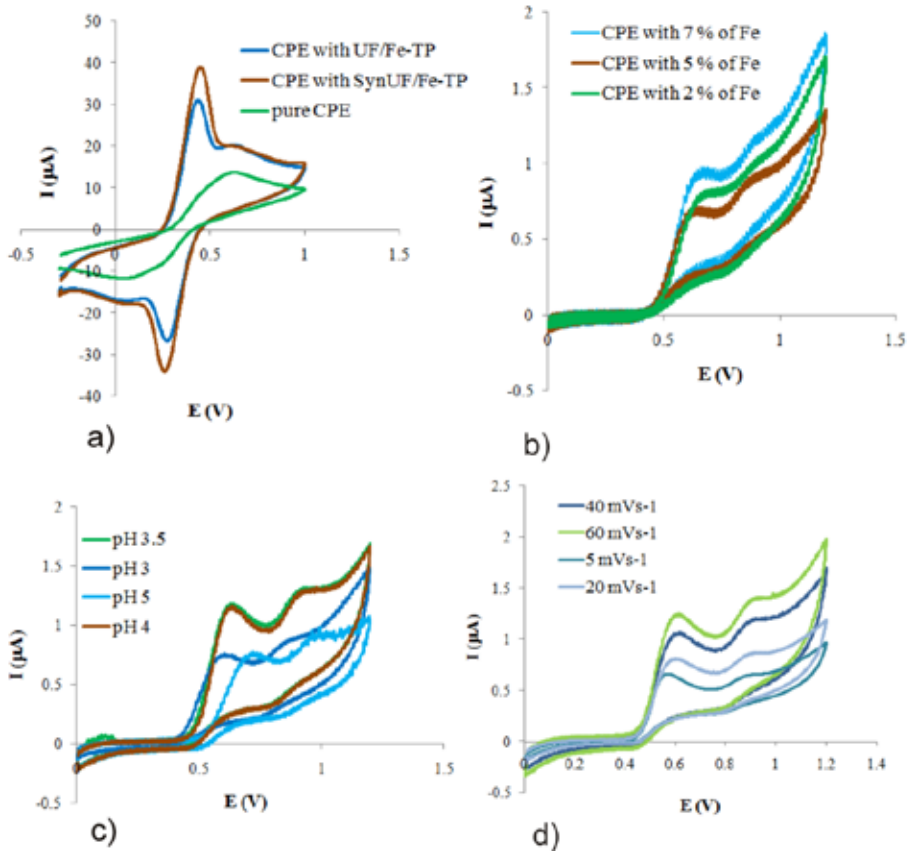

Figure 2. a) CVs of CPE with material doped with 5% of Fe recorded in 0.1M KCl solution containing 5 mM $[Fe(CN)_6]^{3-/4-}$ redox couple (scan rate: 50 mV/s); b) CV profiles of 100 μM of GA in BR buffer pH 3 at SynUF/Fe@CPE with different content (%) of Fe; c)Effect of pH of BR buffer solution and 100 μM of GA, recorded at SynUF/Fe@CPE; d) Effect of scan rate in the same solution and electrode as c).

As the catalytic activity of the material evidently depends mostly on the present iron, From Fig. 2a is evident that peak current in test solution increased in SynUF/Fe@CPE, indicating that *in situ* synthesis of UF and Fe produce material with improved conductivity and electron transfer property. The best voltammetric response to GA was recorded at the electrode with 5% of Fe (Fig. 2b). CV profiles show characteristic peaks for GA recorded in previous works (Petković et al. 2015, p.513). To optimize experimental conditions in terms of pH of supporting electrolyte, cyclic voltammograms of 100 μM of gallic acid in used Britton-Robinsons buffer (pH from 3 to 5) at SynUF/Fe@CPE were recorded (Fig. 2c). The optimal value of pH 4 was chosen for further experiments. From Fig. 2c, which shoves series of CV measurements of 100 μM of GA at different scan rates in BR buffer pH at SynUF/Fe@CPE, it can be seen that the anodic peak currents increased with an increase in scan rate from 5 to 60 mV/s. The relationship between anodic peak current *vs* square root of scan rate showed linear dependence, and it was expressed by regression equation I (μA) = 0.11 × $\nu^{1/2}$ ($mV^{1/2}s^{1/2}$) + 0.38; R = 0.989. This result suggests that the electrode reaction is controlled by diffusion as a rate-determining step while the adsorption and/or other specific interactions on the SynUF/Fe@CPE surface are negligible.

Development of an analytical procedure

The differential pulse voltammetry (DPV) and square wave voltammetry (SWV) are frequent pulse electroanalytical techniques used in electroanalysis due to good discrimination against background current, which results in lowering of detection limits of voltammetric measurements (Wang 2000, p. 68). SWV technique was chosen for GA determination at SynUF/Fe@CPE due to higher and better-shaped peak current. The optimal working conditions for SWV were found by changing the parameters of the technique (see Materials and Methods), and they were: pulse amplitude of 90 mV, frequency of 70 Hz, and potential step of 18 mV.

The calibration curve (Fig. 3b) was constructed based on values of peak currents from voltammetric SWV profiles and used concentrations of GA (Fig. 3a).

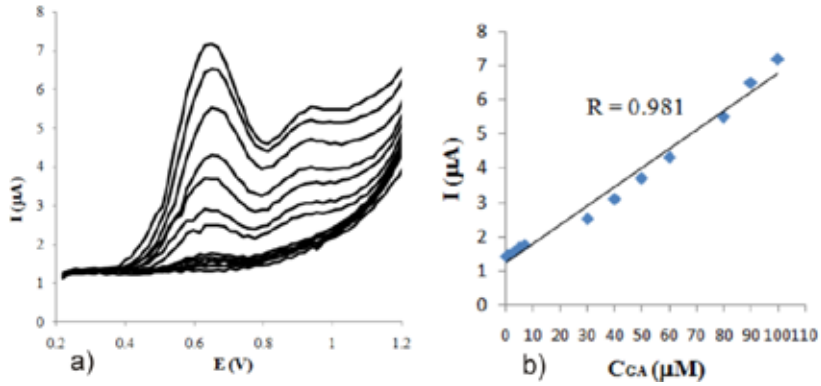

Figure 3. a) SWV profiles of various concentrations (0, 0.5, 1, 3, 5, 7, 10, 30, 40, 50, 60, 80, 90, 100 μM) of GA, in BR buffer at pH 4 at SynUF/Fe@CPE, under optimized experimental conditions;

b) Corresponding calibration curve.

The corresponding regression equation was: I (μA) = 1.243 + 0.055 × C (μM); R = 0.981. The detection limit (calculated as three times the standard deviation for the blank solution divided by the slope of the calibration curve, $LOD = 3s/m$) find to be 0.25 μM. To evaluate the reproducibility of the SynUF/Fe@CPE, 7 successive measurements of 30 μM of GA were determined. The relative standard deviation (*RSD*) of 3.68 % was obtained.

CONCLUSION

This work presents the application of the homely synthesized iron modified UF composite prepared by thermolysis, for the construction of the carbon paste based electrode. This is a new possible application of UF composites primarily used as adhesives in wood panel manufacturing. Electrochemical characteristics of such prepared material in CPE and developed electroanalytical method for determining of gallic acid open novel approaches in the manufacturing electrode materials and their modification.

Acknowledgment

The research was funded by the Ministry of Education, Science and Technological Development of the Republic of Serbia (contract number 451-03-9/2021-14/200123 and 451-03-9/2021-14/200017).

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THE INFLUENCE OF THE MODIFICATION OF THE MONTMORILLONITE KSF AND K10 ON THE HYDROLYTIC STABILITY OF UF COMPOSITES

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Abstract

In this work, the hydrolytic stability of composites based on the urea-formaldehyde resin (UF) and montmorillonite-MMT (K10 and KSF) as a formaldehyde (FA) scavenger was investigated. K10 and KSF were activated by sodium chloride (NaCl) for the purpose of modified Na-MMT. The degree of activation was determined using specific surface measurement by Sir's method. Evaluation of MMT activation was performed by determining free and liberated FA after acid hydrolysis of synthesized crosslinked UF/MMT composites. The specific surface area (SSA) of montmorillonite KSF and K10 calculated by the Sear's method are 270 m^2/g and 119 m^2/g, respectively. After modification of MMT, the SSA of Na-KSF is 48.6 m^2/g and 71 m^2/g for Na-K10. The amount of free formaldehyde is 0.6% for both UF/K10 and UF/Na-K10 and 0.4% and 0.12% for UF/KSF and UF/Na-KSF composites. The content of liberated FA are 2.1% and 2.2% for UF/K10 and UF/Na-K10 composites and 1.2% and 2.3% for UF/KSF and UF/Na-KSF composites, respectively. It was concluded that the UF composite with modified KSF has a smaller content of free formaldehyde (0.2%) compared to UF composites with pure and modified K10. The UF composite with pure KSF has the highest resistance to acid hydrolysis and the lowest released FA percent.

Keywords: Montmorillonite, Urea-formaldehyde resin, Formaldehyde, Hydrolytic stability

INTRODUCTION

Chemically, UF adhesives are duromers. They belong to the group of thermosetting aminoplastic resins, formed by polycondensation reactions of urea and formaldehyde (FA) (Samaržija-Jovanović et al. 2020, p. 3575). The biggest disadvantage of using UF resins is the emission of FA from the panels and low resistance to moisture. This leads to the hydrolytic degradation and subsequent emission of FA. FA emission can be affected by external factors such as temperature, humidity, air movement over the panel surfaces, changes in air velocity and local formaldehyde concentrations in the space where the material is located; as well as internal factors, type of wood and percentage of moisture in it, types and chemical composition of used binders, additives that are added, surface treatment, etc.

The reversibility of methylation reactions is one of the most important characteristics of UF adhesives and is responsible for its poor resistance to hydrolytic degradation in conditions of increased humidity and temperature, and at the same time affects the emission of FA from the finished product.

The World Health Organization (WHO) refers to FA as a compound that can be carcinogenic, while in 2004, the International Agency for Research on Cancer (IARC) included FA in the group of substances that have been proven to be carcinogenic to humans, with emissions higher than 5.65 ppm. Its harmful effect is reflected on the respiratory organs, where it can cause irritation in the case of lower concentrations, but it can leave permanent consequences and cause chronic diseases in the case of high concentrations. The first reaction to formaldehyde is irritation of the respiratory organs, while the other symptoms that occur are: nausea, headache, dizziness, abdominal pain, irritation in the oral cavity. When it comes to the carcinogenicity of formaldehyde, data showing this is very scarce. Most studies state that it is cancerogenic after prolonged exposure to it, especially to workers in the wood industry (production of boards and formaldehyde adhesives), and to workers in the medical industry where formalin is used (Kalinić, 1995, p. 259).

Modified clays are increasingly being used for the reinforcement of polymeric materials (El Achaby, 2013, p. 310) and as scavengers of formaldehyde in cross-linked UF composites (Samaržija-Jovanović et al. 2020, p. 3575). Clays, such as montmotillonite (MMT), are used to modify the characteristics of certain polymers (Krupskaya et al., 2017, p. 49). Montmorillonite (MMT) is an aluminum phyllosilicate with hydroxyl groups and water. It may contain other cations (calcium, magnesium, sodium, iron). Out of all the phyllosilicates,

MMT is the most promising due to its natural abundance on a high scale (Ke and Stroeve, 2005). MMT is a derivative of pyrophyllite. The difference between the crystal structure of MMT and pyrophyllite is that the latter is neutral while the former has deposits due to isomorphic substitution. The high value of cation exchange capacity (CEC) is one of the properties of MMT that defines it as a good adsorbent. It is known that MMT has two types of charges. In addition, negative charge originates from the mentioned isomorphic substitution (permanent charge) which does not depend on the pH value and contributes to 80% of the CEC value, there is also a variable edge charge which makes up the other 20% of the total CEC value.

The goal of this work was to examine the effect of modification of the MMT on hydrolytic stability modified UF/MMT composites.

MATERIAL AND METHODS

Materials

Urea (Alkaloid-Skopje, Republic of North Macedonia); 35% Formaldehyde Unis-Goražde, Bosnia and Herzegovina); Montmorillonite-K10 and KSF (Sigma-Aldrich Chemistry, Germany) with specific surface area (SSA) of 220-270 m^2/g and 20-40 m^2/g were used. All the other materials and solvents used for analytical methods were of analytical grade.

Modification of montmorillonite

Activation of MMT was performed in such a way that 11.66 g of MMT (K10 and KSF) were treated with 250 cm^3 of 1M NaCl solution with constant stirring for 24 h, after which Na-MMT was washed with deionized water until negative reaction to chloride ions. After removal of the chlorides, the clay was dried in an oven at 100°C (Ainurofiq et al., 2014, p. 131). The activated samples are referred to as Na-K10 and Na-KSF later in text.

Characterization of the MMTand modified MMT

The SSA of adsorbents was determined using the Sear's method (Sears, 1956, p. 1981). The volume (V) required to raise the pH from 4 to 9 is recorded and the specific surface area was calculated by the **Eq. (1)**:

$$SSA\ (m^2/g)=32 \cdot V-25 \quad (1)$$

Synthesis of modified UF/MMT composites

Synthesis of UF/K10 composites with molar ratio of UF/U = 0.8 with pure and modified MMT takes place using the procedure (Jovanović et al. 2015, p. 59715).

Determination of the hydrolityc stability of modified UF/K10 composites

The percentage of free and liberated FA was determined by the sulphite method (Walker, 1964). The percentage of free FA content was calculated from **Eq. (5)**:

$$FA(\%) = \frac{V \cdot c \cdot E \cdot 100}{1000 \cdot a} \quad (5)$$

where V is the voume of HCl (cm^3), c is the contrentration of HCl ($moldm^{-3}$), E, is the equivalent weight of FA, and a is the weight of the samples (g).

The synthesized UF composites were subjected to hydrolysis according to the procedure (Samaržija-Jovanović et al. 2011, p. 1159).

RESULTS AND DISCUSSION

FA emitted from UF resins can come from several sources: (a) unreacted FA resin; (b) FA which is released when the ether bonds are converted to methylene bonds; and (c) FA which is released due to hydrolytic degradation of weak bonds in the crosslinked resin. All these factors form the sources and generative processes for longterm FA emission. Decreasing the content of FA in the formulation of such resins decreases the amount of terminal CH_2OH groups, which are surely more reactive than the methylene ones. However, a lower F/U molar ratio allows producing a crystalline framework, which reasonably hinders the penetration of water in the bulk of the material, thus making the reactive moieties less available for hydrolysis (Park and Causin, 2013, p. 532).

Since the SSA is inversely proportional to the particle size, the smaller particles will have a larger specific surface area and the other way around. SSA has several consequences, and that means there is a possibility of the adsorption and absorption of various substances. The values of specific surface area of KSF and K10 determined by the Sear's method are 269.5 m^2/g and 119 m^2/g, respectively, and is shown in Figure 1.

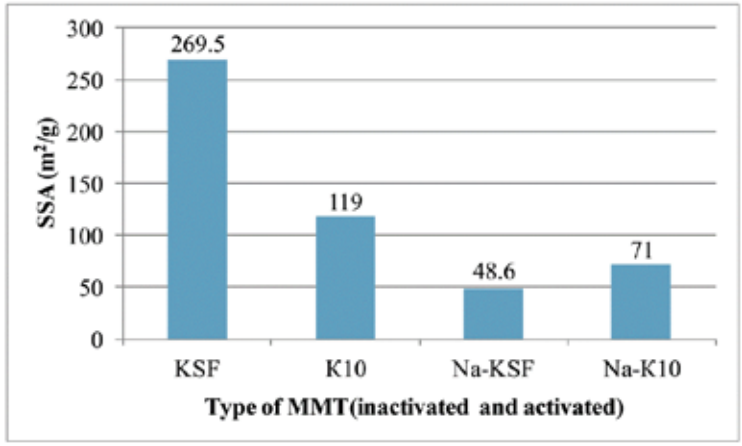

Figure 1. The SSA of pure and activated MMT determined by Sear's method.

This is intriguing because the determined values of the specific surface area by the BET method are 20-40 m^2/g for KSF, and 220-270 m^2/g for K10. One of the possible causes for such differences in the obtained results is the possible agglomeration of K10 particles. BET method measures the specific surface area of a dry solid which is available for the adsorption of N_2. Sear's method gives the number of silanol groups accessible for chemical reactions in an aqueous environment (Yuan , 2017, p. 8724). After modification of MMT, the values of the specific surface area of Na-KSF and Na-K10 are 48.6 m^2/g and 71 m^2/g.

Free and liberated FA of UF/KSF and UF/K10 composites

The hydrolysis of hardened resins is considered to be the main factor that influences the long-term emission of formaldehyde from the panel. The hydrolysis of UF resins depends on their chemical structure and the degree of crosslinking. The presence of crystallyne regions in hardened UF resins affects the degree of hydrolysis of cured UF resins (Stuligross and Kousky, 1985, p. 281). That is, UF resins with a lower FA/U mole ratio will be less susceptible to hydrolysis than those with a higher FA/U mole ratio. Since the FA/U ratio is low and is 0.8, it is not expected of the resin to have a branched structure, which means that it has fewer terminal methylol groups, i.e. there are more stable methylene groups (Lubis and Park,. 2018 p.759).

Figures 2 and 3 shows the percentage of free and liberated FA from pure UF resin, modified UF resin with unmodified MMT, and UF/Na-KSF and UF/Na-K10 composites. The lowest percentages of free FA and liberated FA of 0.12% and 1.2% are shown by the UF/Na-/KSF and UF/KSF composite, respectively.

KSF has a higher SSA (269.5 m^2/g) compared to K10 (119 m^2/g) which is determined by the Sear's method. Due to the large SSA of K10 particles (determined by BET method), their agglomeration occurred, and thus the interconnection of groups on the surface of the particles, which were irreversibly lost in this process for the binding of free FA from UF resin.

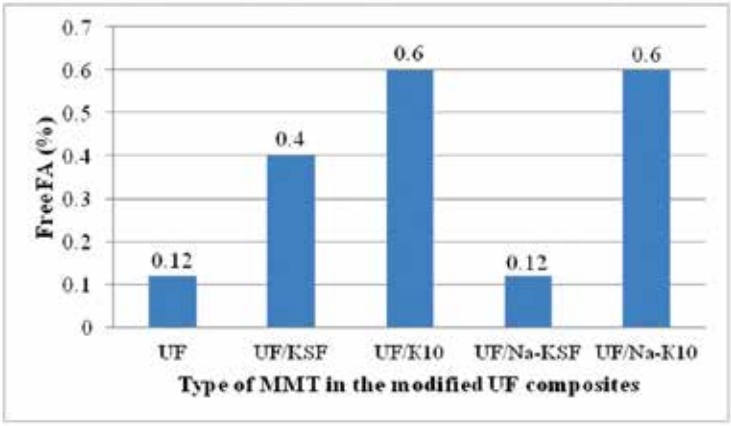

Figure 2. Content (%) of free FA from pure UF resin, UF resin with unmodified MMT and modified UF/MMT composites with activated MMT composites

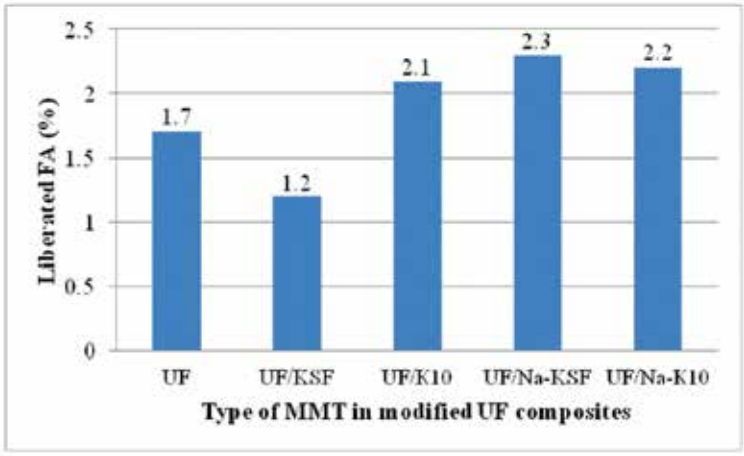

Figure 3. Content (%) of liberated FA from pure UF resin, UF resin with unmodified MMT and modified UF/MMT composites with activated MMT composite

The UF/KSF composite shows a higher resistance to acid hydrolysis, due to the lower percentage value of the released FA, which is 1.2%. It is considered that in this sample, at elevated temperatures and in an acidic environment during hydrolysis, there is an additional bond between the hydroxyl and methylol groups of the UF resin and the hydroxyl groups of the KSF, which further strengthens the structure of the composite. Free active centers can react with FA and thus cause a decrease in the percentage of FA released after hydrolysis. In this way, the KSF which contains OH-groups reacts with the liberated FA from UF resins as a "scavenger" of FA (Abdullah and Park, 2010, p. 3181).

CONCLUSION

Based on the experimental data, the following can be concluded:

- The lowest content of free formaldehyde is in the modified UF / Na-KSF composite and is 0.12%.
- UF / KSF composite has the highest resistance to acid hydrolysis and the content of released formaldehyde is equal to 1.2%.

Acknowledgment

The research was funded by the Ministry of Education, Science and Technological Development of the Republic of Serbia (contract number 451-03-9/2021-14/200123 and 451-03-9/2021-14/200017).

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IDENTIFICATION OF POLLUTION DEGREE OF THE NIŠAVA RIVER IN SERBIA

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Abstract

This paper presents the analysis of water pollution of the Nišava River at two monitoring station (Dimitrovgrad and Niš) for the monitoring period from 2015-2019 using the combined approach by Water Pollution Index (WPI) and Pearson's correlation test. Data from the Environmental Protection Agency of the Republic of Serbia for nine parameters: pH, dissolved oxygen (DO), ammonium ion (NH_4-N), nitrate (NO_3-N), orthophosphate (PO_4-P), total phosphorus (TP), 5-days biochemical oxygen demand (BOD_5), total organic carbon (TOC) and chloride (Cl-) were used. The WPI values were reduced towards the downstream of the river and water at Dimitrovgrad station is moderately polluted (class III), whereas at Niš station is polluted (class IV). Results of correlation analysis showed that the potential main sources for contaminating the Nišava River were discharging of industrial and domestic wastewater without prior treatment, and runoff from agricultural land. The exit monitoring profile (Niš) is more polluted, especially by organic matter and nutrients than the entry monitoring profile (Dimitrovgrad), and had an increasing pollution trend over a 5-year period. The WPI and correlation method represents a reliable tool in identifying the pollution source and their trends in the long-term, in order to develop strategies for revitalization and protection of degraded watercourses.

Keywords: Nišava River, pollution, WPI index method, correlation analysis

INTRODUCTION

Rivers are the main water resources that find application for household, industry, and irrigation. These are complex and dynamic aquatic systems

susceptible to anthropogenic activity, i.e. to pollution of wastewater from urban areas and industrial processes. New aspects of natural river pollution include land drainage, and so the watercourse becomes a recipient of nutrients and fertilizers (Leščešen et al., 2018; Milošević et al., 2015; Panda et al., 2006). With urbanization, watercourses in the Republic of Serbia are becoming more polluted by untreated industrial and domestic wastewater, by chemical and organic pollution due to uncontrolled use of pesticides and fertilizers (Milanović et al, 2011).

Water resources are considered an important part of the environment, so it is necessary to manage the protection of rivers through monitoring, classification, and categorization of waters (Milošević et al., 2015), as well as through adoption of regulations on water quality, which is provided in Europe by Water Framework Directive (Directive 2000/60/EC - WFD). This directive has defined surface water quality standards, with the aim of achieving good hydrological and eco-chemical status of natural waters (Popović et al., 2016). The concept and standards of the EU WFD were implemented in the Republic of Serbia through the enactment of the regulations which serve to assess the quality of surface water.

The assessment of the quality of surface water is performed by different index methods such as Serbian Water Quality Index (SWQI) and Water Pollution Index (WPI) (Leščešen et al., 2018; Milanović et al, 2011). WPI method summarizes physical, chemical, and biological data, which determine water quality in a single value (Popović et al., 2016). This method not only determines the degree of pollution, but in combination with correlation analysis provides data on the state of the aquatic environment and its relationship with potential sources of pollution (Leščešen et al., 2018; Milanović et al, 2011).

This paper's aim is an assessment of the Nišava River water quality as a function of physical and chemical parameters through the index method and determination of the relationship between quality parameters in order to detect sources of pollution.

MATERIAL AND METHODS

Study area

The Nišava River flows 248 km in length through the territory of eastern and southeastern Serbia and parts of the territory of western Bulgaria. The Nišava enters into Serbia 6 km upstream from Dimitrovgrad, and flows to the west with a length of 151 km through Pirot, Bela Palanka, Niška Banja, and Niš town. The

largest tributaries of the Nišava River are Temska and Visočica on the right and Kutinska, Crvena reka, Koritnička, Rogoz, Jerma and Gaberska on the left side (Ducić and Luković, 2009; Manojlović, 2002; Milošević et al., 2015; Leščešen et al., 2018). The Nišava River flows through towns, except Dimitrovgrad, in which municipal wastewater treatment does not exist. The sewerage system in the villages is not regulated, so the watercourse is additionally loaded by the existence of septic tanks of unknown correctness. Therefore, it can be concluded that this water body is a recipient of industrial and sanitary waters. Wastewater from the Niš town is currently discharged into the Nišava River without prior treatment through a series of existing outlets. After heavy rains or illegal exploitation of sand and gravel, the river transports a certain amount of sand, clay, and sludge (Manojlović, 2002). Surface water pollution of the investigated water area was examined at two monitoring stations: Dimitrovgrad (Nis_3) and Niš (Nis_1), Figure 1.

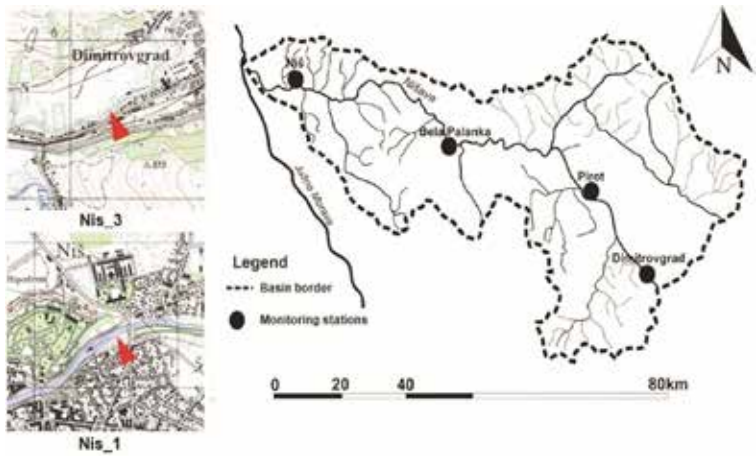

Figure 1 Hydrological map of monitoring stations in the Nišava river basin. Reprinted and modified from "Correlation Between Discharge and Water Quality – Case Study Nišava River (Serbia)", by I. Leščešen, D. Pavić and D. Dolinaj, 2018, Geographica Pannonica, 22(2) pp. 97–103.

Data and methods

In this paper, the data of the publication "Results of surface and groundwater quality testing" of the Environmental Protection Agency of the Republic of Serbia were used for the analysis of surface water quality (Annual report). The assessment of watercourse pollution is based on the average annual values of 9

physico-chemical parameters: dissolved oxygen (DO), pH, chloride (Cl^-), ammonium ion (NH_4-N), nitrates (NO_3-N), orthophosphate (PO_4-P), total phosphorus (TP), 5-days biochemical oxygen demand (BOD_5) and total organic carbon (TOC), for the period from 2015 to 2019.

The Nišava River is loaded with pollutants from point and diffuse sources of pollution, which imposes the need to analyze the degradation degree of watercourse quality over a five-year period.

Evaluation of the physical and chemical composition of water at the examined stations was performed through the index method (WPI) and correlation analysis. The WPI determines the deviation degree of an analyzed parameter from the values defined by regulations and thus the pollution degree of the investigated watercourse (Brankov et al., 2012). The index is calculated as the sum of ratios between mean annual value of parameters (*C*i) and values of parameters for class I of surface water according to Official Gazette of the Republic of Serbia, No. 74/2011 (standard threshold values - *T*i), divided by the number of used parameters (*n*) (Milanović et al., 2011; Popović et al., 2016):

$$WPI = \sum_{i=1}^{n} \frac{C_i}{T_i} \times \frac{1}{n}$$

Based on WPI values, surface waters are classified as: very pure (WPI ≤0.3, I class), pure (WPI=0.3-1, II class), moderately polluted (WPI=1-2, III class), polluted (WPI=2-4, IV class), impure (WPI=4-6, V class), and heavily impure (WPI>6, VI class) (Lyulko et al., 2001).

A correlation statistical method was used to consider the degree of correlation between water quality parameters. The correlation value is expressed by the coefficient of simple linear correlation - Pearson coefficient (r_p). The value of the Pearson correlation coefficient is in the range from +1 to -1 and determines the strength of the correlation, while the sign of the coefficient indicates whether the dependence is positive or negative. The Pearson coefficient can be calculated only if there is a linear relationship, a normal distribution of data of one parameter, and a sufficiently large group of data ($n \geq 30$) (Dawson and Trapp, 2004). Data or annual mean concentrations of physico-chemical parameters were processed by the software package Statistica Version 7.0 (Statsoft, Tulsa, Oklahoma, USA).

RESULTS AND DISCUSSION

By legislation of the Republic of Serbia in the field of surface water, Regulation on determining the water bodies of surface water and groundwater (Official Gazette of the Republic of Serbia, No. 96/2011) and Regulation on the parameters of ecological and chemical status of surface water and parameters of the chemical and quantitative status of groundwater (Official Gazette of the Republic of Serbia, No. 74/2011), watercourse Nišava at the monitoring station Dimitrovgrad (Nis_3) is classified into type 3 water bodies and categorized as a river, while at the monitoring station Niš (Nis_1) into type 2 and the watercourse belongs to the category of a heavily modified water body. Small and medium watercourses, altitude up to 500 m, with a dominance of large subsoil represent type 3 water bodies. Type 2 includes large rivers, with a dominance of medium sediment, except for the rivers of the Pannonian Plain. Rivers represent a category of water bodies that arose naturally and which are not significantly altered by anthropogenic factors. On the other hand, heavily modified water bodies have changed by the human factor due to exploit water, protect water resources, etc.

Table 1 shows the average annual values of water quality parameters at the monitoring stations Dimitrovgrad and Niš for the period 2015-2019. Surface water at the examined stations had a basic character. The oxygen regime is ununiform, higher concentrations were recorded at the monitoring station Dimitrovgrad (DO=10.90-11.78) compared to the station Niš (DO=6.07-8.94). Indicators of river water load with organic matter (BOD_5 and TOC) as well as nutrients (NH_4-N, NO_3-N, PO_4-P, and TP) are present in a lower concentration at the monitoring station Dimitrovgrad, at the entrance to the Republic of Serbia. The presented results showed better water quality at the Dimitrovgrad station. It can be seen from Table 1 that the water of the Niš station had a trend of deteriorating quality, while the values of physical and chemical parameters of the water of the Dimitrovgrad station were more uniform. The surface water on the city of Niš territory probably suffers a large load from point sources of pollution, inflow of industrial and municipal wastewater (Manojlović, 2002).

Table 1 Mean annual values of water quality parameters at monitoring stations Dimitrovgrad and Niš on the Nišava River for the time period from 2015 to 2019

Parameter	Monitoring station									
	Dimitrovgrad (Nis_3)					Niš (Nis_1)				
	2015	2016	2017	2018	2019	2015	2016	2017	2018	2019
DO (mg/dm^3)	10.90	11.78	11.36	11.40	11.58	8.78	8.92	8.67	8.94	6.07
pH	7.99	8.26	8.31	8.32	8.31	7.91	7.87	7.83	7.96	7.79
NH_4-N (mg/dm^3)	0.05	0.07	0.07	0.06	0.09	0.16	0.13	0.19	0.17	0.22
NO_3-N (mg/dm^3)	0.54	0.84	0.94	0.86	1.02	1.34	1.43	1.92	1.86	2.67
PO_4-P (mg/dm^3)	0.045	0.035	0.038	0.026	0.042	0.104	0.094	0.141	0.134	0.175
TP (mg/dm^3)	0.089	0.063	0.057	0.043	0.104	0.239	0.236	0.327	0.333	0.428
Cl^- (mg/dm^3)	6.83	13.37	10.28	8.80	9.73	8.91	11.69	12.42	10.89	13.94
BOD_5 (mg/dm^3)	2.12	2.54	2.29	2.09	1.97	3.22	3.42	4.08	4.33	4.31
TOC (mg/dm^3)	3.95	3.21	3.32	3.71	3.84	5.95	5.21	5.49	6.54	6.52

In order to define and classify more precisely the surface water pollution of the Nišava River at the examined stations, a larger number of data were processed and converted into single values of the WPI index. The obtained WPI values of the water of Nišava River are given in Table 2.

Table 2 The WPI index values of water at the monitoring station Dimitrovgrad and Niš

Parameter	Dimitrovgrad						Niš					
	Type 3	2015	2016	2017	2018	2019	Type 2	2015	2016	2017	2018	2019
		$Ci/Ti\times(1/n)$						$Ci/Ti\times(1/n)$				
pH	8.5	0.104	0.108	0.109	0.109	0.109	8.5	0.103	0.103	0.102	0.104	0.102
DO	8.5	0.142	0.154	0.148	0.149	0.151	8.5	0.115	0.117	0.113	0.117	0.079
NH_4-N	0.05	0.111	0.147	0.167	0.133	0.200	0.05	0.356	0.284	0.422	0.378	0.489
NO_3-N	1.5	0.040	0.062	0.070	0.064	0.076	1.5	0.099	0.106	0.142	0.138	0.198
PO_4-P	0.02	0.250	0.194	0.211	0.144	0.233	0.02	0.578	0.522	0.783	0.744	0.972
TP	0.05	0.198	0.140	0.127	0.096	0.231	0.05	0.531	0.524	0.727	0.740	0.951
BOD_5	1.5	0.238	0.253	0.302	0.321	0.146	1.8	0.199	0.211	0.252	0.267	0.266
TOC	2	0.331	0.289	0.305	0.363	0.213	2	0.331	0.289	0.305	0.363	0.362
Cl^-	50	0.020	0.026	0.028	0.024	0.022	50	0.020	0.026	0.028	0.024	0.031
WPI=$\Sigma(Ci/Ti)\times(1/n)$		**1.434**	**1.373**	**1.467**	**1.403**	**1.381**		**2.332**	**2.182**	**2.874**	**2.875**	**3.450**

Surface water at the monitoring station Dimitrovgrad in the period 2015-2019 has the character of moderately polluted water (WPI=1.373-1.467, Table 2) and belongs to class III. The combined physical-chemical index method indicated the polluted level of this river at station Niš, WPI=2.182-3.450 - class IV. WPI value for water at monitoring station Niš shows an increasing trend of

pollution for the investigated period. Parameters that significantly contribute to the WPI values of Nišava water at Dimitrovgrad are PO_4-P, BOD_5, and TOC, while in the case of Niš, in addition to the mentioned indicators, there are also nutrients (NH_4-N and TP).

In the work of Leščešen and associates (2018), the SWQI index average value of 89 (very good) was obtained for the monitoring station Dimitrovgrad and the SWQI average value of 78 (good) index points for the station Niš, for the period from 2005 to 2014. Descriptive index of water quality Nišava in the research of other authors, according to the classification criteria, is varied from 92 to 82 from the station Dimitrovgrad to Niš, respectively (Milošević et al., 2015**)**, which is another confirmation of the poorer physical and chemical composition of water in the watercourse sector at Niš.

In this paper, the potential causes of deterioration of the quality of surface water was identified by correlation analysis. For statistically significant correlations, the value of occurrence of an error (*p*) less than 0.05 is taken. In the analysis, only a strong correlation between the parameters, $r_p \geq 0.8$, was considered. The results of the correlation analysis of water quality parameters for station Dimitrovgrad and Niš are given in Table 3.

Table 3 Correlation matrix of quality parameters at the monitoring station Dimitrovgrad and Niš

	DO	pH	NH_4-N	NO_3-N	PO_4-P	TP	BOD_5	TOC	Cl^-
Dimitrovgrad									
DO	1.00	0.77	0.60	0.75	-0.41	-0.17	**0.90**	0.43	-0.63
pH		1.00	0.68	**0.94**	-0.61	-0.40	0.57	0.07	-0.49
NH_4-N			1.00	**0.89**	0.15	0.36	0.39	-0.21	-0.16
NO_3-N				1.00	-0.30	-0.08	0.52	-0.06	-0.37
PO_4-P					1.00	**0.85**	-0.28	-0.18	0.34
TP						1.00	-0.27	-0.45	0.56
BOD_5							1.00	0.77	**-0.87**
TOC								1.00	**-0.88**
Cl^-									1.00
Niš									
DO	1.00	0.73	-0.79	**-0.88**	**-0.81**	**-0.82**	-0.72	-0.47	-0.51
pH		1.00	-0.57	-0.63	-0.55	-0.52	-0.79	-0.20	0.16
NH_4-N			1.00	**0.90**	**0.96**	**0.92**	0.61	0.73	0.62
NO_3-N				1.00	**0.97**	**0.99**	**0.84**	**0.82**	0.60
PO_4-P					1.00	**0.99**	0.74	**0.86**	0.64
TP						1.00	0.77	**0.88**	0.67
BOD_5							1.00	0.67	0.11
TOC								1.00	0.61
Cl^-									1.00

Marked correlations are significant at $p<0.05$

Table 3 shows a strong positive correlation between nitrate (NO_3-N) and pH value, $r_p = 0.94$, as well as between nitrate and ammonium ions (NH_4-N), $r_p = 0.89$, in the water of the monitoring station Dimitrovgrad. The increased concentration of nitrate and ammonium is probably the result of the leaching of fertilizers (NH_4-NO_3) from treated agricultural areas (Panda et al., 2006). Orthophosphates are positively correlated with total phosphorus ($r_p = 0.85$), which is obvious, because PO_4-P are part of total phosphorus in surface water systems. Strong positive correlations between nutrients and indicators of organic pollution (Table 3) unequivocally indicate that the water at the monitoring station Niš is polluted from a point source of pollution, more precisely due to the inflow of municipal or industrial wastewater into the recipient. This is explained by the fact that ammonia is a component of surface water in higher concentrations only as a consequence of organic load which originating from industrial and municipal wastewater, while orthophosphates are components of detergent found in municipal waters (Agbaba and Maletić, 2012). The negative strong dependence between DO and NO_3-N, PO_4-P, and TP is the result of disturbed balance in the water system by algae growth, which in turn leads to oxygen deficiency.

The water of the Nišava River in the city of Niš contains a significant concentration of nutrients and organic matter (Table 1). As high concentrations of nutrients and organic matter originate from wastewater, their treatment can achieve a significant improvement in watercourse quality and more adequate wastewater management. The watercourse sector at the monitoring station Niš does not show sufficient self-purification potential and provides another confirmation for needing for the construction of a central wastewater treatment plant. The lower pollution of the Nišava water at station Dimitrovgrad is influenced by the lower development of this area, and as it has already been said, the dominant source of river pollution is a diffuse character. Although across-the-border inflow from Bulgaria cannot be ruled out.

CONCLUSION

In this paper, comprehensive monitoring of the surface water of the Nišava River by WPI index method and correlation analysis was performed in order to determine the trend of water pollution and identify potential sources of pollution. Pollution status determined via the WPI index indicates water pollution at both examined monitoring sites, Dimitrovgrad and Niš, in the analyzed period from 2015-2019. Based on 9 selected physical and chemical parameters, the water of the Dimitrovgrad station is classified in class III (WPI=1.373-1.467). The WPI

value of the water of the Niš station varies in the range from 2.182 to 3.450, which classifies the surface water in class IV. Significant deviations of physical-chemical parameters (indicators of organic pollution and nutrients) from I class of surface water according to the national Regulation on the parameters of ecological and chemical status of surface water and parameters of chemical and quantitative status of groundwater (Official Gazette of the Republic of Serbia, No. 74/2011), is primarily identified at the water which flows through the city of Niš. The data also indicate that the water in this sector of watercourse had a decreasing trend of water quality in the period from 2015-2019. The obtained correlation matrix of Pearson's correlation coefficients enabled the determination of the dependence between the parameters, and defined the potential causes of pollution: discharging of untreated wastewater from industry and households (monitoring station Niš) and runoff from agriculture field (monitoring station Dimitrovgrad). The combined analysis in this paper can serve as a basis for the development of programs for the management and protection of watercourses in this part of Serbia.

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ANTHROPOGENIC IMPACTS ON THE QUALITY OF THE RIVER TOPLICA

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Abstract

The River Toplica is the main source of water supply in Toplica Municipality. In the last decades, its quality dropped from surface water II degree of quality to III or even IV degree due to anthropogenic impact. The cause of this phenomenon is mostly an accelerated increase in the amount of solid waste from urban areas and industry and its accumulation in the river. Using the results of physical and chemical analysis of the databases of the Environmental Protection Agency, methods of analysis, synthesis and visits to critical points on the river, this paper identifies the biggest polluters, as well as ecological and hydrogeological status of the river from its source to the town of Prokuplje. Our results are a contribution to the application and implementation of the Toplica River Management System in accordance with the Ecosystem Approach to Environmental Management.

Key words: Toplica, polluters, physically - chemical analyses, water quality

INTRODUCTION

In order for water to enable a normal and healthy life, two basic conditions must be met - it must be in sufficient quantity and it must be hygienically correct. The term "hygienic correctness" implies consideration of physically-chemical, microbiological, biological and radiological properties of water. The purpose of all studies is to consider water in terms of its (in)correctness, classification and determination of methods of water quality correction and the possibility of its application. This paper shows that the watercourse of the river Toplica is extremely polluted and dangerous to human health. The reason for the contamination is anthropogenic in nature.

Toplica river basin

In the south of Serbia, in the Toplica district, the most important source of drinking water is the watercourse of the river Toplica together with its tributaries. The river Toplica is the largest left tributary of the South Morava. It is about 136 km long. The Toplica basin covers an area of 10,280 km². The average water flow at the mouth is 102 m³/s. Fluctuations in flow during the year are very large. The most important tributary is the river Kosanica.

Geological and petrographic features of the river Toplice

The lithological composition, especially the development of tertiary classic sediments, controls the development of instability and erodibility. The main hydrogeological feature of the investigated catchment area is the absence of significant retention of atmospheric water in the terrain above the erosion base. The consequence of this condition is a relatively fast surface runoff of atmospheric waters and a very small amount of river flow in the recession period (Kostadinov et al., 2008).

Climatic characteristics

Climate, the most important physical-geographical factor, significantly influences the hydrological characteristics of the Toplica river basin. The investigated basin is located in the area of moderate continental climate. The source part of the basin belongs to a mountainous area characterized by abundant atmospheric precipitation. Based on the isohyet map for the catchment area, the average multi-year precipitation height of 891.9 mm was determined. In addition to precipitation and temperature, the regime of water and sediments in the basin is also affected by wind. The spring wind "south" has a particularly great influence, which mostly melts the snow, which remains in the higher parts of the basin (above 1,200 m above sea level). The snow then melts quickly and leads to a sharp rise in water levels, and large amounts of sediment are introduced into watercourses (Smailagić et al., 2013).

SUBJECT OF THE RESEARCH

The subject of this paper is the research of pressures on the river Toplica, which determines the quality of the river Toplica based on the monitoring of the Environmental Protection Agency, which performed chemical, physically-chemical and microbiological analyzes as well as data collected from the field to determine anthropological influence on water quality.

AIM AND SUBJECT OF RESEARCH

The aim of the research is to determine all the pressures, especially anthropogenic, on the quality of the river Toplica from the source to the town of Prokuplje (especially the municipality of Kuršumlija).

The goal will be achieved through the following tasks:

- Identification of point sources of pollution: 1). Industrial wastewater, 2). Municipal wastewater

- Identification of diffuse sources of pollution: 1). Pollution from agriculture 2). Pollution from households that are not connected to the sewerage network

- Determining water quality based on the results of water quality monitoring that it conducts.

METHODOLOGY

The methods used are data collection from various literature sources and the database of the Environmental Protection Agency, a tour of the studied part of the river watercourse to determine the existence of illegal landfills, as well as methods of analysis and synthesis of the obtained results.

RESULTS

Point sources of pollution of the river Toplica

There are several sources of pollution of the river Toplica, the most significant of which are listed below.

Frigonais DOO NIS - Kuršumlija

The production program of the company includes the purchase and processing of fruits and forest fruits. The entire production process is performed according to ISO 22000 and HACCP quality system. By reviewing the documentation submitted by Agency of Environmental Protection, Wastewater Treatment Plan (WWTP) exists and performs mechanical treatment using: grates, sieves (mechanical filter), aerated sand trap and longitudinal precipitator. In principle, they do not belong to significant environmental pollutants because of usage chemically non-reactive, non-explosive and non-toxic substances in their technological treatment. The most significant negative impacts of the facility on the environment are reflected in the segments: air, noise, surface water, soil, local popula-

tion, vibrations, heat and radiation. In this type of industry, the risk is a failure of refrigeration devices and the release of freon, or ethylene glycol (which was not confirmed by chemical analyzes), but classifies them as a group of potential pollutants (Municipality of Kuršumlija, 2020).

JPKD Toplica – Kuršumlija

According to the available data, this public company for communal activities belongs to the category of real, not potential polluters. Kuršumlija is the poorest municipality in Serbia and they do everything within their means, but that is not enough and results in pollution and eutrophication of the river. The sewage system does not have collectors for the treatment of municipal wastewater, so they are simply discharged into Toplica (JKP Kuršumlija, 2021).

AD Planinka – Kuršumlija

Within A.D. Planinka operates a factory for packaging natural Prolom water and hotels with 2 profit centers: Prolom Banja and Lukovska Banja. The natural filling station of Prolom water is located in Prolom Banja and has the most modern equipment, as well as HACCP and ISO 9001 certificates. According to the submitted documentation, we cannot mark the water filling station as a potential polluter of the river Toplica AD Planinka also includes: hotels and restaurants. Hotels and restaurants present do not have systems for the treatment of municipal wastewater of the food industry, ie: proteins, fats and oils, carbohydrates and other waste waters. They discharge it directly into the recipient.

Simpo ŠIK DOO

Kuršumlija Simpo ŠIK d.o.o. was founded on 2010. as a subsidiary within the company Simpo A.D. Vranje. Production organized in a sawmill, parquet factory, solid wood, plywood factory, raw hardboard factory and refined hardboard factory which are produced in accordance with SPRS ISO 9001: 2008. We label them as air and river pollutants. It uses three biogas boilers and emits nitrogen oxides, sulfur oxides, carbon monoxide and powders. Waste water is discharged into the river Banjska, which flows into Toplica. According to the data of the Environmental Protection Agency, there are no data on the disposal of waste sludge generated during the wastewater treatment at the plan for primary wastewater treatment from the hardboard factory, the sludge is dehydrated in the amount of 250,000 tons per year. (Municipality of Kuršumlija, 2020).

Metalac Company DOO Kuršumlija

The company, which often changes owners, is officially listed as company for the production of metal structures, however, the site states as an activity: Exploitation of gravel, sand, clay and kaolin. Wastewater is discharged directly into the sewer without treatment. If they exploit gravel, sand, clay and kaolin, it is not stated where they exploit them, where they store them and under what conditions. (Municipality of Kuršumlija, 2020).

Kalča diary – Šišmanovac

The dairy is engaged in the purchase and sale of milk as well as the production of dairy products. According to the situation determined in the field, there is no wastewater treatment plant. The basic characteristic of wastewater from the dairy industry is their organic character, they are similar and belong to the same category as municipal wastewater, so for their treatment can be used common methods of biological treatment, with certain modifications.

City landfill - Kuršumlija "Lakovski bregovi"

Municipal waste is disposed of in the landfill for municipal solid waste "Lakovski bregovi", conditions are inadequate, the duration of the landfill was predicted five years ago, which is long overdue, waste is not sorted. The findings of the Inspection presents it as inadequate and requires reclamation and construction of a city landfill that will meet the prescribed norms. It can be concluded that since the landfill is inadequately arranged, its contents reach groundwater through leachate and Toplica is additionally polluting.

Health center with dispensary – Kuršumlija

The health center with the dispensary submitted to the Environmental Protection Agency documentation and protocols on the disposal of medical and hazardous and non-hazardous waste, but by the decision of the director of that institution it was refused to make it available and it could be doubted that they adhere to those protocols. Following departments might pollute with the disposal of their waste: Dialysis department, Department of Laboratory Diagnostics, Department of Radiological Diagnostics, Dental service. (CHC Kuršumlija, 2020).

Diffuse pollution of the river Toplice

Households not connected to the sewerage network

There are two categories of households, suburban settlements with septic tanks and rural households. The data of the Statistical Office, the 2011 census, the Municipality of Kuršumlija, which is the main area of research, show that

within an area of 952 km² there are 90 settlements with 19,213 inhabitants. It should be noted that there are 11,097 inhabitants aged 0-49, which leaves a number of 8,116 elderly households. It is true that rural area has field toilets without septic tanks and definitely leachate. It passes into the underground, causing their pollution, but to a much lesser extent than the city itself (Federal Bureau of Statistics, 2020).

Pollution from the agriculture

In the Toplica region, especially in the municipality of Kuršumlija, there is an extensive type of agriculture. The number of agricultural holdings is 2,969, of which 11,981 km are agricultural land and it includes 4,069 km of arable land and gardens, 2,247 km of orchards, 3 vineyards and 5,586 km of meadows and pastures. A total of 1,162 farms raise animals, a total of 2,856 cattle, 2,002 pigs, 4,389 sheep and 28,478 poultry. According to chemical analysis, the parameters that would indicate artificial fertilizer are below the prescribed concentration. It is indisputable that there is waste municipal water during animal breeding, but to a much lesser extent than in other parts of Serbia (Federal Bureau of Statistics, 2020).

Wild landfills

Wild landfills are a serious problem that must be seriously addressed. Municipal solid waste bins are set up in a small number of villages and are emptied irregularly. Along the entire Toplica basin there are a large number of illegal landfills where, in addition to solid municipal waste, households also contain biologically hazardous waste (dead animals), a large amount of non-degradable plastic, electrical and electronic waste. All the draining water goes directly to Toplica, it is directly polluting which endangers the health of the population.

RESULTS AND DISCUSION

A river Toplica till Kuršumlija belongs to the class II of watercourses, and from Kuršumlija III and / or IV (SEPA, 2020, p. 370, 372, 374, 378, 380), potential pollutants have been listed and it is necessary to support it with physical and chemical analyzes. For that, the results obtained from the Environmental Protection Agency and the South Morava Fishery Service 2 will be used (Fish Guard Service South Morava 2, 2019). The analysis of the results will cover the period of September 2019, when there was a mass death of fish in Toplica. Differences in results may have occurred due to different time and place of sampling, which is especially true in September 2019. Comparative analysis will provide a broad-

er and clearer picture of the physically-chemical and microbiological status of the Toplica river in Kuršumlija and its vicinity. The water that citizens drink is chemically and bacteriologically correct. The problem of pollution can be seen in the monitoring of river water outside Kuršumlija after the confluence with the river Banjska, into which the collectors of municipal wastewater and industrial water flow. The website of the Environmental Protection Agency states that in the village of Pepeljevac, where the measuring station also recorded an excessive amount of mercury of 0.9 μg/l (SEPA, Serbian Agency for Environmental Protection, 2020, p 272-274), it is not written when sampling was performed and it was not possible to conclude whether it is autogenous or allogeneic. The concentration of metals varies, with an increased concentration of iron probably of autogenous origin. All data indicate a pronounced eutrophication of the river and bacteriological as a chemical defect, and it is necessary to take measures by which the river will meet the standards prescribed by the regulation. The analysis of heavy metals has not been done and it is recommended to do it. It is also recommended to do a toxicological analysis of fish from the river because there are many active fishermen who use the catch in their diet. It is necessary to apply hydro technical measures in order to stabilize the river bottom and banks, because the tern is extremely prone to erosion.

CONCLUSION

The Toplica region is rich in mineral water springs, even with a geothermal spring in Lukovska Banja. Many of them flow into the river Toplica, which on the left bank belongs to the Kopaonik National Park and the right bank of the Radan Nature Park, Toplica itself does not seem to belong to anyone because it was carelessly reduced to water that sometimes exceeds IV class. The river used to be the lifeblood of the whole region, a source of drinking water, watering gardens, watering cattle, which is no longer possible due to the present pollution. The whole region has great tourist potential, but at the moment Toplica is a possible source of various intestinal infections and poisonings. It is necessary to build collectors for municipal wastewater treatment, recultivate the landfill, regularly clean the industrial wastewater treatment plan ŠIK Simpo and close and recultivate illegal landfills. It is necessary to remove Small Hydropower Systems and take anti-erosion hydrotechnical measures. Everything should be done in accordance with the Law on Water Protection, the Law on Habitat Protection, Clean Toplica means a healthy population of the Toplica region, but it has not only local but regional and international significance because it represents a con-

tribution to planning the management of the Velika Morava basin, but also contribution to the amendment of the Danube River Management Plan.

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PROPOSAL OF MEASURES FOR THE QUALITY IMPROVING OF THE RIVER TOPLICA

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Abstract

Environmental protection has become a priority in the modern world. The river Toplica is the main source of water supply in the municipality of Toplica, but due to its anthropogenic impact, its quality is rapidly deteriorating. Pollution of the Toplica River negatively affects human health and the ecosystem in general. The aim of this paper is to propose measures to improve river quality through better water management, which includes wastewater treatment systems and solid waste management (removal and sustainable storage). We used method of analyses to purpose measures for each of polluter in accordance to the Ecosystem Approach and sustainable planning of Water and Environmental Management. The proposed measures are accompanied by changes in the law, monitoring the level of river quality and raising the level of environmental awareness.

Key words: Toplica, pollution, water management, proposed measures, waste water purification systems

INTRODUCTION

The quality of human life and the survival of ecosystems depends on the quality of the surface waters. There are many factors that can affect surface water quality, allogeneic and autogenic, some depend on the pedological and geological background as well as the composition of the springs themselves and others are anthropogenic in origin and have been increasingly pronounced since the industrial revolution until they took the lead in surface water pollution. Surface waters can be a significant source of water-borne infections - hydroses, which once posed a major problem and decimated humanity, but can also have a detrimental effect on human health and wildlife in general through various

municipal and industrial wastewaters. Having singled out anthropogenic impact as the main source of pollution of the Toplica River, it will proposed measures to correct and improve its quality in order to provide the population with a healthy environment, usable and healthy water and thus repair and recover aquatic ecosystems and actions closely related to water quality (livestock, recreational swimming and fishing).The measures will be proposed in the paper in accordance with the ecosystem approach to the environment and sustainable development of the Municipality of Kuršumlija and the Sustainable Development of Environmental Protection of the Municipality with the remark that up to the town of Kuršumlija Toplica belongs to the class IIa water and after it, III or even IV (SEPA, 2020, p. 370, 372, 374, 378, 380).

Geological and petrographic features of the river Toplice

The lithological composition, especially the development of tertiary clastic sediments, controls the development of instability and erodibility. The lithological composition, especially the development of tertiary clastic sediments, controls the development of instability and erodibility . as a result, erosion is expressed along the entire course of the river and it is necessary to take hydro-technical measures to mitigate it and preserve the river (Kostadinov et al., 2008).

Climatic caracteristic

Climate, the most important physical-geographical factor, significantly influences the hydrological characteristics of the Toplica river basin. The investigated basin is located in the area of temperate continental climate. The source part of the basin belongs to a mountainous area characterized by abundant atmospheric precipitation. Winters are harsh and cold, and summers are fresh. Spring is changeable, with frequent shifts of warm and cold and windy days and frequent rains. Autumns are relatively warmer than spring. The average air temperature in a multi-year period, measured in the climatological station Kursumlija as the closest basin, is 10.3°C. January is the coldest and only month of the year with a negative average monthly temperature (-0.49°C). The warmest month with 19.8°C is July. Based on the isohyet map for the catchment area, the average multi-year precipitation height of 891.9 mm was determined. In addition to precipitation and temperature, the regime of water and sediments in the basin is also affected by wind. The spring wind "south" has a particularly great influence, which mostly melts the snow, which remains in the higher parts of the basin (above 1,200 m above sea level) in April. The snow then melts quickly and leads to a sharp rise in water levels, and large amounts of sediment are introduced into watercourses. (Smailagić et al., 2013). This is very important because

during summer with high temperatures its evaporation is pronounced, which automatically means a decrease in oxygen solutions and a more pronounced concentration of pollutants. More than once ecological accident happened followed by fish death and destruction of ecosystem in general.

AIM AND SUBJECT OF RESEARCH

The subject of this research is to purpose measures water quality correction through identifies polluters and their water quality menagment.

The aim of this work is to propose for each individual pollutant measures of effluent release after treatment in order to improve the quality of the Toplica river in accordance with the applicable legislation in this area (Regulation RS, 2017) and (Regulation RS, 2016). The goal will be achieved by proposing certain measures for the correction of the quality of the river Toplica.

METHODOLOGY

The methodology of the work is based on a careful analysis of the physical, physico-chemical and microbiological parameters of the river, and then the selection of sustainable and adapted solutions.

RESULTS

Following the order of pollutants that have already been singled out (Municipality of Kuršumlija, 2020), the following measures are suggested.

Frigonais

Regular control of the temperature of water discharged due to possible thermal pollution, control of the disposal of detergents and disinfectants as well as possible accidents due to the release of freon.

JPKD Toplica

It is necessary to renew the sewerage infrastructure and include all houses in the city that are not attached to it, but discharge wastewater directly into the recipient or illegal septic tanks. It is necessary to build collectors for municipal water treatment that would include primary, secondary, tertiary treatment (to reduce river eutrophication), but also quaternary to disinfect due to the enormous amount of bacteria many times over limits.

AD Planinka

It would be desirable to connect the village with sewage and wastewater treatment, since due to hotels and restaurants releasing significant amounts of grease and detergents, they could also use biodisk. Lukovska Banja is a geothermal source and hot water is discharged directly into the river, which is thermal pollution, so it is desirable to include the cooling process before discharging into the recipient.

Simpo ŠIK DOO

Since they already have a plant for industrial wastewater treatment, it is necessary to use it regularly by professional and trained employees, monitoring and doing constant monitoring in accordance with the weather conditions (especially during summer). It is necessary to clean the filters regularly. and to dispose of hydrated sludge in a special landfill where the release of phenol by leachate would be prevented. They also should monitor temperature of the water they release to avoid termal pollution.

Metalac Company DOO Kuršumlija

It is desirable to inspect this company and determine whether they really cast metal objects, which technological processes they use and which metals and other substances in their processing. Only then can we propose measures with certainty.

Dairy Kalča - Šišmanovac

According to the situation determined in the field, there is no wastewater treatment plant. The basic characteristic of wastewater from the dairy industry, as well as other wastewater from the food industry, is their organic character, ie. high content of organic substances that are dispersed in them. In their composition they are similar and belong to the same category as municipal wastewater, so for their treatment can be used common methods of biological treatment, with certain modifications. Another characteristic of the dairy industry is great water consumption, which is consumed at all stages of the technological process. Also, problem is the discharge of whey, which increases the acidity of wastewater, makes it more aggressive and burdens the water with an increased content of proteins and milk sugar. Wastewater coming from the plant can be divided into four groups of different compositions, depending on the treatment process.

Processing technology includes the following groups of operations:

1. reception of milk, cooling and storage of raw milk, collection and storage of skimmed milk and sour cream, pasteurization, sterilization and filling of milk, fermentation and filling of fermented milk beverages. Wastewater from both operations contains milk, lactic acid, lactic sugar, proteins, vitamins and enzymes.

2. production of soft cheeses, production of hard cheeses, and production of butter. These wastewaters contain large amounts of lactic acid (whey), lactose, proteins, milk fats, enzymes and vitamins. They are very acidic.

3. melting cheese, wastewater is contaminated with large amounts of milk fat and pieces of cheese.

4. washing of plants and washing of machines and devices, where the content of these waste waters is similar to the previous processes, except that they also contain emulsified milk fats and large amounts of phosphates, detergents and other surfactants, which are used for wash.

The main loads of this wastewater are: fats and solid waste, lactic acid, low pH, lactose and high-value proteins HPK, BOD and detergents.

Given the composition, wastewater from the dairy industry requires three stages of treatment:

-mechanical separation of floating fats,

-physico-chemical flocculation and neutralization,

-biological processing.

City landfill „Lakovski bregovi"

The landfill is old and has exceeded the planned shelf life several times. It is not bordered with a protective material, does not have a filter layer or pipes for collecting leachate and there are no geotextile and PEHD foils which would also prevent the discharge of leachate into the environment and groundwater. It is necessary to recultivate and build a new one that will meet the prescribed standards.

Health center with dispansery

It is necessary to submit contracts with authorized waste distributors and determine the final place of disposal, ie. destruction of waste in a manner that is in accordance with legal regulations.

Parameters	Unit of measure	**Measured value**
Percentage of water saturation with oxygen	%	**<10**
BPK	mg/l	**165**
HPK	mg/l	**178**
Suspended matter	mg/l	**288**
Ammonium ion	mg/l	**37.5**
Total nitrogen	mg/l	**29.2**
Total phosphorus	mg/l	**2.4**
Residue after evaporation	mg/l	**494**
Chlorides	mg/l	**<5**
Nitrates	mg/l	**<1.0**
Nitrites	mg/l	**<0.005**
Electrical conductivity at 20C	mS/cm	**1007**
Total coloriform bacteria	n/100 ml	**>1209800**
Escherishia coli	n/100 ml	**>1209800**
Ordo *Enterococ*	n/100 ml	**>96784**

Table 1 River Toplica - 100m after collector inflow

Note. Reprinted from Accident Monitoring Report of the Toplica River by Fish Guard Service South Morava 2, September 9.2019. (2019).

CONCLUSION

As mentioned at the beginning, healthy people live around healthy rivers, and in the case of Toplica it is unfortunate that it is extremely polluted and this pollution is transferred to agriculture, and the poor quality of groundwater is reflected in the quality of drinking water and human health. In this case, both solid and liquid waste are a problem. The biggest problem for the quality of the Toplica River is the communal and industrial wastewaters, which have completely damaged the ecosystem and endangered human health. Measures have been proposed for each polluter, which could be a short-term solution to the problem. The long-term solution that will clean the river for the benefit not only of the citizens of Kuršumlija, but also of the entire Toplica administrative district, is the

construction of a wastewater treatment system. In that case, the use of the river Toplica would be ensured in agriculture, tourism, sport fishing and there would no longer be a danger of mass death of fish or intestinal diseases of various species, such as phenol poisoning.

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WASTEWATER OF THE CITY NIŠ

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Abstract

In order to prevent direct inflow of untreated wastewater from the city Niš into the reception water bodies (Nišava River) which the quality of water became worse , has been prepared for the city of Niš feasibility study within the wastewater collection and treatment project. Through the project introduced a wastewater treatment plant, which would improve the quality harmonized with the Urban Waste Water Treatment Directive 91/271 / EEC. As the best location for the construction of a central wastewater treatment plant selected is a location called Ciganski ključ, on the left bank of the Nišava about 7 km downstream from the city. In accordance with the required quality of wastewater, flow, concentration of pollutants measured on the left and right collector, a plant with a capacity of 286,000 PE was designed. The project proposes conventional processing with activated sludge with biological removal nutrients.

Key words: conventional processing, biologically nutritious substances, Urban Waste Water Treatment Directive 91/271 / EEC.

INTRODUCTION

The city Niš, stretches along the river Nišava and is located 230 km southeast of Belgrade.

Niš is the administrative center of the Nišava region and consists of five communities,four of which are in the city zone, while the fifth community, Niška Banja, is a suburb an community.

The public utility company JKP Naisus is responsible for water supply and wastewater services. Water supply is provided from a number of sources which, in certain periods of the year, are supplemented with processed surface water from the Nišava River.

Water supply is provided from a number of sources which, in certain periods of the year, are supplemented with processed surface water from the Nišava River.

The centralized sewage system of the urban area of Niš is the so-called "combined" type, where wastewater and stormwater precipitation are collected and evacuated through a single system. For the future development and expansion of the sewerage system, was adopted the concept of the so-called "separate system" .

The overall coverage in the area of wastewater collection is 78%.

The length of sewer pipes is about 400 km.

The existing sewerage system needs to be upgraded and improved while optimizing the use and connection with new zones and users as much as possible.

Although one of the largest urban aglomerations in Serbia, Niš does not have an appropriate wastewater transport system to the selected central location of the wastewater treatment plant, nor a modern communal wastewater treatment plant in accordance with National EU regulations.

CHARACTERISTICS OF THE SEWERAGE SYSTEM

The sewage system of the city of Niš is of the combined type, and during the rainy season a significant amount of atmospheric water is collected.

For the sewerage system of the city of Nis, infiltration has been identified as the main problem. The main identified sources of infiltration into the sewage system of the city of Niš are:

- continuous pumping of drainage water the purpose of protection of water sources Mediana (30-50 l/s)
- continuous pumping of drainage water (protection against lifting) for the Čair sports center (average 30 l/s)
- infiltration along the length of the damaged main drainage channel

The total wastewater load consists of:

- loads of wastewater from the population
- loads of wastewater from industry
- wastewater loads from infiltration

EFFLUENT REQUIREMENTS

The basic parameters of wastewater are: flow, (air temperature, water temperature, barometric pressure, color, odor, visible substances, sediments (after 2h), pH value, BOD5, COD, oxygen content, dry residue, calcined residue, loss on ignition, suspended solids and electrical conductivity, according to the Rulebook on the manner and conditions for measuring the quantity and testing the quality of wastewater and the content of the report on the performed measurements - "Official Gazette of RS" 33/2016

A typical indicator of wastewater quality is BOD5 and represents the mass concentration of dissolved oxygen that is consumed under certain conditions by biochemical oxidation of organic and / or inorganic matter in water where the incubation time is 5 days.

The effluent requirements are based on the EU Urban Wastewater Treatment Directive 91/271 EEC and 98/15 / EC. This Directive applies to the collection, treatment and discharge of urban waste water and the treatment and discharge of waste water from certain industrial sectors. The aim of the Directive is to protect the environment from the adverse effects of the above-mentioned waste water discharges.

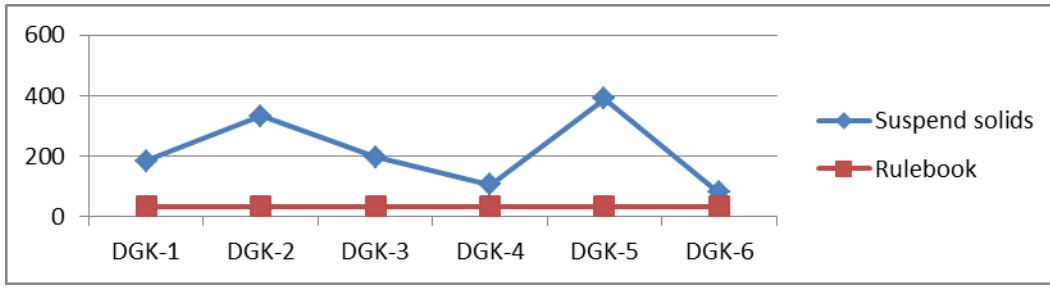
In this paper, three physico-chemical indicators of water quality (COD, BOD5, concentration of suspended solids) during 2019 are analyzed, and for samples of the left and right city collector of city Niš, in which wastewater is collected. Sampling was performed once a month, during periods of maximum daily load, and the results were compared with the requirements to be met by wastewater discharged into the recipient.

Table 1. Results of wastewater samples from the right city collector of the city Niš

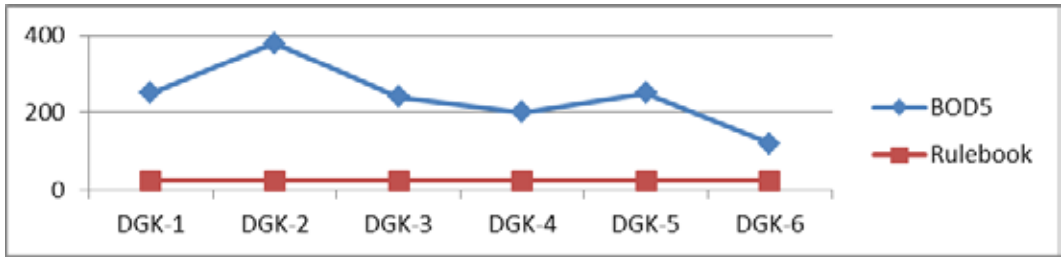
	suspended solids (mg/lit)	**Rulebook**	BOD 5 (mgO_2/ lit)	**Rulebook**	COD (mg O_2/lit)	**Rulebook**
right GK-1	186	35	250	25	411	125
right GK-2	333	35	380	25	693	125
right GK-3	198	35	240	25	558	125
right GK-4	106	35	200	25	393	125
right GK-5	390	35	250	25	510	125
right GK-6	81	35	120	25	241	125
(min-max value)	81-390		120-380		241-693	

DGK-right city collector ; DGK(1-6)- samples of the right city collector - source JKP,, Naisus,,

Graph 1.1. Tabular presentation of deviations of measured values from allowed per parameter of suspended solids



Graph 1.2. Tabular presentation of deviations of measured values from allowed per parameter BOD5



Graph 1.3. Tabular presentation of deviations of measured values from the allowed ones according to the COD parameter

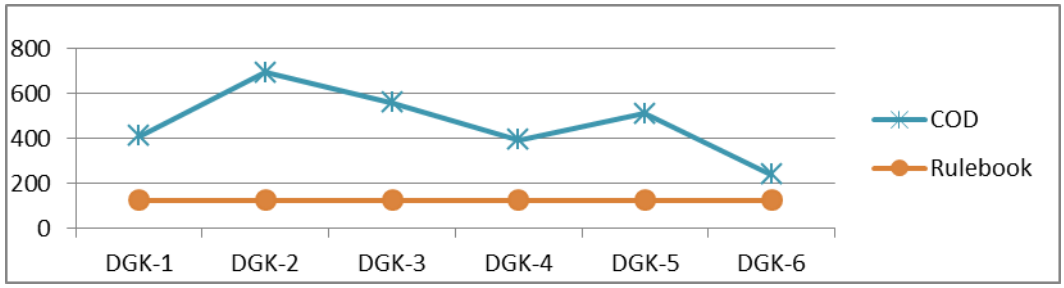
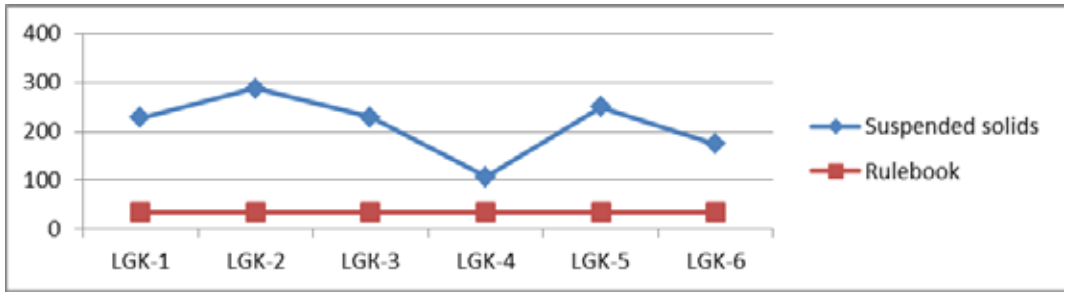


Table 2. Results of wastewater samples from the left city collector of the city Niš

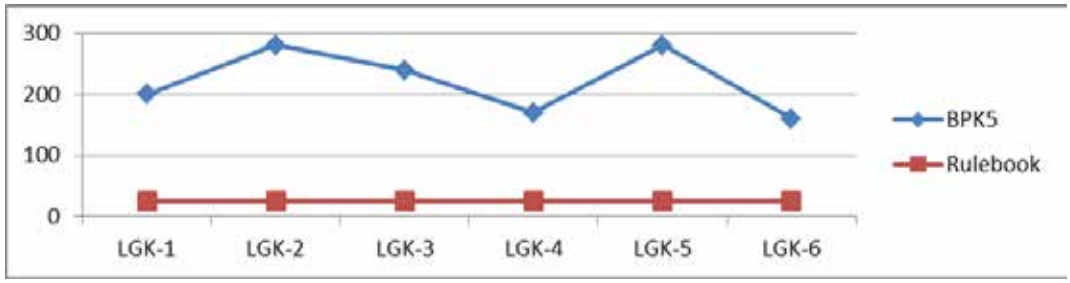
	(suspended solids) (mg/lit)	Rulebook	BOD5 (mgO_2/lit)	Rulebook	COD (mgO_2/lit)	Rulebook
left GK-1	227	35	200	25	348	125
left GK-2	287	35	280.0	25	480	125
left GK-3	229	35	240	25	48	125
left GK-4	106	35	170	25	340	125
left GK-5	249	35	280	25	570	125
left GK-6	174	35	160	25	310	125
(min-max)	106-287		160-280		48-570	

LGK- left city collector ; LGK(1-6) samples of the left city collector, source *JKP,, Naisus,,*

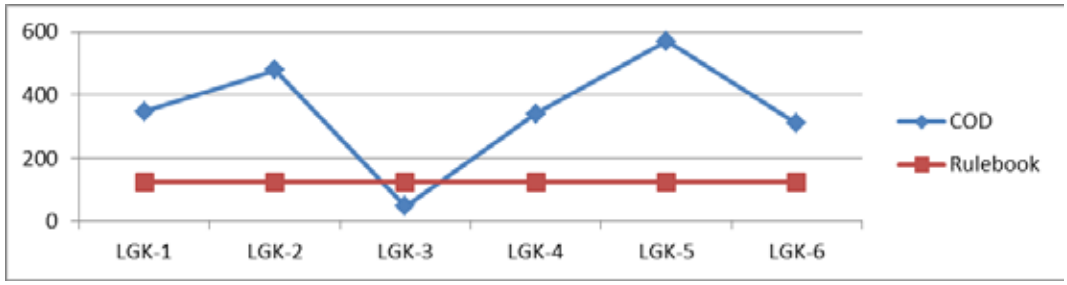
Graph 2.1. Tabular presentation of deviations of measured values from the allowed ones according to the parameter of suspended solids



Graph 2.2 Tabular presentation of deviations of measured values from allowed per parameter BOD5



Graph 2.3. Tabular presentation of deviations of measured values from the allowed ones according to the HPK parameter



PLANT FOR TREATMENT WASTE WATER

Within the proposed wastewater treatment plant are the following processes:

1-Preliminary Treatment (Mechanical removal of coarse organic and inorganic material, including screenings and grit).

2- Primary Treatment (Primary sedimentation and removal of suspended solids)

3-Secondary Treatment (Biochemical oxidation and removal of dissolved organic material, along with organic solids).

4-Tertiary Treatment (Biological removal of nitrogen and phosphorous compounds).

5-Sludge Treatment (Full stabilization of bio-solids enabling reuse or disposal).

6- Sludge Dewatering (Dewatering of residual bio-solids to improve handling and reduce volume for transport)

The study planned a wastewater collection and treatment plant with a capacity of 286,000 P.E., based on mandatory effluent requirements, load calculated based on the flow and concentration of pollutants, measured on the left and right city collector, planned sewerage network development, industry development and population growth.

„ 1 P.E. „ - (Population equivalent) is an organic biodegradable load that has a five-day biochemical oxygen demand (BOD5) of 60 grams of oxygen per day;

Table 3-Design criteria load pollutants

criteria load pollutants		**Population equivalent: 286 000 PE**
BOD_5	kg/day	17160
COD	kg/day	34320
TSS	kg/day	20020
Total nitrogen	kg/day	3146
Total phosphorus	kg/day	515

Source: Feasibility study - wastewater collection and treatment project for the city of Nis-IMG

Table 4- Average pollutant concentration

Average concentration of pollutants in wastewater based on a series of measurements		
BOD_5	mg/lit	281
COD	mg/lit	562
TSS	mg/lit	328
Total nitrogen	mg/lit	52
Total phosphorus	mg/lit	8

Source: Feasibility study - wastewater collection and treatment project for the city of Nis-IMG

CONCLUSION

A feasibility study has been prepared for the collection and treatment of wastewater in the city of Niš on behalf of the Swedish International Development Cooperation Agency (SIDA), whose priorities are democracy and human rights, environment and climate, gender equality and the role of women in development.

The project of collecting and treating wastewater for the City of Niš includes the preparation of documentation for 6 components:

1. Wastewater treatment plant (WWTP) Niš
2. WWTP Niš - additional treatment of sludge
3. Main collectors to WWTP Niš
4. Reconstruction of the collector in Niš
5. Expansion of the collector network
6. Drinking water treatment plant-Mediana- water treatment from filter washing

The feasibility study was done through an EISP project funded by the Swedish Development Agency. This created the conditions for access to the preparation and completion of technical documentation with the tender. The next step is to prepare the technical documentation through the PEID program.

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Rulebook on the manner and conditions for measuring the quantity and testing the quality of wastewater and the content of the report on the performed measurements - "Official Gazette of RS" 33/2016

COUNCIL DIRECTIVE 91/271 / EEC of 21 May 1991 which refer to purification urban wastewater

DISTURBANCES OF THE LOWER IONOSPHERE INDUCED BY X-RAY SOLAR FLARES: SUSTAINABLE ENVIRONMENT

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Abstract:

Solar flares and intense radiation can generate additional ionization in the Earth's atmosphere and change its structure. This extreme solar radiation and activity create sudden ionospheric disturbances and consequently affect electronic equipment on the ground and signals from the space, potentially induce various natural disasters and influence on sustainable development. The aim of this work is to present our study, on few examples, of sudden ionospheric disturbances induced by the large solar flares.

Keywords: observations; solar radiation; Sun activity; atmosphere; disturbances; dataset; modeling, sustainable development

INTRODUCTION

Ionosphere as a huge segment of atmosphere has a tendency to be constantly separated in different regions D, E, and F, with different physical characteristics and chemistry (Brasseur & Solomon, 2005; Mitra, 1974; Nicolet & Aikin, 1960) which depend on incident radiation (see Figure 1).

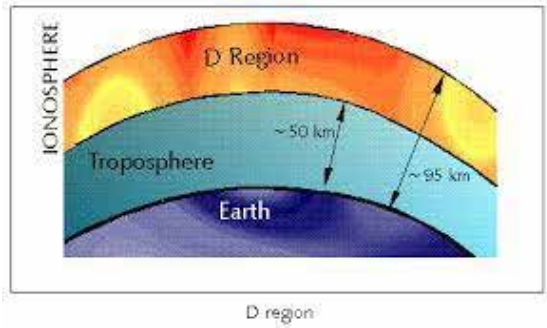

Figure 1. D region

At the time of solar flares and consequently during sudden ionospheric disturbances (SID) events the increase of the ionospheric electron concentration at all altitudes is noticeable. As a result of radiation effects, the solar-induced SID and plasma irregularities causes perturbations in the received amplitude and phase of Very Low Frequency (VLF in narrow band 3 -30 kHz) radio signals mainly in the D region which is located between the Earth's lower atmosphere with dense air and its strongly conducting ionosphere. Nowadays, special attention is paid to the extreme weather events, climate change, preservation and protection, because they have been identified as important for sustainable development in our century. Consequently, a very important question in modern society is can we predict the magnitude of impact of explosive solar events such as solar flares on the Earth, humans, electronic equipment and on nature generally and can we estimate the consequence of these catastrophic events?

In this contribution we focus on amplitude and phase data of worldwide transmitters of radio signals recorded by Belgrade VLF stations (Scherrer et al., 2008; Šulić & Srećković, 2014)

.VLF signals from the emitters located all over the world are constantly recoded by this equipment. Events of X-ray solar flares monitored by GOES satellites are further identified using radio stations system of receivers. For these events, VLF wave enhancements are measured and analyzed for daytime atmosphere. Our research aims to improve the knowledge on the importance of extreme events and space weather for the overall sustainable development.

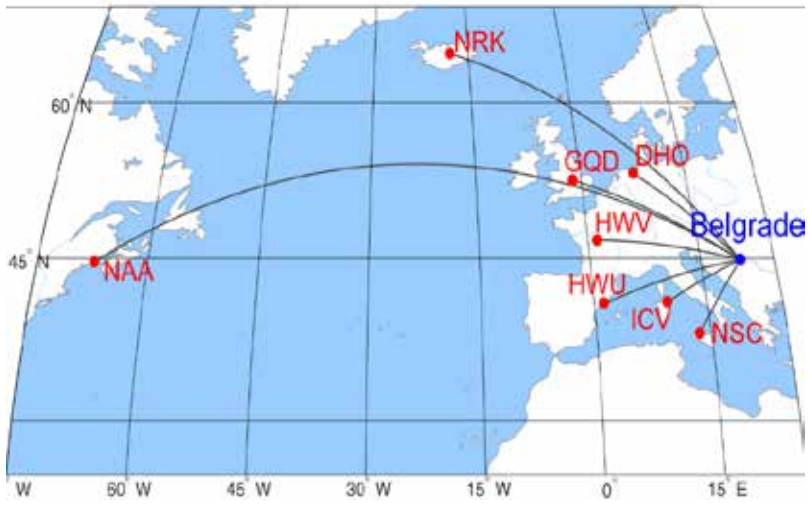

Figure 2. The geographic location of BEL system of VLF receivers (blue circle) and the worldwide transmitters (red circles) with GCPs of subionospherically propagating VLF/LF signals.

RESULTS

In this research we have study the amplitude (*A*) and phase (*P*) data, obtained by monitoring VLF radio signals emitted by worldwide transmitters during solar-induced SIDs. All the data were registered by receiver systems at a Belgrade site. The receivers can simultaneously record several signals emitted by different emitters (located at different countries and territories) at the fixed frequencies. The time resolution of the recorded data can be in range from 0.001 to 1 s, which is applicable for detection various SIDs from very short-term disturbances lasting several ms to very long perturbation. The technicalities and description of the Belgrade site are presented in (Šulić & Srećković, 2014).

Location of emitters and the receiver site and great circle paths (GCPs) of subionospherically propagating VLF radio signals are provided in Figure 2.

Here we present the study of sudden ionospheric disturbances induced by the large flares of the solar cycles 24 and 25. We compare data with previous examples of solar flares. The monitoring and investigation of VLF data has been carried out simultaneously with the examination of the correlative incoming solar X-ray fluxes collected from Geostationary Operational Environmental Satellite (GOES) (Garcia, 1994). For our study the most important are registered data of incoming solar radiation X-ray flux in the XRS band of 0.1-0.8 nm.

In the presence of SIDs, a standard numerical procedure for the estimation of plasma parameters is based on comparison of the recorded changes of amplitude and phase with the matching values acquired in simulations by the Long--Wave Propagation Capability (LWPC) numerical software package (Ferguson, 1998) as explained in (Nina, Čadež, Srećković, & Šulić, 2012; Nina, Čadež, Šulić, Srećković, & Žigman, 2012; Šulić, Srećković, & Mihajlov, 2016)

. The NAA-BEL path is sufficiently long (D = 6540 km) and correctly oriented west-east. The point is that NAA/24.00 kHz radio signal at Belgrade shows nighttime and daytime characteristics in according to time interval between sunrises and sunsets at Belgrade and Maine, USA.

Representative example of flare-induced phase and amplitude perturbations, measured for the NAA/24,00 kHz signal, on the active day of 10 May 2013, in particular, is given in Fig. 3 (red lines on the upper and lower panel). The measured unperturbed daytime values of phase and amplitude are data for 09 May 2013 (black lines on the upper and lower panel of Fig. 3). There were visible changes in the VLF daily signal during the duration of M1.3 (peak time, 12:56.

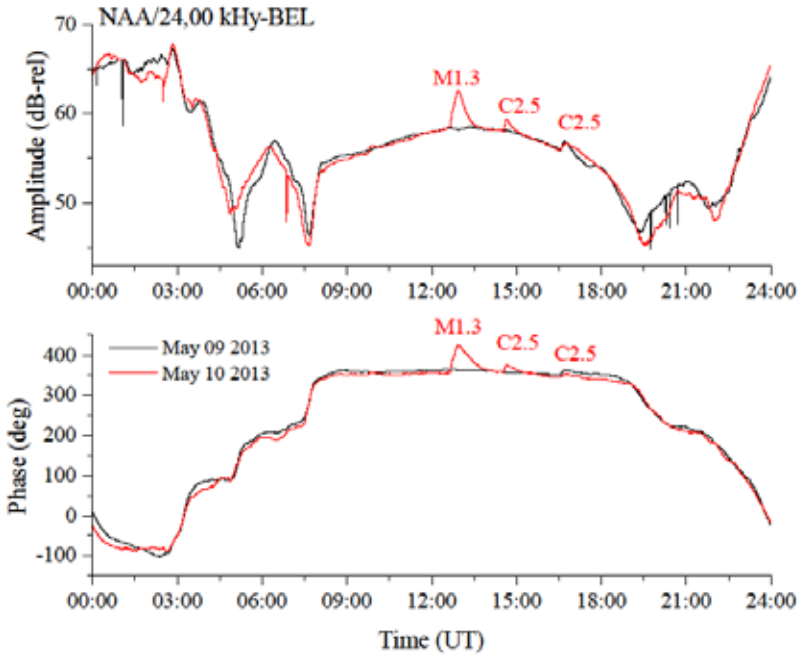

Figure 3. Measured diurnal variation of amplitude and phase on VLF signals at NAA/24.00 kHz obtained for 09 May 2013 (on quiet day) and 10 May 2013 with well defined SID events.

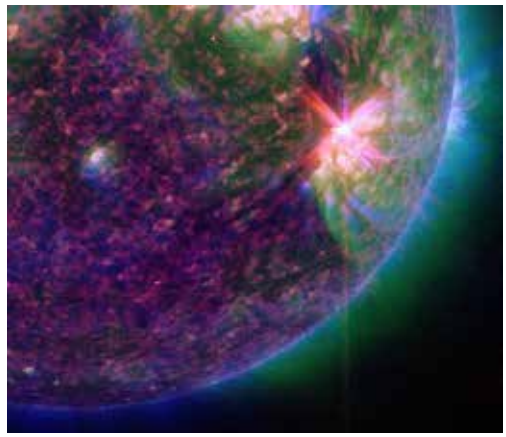

Figure 4. The solar flare on 10 May 2013 (from https://solarmonitor.org).

As instructive example of active day we present 10 May 2013 (see Figures 4 and 5). In Figure 5 we present measured amplitude for NAA/24,00 kHz VLF signal on high solar activity during M1.5 (I_x = 1,5E-5 Wm^{-2} at peak time, 09:54

UT), M7.3 (10:15 UT), C3 (12:14 UT) and X1.3 (14:36 UT) events on 07 September 2017 as a function of time. There were visible changes in the VLF daily signal during the duration of C, M and X flares (see signal peaks on panels). From the Figure 5 one can see that those VLF and GOES peaks are happened simultaneously.

The daytime exponential profile of electron density in general use for VLF modeling (Wait and Spies, 1964) is given by:

$$N_e(h,H',\beta) = 1.43\cdot 10^{13} \exp(-0.15\cdot H')\exp[(\beta-0.15)\cdot(h-H')] \quad \mathrm{m}^{-3} \quad (1)$$

where β in km^{-1} is time-dependent parameters of sharpness and H' a reflection height in km. Here *Ne (h,H',β)* and *h* are given in m^{-3} and km, respectively. Electron densities can be obtained from the observed amplitude and phase perturbations by a trial-and-error method where density profile is adjusted until the simulated amplitude and phase (using LWPC code) match with observed data. In this way, the obtained Wait's parameters β and H' can be used in Equation (1) for further simulations.

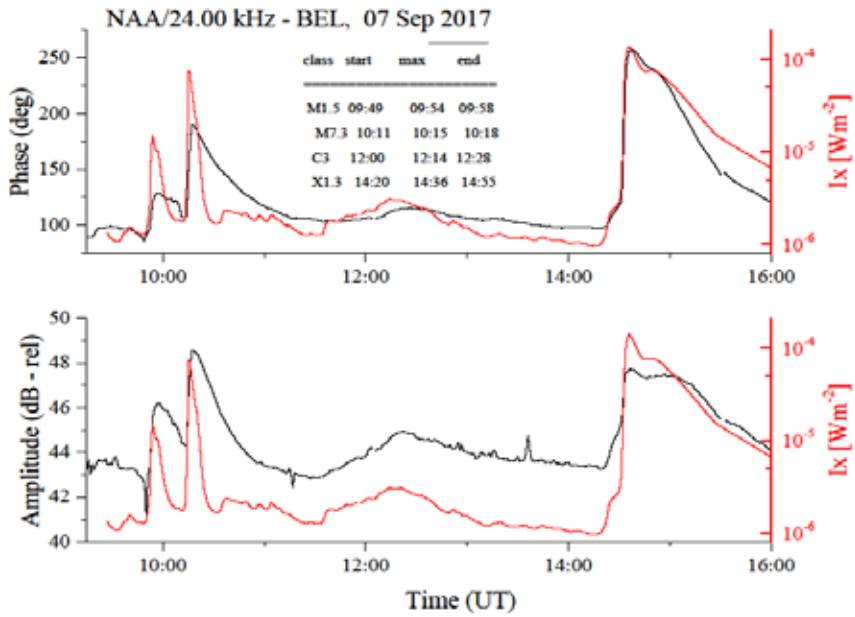

Figure 5. Time variation of X-ray irradiance, NAA/24.00 kHz signal phase and amplitude during M1.5 (09:54 UT), M7.3 (10:15 UT), C3 (12:14 UT) and X1.3 (14:36 UT) events on 07 September 2017.

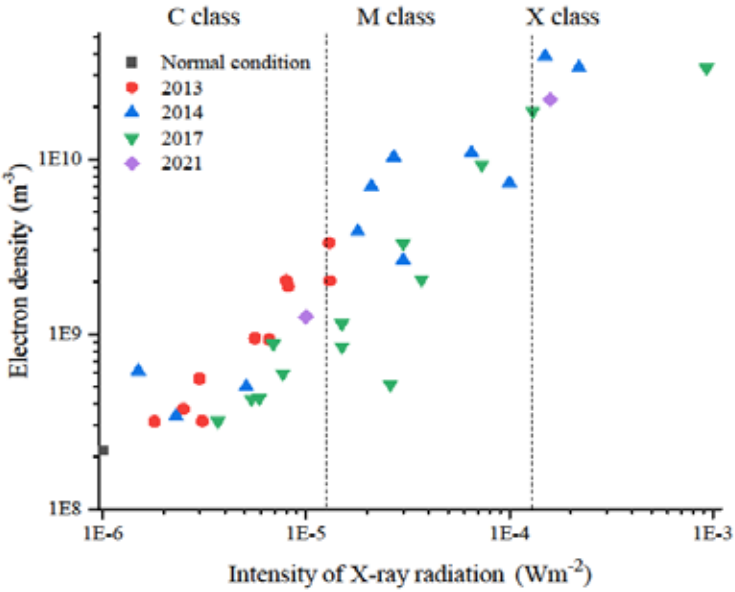

Figure 6. Electron density at reference height, h = 74 km as a function of maximum intensity of X-ray flux during solar flares of different class for different solar activity. Electron density are calculated on the basis of VLF propagation data recorded at Belgrade.

In Figure 6 we present our results and the data from for electron density *Ne* at reference height of *h* = 74 km as a function of X-ray flux. Although the data are scattered, they still tend to increase with the intensity of the X-ray radiation. As noted, the results were acquired on the basis of analysis of numerous SID events during 2013, 2014, 2017, 2021 on NAA 24,00 kHz signal and using equation (1). Electron density at refernce height *h* = 74 km changed from Ne = 2.16 x 10^8 m^{-3} to Ne = 3.9 x 10^{10} m^{-3}. The obtained data can be used in investigation of the radiation characteristics, modelling of radiation propagation in the atmosphere, modelling of processes which induce natural disasters, etc.

CONCLUSION

The magnitude of impact of solar flares on Earth and consequences of these explosive events is analyzed. The VLF radio data and important ionosphere parameters, during the enhancements of X-ray flux due to the flare, are presented and obtained in our study. The computation is applied to map the perturbed D layer, during occurrences of large flare of the solar cycles 24 and 25.

It can be noticed that the intense solar radiation namely solar extreme events lead to an increased electron production rate and consequently deform the VLF signal. The results confirmed the advantageous usage of presented method for investigation solar-terrestrial coupling processes and detecting and analyzing space weather phenomena such as solar explosive events. This study advances knowledge about the extreme radiation, as an undoubted requirement for understanding space weather and sustainable development.

The presented data can be used in practice in different areas of science and in several possible ways:

- for a sensitivity analysis of the Earth atmosphere.
- for predicting natural disasters and some consequences of solar flares (which obstruct the rate of sustainable development).
- for investigation of coupling atmospheric electricity with biological systems.
- for identification and classification of solar explosive events i.e. solar X-ray flares.
- for obtain the daytime atmosphere parameters induced by extreme solar radiation.
- for understanding space weather and prevention of extreme weather within the sustainable progress cycle.

Notably, the data and its complexity in analysis and research of D region and space weather highlight interdisciplinary nature of study.

Acknowledgments: This work was funded by the University Union – Nikola Tesla Belgrade, Institute of Physics Belgrade, through the grant by the Ministry of Education and Science of the Republic of Serbia and by the European Cooperation in Science and Technology (COST) Action CA18212.

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INFLUENCE OF HEMP PARTICLE SIZE AND MASS RATIO OF COMPONENTS ON MECHANICAL PROPERTIES OF HEMP BLOCKS

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Abstract

The aim of the present study is to investigate the performances of hemp block made of hemp shives and CaO binder (lime). In order to improve the performances of cono block, a selection of particle size from 1 mm to 40 mm of hemp shiv was made. The optimization of the mass ratios of the components was also done. The results show that there is a positive effect of reducing the dimensions of the hemp shiv particles on the mechanical properties of the formed cono block. Also, there is a significant influence of the mass ratio of the components on the mechanical properties of the obtained cono blocks.

Keywords: hemp shive, hemp block, lime, CaO, mechanical properties

INTRODUCTION

One of the biggest concerns of building construction in the context of sustainable development, is the choice of environmentally friendly materials. In fact, it has some effects on the depletion of natural resources, energy consumption, pollution emissions, etc.... The use of different fibres, woods and byproducts issued from plants have been investigated by numerous studies in building materials. Plant co-products in general, and hemp shives in particular, have been used to fabricate new materials, which provide good thermal insulation, limited impact on the environment and a low cost. In the process of hemp fiber extraction as a co-product hemp shives are produced from hemp stems, in form of ligneous particles. Hemp concrete (mix of hemp shives and CaO or other mineral binder) is a relatively new material that has been increasingly studied (Samri 2008). There is a need for some improvements to allow the large scale development of these kinds of materials. In fact, due to the high water absorption rate of hemp shive, hemp blocks requires an excessive amount of water, which leads to a very long drying time, and decrease in mechanical strength. Pretreatment of the hemp shiv could be a solution to reduce its water absorption rate. Finally, with regard to binder, hemp concrete using CaO has been successfully studied by several authors (Nguyen, 2010). The mechanical and thermal properties of hemp concrete using this binder are comparable to those found in the literatures (Arnaud, 2012). In order to predict the mechanical properties of hemp blocks, a cooperative project with industrial partners was studied, and experimental tests and numerical studies were carried out. The main purpose of this article is to relate the influence of hemp particle size and mass ratio of components on mechanical properties of hemp blocks.

MATERIAL AND METHODS

Binder

In this study, a commercial binder CaO, was used. Chemical composition of used binders are presented in Table 1.

Table 1. Chemical composition of binder

CaO							
Components							
	CaO	MgO	Fe_2O_3	SiO_2	Al_2O_3	$CaCO_3$	Impurities
Content by weight (%)	94.5	0.4	0.1	0.13	0.87	3.8	1.2

The structural properties of the used calcium oxide were determined by XRD technique. The results of the structural properties of the used calcium oxide (CaO) adhesive / binder are presented in Figure 1.

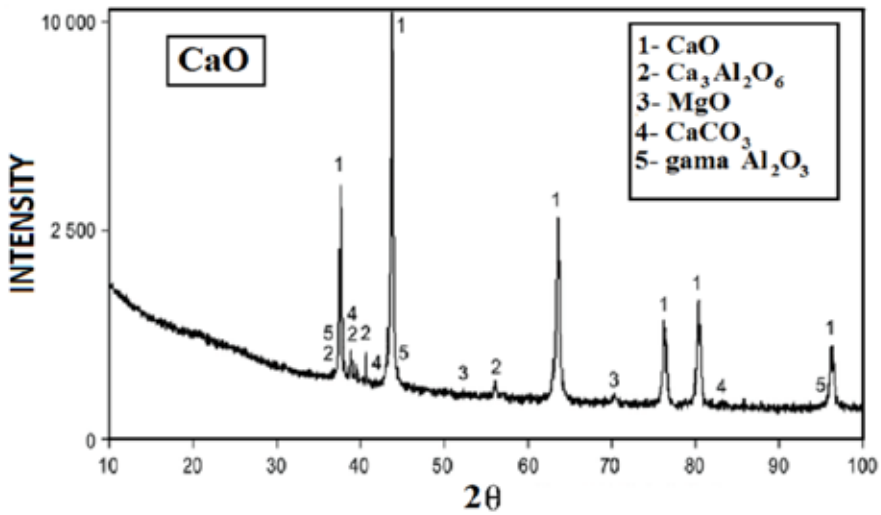

Figure 1. The XRD of the used calcium oxide CaO

As can be seen in Figure 1, the XRD results confirm the presence of crystalline phases of all components found in the chemical composition of the binder used. It can also be noticed that this is a material with a high degree of crystallinity based on the intensity of the obtained peaks and their sharpness.

Plant aggregates

The plant aggregate used in this study was hemp shiv, the ligneous particles extracted from hemp stems as a co-product of the process of hemp fiber extraction. Hemp shiv is obtained through an industrial defibration process by mechanical breaking, after which particles are dusted and calibrated. Table 2. shows the results of testing the chemical composition of the hemp used to form the cono block.

Table 2. Chemical composition of hemp

	Hemp						
	Chemical composition						
	Celulose	Hemicelulose	Lignin	Ash	Waxes	Proteins	Pectin
Content by weight (%)	48	12	28	2	1	3	6

Particle size distribution of the used plant aggregate (hemp shiv) was examined by vibrating shaker with sieves of different pore dimensions, and also with digital scanning software. The results of particle size distribution are presented in figure 2.

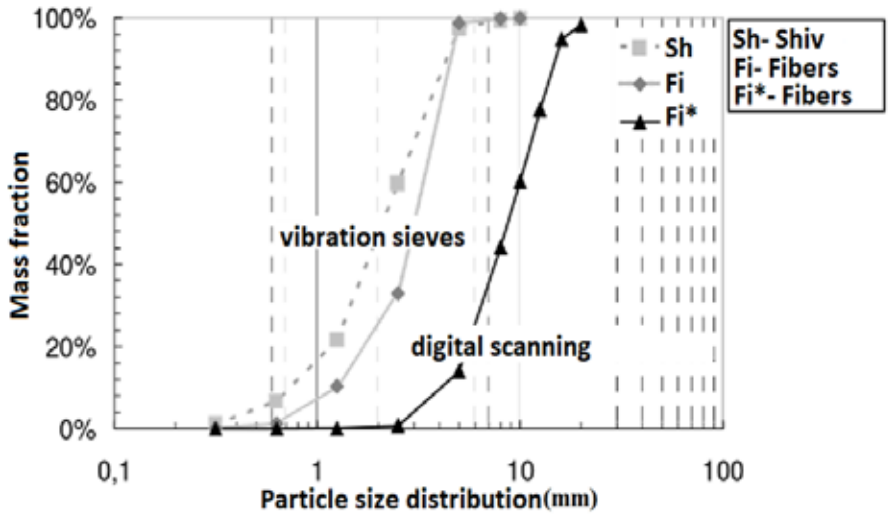

Figure 2. Particle size distribution of used hemp

As can be seen from Figure 2. less than 7% of the particles have a dimension below 1mm, 90% of the particles are in dimensions from 1mm to 10mm, and 3% of the particles have a dimension larger than 10mm.

Composites

First of all, the selection of the granulate fraction with particles from 1 mm to 40 mm was performed based on the test of the compressive strength of the cylindrical block formed by the hemp shiv (results are not presented in this work). It was concluded that there is a positive effect of reducing the dimensions of the hemp shiv particles on the mechanical properties of the formed cono block. Three mixing ratios of industrial hemp (hemp shiv), CaO (binder) and water were defined in the function of forming a hemp block with excellent performance, and also in order to determine the influence of mass ratios of components on the mechanical properties of the formed hemp blocks. Table 3. shows the mass ratio of the components at which the cono blocks were formed.

Table 3. Mass ratio of the components used for composite material

	Mass ratio of components of cono block	Low binder content (A)	Medium binder content (B)	High binder content (C)
1	Binder to hemp (CaO / hemp shiv)	1.0	2.0	3.0
2	Initial density (kg/m^3)	635	839	913
3	Water to binder (Water / CaO)	0.55	0.85	0.95

Compressive test

The compressive tests were realized on the cylindrical samples at 14 and 28 days of age. The device used was the HOUNSFIELD H50KS machine (load cell capacity: 50 kN) with a constant displacement rate of 5 mm/minute.

RESULTS AND DISCUSSION

Based on the selection of the fraction fraction in terms of particle size in the range from 1mm to 40mm and previously defined mixing ratios of cono block components, three different cono blocks with different binder proportions were formed (Low binder content (A), Medium binder content) (B) and high binder content (C)), and they are tested in terms of mechanical properties, ie. the following properties: strength, elasticity, toughness and hardness. Table 4 shows the

results of compaction and bending tests of formed cono blocks, according to the mass ratio of weights and binders as well as in the function of block aging.

Table 4. Results of compaction and bending tests of formed cono blocks

Low binder content (A)	Bending strength (range) (N/mm^2)	Compression force (range) (N/mm^2)	Bending / Compression ratio
14 Days	2.6 (2.4 – 2.7)	5.1 (4.8 – 5.6)	1.96
28 Days	3.6 (3.4 – 3.9)	9.4 (8.9 – 10.1)	2.61
Medium binder content (B)			
14 Days	5.3 (5.2 – 5.5)	25.1 (24.6 – 25.8)	4.73
28 Days	7.3 (7.0 – 7.6)	31.1 (29.6 – 32.8)	4.26
High binder content (C)			
14 Days	3.7 (3.5 – 3.8)	11.8 (11.5 – 12.2)	3.18
28 Days	4.6 (4.5 – 4.8)	14.9 (13.8 – 15.3)	3.23

Based on the results shown in Table 4, and as it was also found in literature (Woolley, 2008), it can be concluded that the proportion of binder in the cono block is of great importance for the mechanical properties of the formed cono blocks. According to the test of resistance to compression and bending, it can be noticed that the ratio of binder to hemp shiv (CaO / hemp shiv) of 2.0 with medium binder content (B) is significantly better than the ratio with low and high binder content, in terms of mechanical properties of the obtained cono block. The trend of hardening of the obtained cono blocks as a function of aging can also be noticed, which is in accordance with literature findings (Jonaitienė et al., 2016).

CONCLUSION

In terms of environmental acceptability when using industrial hemp weights to form kono blocks-ie composite material, the conclusion is that the material is completely Eco-friendly due to the unknown content of pollutants in the sample. The mechanical and physical properties of the obtained composite

materials largely depend on the mutual relations of the mass fraction of hemp shiv and CaO. Based on the measurements, it was concluded that the best ratio is 2: 1-binder to hemp shiv.

The mechanical and physical properties are influenced by the granulate fraction, ie. the size of the hemp shiv particles that enter the formation of cono blocks. It was shown on the basis of measurements that the most suitable fractions of granules are 1-40 mm. According to our assumptions and literature, there is an additional possibility of improving the cono blocks, which would be based on the introduction of various additional components such as pozzolan, Al_2O_3, MgO, cellulose acetate etc., which would further improve all characteristics of the cono block.

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CHARACTERIZATION OF HYDROCARBON-CONTAMINATED SITES USING DIRECT SENSING TECHNOLOGIES: ADVANTAGES AND LIMITATIONS

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Abstract

Understanding of nonaqueous-phase liquids (NAPLs) distribution in the subsurface is a fundamental component of any hydrocarbon-contaminated site remediation strategy. A recent trend in direct push (DP) technology is the use of direct sensing technologies such as Laser-Induced Fluorescence (LIF) and Membrane Interface Probe (MIP) in the investigation of hydrocarbon-contaminated sites. This study provides an overview of the key elements of LIF and MIP as screening tools for the contaminant spatial distribution characterization. Both technologies exhibit different advantages and limitations. In general, LIF enables the screening of residual and free-phase hydrocarbon petroleum products by detecting polycyclic aromatic hydrocarbons (PAHs). On the other hand, MIP enables detecting and distinguishing different zones of VOC contamination within a site. Overall, the qualitative to semi-quantitative information provided by these innovative techniques is highly valuable for the spatial characterization of hydrocarbon contamination, the development of a conceptual site model (CSM), and remediation activities.

Keywords: groundwater, contaminant distribution, petroleum hydrocarbons, remediation

INTRODUCTION

Petroleum hydrocarbons are among the most common groundwater contaminants, due to their widespread use (Alvarez and Illman, 2006). U.S. EPA (2003) listed about 440,000 sites impacted by gasoline releases only from leaking underground storage tanks. Other sources of hydrocarbon contamination include leaking pipelines, petroleum exploration, and disposal of refinery wastes. Once reaching the subsurface, this diverse group of compounds represents a persistent source of groundwater and geologic media contamination (Marić et al, 2015). Thus, an understanding of the hydrocarbon distribution is a fundamental component of any remediation of contaminated sites. The direct push (DP) technology pioneered by Geoprobe is the least expensive used drilling method in professional hydrogeology in the United States (Kresic and Mikszewski, 2013). A new trend in DP technology is the use of direct sensing technologies such as Laser-Induced Fluorescence (LIF), and Membrane Interface Probe (MIP). These innovative techniques can provide qualitative to semi-quantitative information about the spatial distribution of subsurface hydrocarbon contamination. This study aims to provide a brief overview of LIF and MIP key elements regarding their application at hydrocarbon-contaminated sites.

OVERVIEW of LIF and MIP TECHNIQUES

LIF technique

This innovative technology can be used for detecting residual and free-phase nonaqueous-phase liquids (NAPLs) containing polycyclic aromatic hydrocarbons (PAHs) (U.S. EPA, 2016). Although petroleum hydrocarbons are a mixture of different compounds, they nearly always contain enough PAHs for detection by LIF. However, it should be emphasized that LIF screening cannot detect the dissolved phased contaminants in groundwater (U.S. EPA, 2016). The probe is pushed or driven at a constant rate through the sediments, while ultraviolet light emitted through a sapphire window causes fluoresce of PAH compounds. The current LIF sensors cannot identify individual chemicals (U.S. EPA, 2016), but the relative product saturation in soil and product types present (gasoline, diesel, jet fuel, motor oil, cutting fluids, hydraulic fluid, and crude oil) (U.S. EPA CLU-IN, 2015b). Five of the six currently commercially available UV fluorescent systems in the United States use a technology developed wholly or in part by Dakota Technologies (U.S. EPA CLU-IN, 2015b). The key elements of the LIF technology available on the Dakota Technologies website are summarized in Table 1.

Table 1. The main advantages and limitations of LIF technology modified from https://www.dakotatechnologies.com/learn-more/intro-to-lif/overview

Key element	Description
Contaminants and concentrations	LIF detects the PAH fluorescence in NAPL In general, LIF does not detect chlorinated solvent DNAPL because they aren't fluorescent molecules. The exception is chlorinated DNAPL that contains enough fluorophores. LIF does not detect dissolved phase VOCs or SVOCs. LIF does not detect BTEX and/or other VOCs, since their wavelength is incompatible with fiber optics. LIF lower detection limit ranges between 10 and 1000 mg/kg (TPH), depending on fuel type and soil matrix.
Geologic media and materials	LIF detects NAPL both in vadose and saturated zones. rix affects fluorescence response – sands and gravels may have as much as 10 times higher response than clays and silts. LIF's potential false-positive responses include shell hash, meadow mat, peat, wood, and calcareous sands. Relative waveform shape and generally low intensity nearly always identify these as a suspect.
Technology production and compatibility	Typical LIF production is 200-500 feet per day. LIF probe is logged continuously with depth (2cm/s). No data gaps should be expected. LIF is compatible with both DP and cone penetration tests (CPT) and technologies.

MIP technique

The MIP is a semi-quantitative, field-screening tool for detecting VOCs and some SVOCs in the subsurface (U.S. EPA, 2016). It uses heat to volatilize and mobilize contaminants for sampling both from the sediment and groundwater. This technology should be used primarily to distinguish different zones of VOC contamination within a site (U.S. EPA, 2016). In other words, the use of MIP technology enables to focus on the most contaminated zones within the site. Moreover, MIP can help evaluate soil type and delineate groundwater contaminant locations in real-time (Kresic and Mikszewski, 2013). Key advantages and limitations of MIP technology, modified from (U.S. EPA, 2016) are summarized in Table 2.

Table 2. Key MIP elements, modified and summarized from (U.S. EPA, 2016)

Key Advantages	Key Limitations
Can detect the presence or absence of subsurface VOC contamination and relative degree of contamination both in vadose and saturated zones	Detection limits depend on soil type, temperature, and detector used. Finer soils tend to yield lower detection limits than coarser soils. (U.S. EPA CLU-IN, 2015c).
Can advance relatively rapidly (1 foot/min).	Cannot readily distinguish between high concentration soil levels and free-phase NAPL (ITRC, 2015)
Acquires and analyzes data in near real-time.	Contaminant carryover indicated on MIP logs as extended contaminated zone likely in NAPL or high-concentration zones (ITRC, 2015)
In combination with other probes or sensors, can provide simultaneous logging of precise three-dimensional delineation of source and plume areas.	Because the sample mass and volume are not known, MIP data should be considered estimates (Myers et al., 2002).

Both LIF and MIP are direct sensing tools - enhancements of the DP technology. The general limitations of a DP system are that most sites have a practical depth limitation of 50 ft or less, while only small-diameter wells (2 in. or less) can be installed (Kresic and Mikszewski, 2013).

ConclusionS

Due to the uncertain spatial distribution of the contaminants in the subsurface, the reliable characterization of contaminated sites is of paramount importance. Thus, the use of cost-effective investigation and remediation techniques is important both from the practical and scientific standpoint. A recent trend in DP technology is the use of direct sensing tools such as LIF and MIP in the investigation of hydrocarbon-contaminated sites. In general, LIF enables the screening of residual and free-phase hydrocarbon petroleum products by detecting PAHs, while MIP enables distinguishing different zones of VOC contamination within a site. Both technologies exhibit their advantages and limitations. When used simoultaneously over an extended area, LIF and MIP can provide a valuable spatial characterization of hydrocarbon contamination in the vadose zone, sediments, and groundwater.

Acknowledgments

This research was supported by the Science Fund of the Republic of Serbia, Program DIASPORA, Grant No. 6455306, GRACE.

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EVALUATION OF RADIATION DOSES RECEIVED THROUGH NATURAL WATER DEPENDING ON THE AGE OF POPULATION IN TOPLICA DISTRICT

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Abstract

The presence of radon in drinking water leads to internal exposure - through ingestion and inhalation and indirectly - as part of the food chain. Measuring the presence of radon in drinking water helps to assess the risk of radiation exposure during daily water consumption. In this work, the activity concentration of the radon in water from the alternative sources in Toplica district at 20 for characteristic points, measured by the alpha spectrometric method RAD7 device (Durridge Co.). The value of the concentration ranged from 1.4±0.7 Bq/l to 76.0±4.0 Bq/l, with average value of 14.0 Bq/l. Based on these values, the annual effective inhalation doses were determined, whose mean value was 39.6 μSv/y, as well as the annual effective ingestion doses for certain age groups, the following average values: infants (≤1 year) 74.5 μSv/y, children (2-17 years) 26.4 μSv/y and adults (≥17 years) 35.9 μSv/y.

Keywords: water supply, radon, ingestion, inhalation

INTRODUCTION

Water is not only a very important parameter for human life, but also a significant subject of research of numerous ecological, geological and radiological studies. In rural and some urban environments population supplies themselves with drinking water from alternative sources of underground waters due to the lack of water or irregular supply. Accumulation of radionuclides, radon in the first place, in underground waters is the function of various parameters such as the characteristics of water-bearing layer, the trajectories of water flow, interaction water-rock, content of minerals in the substrate, temperature, pressure, and the presence of gasses (Isinkaye et al, 2021; Vučković et al, 2021). Consumption of such waters could increase the effective dose of people's exposure and increase the risk of the appearance of lung and stomach cancer (Rožmaric ***et al, 2012, Fakhri et al, 2016).*** That is why it is important to control the concentration of radon in waters at the springs and public drinking fountains, if they are used as alternative sources, so that it would be determined if it was safe for drinking from the radiological aspect.

The allowed concentration of radon in drinking water is 11 Bq/l (USEPA, 1999), while in underground waters the maximum presence of radon is 100 Bq/l (WHO, 2004).

The aim of this paper is determining the concentration of radon in drinking water from different sources of underground water in the researched area and establishing annual effective doses the population is exposed to both by inhalation and ingestion. The research was carried out in Toplica district on 20 carefully chosen measuring sites: 4 in the Municipality of Blace, 9 in the Municipality of Kuršumlija, 6 in the Municipality of Prokuplje and 1 in the Municipality of Žitorađa. Based on the value of radon present in water, the health risk of radiation exposure was estimated due to the daily water consumption**.**

THE RESEARCHING AREA

Toplica district is situated in the southern part of Serbia and consists of four municipalities: Blace (43^{o}17'N and 21^{o}17'E), Kuršumlija (43^{o}09'N and 21^{o}16'E), Prokuplje (43^{o}14'N and 21^{o}35'E) and Žitorađa (43^{o}11'N and 21^{o}43'E). Various rock masses are present on the researched terrain, susceptible to physical-chem-

ical changes in surface parts, which enables water accumulation in the system of cracks and fissures whose level is changeable and depends on the external conditions. This area is characterized by alluvial and river terrace plateaus, complexes of crystalline shales and Neogene hilly terrains. The relief is of considerable morphological diversity, built of fine-grained gneisses of Proterozoic age and uncultivated sediments of the hills, ie Quaternary sediments in the Toplica valley and its smaller tributaries. Various rock masses are subject to physical and chemical changes in the surface parts, which enables the accumulation of water in the systems of cracks and fissures, the degree of which is variable and depends on external conditions. The hypsometric values show that the relief is dominated by several fluvial-denudation levels placed in vertical succession.

MATERIAL AND THE METHOD

The water was sampled in plastic bottles of 1.5 l filled by a thin stream of water up to the very top, by which it was tried to avoid the stirring of the water in the bottle, the release of radon from water and its accumulation in the free space just under the bottle cap, so they were closed immediately. Radon concentration in water samples was measured by the system RAD7 RAD H2O (Durrige Co., 2012), whose lower borderline of detection is smaller than 0.37 Bq/l. Radon detection was performed in the Laboratory for testing the radioactivity of samples and the dose of ionizing and non-ionizing radiation of the Faculty of Sciences of the University in Novi Sad. As the concentration could not be measured by the very sampling, water was poured into glass containers from plastic bottles, by a special adapter. The aeration of a water sample is done by a pump, and thus released radon goes into the chamber. The system reaches balance in up to 5 minutes. The exact value of efficiency of radon separation is almost always larger than 90%. Before every measuring the detector must be freed of the remaining radon and dry, which is achieved by blowing the instrument.

RESULTS AND DISCUSSION

Radon detection

Summarized results of the research are presented in table 1. The research was carried out on 20 measuring sites: 8 captured wells and 12 public fountains.

Table 1. Summarized research results at selected localities in the Toplica district

	C_{corr} (Bq/l)	E_{inhal} (μSv/y)	E_{ingest} (μSv/y)		
			Infants	Children	Adults
Blace					
Min	2.0±	5.6±2.2	10.6±4.2	3.9±1.5	5.1±2.0
Max	30.6±2.9	85.68±8.1	161.8±15.3	59.6±5.6	78.2±7.4
Av	14.5	40.5	76.5	23.3	36.9
Kuršumlija					
Min	4.4±1.2	17.3±3.4	23.3±6.3	8.5±2.3	11.2±3.0
Max	22.4±0.4	62.7±1.1	118.5±2.1	43.6±0.8	57.2±1.0
Av	14.04	39.8	74.3	27.3	35.7
Prokuplje					
Min	1.4±	3.9±1.9	7.4±3.7	2.7±1.3	3.6±1.8
Max	76.0 ±	212.0±11.2	402.0±21.1	147.9±7.7	194.2±10.2
Av	15.5	43.3	82.1	30.2	39.7
Žitorađa					
	4.3±0.8	12.04±2.2	22.7±4.2	8.4±1.6	10.9±2.0
All results					
Min	1.4±	3.9±1.9	7.4±3.7	2.7±1.3	3.6±1.8
Max	76.0 ±	212.0±11.2	402.0±21.1	147.9±7.7	194.2±10.2
Av	14.0	39.6	74.5	26.4	35.9

As the sample analysis was performed later, and not during the sampling itself, the corrected value of radon concentration was determined and presented in table as: Ccorr = Co×δ; where: δ= eλt, λ=0.00756 h-1, Co (Bq/l) the value of radon concentration in water measured in the laboratory after several days, and t defines the time elapsed from the sampling to the laboratory analysis (Todorovic et al, 2012a). Radon concentration range in water is from 1.4±0.7 Bq/l to 76.0 ±4.0 Bq/l, average value from 14.0 Bq/l, which is under the recommended value of 100 Bq/l (WHO, 2004) and little above the value of 11 Bq/l (US EPA, 1999). Average values of radon concentracions in water in selected municipalities are: 14.5 Bq/l, 14.04 Bq/l, 15.5 Bq/l and 4.3 Bq/l, respectively. The largest concentration of radon in water was measured in this district at all - 76.0 ±4.0 Bq/l, in municipality of Prokuplje. As a place of water springing is not defined by the

increase presence of radionuclides, it can be concluded that this higher radon concentration in water is consequence of movement of the underground waters which come across the rocks with the increased content of radionuclides on their trajectory. Average value of radon concentration in water was In the Observing the ranges of radon concentration, as well as mean values by municipalities in Toplica district the presence of radon in water is perceived to be below the recommended value of 100 Bq/l (WHO, 2004), and a little above the value of 11 Bq/l (USEPA, 1999). By the data presented in table, as many as 11 samples (55%) are characterized by the radon concentration below 11 Bq/l. All of this leads to the conclusion that the water sampled on this area is radiologically adequate, and can be used as for drinking, but also for other household purposes. The research results of radon concentration in waters of this area are comparable to the similar researches of other authors (Somai et al, 2007; Cosma et al, 2008; Akar et al, 2012; Cantaluppi et al, 2014; Srinivasa et al, 2015; Fonollosa et al, 2016).

Annual effective doses of inhalation and ingestion

The carcinogenic effect of radon, in the long run, refers to the determination of the total effective dose of internal radiation by radon dissolved in water consisting of two components: the first one is defined by the effective dose of inhalation, while the second is defined by the effective dose of radon ingestion. Calculated values of the annual effective dose of exposure are presented in Table 1.Radiation dose in the lungs mostly comes from radon short-lived descendants deposited on bronchi, less than from radon itself. Radon mostly comes back by the inhaled air. The effective dose of inhalation received by the lung tissue is received by the multiplying of radon concentration in water by the conversion factor of 2.8 μSv Bq-1 m3 (WHO, 2004). The interval of annual effective doses by inhaled radon on the area of Toplica district is from 3.9±1.92 μSv/y to 12.0±11.2 μSv/y, mean values of 39.6 μSv/y. Mean values of the effective dose of inhalation by municipalities are: 40.5 μSv/y, 39.8 μSv/y, 43.3 μSv/y and 12.04 μSv/y, respectively. Based on these mean values which are below the recommended value of 100 μSv/y (WHO, 2004). It can be concluded that waters from these locations are safe for use from the radiological aspect. It is known that radon rich water goes directly to stomach, where radon can enter the organism by passing through the walls of the stomach. A part of the taken-in radionuclides can remain in the same places for a long time, and some can get attached to macrophages and carried further on to lymph cells. Special attention should be paid to the radiation dose children are exposed to, because they have a bigger risk factor due

to the intensive bone growth and that is why big steps should be taken to restrict their exposure in any way (Alseroury et al, 2018; Duggal et al, 2020). That is why the dose of ingestion was calculated in this paper for different age groups: newborns (< 1 year), children (2-17 years) and adults (> 17 years). Effective doses of ingestion were determined through the following pattern (UNSCEAR, 2000; Duggal et al, 2020):

$$E_{ing} = C_{wRn} \times A_i \times D_f \quad (1)$$

where: CwRn is the concentration of radon in water (Bq/l), Ai is the value of the annual intake of water (l/y): for the infants - 230, for children - 330 and for adults - 730, and Df is the conversion dose factor for the intake (Sv/Bq): for the newborns (≤1 year) - 23, for children (2–17 years) - 5,9 and for adults (≥ 17 years) - 3,5 (UNSCEAR, 2000).

The effective dose interval of radon taken in by ingestion on the total researched area is: for the infants 7.4±3.7 μSv/y - 402.0±21.1 μSv/y, for children 2.7±1.3 μSv/y - 147.9±7.7 μSv/y, and for the adults 3.6±1.8 μSv/y - 194.2±10.2 μSv/y. Mean values of ingestion effective doses in Toplica district are: 74.5 μSv/y, 26.4 μSv/y and 35.9 μSv/y, respectively. Mean values of ingestion effective doses by municipalities of Toplica district are the following: Blace – 76.5 μSv/y (newborns), 23.3 μSv/y (children) and 36.9 μSv/y; Kuršumlija – 74.3 μSv/y (newborns), 27.3 μSv/y (children) and 35.7 μSv/y (adults); Prokuplje – 82.1 μSv/y (newborns), 30.2 μSv/y (children) and 39.7 μSv/y (adults); Žitorađa – 22.7 μSv/y (newborns), 8.4 μSv/y (children) and 10.9 μSv/y (adults). The data shown in Table 1 point out that the values of inhalation effective doses (with children and adults) are somewhat higher than the effective doses, which leads to the conclusion that there is a higher probability of bronchial tissue becoming carcinogenic, than the stomach tissue.

Results presented in Table 1 point out that the value of inhalation effective dose as well as ingestion dose is above the recommended value of 100 μSv/y only on one site in municipality of Prokuplje, while it is below the value on all other localities. In the case of waters from this locality it is necessary to take certain steps so that radon concentration in water would decrease, the aeration samples, in the first place. Generally it can be said that from the radiological aspect these waters can be used for drinking, but for wider use as well.

CONCLUSION

The research comprised alternative sources of water supply on 20 measuring sites in rural and urban environments of Toplica district. The value of radon concentration on all the researched locations of Toplica district ranges from 1.4±0.7 Bq/l to 76.0 ±4.0 Bq/l, with average value of 14.0 Bq/l, which is significantly below the recommended value of 100Bq/l, and very close to the recommended value of 11 Bq/l. Average values of the annual effective inhalation dose are the following: 40.5 μSv/y, 39.8 μSv/y, 43.3 μSv/y and 12.04 μSv/y, respectively. Average values of the annual effective doses taken in by ingestion for certain age groups on the researched locations of Toplica district are: infants (< 1 year) 74.5 μSv/y, children (2-17 years) 26.4 μSv/y and adults (> 17 years) 35.9 μSv/y. By comparing the values of effective doses of inhalation and ingestion it can be noticed that the dose received by lungs is somewhat larger than the one received by the stomach during ingestion (with children and adults), which means that there is a higher probability of bronchial tissue becoming carcinogenic than the stomach tissue. According to these mean values of annual effective doses of inhalation and ingestion which are below 100 μSv/y, it can be concluded that waters from these locations are radiologically adequate and can be used both for drinking, and for other household purposes.

The results presented in this paper represent the starting point of forming a radon map of natural sources on the territory of the Republic of Serbia, as well as the basis of further and more detailed researches.

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TOXIC METALS IN SOIL SAMPLES NEAR SOURCE OF POLLUTION WITH ECOLOGICAL RISK IN NORTHERN KOSOVO AND METOHIJA

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Abstract

The term toxic metals means heavy and light metals. Higher toxicity of heavy metals compared to light ones was stated, while many light metals belong to physiological and oligo-elements. The term heavy metals means metals that have specific gravity > 5 g/cm^3. In this work the concentrations of Pb, As, Cd, Cr, Th, U in soil samples were determined by the ICP-MS and ICP-OES method. Pb/Zn production and industrial waste disposal significantly increased the pseudo-total concentrations of heavy metals in the soil. This paper examines the contents of metal ions that are important to the environment and humans, their correlation in the analyzed samples depending on the geographical area and industrial pollution. Range of concentrations of several determined toxic elements were: lead (Pb) 78.3-6565.5 mg/kg, arsenic (As) 17.9-9647mg/kg, cadmium (Cd) 3.72-59.8 mg/kg, chromium (Cr) 10.5-170.5 mg/kg, thorium (Th) 0.89-1.89 mg/kg and uranium (U) 0.075-2.75 mg/kg. The samples were recorded on ICP – OES (ICP – OES, iCAP 6500 Duo, Thermo Scientific, UK) and ICP - MS (ICP-MS, iCAP Qc, Thermo Scientific, UK) instruments. Elemental analysis of soils could provide information about the state of the pollution of the environment and health risk for inhabitants of this area. Contamination of soils in the province of Kosovo and Metohija is caused mainly by anthropogenic activities (numerous mines, pollution as a result of post-war effects, ethnic war 1999) and geological composition of the soil.

Keywords: metals, soil, pollution

INTRODUCTION

The earth forms a thin surface layer of the Earth's crust, or lithosphere. It is formed during long processes rock decay under the influence of weather changes and the interaction of climatic, ie abiotic and biotic factors. Various physical and chemical properties of the basic components of the soil that are formed during these long-term processes, condition its character and determine it as a substrate, less, or more suitable for the life of organisms that live in/on it. This situation is further complicated by the massive and rapid expansion of industrial activities, which unfortunately usually lead to adverse and dangerous consequences for the land itself, but also the overall environment and most importantly, by all living organisms (Peralta-Videa, 2009). Rapid industrial developments have increased the environmental pollution level particularly in the nearby areas of industrial activity. The lack of proper management of the industrial waste leads to contamination of soil and in this process chemical elements with toxic effects enter the biosphere affecting human health (Lofts, 2015). Industrial wastes in the form of effluents are one of the major sources of soil pollution. Chemical elements such as Pb, As, Hg, Cd and Cr with toxic effects have several industrial uses. Almost all heavy metals are serious toxicants as carcinogens. However, due to their chemical and physiological properties, heavy metals are useful in industrial areas including alloy, smelting and production of commercial products. Contamination of environments (sourface water-rivers, lakes, soils, ect) in the province of Kosovo is caused mainly by anthropogenic activities (numerous mines, pollution as a result of post-war effects, ethnic war 1999) and geological composition of the soil (Barać, 2016). The main sources of contamination by heavy metals are industrial waste, mine tailings, leaded gasoline, spillage of petrochemicals, and atmospheric deposition. The term heavy metal is often used to refer to the group of metals and semimetals (metalloids) that have been associated with contamination and potential toxicity or ecotoxicity. Pollution by heavy metals from mining and industrial processes has been the main subject of many studies due to health risks associated with metal contamination (Micic, 2019). The mining district contains about 40 mines. There is evidence for the first phase of extraction dating from the mediaeval age (for Ag, Pb and Fe), with intense activity beginning in 1303 (Stafilov 2013).

Arsenic As is a metalloid that exists in inorganic and organic compound forms. Inorganic As is more harmful than the organic form. Pentavalent inorganic compounds of As solubilize in water to weak acid forms and produce salts called arsenate.

Cadmium Cd is rare in the natural in environment. It generally comes from environmental pollution from industrial and agricultural waste.

Cr is abundant in the earth's crust, and its toxicity depends on its chemical state. It exists in divalent to hexavalent compounds, but only the trivalent and hexavalent compounds have significant biological toxicity. Cr compounds are usually found in industrial purposes such as chromite ore mining, pigmentproduction, tanning of leather, formation of wood preservatives, and anticorrosive agents. Paint is a significant source of hexavalent Cr but is still used for industrial applications. The salt form of trivalent and hexavalent Cr compounds, called chromate, are produced through mining, smelting, roasting and extraction.

Thorium together with the other long-living nuclides such as -K-40, Re-187, Rn-222, C-14, U-235, U-238, and its products such as Ra-226, Lu-176, remain present in nature for billions of years. The concentration of radionuclides in natural water varies and depends on the concentration of the minerals and rocks in the Earth's crust (Lofts et al. 2015). The appearance of radionuclides in nature is the result of their crystal-chemical and physico-chemical properties.

Uranium is the only naturally occurring fissile element that can be directly used in a nuclear reactor to produce energy through nuclear fission. As a natural element, uranium (U) is found in certain concentrations in the environment and living beings. Uranium is a radioactive and toxic element.As a radioactive element, uranium emits alpha, beta and gamma during disintegration radiation.

The results of a study on the spatial distribution of toxic elements in surface soil (0–5 cm) in the former Pb—Zn mining Kosovska Mitrovica region, in north Kosovo are reported, by ICP – OES (ICP – OES, iCAP 6500 Duo, Thermo Scientific, UK) and ICP - MS (ICP-MS, iCAP Qc, Thermo Scientific, UK) instruments. Analyzed areas are under strong anthropogenic influence of mining and metallurgical activity.

MATERIALS AND METHODS

Sampling and sample preparation

At the beginning of October 2020, systematic random sampling of uncultivated soil was sampled. Soil samples were dried at room temperature to constant weight, minced and sifted through the 2 mm mesh sieve. Composite topsoil samples were collected with a manual blades at depth 0-15 cm from each sampling sites, and transported to the laboratory in sealed polyethylene containers. Samples of the surface soils from analyzed points were selected randomly from

the study area. About 1 kg of each soil sample was taken by applying systematic random sampling described by IAEA-TECDOC-1415. Soils samples were air-dried indoors, at room temperature for about 2 weeks. Then, samples were gently disaggregated, cleaned of extraneous material, and sieved through a nylon sieve of 2 mm. The pseudo-total contents of heavy metal of soils were obtained by wet acid decomposition in a closed system (reflux) with the addition of hydrogen-peroxide (30%) (USEPA 1996).

Conditions of the operation and reliability of chemical analysis

Working parameters of plasma operation conditions were: flush pump rate (100 rpm), analysis pump rate (50 rpm), RF power (1150 W), nebulizer gas (0.7 L/min), coolant gas flow (12 L/min), auxiliary gas flow (0.5 L/min), plasma view (dual mode (axial/radial)), and sample uptake delay (30 s).

Instrumentation and Reagents

The samples were recorded on ICP – OES (ICP – OES, iCAP 6500 Duo, Thermo Scientific, UK) and ICP - MS (ICP-MS, iCAP Qc, Thermo Scientific, UK) instruments An Ultra-Scientific (USA) ICP multi-element standard solution of about 20.00±0.01 mg/L was used as a stock solution for calibration. The PVC containers were treated with 20% nitric acid and washed with ultra-pure water 0.05 μS/cm (MicroMed high purity water system, TKA Wasseraufbereitungssysteme GMBH). Nitric acid (65%) (Merck, Darmstadt, Germany) and hydrogen peroxide (30%) (Fluka, Buchs, Switzerland) were both of analytical grade. All reagents used were of analytical grade. For the analyzes, calibration solutions were made from the standard stocks (Multi – Element Plasma Standard Solution 4, Specture®, Alfa Aesar, John Mutthey Company; Vanadium Plasma Standard Solution, Specture®, Alfa Aesar, John Mutthey Company; Tungsten, Specture®, Alfa Aesar, John Mutthey Company; Major Elements Stock, EPA Method Standard, VHG Labs; 6020A ICS Stock, EPA Method Standard, VHG Labs; Multi – Element Aqueous CRM, Comprehensive Mix A, VHG Labs; Selenium Standard for AAS, Fluka; Mercury Standard, Merck; Arsen Standard, Merck; Molybdenum, Plasma Standard Solution, Specture®, Alfa Aesar, John Mutthey Company). Values of measured samples are expressed as the mean of three repeated measurements.

RESULTS AND DISCUSSION

Limit of detection (LOD), and limit of quantification (LOQ) of applied method were presented in Tble 1. Obtained concentrations of the elements determined in the soil samples are presented in Table 2. The highest concentratin of lead Pb, were determined in samples of soils near Trepča, Zvečan, and the lowest in Landfill/Lešak. The highest concentration of As were in samples Pirit/Žitkovac, and the lowest concentration of As were in samples of Road/Lešak-Kosovska Mitrovica. The highest concentration of Cd were in samples near Trepča, and the lowest concentration of Cd were in samples of Road/Lešak-Kosovska Mitrovica. The highest concentration of Cr were in samples near Landfill/Lešak , and the lowest concentration of Cr were in samples Trepča. The highest concentration of Th were in samples near Road/Lešak-Kosovska Mitrovica , and the lowest concentration of Th were in samples samples Pirit/Žitkovac. The highest concentration of U were in samples near Landfill/Lešak, and the lowest concentration of U were in samples near complex Trepča. By comparing the results, it can be concluded that the concentration of toxic metals varies depending on the source of environmental pollution. In the samples Trepča and pirit Žitkovac, concentration of lead Pb significantly overloaded permited level, while concentration of Cr overloaded only in samples of Landfill/Lešak. In all analysed samples concentration of arsen As were significantly overloaded in order to permitted level.

Table 1 Limit of detection (LOD), and limit of quantification (LOQ)

Element	LOD (ppb)	LOQ (ppb)
Pb	0.00697	0.02324
As	0.024962	0.083208
Cd	0.003335	0.011116
Cr	0.004853	0.016176
Th	0.000561	0.00187
U	0.00038	0.001267

Table 2 Concentrations of the elements determined in the soil samples

Samples	Pb(mg/kg) (RSD%)	As(mg/kg) (RSD%)	**Cd(mg/kg) (RSD%)**	**Cr(mg/kg) (RSD%)**	**Th(mg/kg) (RSD%)**	**U(mg/kg) (RSD%)**
Trepča	6565.5(1.87)	4054.4(1.48)	59.8 (0.78)	10.5 (1.61)	1.03(0.57)	0.075(4.76)
Pirit-Žitkovac	1159(2.57)	9647.7(0.84)	4.11(0.87)	11.6 (0.61)	0.89(3.83)	0.167(1.39)
Landfill/Lešak	78.3(2.82)	18.1(6.57)	8.12(3.93)	170.5(1.70)	1.45(0.91)	0.268(1.37)
Road/Lešak-Kosovska Mitrovica	94.23	17.9(2.89)	3.72(7.03)	36.53 (0.58)	1.89(2.15)	0.260(1.46)

Values of measured samples are expressed as the mean of three repeated measurements.

CONCLUSION

Based on the results obtained in this paper, it can be concluded that anthropogenic and industrial sources, mines, smelters, strongly influence soil and environmental pollution. High concentrations of toxic metals were found in the vicinity of tailings and mines, roads. Given the health risk, there is a clear need for constant monitoring in order to improve the quality of the environment, which is the contribution of this paper.

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REMOVAL OF ARSENIC FROM RAW DRINKING WATER OF VOJVODINA, IN SITU BY FERRATE(VI): PROOF OF PRINCIPLE AND EXAMPLE

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Abstract: Groundwater in the territory of the Republic of Serbia are the basic resource of water, and in the Autonomous Province of Vojvodina water supply is exclusively oriented to groundwater. Most of these groundwater contains unacceptably high level of arsenic (As). According to the Regulation on hygienic quality of drinking water maximum allowable concentration of arsenic in drinking water is 10 mg/l. More than 40% of the population of Autonomous Province of Vojvodina is supplied with water which contains a higher concentration of As than it is allowed.The presence of organic matter in raw water additionally complicates As removal by the conventional methods of coagulation due to complex that As forms with organic matter.

The subject of this work is As removal from raw drinking water by electrochemically synthesized ferrate(VI) and by ferrate(VI) in combination with conventional coagulant ($AlCl_3$). The initial As concentration of 15,08 μM was removed with an efficiency of 99% by ferrate(VI) in two steps, whereas in combination with $AlCl_3$ removal efficiency was 95,62%. Artificial sample of raw drinking water (As=15,08 μM, permanganate index=10,11 mg/l) was treated in two steps by ferrate(VI). Arsenic removal was 71,79% and permanganate index decreased to 6,32 mg/l. $AlCl_3$ addition showed As removal in the presence of organic matter of 95,97% and reduction of permanganate index to 1,26 mg/l.

Key words: Arsenic, ferrate(VI), drinking water, humic substances, spectrophotometry

INTRODUCTION

Water scarcity affects more than 40% of the global population and is projected to rise. Water resources are under ever-increasing strain, which makes innovations in treatment technology of both scientific and practical importance. According to the Global Burden of Disease study, as the most comprehensive worldwide observational epidemiological study, in 2015 about 1.8 million deaths resulted from diseases related to water pollution.

Very serious difficulties in the process of preparing high-quality drinking water is the increased amount of natural organic matter in water resources, or the formation of a large number of by-products of disinfection and coagulation. In addition to organic matter in water resources a large number of inorganic pollutants, including arsenic, as one of the most widespread, can be found.

In many parts of the world arsenic (As) is one of the most important contaminants of resources of raw drinking water for both surface and groundwater. A large number of adverse effects of As on living organisms is proven: appearances of cancerous diseases, neurological diseases, cardiovascular and respiratory system diseases (Yoshida T., 2004). According to UN Synthesis Report arsenic poisoning is the second major health risk which is linked to drinking water. In 2001 The World Health Organization estimated that about 130 million people are exposed to a concentration of 50 μg/l of arsenic in drinking water, so the European directive define the maximum allowable concentration of arsenic in drinking water of 10 μg/l.(WHO 2006, 2008) In some countries such as Hungary, Serbia, Croatia, Greece, Italy and Spain it was found significantly elevated arsenic content in drinking water, which requires additional efforts in the treatment of raw water with the aim of achieving the maximum allowable concentration of 10 μg/l.

Groundwater in the territory of the Republic of Serbia are the basic resource of water, and in the Autonomous Province of Vojvodina water supply is exclusively oriented to groundwater. More than 40% of the population of Autonomous Province of Vojvodina is supplied with water which contains a higher concentration of arsenic than it is allowed. In most cases, the concentration of arsenic in drinking water ranges from 50 to 100 μg/l, but there are also municipalities, such as Zrenjanin, where the concentration of arsenic in drinking water ranges from 150 to 250 μg/l (figure 1). At the same time the content of natural organic matter in the raw water, expressed as the consumption of potassium permanganate, ranges from 20 to 150 μg/l, and in extreme cases up to 200 μg/l (Dalmacija B. et

al, 2011). The presence of organic matter in raw water additionally complicates As removal by the conventional methods of coagulation due to complex that As forms with organic matter. In the coagulation process also may be present the competition between natural organic matter and arsenic for free adsorption places on the formed hydroxide (Pallier V., 2010).

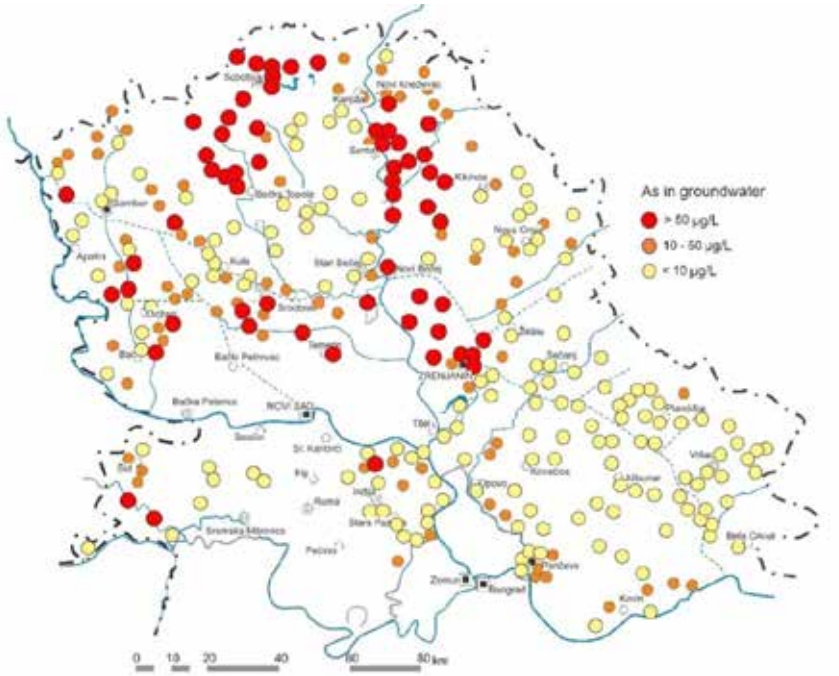

Figure 1. Arsenic in groundwater of Vojvodina (modified by Dalmacija B. et al, 2011)

Most of the water supply systems in Vojvodina, except the water supply system in Subotica do not own the technology for arsenic removal from groundwater. Efficient removal of organic matter and arsenic from drinking water resources is still one of the greatest challenges in modern production of safe drinking water. A significant number of works based on the toxicity of arsenic and the techniques of arsenic removal from drinking water has been published in recent years (Han B., 2003, Pallier V., 2011, Ihos M., 2005). Techniques for the removal of organic matter and arsenic from raw water are based on: oxidation, flocculation with microfiltration, adsorption, ion exchange. The results show that the efficiency of arsenic removal by these techniques is insufficient to meet the prescribed requirements. As(III) is more toxic and mobile than As(V), so it

is highly desirable to oxidize As(III) species for enhancing the immobilization of arsenic. Therefore, many conventional arsenic removal procedures involve a pretreatment for As(III) oxidation, followed by the adsorption or coprecipitation of As(V) formed using adsorbents or coagulants, such as metal oxyhydroxides (Hering, J. 1996). Until now, many oxidants or oxidant-generating systems have been tested for As(III) oxidation: oxygen and ozone, hydrogen peroxide, manganese oxides, UV/iron systems, and TiO_2 /UV systems (Lee, H., 2002).

As an alternative or pre-treatment to conventional methods, the treatment of raw water by ferrate(VI) could be used, which at the same time oxidizes organic material, and convert As(III) to As(V), equation 1, and could be removed from the solution by formed $Fe(OH)_3$ as a slurry during flocculation and coagulation.

$$2HFeO_4^- + 3H_3AsO_3 \longrightarrow 2Fe^{3+} + 3HAsO_4^{2-} \qquad (1)$$

The application of ferrate(VI) in the process of As(III) removal from raw drinking water is compatible with the conventional methods of water purification such as using chloride and sulfate salts of iron or aluminum, and they may supplement each other mutually. Recently, ferrate [Fe(VI), iron in +6 oxidation state] has gained great attention as an environmentally friendly oxidant and coagulant for water and wastewater treatment (Jiang J.Q.,2018, Sharma V.K, 2002). Fe(VI) is a known powerful oxidant over the entire pH range; its redox potentials are 2,20 V and 0,72 V in acidic and basic media, respectively (Sharma V.K., 2002, 2015). Oxidation efficiency of ferrate(VI) solution is increased by formation of atomic oxygen during water oxidation.

The aim of this work is the possibility and application of ferrate (VI) in the process of removing As (III) from raw drinking water in the presence of natural organic matter, in the case of artificial water sample with addition of As (III) and humus substance and in the treatment of raw water samples, taken from four locations from the territory of Banat in Vojvodina.

EXPERIMENTAL

Artificial samples with As(III) concentration of 1130 mg/l (15,08 μM) and with added humic substances (consumption of K_2MnO_4 is 10,11 mg/l) were used in this experimental work. As(III) was in the form of As_2O_3, *p.a.* quality, a mi-

xture of humic acids was used as humic substances and demineralized water was also used in the experiment. A 4% solution of $AlCl_3$ was used as an additional coagulant.

The Na_2FeO_4 solution, concentration of 3,5 g/l used for the treatment was synthesized electrochemically (Nikolić Bujanović Lj.,2012, Čekerevac M.,2010).

Freshly synthesized ferrate(VI) was used for the treatment of the solution.

The treated samples were stirred using Jar test, for 10 minutes at the speed of 240 rpm, and then at the speed of 120 rpm up to the color of ferrate(VI) disappearance. The pH value was adjusted to 5-6 using HCl (Sharma V.K, 2002, Čekerevac M.,2010). The samples were filtered through a filter with the pore size of 0,20 μm. Analysis of the total amount of residual arsenic was determined by atomic adsorption spectrophotometry following the standard method for arsenic determination. The presence of organic matter regarding the changes in the concentration of added humic acid in the treated samples was monitored through the consumption of potassium permanganate.

In the second set of experiments, treatment of samples with the same concentration of As(III) without humic substances was done in two steps. After the treatment by Na_2FeO_4 in the same ratio as in the previous experiment, filtration and pH correction to 5-6 an additional treatment was carried out. In the first step the samples were treated again by Na_2FeO_4 and in the second step the samples were treated by $AlCl_3$ in a molar ratio of 1:1 to Na_2FeO_4.

In the third set of experiments, treatment of samples with the same concentration of As(III) with the addition of humic substances was carried out according to the same procedure as in the second set of experiments.

In the fourth set of experiments, samples of raw drinking water were treated with ferrate(IV) using a laboratory plant consisting of three reaction columns:

- Reaction column for the treatment of water by ferrate(VI),
- Reaction column for coagulation,
- Filtration column.

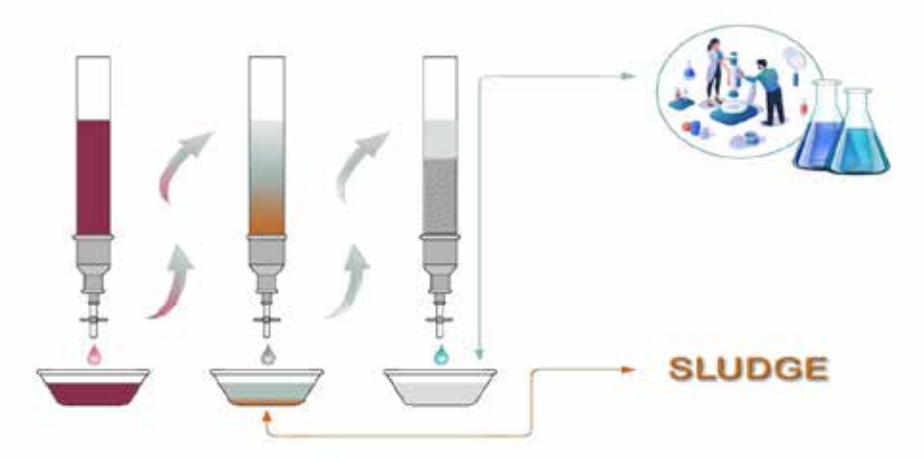

Figure 2 Laboratory plant for the treatment of raw drinking water by ferrate(VI)

RESULTS AND DISCUSSION

Results of As(III) removal from water samples with and without the presence of humic substances by ferrate(VI) are shown in Figures 3 and 4. Figure 3 shows the result of the treatment of water sample with As(III) concentration of 15,08 μM and without humic substances by ferrate(VI) in various molar ratios (As(III): Fe(VI)) 1 : 1,95; 1: 3,6; 1: 4,41; 1: 5,34; 1: 7,1. The results of additional treatments by ferrate(VI) and coagulant $AlCl_3$ are also shown in Figure 3.

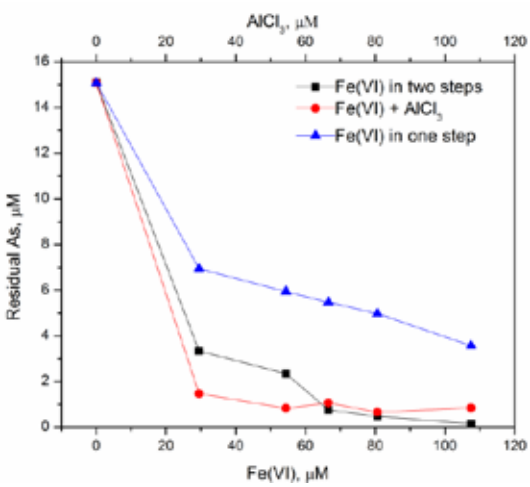

Figure 3 Removal of As(III) by Fe(VI), by Fe(VI) in two steps and by Fe(VI)/ $AlCl_3$

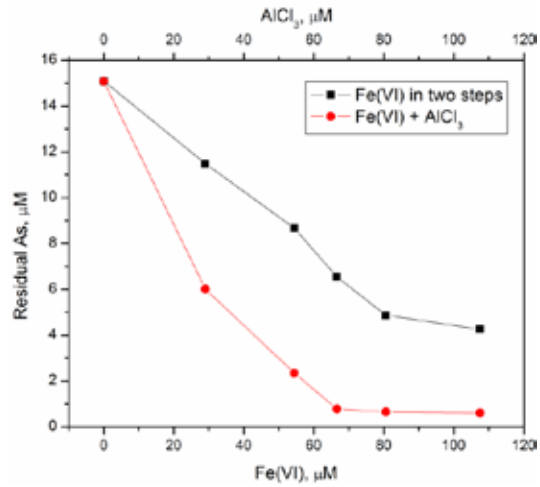

Figure 4 Removal of As(III) in the presence of humic substances by Fe(VI) and by Fe(VI)/$AlCl_3$

Treatment results show high efficiency in As removal by ferrate(VI), table 1, 76,33% in the first step of the treatment at a molar ratio (As (III): Fe(VI)) of 1 : 7,1 or 107,5 μM Fe(VI). As(III), which has mobility and can not be removed from water by conventional flocculants, is oxidized to As(V) by ferrate(VI) due to the high oxidation potential of Fe(VI). Ferrous hydroxide, formed by reduction of ferrate(VI), as a powerful coagulant removes it from the solution. Due to the small amount of ferrate(VI), and therefore the small amount of formed ferrous hydroxide, in the first set of experiments the complete removal of As was not achieved.

By repeated treatment of the samples, with the same concentration of ferrate(VI), 99% of As is removed, whereas the addition of coagulant $AlCl_3$ removes 95,62% of As. In the second set of experiments it was shown that with the increase of added amount of ferrate(VI) it is possible to achieve complete As removal. It is necessary to add ferrate(VI) in two steps (each of the steps includes addition of Fe(VI), filtration, and pH adjustment to 5-6) due to the catalytic activity of ferrous hydroxide on ferrate(VI) decomposition which may decrease the efficiency of the added ferrate(VI). Slightly lower efficiency is obtained by the addition of a conventional coagulant $AlCl_3$ after the ferrate(VI) treatment, which shows that ferrous hydroxide is more effective coagulant, but also environmentally more favorable because, contrary to conventional aluminum- and chlorine- based coagulants, it produces no toxic by-products.

Table 1 As removal under different conditions

Treatment	As removal, % (without humic substances)	As removal, % (with humic substances)
Fe(VI)	76,33	-
Fe(VI) in two steps	99,0	71,79
Fe(VI)/$AlCl_3$	95,62	95,97

Artificial raw drinking water sample contains, besides As (15,08 μM of As(III)), natural organic matter in the form of humic acid, whose concentration, expressed as the consumption of potassium permanganate, was 10,11 mg/l. Treatment by ferrate(VI) in two steps wherein the As removal was 71,79% and permanganate index decreased to 6,32 mg/l, Figure 3, shows that a large part of ferrate(VI) is spent on the oxidation and a large part of ferrous hydroxide on the absorption of organic material which reduced the overall efficiency of arsenic removal.

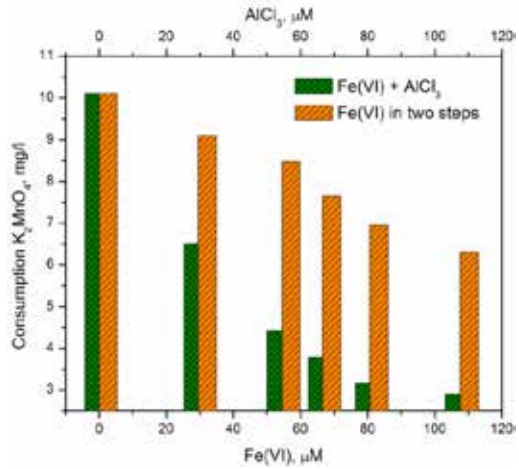

Figure 5 Change of permanganate index in the treatment of artificial water sample with the presence of As and natural organic matter

The addition of coagulant in the form of $AlCl_3$ shows far higher efficiency in As removal, 95,97% and higher reduction of permanganate index, 1,26 mg/l,

because $AlCl_3$ absorb all the material oxidized by ferrate(VI). By applying larger amounts of ferrate(VI) a more efficient removal of As in the presence of natural organic matter could be reached which requires further optimization of the treatment process of raw drinking water by ferrate(VI).

Laboratory plant is applied for the treatment of raw drinking water by ferrate(VI). Raw water was sampled from 4 different locations from the territory of Banat (locations known to the authors), with the initial characteristics given in Table 2.

Table 2. Initial content of As and permanganate index of raw drinking water from various locations

Location 1		**Location 2**		**Location 3**		**Location 4**	
As, mg/l	$KMnO_4$, mg/l	As, mg/l	$KMnO_4$, mg/l	As, mg/l	$KMnO_4$, mg/l	As, mg/l	$KMnO_4$, mg/l
38,66	94,82	1,62	13,91	1,1	38,56	3,57	16,44

The samples of raw water from all locations were treated with two different concentration of ferrate(VI) of 71 μM and 142 μM in the ratio (As : Fe(VI)) = 1 : 5 and 1 : 10. After ferrate(VI) treatment, in each sample was added a coagulant, $AlCl_3$ in a molar ratio ($AlCl_3$: Fe(VI)) = 1 : 1. After filtration and pH adjustment to 6-7 As concentration and the presence of organic matter (permanganate consumption) are analyzed.

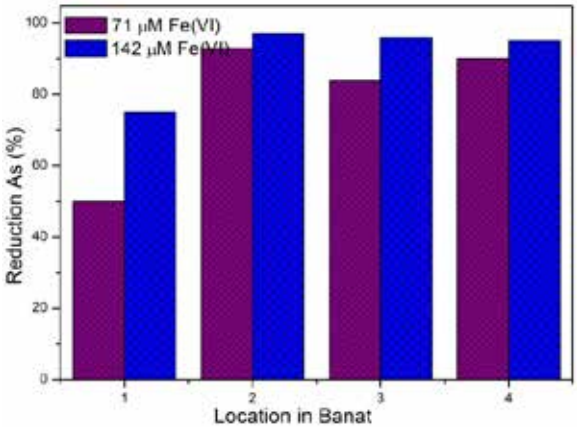

Figure 6 As content in row drinking water from the territory of Banat after treatment by ferrate(VI)

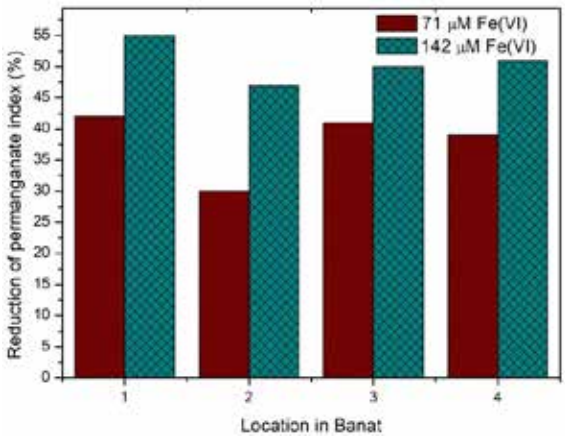

Figure 7 *Percentage of reduction of permanganate index in raw drinking water from the territory of Banat after treatment by ferrate(VI)*

CONCLUSION

Aim of the work to define the procedure for As removal from the raw drinking water by ferrate(VI) is reached. As removal is up to 97%, while permanganate index is close to the statutory limit values (12 mg / l $KMnO_4$). Further optimization of the process would reach the concentration of total As below 10 μg/l which is, according to the Regulations on Hygienic Quality of Drinking Water of the Republic of Serbia, the limit value of arsenic concentration in drinking water.

The application of ferrate(VI) in the treatment of raw drinking water is possible and desirable, due to the high environmental performances of ferrate(VI) in comparison to the oxidants based on oxygen, ozone or hydrogen peroxide and aluminum-based and chlorine-based coagulants. Alternative or pre-treatment to conventional methods, can potentially be the treatment of raw water by ferrate-(VI), which at the same time oxidizes the organic material, and As(III) to As(V), which is far more mobile than As(III) and can be removed from the solution by coagulation and flocculation with the resultant $Fe(OH)_3$ as a slurry.

Acknowledgements

This paper is outcome of survey under projects TR 34025 and TR 31080, funded by the Ministry of Education, Science and Technological Development of Republic of Serbia.

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MICROPLASTICS IN DRINKING WATER: MODE OF ENTRY, DETECTION AND TOXICITY

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Abstract:

The overall scientific conclusion is that, at present, microplastic pollution does not constitute a widespread risk. However scientists also conclude that, if microplastic pollution is left unchecked, business-as-usual would lead to effect concentration thresholds being exceeded in the near future and the occurrence of widespread risk within a century (SAPEA, 2019: 2.8). Three important areas to consider on the subject of microplastics in drinkig water are as follows: (1) what is the evidence of microplastics in drinkig water? (2) how do microplastics enter drinkig water? (3) what are the toxicological implications for humans? We review these issues by presenting the published evidence of microplastics in tap water, bottled water and at intake and outflow of drinkig water treatment plants; discuss the potential routes by which microplastics reach these destinations; address the available evidence of potential impacts of microplastics on humans via drinkig water and provide a preliminary human exposure assessment; and suggest future directions for research and approaches to address emerging concerns.

Key words: microplastik, water, human health, toxicity

Introduction

From the middle of the last century, plastics have been a source of innovation-driven growth due to their unique properties and they hold similar promise for the future. Today, plastics are in high demand and are central to modern living, but their use has become tainted by the unrelenting rise (Geyer R., et al. (2017), and Ryan (2015)) of plastic and microplastic (Iyare et all, 2020) pollution.

Human behaviour is largely responsible for plastic pollution. Sources of microplastic pollution include: textiles, tyres, general waste, products containing microplastics, and equipment/products used in fisheries, agriculture, and industry. Each year, a significant proportion of plastic waste (Plastics Europe, 2018) fragmenting into microplastics enters the environment together with hu-

man-made microplastics. Whilst marine microplastic pollution has attracted the attention of both the public and policy makers, recent reports of the ubiquity of microplastics across the air, soil, sediments, freshwaters, oceans, plants, animals, and parts of the human diet, have amplified concerns. Research on microplastics and their potential threats to the ecosystems and humans is in its infancy and is complex - a lot remains uncertain. Relatively few studies record microplastics in nature at or below the 10-50 micron size range because they are below the detection limit of the most often used analysis equipment. Some experimental studies have shown increasing concentrations of microplastics with decreasing size (Barnes D.K.A. et all 2009) suggesting that actual concentrations in the environment could be higher than those reported to date. Furthermore, toxicity and the relative ease with which microplastics cross biological barriers are expected to increase with decreasing size. This raises further concerns about smaller microplastics, and in particular, nanoplastics.

Growing scientific evidence on the hazards of the uncontrolled, irreversible, and long-term ecological risks due to microplastics do exist for some coastal waters and sediments. Scientists predict that, if emissions to the environment continue at the current rate or increase, ecological risks could be widespread within a century. Since most laboratory studies to date have been conducted for conditions that do not reflect real-world exposure, a better understanding is needed of the effects of different concentrations, compositions, sizes, and shapes of microplastic on ecosystems and humans before robust conclusions can be drawn about real risks.

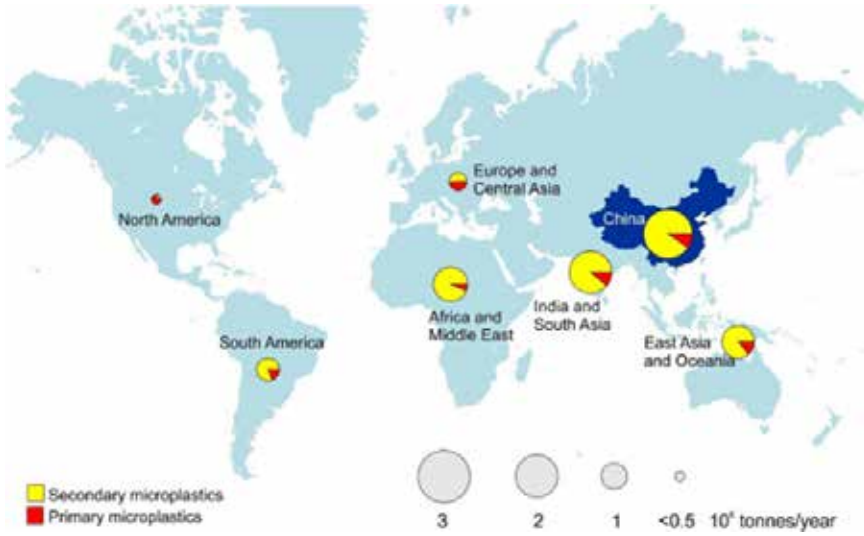

Figure 1. Global shares of major regions in the release of microplastics into the environment, according to data from Boucher and Friot (2017).

Detection of microplastics in water

Microplastics that are not fully retained in sewage sludge or that have not been filtered out during the sewage treatment process will eventually be released into freshwater (Horton et al., 2017). Freshwater bodies are the main drinking water sources for human consumption, which are thus suspected as potential exposure sources of microplastics to humans (Novotna et al., 2019). For primary microplastics, the main sources in freshwater are the ones with industrial origins in plastic resin powder, pellet spillage from air blasting machines, microbeads present in personal care products, as well as raw materials used to produce plastic products (Eerkes-Medrano et al., 2015; Horton et al., 2017). In addition, secondary microplastics, which originate from the breakdown of large plastic debris, can also settle in freshwater. Many factors affect the migration or transport of microplastics in freshwater, including the water body size, wind, currents, and particle density (Eriksen et al., 2013; Fischer et al., 2016; Free et al., 2014). Moreover, urbanization, proximity to a dense human population, water retention time, proximity to urban centers, type of waste management, and sewage spillage could also influence the number of microplastics present in aquatic systems (Horton et al., 2017; Moore et al., 2011; Zbyszewski and Corcoran, (2011). Additionally, the waste water treatment plants (WWTPs) could potentially release microplastics to the environment (Browne et al., 2011). It was reported that the typical removal percentage of microplastics in a WWTP without tertiary treatment was around 88%, which increased to over 97% with the assistance of tertiary treatment (Sun et al., 2019). Although WWTPs could trap plastic fragments in oxidation ponds or sewage sludge, a very large number of microplastics are still released into aquatic water bodies (Okoffo et al., 2019; Sun et al., 2019).

When plastic fragments enter an aquatic environment, these fragments will be quickly colonized by a microbial biofilm composed of bacteria, fungi and algae (Hoellein et al., 2014). The formed biofilm could significantly change the physical and chemical properties of microplastics (e.g., buoyant density, surface charge) and could play an important role in the transport and fate of microplastics in aquatic environments. For example, biofilm is an important food source for higher trophic organisms (e.g., fish) (Hall and Meyer, 1998). After colonization by microbes to form biofilms, these plastic fragments may be swallowed by fish, and their fate in freshwater will be thus changed. Microplastics were detected in freshwater and the sediment of different lakes and rivers all over the world. The occurrence of microplastics in freshwater and sediment varied among different regions. In the freshwater systems of China, the concentration of microplastics ranged from 1597 to 12,611 particles m^{-3} in surface waters, and from 25 to

300 particles m^{-3} in sediments (Three Gorges Reservoir, China) (Di and Wang, 2018); the abundance of microplastics of Dongting, China was between 617 and 2316 particles m^{-3} in surface water, and between 200 and 1150 particles m^{-3} in sediment (Jiang et al., 2018). In the Carpathian basin of Europe, the concentrations of microplastics ranged from 3.52 to 32.05 particles m^{-3} in surface water, and from 0.46 to 1.62 particles m^{-3} in sediment (Bordos et al., 2019). Generally, the microplastics concentrations in freshwater and sediment in China are higher than in other countries, which is associated with China's rapid economic development in recent decades. In addition, the microplastics concentrations in sediment are much higher than that in water, as microplastics settle in freshwater systems, and sediments are the major sink of microplastics in rivers (Wang et al., 2017a). Moreover, in some areas (e.g., Three Gorges Reservoir, China; Antua ˜River, Portugal), the microplastics concentrations in freshwater even exceed the concentrations in marine environments (Di and Wang, 2018; Rodrigues et al., 2018). These studies also show that there is a certain spatial relationship between the microplastics concentration and the levels of human activity, as shown in the surface water concentration difference between Lake Ulansuhai of China and Lake Kallavesi of Finland as well as in sediment concentration difference between the Carpathian basin of Europe and Lake Ontario of Canada (Ballent et al., 2016; Bordos ´ et al., 2019; Uurasj¨arvi et al., 2019; Wang et al., 2019c). It is noted that separation methods (e.g., pore size of meshes, types of filters) and analytical instruments (e.g., micro-Fourier Transform Infrared spectroscopy, micro-Roman spectroscopy) used can highly influence the obtained results.

Methods and results of microplastic detection

MP particles were reported to be present in different environmental systems including aquatic ecosystems (marine and limnic) as well as in the food web (Klein S et all, 2015; Rummel CD et all, 2016). Employing different sampling, sample preparation, and detection methods, the most frequently detected polymer types are PE, PP, and PS. The frequency of findings correlates well with the production volumes of the detected polymers. PE (30%), PP (19%), PVC (10%), and PS (7%) account for almost two thirds of the European polymer production in 2016.

The extraction and detection methods of Liebezeit and Liebezeit 2014, were used for particle ategorization; unidentified particlesdtermed 'anthropogenic ebris'doccurred in 81% of the 159 globally sourced samples. The term 'anthropogenic debris' was applied because particle composition was not tested by infrared spectroscopy. Samples collected on a cellulose filter were stained with Rose Bengal, and non-stained materials were counted under a dissecting

microscope. The highest and lowest mean concentrations occurred in tap water samples from the US (9.24 ± 11.8 particles/L) and Germany (0.91 ± 1.29 particles/L). Developed nations had higher average particle densities than less--developed nations ($p < 0.05$). Most particles were fibres (98%) with size range 0.10-5.00 mm.

Microplastic have conclusively been identified in bottled water (Schymanski et all 2018, Oßmann et all 2018) and in samples collected at drinking water treatment plants (DWTPs) (Pivokonski et all 2018). Two studies investigating the presence of microplastics in bottled mineral water detected size ranges unattainable by previous methodology (micro-Fourier transform infrared spectroscopy, m-FT-IR). Their use of micro-Raman spectroscopy conclusively identified polymers down to 5 mm (Schymanski et all 2018) and 1 mm size (Oßmann et all 2018). Both studies tested DW from multiple types of packaging (e.g. glass, single use plastic bottles, returnable plastic bottles and everage cartons) and found microplastics in DW from all container types, with highest average particle counts in samples from reusable plastic bottles. The respective counts were 118 ± 88 particles/L (Schymanski et all 2018) and 4889 ± 5432 particles/L (discounting an outlying particle count from a glass bottle (Oßmann et all 2018)). Small particle size fractions dominated in both studies: w80% of particles 5-20 μm and over 90% of particles < 5 μm.

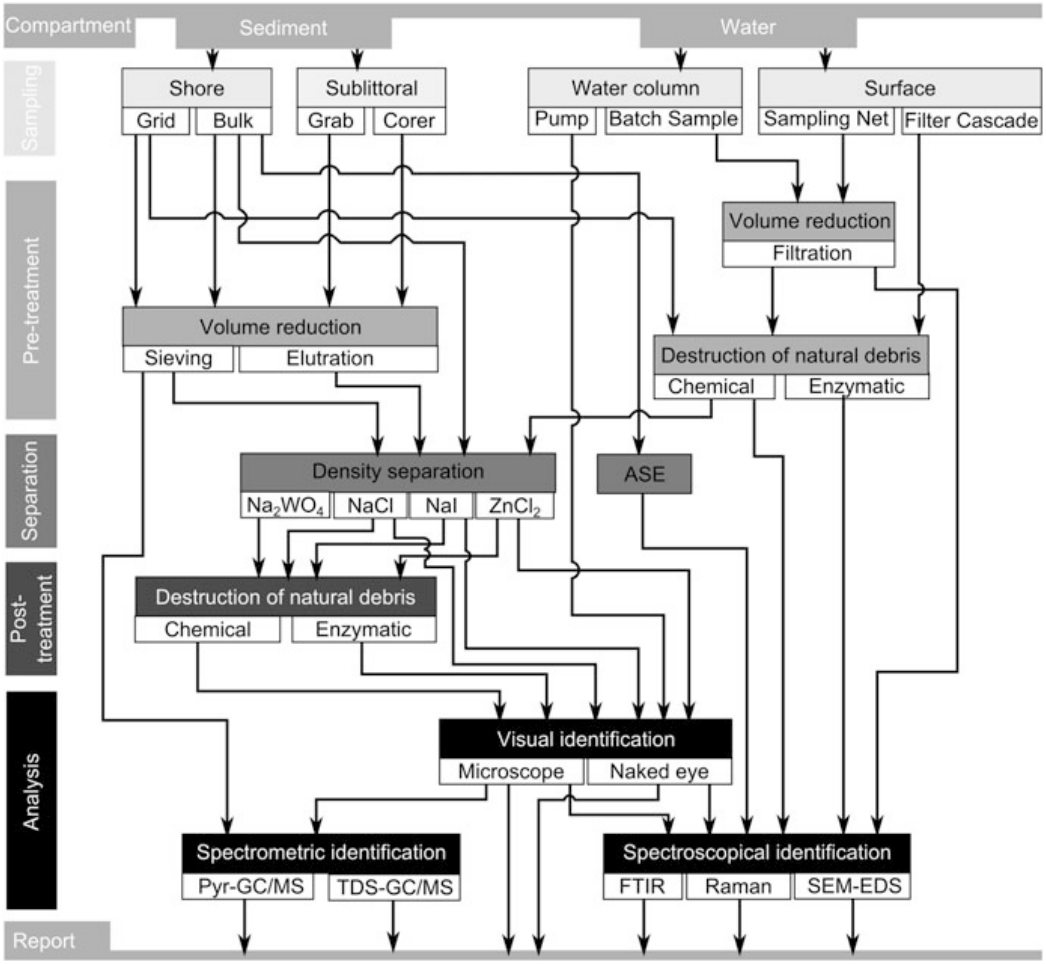

Fig. 2 Possible strategies described in literature for the analysis of microplastics in sediment and water samples starting with the sampling to the report of the results. The sample preparation is split in pretreatment, the density separation, and the posttreatment of the separated microplastics. Fourier transform infrared spectroscopy (FTIR), scanning electron microscopy energy-dispersive X-ray spectroscopy (SEM-EDS), pyrolysis- or thermal desorption-gas chromatography/mass spectrometry (Pyr-GC/MS, TDS-GC/MS) are deployed for the analysis (Klein S, et all, 2018)

Potential human health risks of microplastics

Plastic is considered an inert material; however, there are pathways through which microplastics could cause harm, such as the deposition of PVC granules

causing embolization of small vessels in animals following long-term oral administration (Volkheimer, 1975). Size, shape, solubility, and surface charge all influence the cytotoxicity of particles to cells and tissues in vivo (Nel, 2006). Regarding physical effects, the biopersistence of microplastics could lead to a suite of biological responses including inflammation, genotoxicity, oxidative stress, apoptosis, and necrosis. If these conditions are sustained, a range of outcomes can ensue including tissue damage, fibrosis and carcinogenesis. Chemical effects could establish due to the composition of the polymer itself; the leaching of unbound chemicals and unreacted residual monomers; or the desorption of associated hydrophobic organic contaminants (HOCs). These are often priority pollutants with known human health effects.

The cellular uptake of microplastics would allow adhered or ndogenous contaminants cellular entry (Khan et all 2015). Inhalation exposure studies have previously demonstrated that oxidative stress and subsequent inflammation presents the best paradigm for particle toxicity.

Oxidative stress due to challenge with nanoparticles including PM, quartz, and TiO2 results in airway inflammation and intestinal fibrosis (Nel, 2006). A similar mechanism of toxicity may be observed for micro- and nanoplastics due to their small size and therefore large surface area for functional sites.

All plastics contain reactive oxygen species (ROS) due to their polymerization and processing history. However, the concentration of ree radicals can significantly increase following interaction with light or the presence of transition metals. The weathering of plastics and microplastics leads to free radical formation by the dissociation of the C−H bonds. The free radicals continue to react and therefore may pose danger. Termination of these free radical reactions is achieved through the reaction of pairs of ROS or oxidation of a target substrate, such as tissues (White et all 1994).

CONCLUSION

Firstly, toxicity is expected to increase with decreasing plastic particle size (Jeong et al., 2018) because of the increase in surface-to-volume ratio, in terms of releasing toxic additives from the plastic matrix and potential adsorption and concentration of toxic substances from the surrounding environment (Rios Mendoza, Karapanagioti, & Álvarez, 2018).

Secondly, the ease with which plastic particles can be absorbed by biota also increases with decreasing size. For example, for mammalian bodies, 150

μm33 marks an approximate threshold below which limited systemic absorption (≤0.3%) into the body occurs with progressive ease via inhalation and ingestion (Wright & Kelly, 2017), with the sub 1.5 μm size fraction possibly penetrating deeply into organs and those ≤ 250 nm potentially translocating across loodbrain and placental barriers (EFSA Panel on Contaminants in the Food Chain (CONTAM), 2016).

Thirdly, it may mean that effect threshold concentrations used in quantitative risk characterisation may already have been reached or surpassed in different environmental compartments, though analytical techniques are not yet available to prove or disprove this.

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INNOVATIVE TECHNOLOGIES IN FREE FORM GLASS ARCHITECTURE

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Abstract

Constructing increasingly complex free form shapes is interpreted from the architecture aspect as an expression of freedom and dynamics of architectural expression and usually tied for the expression of modern tendencies in a given historical moment. The overall objective of the presented research is to collect data on the new design technologies on cold bended glass envelope cases. The investigation is focused on new method of curved glass fabrication to bring it into the right shape with a special focus on production process of different geometries, also taking into consideration different glass types: monolithic, laminated safety or insulated glass. This new method is on the first view very easy but very complex in the detail and includes the special glass shaping technique of cold bending by lamination and cold bending by assembling.

Keywords: complex envelope forms, curved glass, cold bending.

INTRODUCTION

In last decades a tendency of an increasing number of in building projects built-in geometrically complex envelopes could be noted. Application of glass is a compulsory part of such projects throughout the world. In terms of the geometry of the glass envelope surface, today, there are no limitations in the process of their modeling. In fact, architectural practice continuously followed the development of the geometry, and many architectural trends were inspired by the latest developments in this field. Constructing increasingly complex curved shape is interpreted from the architecture aspect as an expression of freedom and dynamics of architectural expression and usually tied for the expression of modern tendencies in a given historical moment. The word "free form" says it is possible to create new forms, if the architects and designers are familiar with the geometry of basic geometrical forms, as well as with all elements of geometry.

The overall objective of the presented research is to collect data on the new design technologies on cold bended glass envelope cases. The investigation is focused on new method of curved glass fabrication to bring it into the right shape with a special focus on production process of different geometries, also taking into consideration different glass types: monolithic, laminated safety or insulated glass. This new method is on the first view very easy but very complex in the detail and includes the special glass shaping technique of cold bending by lamination and cold bending by assembling. All these facts point to the need for more investigations in this field.

MATERIAL AND METHODS

This paper discuss in detail new innovative technologies of glass shaping in free form glass architecture. Therewith, the comparison of two cold bending shaping techniques in relation to the ability of getting desired form, the variability of the structural characteristics of glass and consequently the design of glass envelopes, as well as the manufacturing constraints that compared to the flat glass differs considerably, is shown. This shaping technique primarily affect the mechanical characteristics of the final glass element, but also determine the minimum and the maximum production characteristics, the visual quality and the possibility of applying further processes and processing. In order to maximize the benefits of cold bending technique, engineers should be familiar with all constraints regarding the form, strength, dimensions and possibilities of applying different surface treatments and finishing, which are imposed by different processes.

Cold bending technique for free form glass shaping

Recent examples of the use of new technique – cold bending open up possibilities for the application of double curved, toughened and laminated glass panel in order to create glass shell which optical and technical quality meet the requirements for a smoothly curved, transparent surfaces of the building envelopes (Figure 1).

a)  b) 

c) 

Figure 1 Cold bent glass applications (by assembling): a) Victoria & Albert Museum, London; b) Train Station TGV, Strasbourg; c) Bus Station – Zuidpoort, Delft

RFR Company from Paris was among the first to notice the possibilities of a new way of glass shaping since the early 1990s. Unlike traditional (thermal bending), the new technique can significantly improve aesthetic quality, reduce the total cost of curved glass application, but also enable the use of heat-strengthened and toughened (safety) glass of characteristically strength, as well as almost all coatings and films. The main advantage of cold bending techniques is elimination of visual distortions and unchanged physical properties of glass because, unlike thermal bending, there is no change in structure of glass but only in its shape. By this technique is possible to achieve a smooth, distortion free, curved surfaces using each type of glass. However, the main limitation of this process is allowable curvature which has to be considered especially for each project. The decision on design should be made at an early stage following the basic steps (Figure 2).

Cold bending technique uses advantages of the linear elastic deformation of the glass, thanks to the low modulus of elasticity - about 70.000 Mpa (Feldmann, M., Kasper, R., ..., 2014, p. 116). The process itself is based on the prestressed state of tempered glass. Stresses due to cold bending are superposed with residual stresses (prestressing state) and theoretically can compensate the tensile stresses of toughened glass completely.

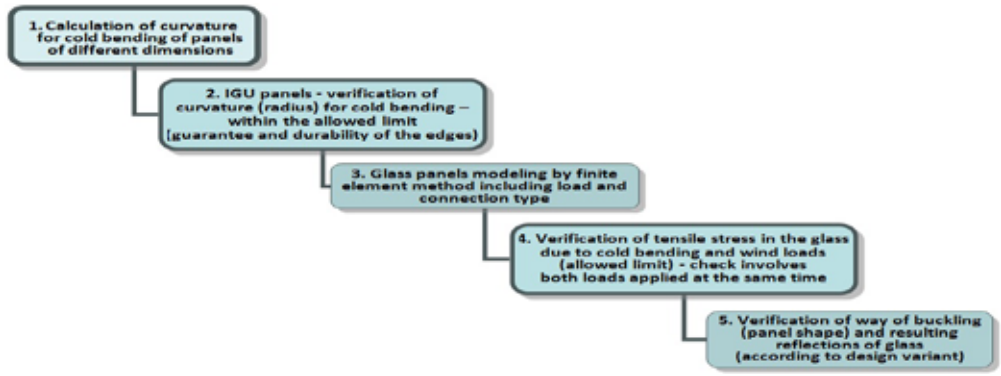

Figure 2 Procedures (steps) in process of cold bending of glass

Although in practice is difficult to apply a constant bending moment to a glass panel, it is possible to create a single curvature according to the static scheme of console beam with a force at the end, or by creating two overhangs and force at both ends. Double curved shape can only be achieved by applying force simultaneously to as many points on both sides of the panel, as otherwise the glass panel tends to return to a single curved shape. Values of stresses and strains in relation to the variations of thickness and bending radius, as well as to ratio of length and width of panels, can be verified by combination of numerical and analytical analysis (Fildhuth & Knippers, 2009). This implies that the curvature depends on glass thickness and possible tensile stress on the surface.

Double curved glass envelope can be created by joining of single curved elements along one of the two directions of main curves, while the glass is curved along other direction ('torsa' geometry). In this case, even small angular deviations can be seen due to the light reflection of the glass surface. On the other hand, the application of quadrilateral panels on a geometrically complex shape has aesthetic and economic advantages. This usually implies one of the four angles out of plane (geometry of negative Gaussian curve), causing a twisted deformation of the glass panel ('hypar' surface). This results in characteristics of the membrane - tensile force along the edges and pressure force around the center of the curved panel.

The study of the principles of cold twisting of glass panels, carried out during 2003, resulted in Staaks theory. In the Octatube lab, it was found that glass panels can be elastically twisted in a way to deform symmetrically creating a 'hypar' surface, as long as the deformation (deviation of one angle from the plane) is less than 16(x) thickness of the panel. A larger twisting will cause de-

formations that will result in single curve bending along a shorter diagonal axis. Generally, deformation of 50-100 mm/m2 of panel width is possible using toughned glass (Eekhout & Staaks, 2012). In adition, it should be taken into account that the glass is only part of the glazing system, since cold bending affects the stresses of various components. Therefore, it is necessary to perceive each component behaviour during the bending process, such as glass, silicone seals, window spacers, interlayers, frames and air.

In order to provide a unique aesthetics and savings enabled by this shaping process, two basic techniques of cold bending of glass are used: Cold bending by assembling (mechanically on site / in factory), and Cold bending by lamination (in autoclave / vacuum bag).

Figure 3 Process of cold bending of glass - on the substructure, in the factory (Molter & Wolf, 2011).

Cold bending by assembling (mechanically)

Flat glass panels can be curved directly at the construction site during assembly process. Due to applied power and depending on the resistance, the glass is mechanically bent by external contact pressure, by pushing or pulling the edges or corners to achieve desired bulge or curvature (Figure 3). Holding the glass in desired shape is achieved by fixing (clumping strips) for the substructure.

Two different types of curvature can be created:

- Bending into a cylindrical shape (single curvature – 'torsa' geometry), when adjacent two edges are always parallel and two are curved (Figure 4a),
- Twisting into a double curved form ('hypar' geometry), when one corner is lift from the plane while the edges remain flat but not parallel (Figure 4b).

Figure 4 Process of cold bending of glass: a) Symmetric external contact pressure to achieve single curvature and b) Asymmetric external contact pressure to achieve double curvature - Bending by assembling; c) Bending by lamination (Neugebauer, Penkova & Iliev, 2013)

Cold bending by lamination

Another way of retaining the form can be achieved through simultaneous bending and lamination process of glass plates by a rigid interlayer (Figure 4c). Seele Sedak company has played a crucial role (Neugebauer, Penkova & Iliev, 2013) in development of this new glass bending technology by the laminating process, which involves a rigid bond between glass and interlayer in order to produce extremely large, curved panels. Cold bending, achieved by a lamination process comprising the following steps: putting together interlayers and flat glass, usually tempered; achieving the desired shape by physically pressing it onto the substructure and clamping into place; laminating to achieve a high shear bond in autoclave (appropriate temp. and press. of 1.2 MPa) or in vacuum bag (appropriate press. of 0.07-0.09 MPa) (Neugebauer, Penkova & Iliev, 2013); releasing from the substructure, hardening of intermediate layer and establishment of shear resistance, neccessity of high quality control due to'spring back' effect. The final state of deformation will be achieved depending on the properties of shear resistance of the interlayer. By this method is possible to create double curved forms whose radius range from 17 m to 40 m, depending on panel dimensions, form and the applied technique. Smaller dimensions allow for greater curvature. The max. panel dimensions are 14.00 m x 2.80 m (Fildhuth & Knippers, 2009).

Technological parameters of glass shaping by cold bending

In order to maximize the benefits of the applied process of cold bending glass shaping, it is necessary to consider different technological parameters related to possibilities and limitations in terms of form, dimensions, strength of glass, possibilities of applying different coatings, as well as the appearance of visual defects on the glass surface such as: optical distortion, anisotropy and

distortion due to reflection. Those indicators, defined and presented in Table 1, have to be considered in assessment of buildability of designed systems, during development phase of detailed project design (Kosić, 2016, p. 282).

Table 1 Technological parameters (possibilities and constraints) of cold bending glass shaping technique

Technological parameters (possibilites and constraints) of cold bending glass shaping technique				
Process			**Cold bending**	
			By assembling (mechanically)	**By lamination**
Form and Dimensions		**Single curved glass**	+	+
		Double (complex) curved glass	+ (except surface with a negative curve and curved edges)	+ (Research in progress)
		Maximal panel dimensions (cm) (width x length x deflection)	330 x 1,500	330 x 1,500
		Maximal radius of curvature (cm)	/	/
		Minimal radius of curvature (cm)	500 (tickness 3 mm) 900 (1,000) (thickness 6 mm) $r_{allow.} = E \cdot z / \sigma_{allow.}$	500 (tickness 3 mm) 900 (1,000) (thickness 6 mm) $r_{allow.} = E \cdot z / \sigma_{allow.}$
		Maximal deviation from the plane (cm)	< 16.8 x glass tickness	< 16.8 x glass tickness
		Tolerances (mm) (in terms of width, lenght and form)	/	/
Type/Strength of Glass		**Float glass**	+	+
		Heat-strengthened glass	+	+
		Toughened glass	+	+
	Further Processing	**Laminated glass**	+	+
	Further Processing	**Termo insulating glass**	+	+
Coating/Film		**Soft coatings**	+	+
		Hard coatings	+	+
		Ceramic coatings (colour)	+	+
Disantva-ntages		**Anisotropy**	+	+
		Optical distortion	–	–

RESULTS AND DISCUSSION

It is obvious that the application of geometrically complex glass envelopes will increase in the future. The modern technique of curved glass shaping by the cold bending process, which has not been applied in Serbia so far, is a solution in according to the physical characteristics of glass, while contributing significantly to economic efficiency, prevention of visual problems of glass surface caused by thermal bending and possibility of applying most coatings and films. By cold bending is possible to create models of a glass envelope whose geometry is represented by:

- 'hypar' (hyperbolic paraboloid – double curved), and
- 'torsa' (single curved) surfaces of individual glass panels.

Defined technological parameters of possibilities and limitations of the glass shaping by cold bending can be used as a basis for determination of the form, dimensions, strength, possible coatings and visual characteristics of curved glass in relation to the particular cold bending shaping technique.

CONCLUSION

New cold bending technique provides opportunities for the application of double and single curved glass panels in order to realize geometrically complex form of glass envelope, given that achieved optical and technical qualities fulfill the requirements for smooth curved and transparent surfaces in buildings. The envelope design development must be carefully assessed since the early step including also selection of appropriate shaping technique. Finally, the production of quality glass curved envelopes obtained by a cold bending must include communication and collaboration among all participants (engineers, manufacturers and assemblers). However, cold bending will not completely replace thermal bending, since only a small curvature/large radius is possible.

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CONCEPTUAL BUILDING DESIGN BASED ON LIFE CYCLE ANALYSIS

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Abstract

Optimum design of an energy efficient building has to meet two confronted demands – to obtain the lowest possible environmental effects at an acceptable total price of construction, equipment and maintenance during the entire life cycle. In order to solve this hard combinatorial problem, it is necessary to implement adequate optimization tool that would provide sufficiently wide range of possible solutions within a reasonable time. The aim of presented study was to explore possibilities of using hybrid Big Bang – Big Crunch algorithm in an energy efficient building design as well as to emphasize the importance of including the life cycle analysis in calculus. Pareto front obtained in presented case study consists of three discrete areas, two of which refer to confronted fitness functions (minimal cost and minimal environmental impact), while the third one represents the intermediate (compromise) solutions. This feature might enable designers to take different possibilities into consideration in order to make adequate decision about the optimum design that would meet both the economic and environmental demands.

Keywords: optimum structural design; multi-objective optimization; energy efficient building; life cycle analysis; Big Bang – Big Crunch algorithm

INTRODUCTION

In terms of sustainable development, the main objective in building optimization is to reduce energy consumption and environmental impact while achieving acceptable total life-cycle cost of a given building. These two objectives are often conflicted because the more energy-efficient is building, the more expensive tends to be its construction. Because of that, there is no unique, "best" solution for this problem, but a wide range of acceptable solutions among which a designer or stakeholder should be able to choose one that would provide satisfactory compromise between environmental and economic performance. During

the conceptual design stage, numerous potential alternatives are generated and evaluated in order to find the most promising solutions (Mendler and Odell, 2001; Miles et al., 2001). Changing and recombining different construction characteristics and parameters such as shape, orientation and envelope configuration can result in lowering the energy consumption up to 40 % (Baker and Steemers, 2000; Cofaigh et al., 1999).

Life cycle analysis (LCA) is another important issue in the sustainable buildings design. The embodied energy represents a large portion of the life cycle energy, sometimes as much as 30–60 % (Dodoo et al., 2011; Gustavsson and Joelsson, 2010), as well as a significant contribution to the total life cycle greenhouse gases emissions (Sharma et al., 2011). Because of that, evaluating energy savings only for the operation phase of the building's life can be deceiving (Blengini and Di Carlo, 2010). For those reasons, LCA can be problematic issue, especially for passive and low energy design and it is necessary to include both the proper LCA method and the optimization approach in design of high performance buildings.

Complexity of the problem and large number of different construction characteristics and positional and structural parameters that should be taken into account as variables indicate that conventional trial-and-error approach is not appropriate for solving this NP-hard combinatorial problem (Wang et al., 2005) and that it should be solved using some appropriately chosen multi-objective optimization technique.

MATHEMATICAL FORMULATION

Two objective functions to be minimized in this research were the life-cycle cost (LCC) and the life-cycle environmental impact (LCI) (Wang et al., 2005):

$$MIN: LCC_{(X)} = ICC_{(X)} + OC_{(X)} \tag{1}$$

$$MIN: LCI_{(X)} = EIC_{(X)} + EIO_{(X)} \tag{2}$$

where *ICC* is the initial construction cost ($); *OC* is the total worth of life-cycle operating costs ($); *EC* is the environmental impact (MJ) due to building construction, and *EO* is the environmental impact (MJ) due to the building operation for heating, cooling, lighting and other similar processes (MJ).

Variables considered in this research can be grouped in three categories: geometry, position and structure. Geometry of a building is defined by its shape and dimensions. In this study, building is limited to a rectangular shape with fixed floor area and floor-to-roof height. The both dimensional variables (a and b) are incorporated into one continuous variable called *Shape Ratio* (a/b). Spatial position of the building is defined by the orientation angle between true North and side a. Structural variables are oriented to the envelope structure and include windows type, windows size (window-to-wall ratio) for each façade and type and thickness of insulation layer in walls and in roof. Every set of these parameters represents one possible solution, i.e. one potential building design.

Problem defined by the fitness functions (1) and (2) is a multi-objective optimization problem with conflicting criteria. Consequently, there is no one optimal solution but a whole set of acceptable solutions called Pareto solutions or Pareto front. A solution is Pareto optimal if and only if it is not dominated by any other solution in the search space. Analysis of the whole Pareto front provides useful information on trade-off relationship between the fitness functions and enables a decision maker to consider different alternatives and make a choice that would represent acceptable compromise for conflicting objectives. In hard combinatorial problems such as this one it is impossible to conduct thorough search for Pareto solutions within the whole search space without appropriate optimization tool.

The BB-BC algorithm is an evolution algorithm introduced by Erol and Eksin (Erol and Eksin, 2006). This method has proven to be more effective than other population-based methods because it provides lower computation time and higher convergence speed (Kaveh and Talatahari, 2009) and it has been applied in many areas, including power systems (Deihimi and Solat, 2014), design and optimization of space trusses (Kaveh and Talatahari, 2009; Camp, 2007), the airport gate assignment problem (Genc et al., 2009) and genetic programming classifier design (Dogan and Istefanopulos, 2007).

CASE STUDY

Proposed approach will be illustrated by the design of a single-story office building in Belgrade, Serbia. The heating season is from November to March while the cooling season is from June to September. The indoor temperatures are set to 22°C for heating and 23°C for cooling, without night setback or setup. A period of 30 years has been taken for life-cycle analysis for building performance.

The building has fixed total floor area of 1000 m^2 and floor to roof height 3.5 m. The floor is rectangular and its sides ratio (a/b) is continuous variable called *Shape Ratio*. Spatial position of the building is defined by the variable *Orientation*, i.e. the angle between true North and bottom side a.

The structural system consists of concrete frame with concrete block walls, cast-in-place concrete slab as a floor and compact conventional roof. Walls consist of cladding (brick veneer), air space (20 mm), rigid insulation (variable *WI*), vapour barrier (polyethylene, 6 mm), concrete block and finish (gypsum, 12.7 mm), while roof consists of ballast, roofing membrane, insulation (variable *RI*), structure and finish. Only the insulation layers in walls and roof are optimized because other layers have no significant impact on two considered performance values [46]. The rigid insulation can be expanded polystyrene (EPS) or extruded polystyrene (XPS) with different thicknesses, as follows: 76 mm EPS (*Ins1*); 102 mm EPS (*Ins2*); 127 mm EPS (*Ins3*); 76 mm XPS (*Ins4*); 102 mm XPS (*Ins5*); and 127 mm XPS (*Ins6*).

Four window types (variable W) are available: double clear glazing (W_1); reflective double glazing (W_2); low-e double glazing with a coating with emissivity 0.2 on the exterior of the inside pane (W_3); and low-e double glazing with a coating with emissivity 0.2 on the interior of the outside pane (W_4). Window-to-wall ratio for each façade (variable WW_i, $i = 1,\ldots4$, counting clockwise from bottom side a) is between 0.2 and 0.8. All variables and their types and ranges are presented in Table 2.

Table 2. Variables details

Variable		Type	Range or value
a/b	Shape Ratio	Continuous	[0.1, 1.0]
W	Window Type	Discrete	(1, 2, 3, 4)
WW_1	Window-to-wall ratio 1	Continuous	[0.2, 0.8]
WW_2	Window-to-wall ratio 2	Continuous	[0.2, 0.8]
WW_3	Window-to-wall ratio 3	Continuous	[0.2, 0.8]
WW_4	Window-to-wall ratio 4	Continuous	[0.2, 0.8]
WI	Wall insulation	Discrete	(1, 2, 3, 4, 5, 6)
RI	Roof insulation	Discrete	(1, 2, 3, 4, 5, 6)

Solutions from the best obtained Pareto front are listed in Table 3, arranged in increasing order of life-cycle cost, and presented in Figure 1. Pareto front and

distribution of the variables can be approximately divided into three zones: *A*, *B* and *C*. Points in zone *A* have lower cost but greater environmental impact, points in zone *C* have lower environmental impact but higher cost, while solutions in zone *B* have intermediate values for both criteria.

Table 3. Pareto solutions obtained by the BB-BC algorithm

№	*a/b*	*W*	WW_2	$WW_{1,3,4}$	*WI*	*RI*	LCC (10^5\$)	LCI (10^7MJ)	Pareto zone
1.	0.989	W_1	0.20	0.2	1	1	3.652	4,398	
2.	0.877	W_1	0.20	0.2	1	1	3.657	4,378	
3.	0.801	W_1	0.20	0.2	1	1	3.661	4,365	
4.	0.729	W_1	0.20	0.2	1	1	3.666	4,340	
5.	0.956	W_1	0.22	0.2	1	2	3.668	4,309	
6.	0.862	W_1	0.24	0.2	1	2	3.672	4,275	A
7.	0.747	W_3	0.25	0.2	3	2	3.679	4,229	
8.	0.688	W_3	0.28	0.2	1	2	3.684	4,222	
9.	0.798	W_1	0.29	0.2	3	2	3.689	4,186	
10.	0.976	W_3	0.30	0.2	3	3	3.694	4,132	
11.	0.961	W_1	0.31	0.2	3	3	3.705	4,105	
12.	0.955	W_3	0.34	0.2	3	3	3.731	4,065	
13.	0.841	W_3	0.36	0.2	3	3	3.740	4,025	
14.	0.795	W_3	0.41	0.2	3	3	3.746	3,988	
15.	0.697	W_3	0.45	0.2	3	3	3.751	3,965	
16.	0.927	W_3	0.54	0.2	3	4	3.754	3,924	B
17.	0.811	W_3	0.63	0.2	3	4	3.761	3,915	
18.	0.769	W_3	0.63	0.2	3	4	3.776	3,900	
19.	0.954	W_3	0.65	0.2	6	4	3.792	3,890	
20.	0.966	W_3	0.67	0.2	3	5	3.815	3,875	

21.	0.878	W_3	0.72	0.2	3	5	3.882	3,830	
22.	0.898	W_4	0.75	0.2	6	5	3.906	3,815	
23.	0.943	W_3	0.80	0.2	3	6	3.934	3,801	
24.	0.922	W_4	0.80	0.2	6	6	3.943	3,790	
25.	0.810	W_4	0.80	0.2	6	6	3.958	3,777	
26.	0.747	W_4	0.80	0.2	6	6	3.967	3,751	C
27.	0.729	W_4	0.80	0.2	6	6	3.987	3,738	
28.	0.702	W_4	0.80	0.2	6	6	3.993	3,731	
29.	0.693	W_4	0.80	0.2	6	6	3.998	3,730	
30.	0.636	W_4	0.80	0.2	6	6	4.004	3,729	
31.	0.612	W_4	0.80	0.2	6	6	4.014	3,728	

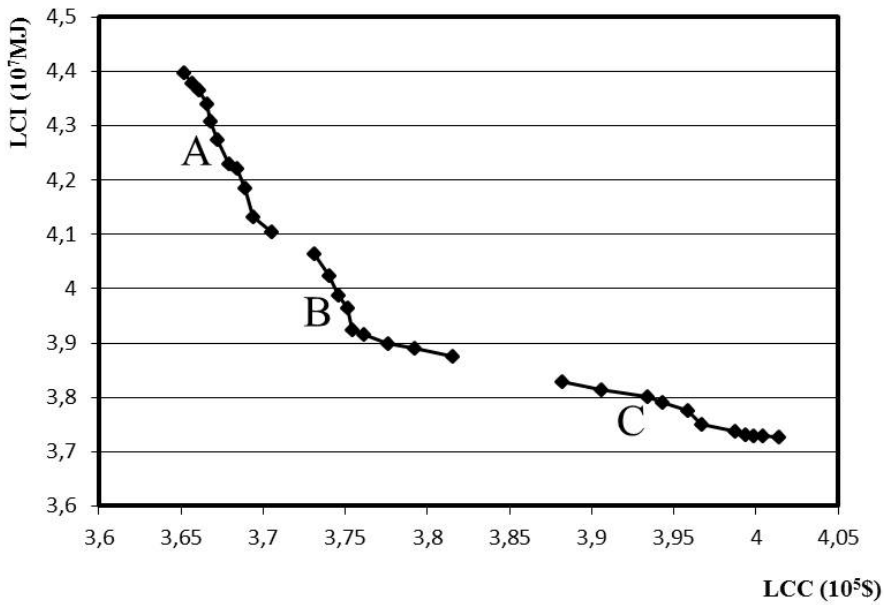

Figure 1. Pareto front obtained by HBB-BC2

Window-to-wall ratio (*WWi*, i = 1,…,4) changes only for the southern wall, while for other three walls remains constant with minimal value of 0.2. It can be observed that window-to-wall ratio for the southern wall changes much slower in zones *A* and *C* and shows more emphasized growth in zone *B*. Shape ratio (*a/b*)

takes different values between 0.612 and 0.989 and it can be observed that more compact building shape might be favourable for cost reduction, while elongated shape with longer southern and northern walls has better performance considering environmental impact. Better insulation increases the cost and lowers the environmental impact, but changes in walls insulation (*WI*) and roof insulation (*RI*) show different behaviour along the Pareto front. While roof insulation increases gradually, taking all six possible values in a more or less steady manner, walls' insulation shows tendency of changing more slowly and discontinuously. Majority of Pareto optimal solutions has windows with low-e double glazing on either exterior of the inside pane (W_3) or interior of the outside pane (W_4). Double clear glazing (W_1) can be found near extreme solutions in zone *A*, i.e. in designs with lower cost and higher environmental impact, while windows with reflective double glazing (W_2) are not included in any solution in Pareto front.

CONCLUSION

Presented interpretation of results shows that obtained Pareto front offers good insight in interdependence between individual design features and confronted objectives and enables a designer and/or a decision-maker to conduct a thorough analysis that would lead to an optimum design considering given demands and restrictions.

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CIRCULAR ECONOMY IN THE FUNCTION OF SUSTAINABLE DEVELOPMENT OF SERBIAN ECONOMY

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Abstract:

Demands for constant and, as high as possible, economic growth, put a strong pressure on the environment and leave numerous negative consequences on the sustainability of development, natural resources and the health of the population. Therefore, new ways of economic development, which take into account numerous qualitative indicators, bearing in mind the long-term perspective while achieving economic, environmental and socio-political principles and goals, are necessary. One of the instruments that achieve the goals of sustainable development is the concept of circular economy, whose application enables raw materials and energy efficiency, uses more renewable sources and protects the environment. By applying the concept of circular economy, Serbia can take advantage of numerous comparative advantages of its economy and increase its efficiency and competitiveness in international relations. The aim of this paper is to point out to economic policy makers the need for consistent and faster implementation of the concept of circular economy in order to enable sustainable economic development of the country.

Key words: circular economy, sustainable development, economic policy, Serbia

INTRODUCTION

Population growth, increasing limitations of natural resources, uneven development of individual countries and other problems of modern civilization have forced humanity to seriously address the issue of sustainable development in all its domains: economic, environmental, social and others. Adapting to the new requirements will temporarily slow down economic growth, but in the long run, such an approach will have positive effects because it will result in a better

quality of life and economic development. Sustainable development issues are addressed, among others, by the European Commission, which in 2015 adopted a legal framework that encourages the transition of the economy to a circular economy, with the aim of strengthening and modernizing the economy, increasing its competitiveness and ensuring long-term sustainable growth.

In the Republic of Serbia, there are negative development trends, which intensified after the economic crisis in 2008. They are accompanied by the departure of young educated staff abroad, migration to large regional centers and increasing inequality in economic development. The concept of circular economy is one of the chances to stop these negative tendencies, especially having in mind the great delay on these issues in relation to developed countries. On the other hand, there are great opportunities to take advantage of the circular economy over the linear economic model, such as protecting resources and the environment, saving energy, reducing unemployment, promoting innovation, and increasing competitiveness.

Sustainable development concept

The concept of sustainability has become widely accepted as a condition for the survival and progress of humanity. Failure to respect this concept leads to inefficient economic development and crisis, which means a waste of resources and energy. Economic growth has created strong pressure on the environment and at some point can cause catastrophic consequences for it (Mandić, et al. 2017). Permanent growth can in no way be an adequate answer to the world's economic problems. The solution is sustainable development which, in addition to economic growth, also pays attention to the future.

Natural resources and the environment are extremely important and therefore all countries are obliged to adapt their development to the principles of the environment. The economic cost of this adjustment is a slower pace of economic growth, but in the long run the effect is better because it will result in a better quality of life and economic development (Pokrajac, 2009). On the other hand, the deterioration of the natural environment and the depletion of natural resources have a negative impact on the economic growth rate.

Sustainable development is a harmonious relationship between ecology and economy, which is a prerequisite for the natural wealth of our planet to be preserved for future generations. It can be said that sustainable development is a

general direction, an aspiration to create a better world by balancing social, economic and environmental factors. It is aimed at improving the living standards of individuals with short-term, medium-term and long-term preservation of the environment.

In the previous thirty years, the concept of sustainable development has been introduced in all areas of human life, given the limitations of the planet Earth: a significant increase in population, increasing limitations of natural resources, uneven development of individual countries, etc. World organizations, politicians, economists, businessmen, various civil society organizations, etc. are engaged in this domain.

Regarding the definition of sustainable development, agreement was reached on the basic principles of sustainable development, namely that: a) sustainable development is a general direction, not an inviolable list of tasks, and b) sustainable development strives to create a better world, balancing social, economic and the factors of environment protection.

According to Goldstein (2003), growth in aggregate productivity should outweigh losses due to resource exploitation and depletion, while Giddens (2007) believes that growth should rely on the recycling of physical resources with minimal environmental pollution, taking into account the balance of economic and social goals, with the goals of protection of environment and natural resources. An alternative method of intensive production that endangers the environment and natural resources should be offered an alternative in the form of sustainable development (Kovačević Milić, 2010).

The definition of sustainable development in the 1987 World Commission for Environment and Development (Brundtl and Commission) report "Our Common Future" reads: "Sustainable development is development that meets the needs of present generations without compromising the ability of future generations to meet their needs. "

Sustainable development can also be defined as maintaining a balance between the human need to improve living standards and make progress, on the one hand, and the preservation of natural resources and ecosystems for future generations, on the other. It can be seen that this term encompasses three parts: economic, environmental and socio-political sustainability, the so-called "Magic triangle". From this point of view, the modern trilemma of globalization is defined: achieving economic growth, full employment and ecological balance.

Sustainable development includes the simultaneous achievement of four goals:

1. social development in which the needs for everyone are recognized,
2. successful environmental protection,
3. moderate (reasonable) use of natural resources,
4. maintaining a high and stable rate of economic growth and employment.

In modern economic conditions, new concepts, paradigms, philosophies, strategies and development policies must be sought, which will, without exception, put the long-term, complete and balanced needs and interests of present and future generations in the forefront. In this sense, the first goal of all development efforts, present and future, is immediately imposed, as a conditio sine qua non not only of any true development but also of survival itself - the preservation of nature and its resources. At the same time, placing such a goal at the very top of development priorities implies a significantly different way of ranking and evaluating all other development goals, especially production, economic, regional and all others.

It is also important to point out the possible ways in which policy responds to appropriate environmental challenges, especially from the point of view of the presence of growing environmental risks, both endogenous and exogenous. In this sense, the following environmental policy options are possible:

• proactive, as a response to small exogenous and large endogenous environmental risks;

• strategic, which represents a possible response of the company to a situation with large both endogenous and exogenous environmental risk;

• reactive, which offers a solution to a situation where low exogenous and low endogenous environmental risk prevail, and

• crisis-preventive which offers a solution for a situation when large exogenous and small endogenous ecological risks prevail.

The advantages of circular economy concept

The previous way of doing business was based on the principle: take - make / use – put off. It is a process in which natural resources and materials are pro-

cessed, shaped into final products, distributed, used and disposed of. With the increase in the number and standards of the population, there is an excessive consumption of natural resources and energy and a drastic increase in the generated waste. The concept of circular economy is based on the assumption of the use of resources in production and use in a way that maximizes the duration of the value of the product or service, and reduces waste that cannot be reused in the production and use process to a minimum. In this way, the utilization of resources is maximized, and at the end of the use cycle, the product or service is returned to the production process in order to create new value.

Circular economy concept implies the circulation of material and its reuse, which at the same time uses drastically less energy and water - in some cases over 90% (Mitrović et al, 2016). Countries that were among the first to adopt a strategy for the implementation of the circular economy were Germany, the Netherlands and Denmark, and individual programs of the circular economy are implemented by China, Sweden, Great Britain, Brazil and others.

The circular economy is an instrument for achieving the goals of sustainable development, the essence of which is long-term investment in raw materials and energy efficiency, along with the use of renewable energy sources, reducing emissions, production and trade of sustainable products, thus closing the circle "product - waste - product". In this way, the source of economic growth becomes the reuse of materials from products that have completed their "life cycle", with the lowest possible use of new resources. The basic characteristics of a product become the way it is designed, how recyclable it is, how it is produced and how environmentally friendly it is (Mitrović, et al. 2016).

Circular economy concept is based on the assumption of the use of resources in production and utilization in a way that maximizes the duration of the value of the product or service, and reduces waste that cannot be reused in the production and utilization process to a minimum. In that way, the utilization of resources is maximized, and at the end of the use cycle, the product or service is returned to the production process in order to create new value (Radivojević, 2018). The concept is designed to lead to the renewal of ecosystems, with a large number of innovations and with a significant impact on the consciousness and habits of society as a whole.

In 2015, the European Commission adopted a legal framework that encourages the transition of the economy to a circular economy, with the aim of strengthening and modernizing Europe's economy, increasing its competitiveness and ensuring long-term sustainable growth. In this way, efficient use of na-

tural resources is achieved, financial benefits too and environmental pollution is reduced. The circular economy ensures that production, trade and consumption are designed in such a way that, by using renewable energy sources, the exploitation of major resources such as various raw materials, fuel, water, land, environment is minimized. The goals of the European Commission are to achieve the recycling of 70% of municipal waste and 80% of packaging waste by 2030, and it is estimated that the circular economy can save businesses in the European Union as much as 600 billion euros.

The advantages of the circular economy in relation to the linear model of the economy are (Kalkan, 2018):

• Protection of resources and the environment,

• Power saving,

• Reduction of unemployment - in the circular economy, companies engaged in maintenance, repair, recycling, design of eco products and services can offer interesting and attractive jobs in the near future,

• Promotion of innovativeness and increase of competitiveness - circular economy requires creativity and the ability to introduce various types of innovations in business, because in the near future only innovative companies and groupings will be able to survive the competition.

Outlooks of circular economy in Serbia

The lag in economic development in relation to EU countries and countries in the region, especially after the great crisis of 2008, requires a change in Serbia's economic policy in order to create preconditions for long-term sustainable development and an increase of competitiveness in regional and global frameworks. The starting point of the concept of sustainable development is based on the relationship between development and the environment, their interdependence, as well as the complementarity of development policy and environmental protection while respecting ecological principles.

The Government of the Republic of Serbia has adopted the Strategy for Sustainable Development of the RS for the period from 2008 to 2017. It defines sustainable development as a goal-oriented, long-term, continuous, comprehensive and synergistic process that affects all aspects of life (economic, social, environmental and institutional) at all levels (National Strategy for Sustainable

Development, 2008). The goal of the National Strategy for Sustainable Development is to balance three pillars of sustainable development: sustainable economic growth and economic and technological development, sustainable development of society based on social balance, and environmental protection with rational use of natural resources, combining them into one unity supported by appropriate institutional frame.

The National Strategy for Sustainable Development of the Republic of Serbia as national priorities defines, among others, development of a competitive market economy and balanced economic growth, infrastructure development and balanced regional development, as well as protection and improvement of the environment and rational use of natural resources. The strategy of sustainable development is also a process of searching for a vision and solutions for sustainability in the social community (Milosavljević, 2009). The experiences of European countries are proof that preserving the environment does not contradict economic development, because without a healthy economy there is no healthy environment, as well as vice versa.

Serbia has a big problem of reducing the number of inhabitants in the country, especially young educated staff, and there are also migrations from underdeveloped regions of the country to large urban centers. Such developments threaten the concept of sustainable development of the country based on economic, environmental and social aspects. Only a small part of the economy is adjusted to the requirements of modern markets, and a large number of jobs are of poor quality and poorly paid. Inequalities increase over time as well as regional disparities in development.

The Republic of Serbia monitors the process of implementation of the circular economy in the EU and has accepted all the recommendations of the EC on the circular economy. The Ministry of Agriculture and Environmental Protection, the Serbian Chamber of Commerce, the Standing Conference of Towns and Municipalities, various business associations and civil society organizations are working on the realization of this work. The introduction of a new institutional structure creates an opportunity to support the third investment cycle in which green infrastructure is a driver of growth, and includes wastewater management, waste management and renewable energy sources (Mitrović, et al. 2016).

Serbia has major problems in the environmental sector, especially in the areas of waste and wastewater management. There are currently more than 3,000 illegal landfills in Serbia, and less than 10% of waste is recycled. The goal is to increase this percentage to a minimum of 50% by 2030, which would enable a

chance to create 30,000 jobs. The introduction of the concept of circular economy requires mutual support of the economy and the environment and would lead to the transformation of the Serbian economy and would be a major step in the process of negotiations for EU membership.

Apart from the improvement of the Serbian economy and the possibility of creating new jobs, the concept of a circular economy is inevitable, because it is built into European regulations that all countries, candidates for EU membership, must harmonize and apply. It is estimated that the introduction of the circular economy in Serbia can create 30,000 new jobs and increase the competitiveness of the domestic economy, especially in the recycling sector (Serbian Chamber of Commerce, 2016).

A small country, such as Serbia, is forced to use economies of scale only if it is oriented to a foreign market and if it is involved in regional integration. A small country has a higher commodity and geographical concentration of exports, because it is usually tied to a large and neighboring country, which means that it is usually a higher degree of openness (Nelo, 2005). Economic policy must be put in the function of economic development, promotion of entrepreneurship, efficiency, full employment, social justice and strengthening of social cohesion and inclusion; development of activities that are based on knowledge, innovation, new technologies and export orientation - knowledge economy (Petrović, 2008).

Appropriate institutions that will create preconditions for the development of entrepreneurship and investment, as well as the rule of law in economic relations, are also necessary for faster sustainable development. A large number of development issues and projects should be left to local authorities, which would be more successful than the central level of government due to their better conversance. Also, the priority is to build a modern and efficient education system that will be able to support the future efficient and competitive knowledge-based economy, and to create a new profile of the workforce that will be more educated in the field of circular economy.

The application of the circular economy concept in Serbia would give multiple positive effects on the development of the economy and society. First, stronger ties would be established with international partners such as the UN and the EU, which would enable easier access to financing projects in the field of production and market modernization, which would enable greater adaptability of the Serbian economy and the possibility of participating in joint projects with countries applying the circular economy.

Through the concept of circular economy, stronger ties are created with international companies that already apply the principles and goals of sustainable development; this increases the chances for the availability of the latest technologies, knowledge and skills, joint appearance on world markets and education of domestic experts on the examples of world-successful companies. This would lead to easier application of ISO standards, as well as the introduction of "sustainable" and "environmental" standards and certificates.

This concept would also lead to raising the overall social awareness of the importance of future development of society, such as issues of sustainable development, public influence on decision-making, social inclusion, greater evaluation of local products and services and similar. All this would lead to the creation of a knowledge economy, orientation towards a green economy, modernization of the entire economy and reduction of the technological gap in relation to the developed countries in the world.

CONCLUSION

Although the application of the concept of sustainable development requires appropriate efforts and costs that will, in the short term, lead to a slowdown in economic growth, this concept is a necessary condition for solving the accumulated problems of the global economy and the environment. Serbia has adopted the Sustainable Development Strategy and accepted a number of obligations from international agreements that define the principles and goals of sustainable development and its implementation. Among other things, the application of this concept will lead to the creation of new jobs, better use of existing resources and environmental protection.

The application of the concept of circular economy in Serbia would give multiple positive effects on the development of the economy and society. The most important are the strengthening of ties with international partners that would enable easier access to financing projects in the field of modernization of production and markets, which would enable participation in joint projects with countries that apply the concept of circular economy. Also, ties with international companies would be strengthened, which increases the chances for the availability of the latest technologies, joint appearance on world markets, easier application of ISO standards and similar.

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CIRCULAR ECONOMY AS A PARADIGM OF SUSTAINABLE DEVELOPMENT OF SERBIA

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Abstract:

Circular economy is an instrument for achieving the goals of sustainable development and implies long-term investment in raw materials and energy efficiency, while reducing harmful greenhouse gas emissions, replacing fossil fuels with renewable energy resources and production and sale of products, thus closing the circle "product - waste - product ", which is recognized within the Strategy of Sustainable Development of the Republic of Serbia. The recommendations, which were adopted at the leading economic forums in Serbia during the second decade of this century, were conveyed to local communities, industry representatives and citizens in order to adopt and apply sustainable production and sustainable consumption models, in accordance with their capabilities. The aim of this paper is to point out the importance of the circular economy in order to achieve sustainable development of the Republic of Serbia, in order to join the family of developed European countries.

Key words: sustainable development, circular economy, Serbia

INTRODUCTION

In line with the umbrella document adopted by the United Nations in 2012, at the RIO + 20 conference, countries were invited to approach sustainable growth and new alternative strategies through the green economy. The need to chan-

ge and redirect the concept of the global economy has long since become inevitable. Countries such as Germany, the Netherlands and Denmark have taken a significant step forward and adopted strategies to implement a circular economy. Also, China, Sweden, Great Britain and Brazil are implementing individual programs towards the circular economy. In this regard, Serbia has adopted a new Development Strategy, which includes the development of "smart" cities, reindustrialization, sustainable consumption and a culture of living. The circular economy is an important tool for achieving sustainable development goals. It implies long-term investment in raw materials and energy efficiency, with the reduction of harmful emissions, the replacement of fossil fuels with renewable sources and the production and trade of sustainable products.

The course of the development of the circular economy in Serbia

Slovenia is called the green heart of Europe and it is considered the leader in the region when it comes to the circular economy. When we see how much capital is interested in financing green and circular solutions, it means that we have realized that the way we now design, produce and spend is not sustainable. Business cannot survive if we do not switch to a circular economy. (E-Gate, 09.12.2020). The work on drafting a plan for the development of the circular economy in Serbia has opened new fields that must change in order to introduce and successfully implement the circular economy as a determinant of the economic development of Serbia. The greatest attention is paid to the improvement of the system of taxation of pollutants, which would improve the protection of the environment, but also the proper management of waste and waste streams in order to prevent pressure on the limited resources of the natural environment. (Dedić, M., 2020).

In order to start building a circular culture and to bring this concept closer to the younger generations, during 2019, a series of lectures were organized: in schools, students are encouraged to think about reducing waste in their daily lives, as well as ways to use existing waste for making new products. Also, in order to start reducing food surpluses, a series of workshops was organized in partnership with the Ministry of Environmental Protection, the Serbian Chamber of Commerce, private companies, the Food Bank, the Association of Catering Facilities and social enterprises, to present innovative solutions to reduce food waste. UNDP has supported an international sustainability festival called "Circles" in Belgrade, in cooperation with the civil society organization Mixer, which is de-

dicated to raising awareness about the circular economy and the need to change awareness about how to use limited resources and what is considered waste.

By establishing a policy-making process, Serbia has initiated procedures that are significantly more thorough and transparent in the announcement and that involve all stakeholders. As one of the first documents being developed is the Ex-ante analysis of effects in the field of circular economy. The aim of this analysis was to point out the complexity of the current situation and the problems that arise from it and to indicate which are the key elements to pay attention to, which should be harmonized and adjusted to domestic needs and conditions dictated by the international market. The reason for the current state of significant lag in the application of modern and efficient development policies lies in the long-term unsystematic approach to building a legal and economic framework in which economic entities in Serbia, as well as citizens, move.

The circular economy is the name for a complex cross-sectoral platform that aims to connect different social processes and to enable the greatest possible degree of mutual harmonization. Every social activity has an economic aspect in some of its dimensions, because the pursuit of social well-being cannot be implemented without economic sustainability. It is also a new business model that envisages maximum optimization of economic processes, with the use of available raw materials and energy resources from waste, efficient use of energy and human resources and savings in time and way of organizing business, with maximum reduction of negative impact on the environment. The main goal of the economy is to achieve economic profit. The task of the state is to create conditions under which economic activities can be carried out in a way that ensures the realization of material profit, but in such a way that other profits for society are also realized. The circular economy contains all these aspects, while sustainable development is approached by the economy. The circular economy is the result of the need to change the existing neoliberal and somewhat dehumanized economic model.

The circular economy presupposes three cycles of product management - prolonged use with intensive maintenance, reparation at the end of its life and reuse, and finally, waste treatment. What cannot be recycled is used for energy purposes, for biodegradation and disposal of unusable or hazardous fractions of waste. In order to achieve that, it is necessary to create preconditions and the task of the state is to regulate the economic space and adopt rules within which such a business model can and must be implemented. The first step is the development of rules, ie laws and bylaws, but for the successful creation of these frameworks, it is necessary to know what the current situation on the ground is, what are the

assumed goals, what is available. By adopting modern standards, Serbia has the opportunity to step out of the stage of economic development in which it finds itself and get closer to modern countries and a more efficient economy with increased competitiveness, employment growth, easier access to the international market and increasing GDP. better quality of life of the population.

Potentials of the Serbian economy for the development of the circular economy

Serbia annually generates a total of about 12,000,000 tons of waste, of which 2,300,000 tons is municipal waste, or 0.32 tons per capita per year. 4,571 waste generators were registered, 331 legal entities that reuse waste and 32 that dispose of waste. There are ten sanitary landfills and in 2018 they deposited only 440,000 tons of waste, but that is why there are thousands of registered illegal landfills (it is estimated that there are over 3,500). The worst situation is in the south of the country, the sanitary landfill "Meteris" exists in Vranje and its capacities are already filled.

According to the data contained in the Report on the conducted ex ante analysis of the effects for the circular economy in 2018, about 2 million tons of waste were treated, of which only 1/4 is reused or recycled and the rest stored, which means that almost 10 million tons are unused and untreated . Serbia exports and imports waste, often of the same type and category, which is an indicator of an unregulated market.

Table No.1: Export and import of waste in Serbia in 2018. G

Type of waste	Export (t)	Import (t)
Metals	211046	23931
Plastic	6397	15744
Glass	18712	278
Wood waste	0	10908
Steam card	73390	127212
Batteries and accumulators	5826	996
Textile	529	479

Source: Environmental Protection Agency, http://www.sepa.gov.rs/

The total amount of packaging waste in 2018 was about 260,000 tons, of which 57% was reused through the system of collective operators. The highest grade is for cardboard, and the lowest for plastic. Serbia generates about 260 grams of waste for every EUR GDP. With the new package of EU Directives for circular economy from 2018, goals have been set that are not easily achievable for Serbia.

Table No.2: Targets for waste recycling according to the package of EU Directives for circular economy

Waste type			CEP 2018	
		2025	2030	2035
Municipal waste	Recycling / reuse			10%
	Landfilling (maximum)			
Packaging waste		65%	70%	70%
Paper		75%	85%	85%
Plastic		50%	55%	55%
Glass		70%	75%	75%
Metals		70%	80%	80%
Aluminum		50%	60%	60%
Wood		25%	30%	30%

Source: https://ec.europa.eu/environment/circular conomy/first circular economy action plan.

It is necessary to work on increasing the recycling rates of specific materials. Representatives of the economy consider the lack of operators for specific types of waste to be a big obstacle. The lack of companies for the purchase of technological and chemical waste is especially evident. It is devastating to take money for recycling, and waste is not disposed of properly or not completely. Also, businessmen perceive waste disposal fees as high.

Serbia annually consumes about 190,000 GWh12 of energy, of which 40,000 GWh is electricity. Most of the primary energy, about 50%, is obtained from coal. Serbia also meets its needs with 1/3 of imported energy. Households

in Serbia consume almost 50% of electricity, unlike developed countries where the ratio is 70:30 in favor of industry. Electricity is generated as follows: Most from coal 70% From oil 8% From natural gas 3.3% Renewable sources 18.7% Hydropower plants 7% Biomass 10.5% Other 1.2%.

Serbia emits about 30,000 kt of CO2 per year, which means that Serbia generates about 0.7 kg of CO2 for every EUR GDP, which is a value that indicates that the economy and population are largely dependent on fossil fuels and that the industry is energy intensive. The world average is half lower, 350 gr / EUR. Energy intensity in Serbia is significantly higher than in European Union countries. The reason is low productive jobs, low economic activity, the environment is not attractive enough for investors, but also the low price of electricity. Research by the Electric Power Industry of Serbia shows that our citizens consume up to 60 percent more electricity than those living in the EU, although the standard of living in Serbia is significantly lower.

New technologies-innovation and technological development foundations of the future of Serbia

In Serbia, the structure of exports is such that most products with a low degree of processing dominate. The exception is the growing ICT economy, which has seen steep, double-digit growth over the past few years. Production activities are stagnant, and efficiency is at an unsatisfactory level. Diversification of resources is practically non-existent, and waste and waste materials are practically not used, energy efficiency is low, the use of energy from renewable sources is negligible and the ecological footprint of the industry is massive. Pollution of air, soil and especially water that originates from production is unacceptably high and far above European norms. Incentives, financing methods and access to the capital market are complicated and direct investments in existing or new companies are limited due to legal uncertainty and unpredictability of the Serbian, shallow and volatile market. One of the main arguments for attracting FDI is cheap, therefore underpaid labor and good quality workers. From an economic point of view, unemployment can be seen as an underutilization of labor capacity. (Stošić Mihajlović, Lj., Nikolić, M., 2017, p. 75).

The digitalization of Serbia is set as one of the three pillars of Serbia's development. At the same time, digitization is a key tool for process integration within the circular economy. In Serbia, the legal system and the way to effectively encourage the implementation of that concept have not been developed yet. According to the Global Innovation Index, Serbia ranks 48th in the world

in terms of infrastructure, out of a total of 126 countries. Products and services with a high content of knowledge and intangible creative products make up a larger part of the Serbian economy than is typical in Europe. The IT sector with its added value participates in the GDP of Serbia with about 2%.

In an effort to improve environmental management, the United Nations Environment Program (UNEP) has introduced a cleaner production program, defined as a preventive environmental strategy that can be applied to processes, products and services, to prevent waste generation and emissions, thereby reducing risks to human health and the environment, and at the same time improving resource efficiency. It is integrated into all phases of the production process and includes an analysis of all its aspects, including its organizational arrangement, in order to identify potentials for reducing or eliminating negative impacts on the environment.

CONCLUSION

Introduction of the principles of circular economy is a process that requires the engagement of human and financial resources for the establishment of the administrative framework and for the implementation of measures and projects for the purpose of achieving the set goals, which are financed from various sources. The effects of the circular economy on the economy can currently only be assessed at a flat rate due to the lack of systemic indicators of success and the only comparable parameters are in countries where this business model has been applied for several years. It is assumed that the introduction of the principle of circular economy would open about 30,000 new jobs in Serbia, and that the application of energy efficiency measures would save 25-30% of energy that is unnecessarily consumed in Serbia. Circular economy includes various activities, integral deadlines do not exist, but they are broken down by areas and the realization of each envisaged goal will give its results. The first visible and tangible results can be expected only in the period of 3-5 years after the introduction of certain measures. For the implementation of public policies aimed at a qualitative step forward, especially as in the case of a circular economy that encroaches on a large number of different areas, it is necessary to set up a systemic solution that has a legal framework, institutional support, enforcement, control and monitoring mechanisms. In addition, ways must be provided so that the economy, which bears the burden of change, has ways to improve its business in accordance with the requirements and its own interests.

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ECONOMIC AND ENVIRONMENTAL BUSINESS EFFECTS OF MULTINATIONAL COMPANIES IN THE FIELD OF NATURAL RESOURCES

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Abstract

Multinational copmanies play a key role in the globalization process. These copmanies has a great influence on opening the borders, flowing of goods, capital and services. Also, these copmanies are carriers of foreign direct investment. In some cases, these companies can foster economic development, but they can also be large "exporters of profits". In addition to the many positive economic effects, these companies have their negative impacts, both economic and environmental. The paper will analyze the economic and environmental effects of the operations of multinational companies in the field of natural resources through the impact on the economy, society and environment.

Keywords: Multinational companies, natural resources, ecology, economics

INTRODUCTION

Multinational companies (MNCs) have large assets, use state-of-the-art technology in production and achieve high production efficiency. These companies generate huge annual revenues and also have enormous financial power. Both multinational and transnational (TNC) are more or less similar in meaning, however, there is a small difference between multinational and transnational. The main difference between multinational and transnational enterprises is that

multinational enterprises have a centralized management system which cannot be seen in transnational enterprise. TNCs locate their activity centers around the world, wherever they can provide the most efficient combination of labor, capital, knowledge and technology, all with the aim of achieving profitable production and improving economic performance. Research has shown that multinational companies can provide developing countries with a critical financial infrastructure for economic and social development. However, there are data that indicate the negative consequences of these companies' business, both economic and environmental (Narula and Pineli, 2019; Narula, 2018; Diemel and Hilhorst, 2019; Wang and Zhao, 2019).

Natural resources (especially non-renewable resources and energy) are a material assumption of industrialization and economic development. This is confirmed by the fact that the largest numbers of transnational companies in the world base their business on natural resources which is discussed in this paper.

METHODOLOGY

Economic and environmental business effects of multinational companies in the field of natural resources will be presented in the paper. In preparing the paper, the authors depend on desk research. The desk research method has been followed to review the existing literature of the subject. The study is based on secondary data. Secondary data has been collected from several sources including relevant books, journals and websites. The survey will use secondary business and revenue data of multinational companies available on the Fortune global 500 site. The analysis of the income and profit data of these companies will draw conclusions about the economic effects of MNCs business.

Given that the business of these companies goes beyond the borders of their home countries and is spread over a large number of countries, many of which are often developing countries, it is necessary to determine what effects these companies have on the developing countries in which these companies have their organizational parts. In addition to the economic effects, the effects of these companies' operations on the environment and society as a whole are significant. Thus, to obtain the necessary data, an index will be used that integrates social and economic development into one unit, the HDI Human Development Index, as well as the EPI Index covering environmental performance.

The Human Development Index (HDI) is a statistic composite index of life expectancy, education, and gross national income per capita. The Environmental Performance Index (EPI) is a method of quantifying and numerically marking the environmental performance of a state's policies (Geenen and Claessens, 2013; Uduji and Okolo-Obasi, 2017; Brancu and Bibu, 2014; Giuliani and Macchi, 2013; Adams et al. 2019)

RESULTS

By looking at the literature sources (Wang and Zhao, 2019; Giuliani and Macchi, 2013; Adams et al. 2019; Diemel and Hilhorst, 2019), it is possible to single out the advantages and disadvantages of multinational companies in the host country, which are given in the following table.

Access to natural resources and their unplanned depletion have been cited as a negative consequence of the MNC's operations. Research has shown that the availability of natural resources, their quality and diversity affect the development of a large number of industries, the volume and structure of industrial production, as well as the investment policy of a country [9].

Table 1 Advantages and disadvantages of multinational companies

Adventages	Disadventages
Balance of payments improvement	Environmental impact and environmental safety
Provision of employment - employment of domestic labor (local population)	Access to natural resources and their unplanned depletion
Source of tax revenue for the host country	Uncertainty about changing the manufacturing plant headquarters in the very short term
Technology Transfer	Low-skilled employment (leveraging cheap labor)
Increased choice of goods and services	Impact on the health and safety of the local population
Improving the national reputation of the host country	"Export profits" into home country

This is confirmed by the fact that the largest number of transnational companies in the world base their business on natural resources, which is given in Table 2.

Table 2 The ten largest industrial MNCs and TNCs in 2013 and 2018 (billion dollar revenues) https://fortune.com/global500/

Rang 2013	Copmany	Industry	Revenues	Rang 2018	Copmany	Revenues
1	Royal Dutch Shell (Nethrlands,UK)	Oil industry	481.7	1	State Grid – China energetics	348.9
2	Exxon Mobil (USA)	Oil industry	444.9	2	Sinopec Group	326.9
3	Sinopec Group (China)	Oil industry	428.2	3	China National Petroleum	326.0
4	China National Petroleum (China)	Oil industry	408.2	4	Royal Dutch Shell	311.9
5	British Petroleum (UK)	Oil industry	388.3	5	Toyota	265.2
6	Toyota (Japan)	Car industry	256.7	6	Volkswagen Group	260.0
7	Volkswagen Group (Germany)	Car industry	247.6	7	British Petroleum	244.6
8	Total Fina SA (France)	Oil industry	234.3	8	Exxon Mobil	244.4
9	Chevron (USA)	Oil industry	233.9	9	Apple – USA– IT	229.2
10	Glencore Xstrata (Switzerland)	Mining industry	214.4	10	Samsung Electronics- South Korea - IT	211.9

The following table shows the HDI Index and EPI Index values for the home countries of the most profitable MNCs and for DR Congo, which is taken as an example of an undeveloped country, and rich in natural resources.

The results in Table 3 show that more than half of the multinational companies that generate the highest revenues in 2013 and 2018 operate in the field of natural resources. The home countries of the most profitable MNCs are the richest countries in the world. This leads to the conclusion that natural resources are important and need to be properly managed. However, the small and undeveloped countries that own them in considerable quantities, unfortunately, lack the necessary political and economic power, and are therefore dependent on those larger and more powerful who, using their resources, increase their wealth. A good example is the Democratic Republic of the Congo, such as one of the

richest countries in the world, owns gold, oil, diamonds, but colonialism made slavery and corruption one of the poorest countries.

Table 3 Values of HDI index and EPI index (http://hdr.undp.org/en/content/table-2-human-development-index-trends-1990%E2%80%932018

and https://epi.envirocenter.yale.edu/epi-topline)

	Year/2013	Year /2018	Year /2014	Year /2018
Country	HDI index	HDI index	EPI index	EPI index
Netherlands	0.924	0.933	77.75	75.46
Germany	0.927	0.939	80.47	78.37
Switzerland	0.938	0.946	87.67	87.42
United Kingdom	0.914	0.920	77.35	79.89
Japan	0.900	0.915	72.35	74.69
France	0.882	0.891	71.05	83.95
United States	0.914	0.920	67.52	71.19
China	0.727	0.758	43.00	50.74
South Korea	0.893	0.906	63.79	62.30
Congo (Democratic Republic)	0.429	0.459	25.01	30.41

When comparing the HDI values of the human development index for the home countries of the most profitable MNCs, it can be concluded that they are the countries with the highest HDI index. Only China had a low HDI index in the 1990s. However, it has grown significantly since 2010. On the other hand, the Democratic Republic of the Congo is a country rich in natural resources, but unfortunately, these resources are exploited by the richest countries and multinational companies that exploit the country's natural resources. This country's HDI index has never exceeded 0.5.

CONCLUSIONS

Based on the results obtained, it can be concluded that the economic effects of the operations of multinational companies for the home countries are indeed of great importance and have a huge share in increasing the GDP of the countries of origin. It can also be concluded that, as one of the biggest negative effects of

the operations of these companies, it is justified that they represent "exporters of profits" to their home country.

An EPI index was used to analyze the environmental performance of these countries. The data obtained show that all the countries from which the multinational companies with the highest revenues are derived also have a very high EPI index. Countries with lower EPI index values (below 70) are the US and South Korea. The country with the lowest value of the EPI index is China. It is known that the USA and China are among the largest polluters in the world, while EU member states attach the highest importance to environmental protection. In 2014, the EPI index of the Democratic Republic of the Congo, it was only 25. This data can confirm that multinational companies have a very negative impact on the environment and the environmental security of the host countries in which they operate, and the fact is that natural resources are inadequately accessed and unplanned in these countries implemented.

The results of the research indicate that the economic effects of multinational parent companies are very large, but when it comes to underdeveloped countries as their hosts, it is imperative that these countries have very strong legal regulations that would affect the business of these companies, especially in areas of environmental safety and environmental protection.

Acknowledgements

This paper is a partly supported by the Registration No. 451-03-9/2021-14/200052 administered by Ministry of Education and Science of the Republic of Serbia.

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COMPETITIVENESS OF LOGISTICS SERVICE PROVIDERS: AN INTERNATIONAL EXAMINATION OF MANAGEMENT PRACTICE IN CHINA AND THE UNITED KINGDOM

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Abstract

Today's logistics service provider (LSP) market is characterized by growing customer sophistication, globalization of business, production, sales and distribution, deregulation around the world, frequent mergers and acquisitions and restructuring of companies, and business in the background of the recent economic recession. In such a market, faced with enormous pressures and enormous challenges imposed by external and internal factors, the extent of competition between LSPs is undoubtedly far more intense and complex than it has been. To protect market share and remain competitive, LSPs strive for excellence through the launch of various management practices. Nevertheless, surprisingly little research has been published in the LSP literature that addresses the question of how the LSP translates its vision of competitiveness into management practices.

Some studies describe specific management practices that are claimed to lead to a company's competitive advantage or superior performance. For example, Visner and Levis (1997) examined quality improvement practices in the transportation industry and their relationship to company success, highlighting improvements in customer service and timely deliveries and consequently increased competitiveness. Van Hoek and Chong (2001) illustrated the experiences of United Parcel Service (UPS), one of the leading global logistics operators specializing in package delivery, in developing the 4PL business model.

Keywords: competitiveness, e-supply

INTRODUCTION-MANAGEMENT PRACTICE AND COMPETITIVENESS

Competitiveness has long been a goal of the company, and is achieved through the adoption of successful management practices by entrepreneurs or corporate executives (OECD 1992). Practices are "characteristics that describe business behaviors that tend to cause performance differences" and can be related to many aspects, such as: processes; organizational structures; management system; human factors; strategic approaches.Researchers from Michigan State University (MSU) argue that practice consists of ways of doing essential work. Practice is the most obvious aspect of discipline because it involves what people do and where they spend most of their time. Various authors have shown a link between practice and competitiveness (e.g., Voss and Johnston 1995; Voss et al., 1997; Meier et al. 1999). In these studies, the central hypothesis is that the adoption of best practices for a service company is directly related to achieving a high standard of service and this in turn will lead to superior business performance and competitiveness. with a comparison of performance measures in identifying best practices and what can be achieved (Andersen and Camp 1995; Rogers et al. 1995; Woodburn 1999; Smith 2000). Being world-class means identifying practices that can deliver superior performance across the entire business spectrum (MSU 1995). The above discussion underscores the cause-and-effect relationship between management practices and firm competitiveness, noting that competitiveness in a company may be the result of achieving best management practices. This suggests that it makes sense to look at the perspective of management practice when considering the competitiveness of LSPs.

QUESTIONNAIRE DESIGN, SURVEY INSTRUMENT AND ADMINISTRATION

A questionnaire was used to collect data. Survey questions were guided by the literature and continued to be analyzed by LSP professionals, before interviews were conducted in China and the UK. The aim of the interview was to clarify the different concepts, dimensions and variables proposed by practitioners, but not necessarily discussed in the literature, and to further confirm and verify a number of important issues. Topics covered many areas of business, such as strategy, work, customer service, service quality, customer relationship, information

technology (IT), innovation, human resources, inventory and cost management, of which the focus was specifically on three aspects:

• What practices do LSPs apply?

• To what extent can LSP gain a competitive advantage through these practices?

• How do LSPs assess the impact of these practices on competitiveness?

The survey was originally designed in English and later translated into Chinese. Given the different contexts, there were some differences between the two versions of the questionnaire. Two versions of the questionnaire were piloted within four LSPs of the United Kingdom and three KSPs in China. For research in the UK, a total of 150 UK LSPs were selected from a sampling frame based on trade publications, recommendations and the Internet. The administration questionnaire was sent by mail. Thirty-eight responses were received within the deadline, and 35 returned forms were helpful. This gave a response of 24%. In China, the survey questionnaire was managed by the Chinese Association for Communication and Transport (CCTA), a former employer of researchers. CCTA is the most influential organization in the Chinese logistics and transportation community. The CCTA is also a branch of the Chartered Institute of Logistics and Transport (UK) in mainland China. The CCTA used three survey methods to collect data: mail, exhibition, and the Internet. A total of seven hundred and thirty questionnaires were distributed. The collection took three and a half months due to the wide coverage in China. A total of one hundred and fourteen completed questionnaires were returned: 111 by mail and 3 via the Internet. All 114 responses were useful, giving a response rate of 15.6%.

PERFORMANCE MODEL FOR PUBLIC-PRIVATE PARTNERSHIPS: AUTHORIZED ECONOMIC OPERATOR AS AN EXAMPLE

Border agencies, importers and exporters were required to improve their processes and technologies to help move goods across borders faster, easier and safer. As the size and complexity of goods grow, public administrations try to address increased turnover without additional resources, taking into account the business community's awareness of trade costs. Trade simplification is a response to increased uncertainty in global supply chain operations. Trade simplification can be explained as a reduction barriers that can hinder trade in global

operations. Its overall goal is to increase the flow of goods, services and people across international borders without compromising the security of this process or the ability of government agencies to collect taxes and collect revenues. One of the biggest benefits of trade simplification is the reduction of trade-related costs. Both the private and public sectors are interested in this benefit because of the advantages for the former and clear visibility for the latter. When applied to developing countries, the need for TF measures has accelerated as a result of increased trade participation in gross domestic product (GDP) and depends on supply chain management techniques, among other factors.

On the other hand, although TF (Trade Simplification) represents long-term savings and benefits for the country, there are also many set-up and operating costs involved in implementing the measures. TF involves the relationship between a public and a private party. Therefore, this process can be seen as a type of public-private partnership (PPP), but simply establishing a connection does not guarantee that all the benefits of TF will be available to everyone.

This paper aims to propose and validate a theoretical model that is able to measure the main factors influencing the operation or success of a TF-oriented PPP. This model derives from PPP theory and presents a relational model between the critical success factors and the observed / expected effect of PPP. The relationship between each factor and the success of the partnership is examined, measuring the strength of such relationships by applying modeling of structural equations. Once it is known which factors have a stronger impact on PPP performance, the decision-making process can be improved, in addition to the chances of both public and private parties gaining access to the benefits of participating in the TF program.

TRADE SIMPLIFICATION

International trade consists of the interaction between economic operators and the border administration, both immersed in an environment full of national and international rules and regulations. In this environment, TF is attracting the attention of fellows, the government and the international trade community, especially after the World Trade Organization's Simplified Trade Agreement entered into force in February 2017. At the heart of this law is concern for the operational quality of business, firmly rooted in the frustrations experienced by firms when goods cross borders. TF must balance the pursuit of competitiveness

by enterprises and other economic entities with the need for state control (Morini, 2014). However, despite being easily connected to customs and other border agencies, TF is not limited to them, and therefore reaches out to other fields, such as the international business environment, the quality of infrastructure between countries and their internal regulations.

The overall goal of the TF and its various aspects is to increase the flow of goods, services and people across international borders without compromising the security or ability of government agencies (mainly customs) to collect taxes and collect revenue. Reducing cargo inspection time can be considered a TF measure at the operational level that has a significant impact on business competitiveness. This reduces delivery times and speeds up supply chains, also allowing national governments to increase tax revenue collection. Moreover, TF is based on other basic concepts, such as: transparency, network predictability, process rationalization, integration of border agencies and harmonization of procedures and norms. Governments and businesses can form partnerships to develop a given project that combines their common interests. This is also happening in the area of customs and international trade. Some of these PPPs, as they are called, are TF-oriented and can be found in the common PPP universe.

Knowing that not all partnerships are infrastructure-oriented and that some can be service-oriented, a special type of PPP can be found among them: CBP. CBP is a type of relationship that is built between government and private initiatives to reduce transaction costs and the need for ongoing interventions in the process of crossing goods across borders, rather than undermining security standards imposed by customs. In this sense, CBPs can be viewed as a specific type of PPP that describes a synchronous partnership between enterprises and border authorities for the purpose of TF. Therefore, it is a TF-oriented PPP.

PERFORMANCE EVALUATION OF PUBLIC-PRIVATE ENTERPRISES AND EVALUATION OF FORMATIVE MEASUREMENT MODELS

Structural equation modeling (SEM) can be used as a means of measuring performance in a quantitative way because it has the ability to link latent and observed variables using statistical tools. However, in order to use SEM, a theoretical model must first be built to explain the relationship between these variables. Highlighting TF as a partnership, a criterion for case analysis can be developed,

so measurement could become possible using CSF. In other words, PPP theory was used as a platform to develop a performance measurement model for TF.

Aerts, Grace, Dooms, and Haezendonck (2014) and Chou and Pramudavardhani (2015) use the CSF concept in PPPs. CSFs are the elements that determine how well PPPs work. Based on previous studies (Osei-Kiei & Chan, 2015), CSFs in PPP are related to the quality of the relationship established between the parties.

One of the TF surveys in the PPP was conducted with the help of a questionnaire consisting of 52 questions. The sample of the study were professionals from academia and the private and public sector who addressed the TF within their regular functions, ie international trade researchers, customs officers, export and import agents, lawyers and many other professionals in the field of international trade. They were accessed either by e-mail or at the contact center from their organization with which the researchers contacted. G * Power 3.1 software was used to estimate the sample size and statistical strength of the analysis. The questionnaire was sent to the International Network Customs Universities (INCU). INCU is the main research center for customs issues.

The questionnaire was completed by 123 INCU members. Of these, a total of 83 responses were from national respondents, as opposed to 40 international respondents, with a global geographic distribution ranging from, for example, Afghanistan to the United States. Interestingly, more than 67% of contributions came from the private sector alone. Lawyers, customs brokers, consultants, importers and professionals from the general industry, inspection companies and trading companies are some examples of the various agents who participated in the study. In contrast, the public sector gave only about 11% of the total responses, which is the least representative group. Academia, for its part, accounted for approximately 17% of responses and was the group with the largest contribution from foreign professionals (approximately 80%). The remaining 5% of respondents were categorized as "others" because they did not claim to have a unique affiliation with either the public / private sector or the academy. Gender and age were not included in the final profile questionnaire because they were not selected as measurable variables for this study.

According to Hair et al. (2013), the criteria for evaluating formative measurement models are: convergent validity, multicollinearity, and significance and relevance. Convergent validity was studied by redundancy analysis. This analysis was performed by correlating the formative construction variables with the global measure of indicators. When analyzing T-statistics of external loads, most

variables have significant values ($p < 0.01$), while some represent insignificant values. The SEM research model uses a quantitative approach to its topic with the help of multivariate data analysis. Since the theories of public-private partnership for TF are briefly considered and since they aim to predict and explain the established structures, it is recommended to model the path of partial least squares (PLS-SEM). The proposed model presents both reflective and formative indicators, which is another reason for using PLS-SEM (Chin & Nevsted, 1999; Hair et al., 2013). SmartPLS 3.0 (Ringle, Vende, & Becker, 2014) and SPSS Statistics 21 software packages can be used to calculate and validate the statistical test, developed by multivariate SEM analysis.

CONCLUSION

Since a company wishing to be certified by a TF program must follow a certain set of rules within a previously structured program, it is no surprise to note that project quality is not among the confirmed hypotheses, as not all participants within such programs could decide on its design. However, it has been proven somewhere that the "micro environment" has shown the strongest link to TF-oriented PPP performance. Therefore, initiatives that promote TF programs, such as workshops, meetings, and other events, can have an impact on merging companies with such programs. Moreover, the financial capacity of companies is also an important factor as it affects their ability to meet all the investments required to implement the TF program. The second most influential construction related to the performance of TF-oriented PPFs was "party capabilities", which included the dimensions of "communication", "leadership" and "commitment". The latter is one of the most important discussions of CSF in the literature. Similarly, communication is also an important factor for PPPs in general, but within the TF field it falls under the "soft" dimension of trade, as opposed to the "hard" dimension (discussed by the World Trade Organization / OECD, 2013). A still significant but least influential construct is the "macro environment". It has the dimensions of "economy", "government" and "regulation". Of these, government and regulations provided the best questions for the survival of this construct, with the latter asking the questions with the highest factor burdens, such as "stable regulatory brand, contributes to law enforcement and partnership guarantees." As for measuring PPP performance, all the dimensions that are formed have created issues with high factory loads. Such dimensions included

"operating gains over time", "operating gains in bureaucracy", "financial gains" and "indirect competitive gains".

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IMPACT OF GREEN ECONOMY ON ENTREPRENEURSHIP

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Abstract

The aim of this paper is to present entrepreneurial ventures as well as small and medium enterprises for adapting to the modern way of doing business and the green economy. The green economy is a very important link in achieving coherence between sustainability and development. It is also an important part of entrepreneurship in the world and in our country. Environmental entrepreneurship is becoming more widespread as a new economic approach to finding opportunities to improve the quality of the environment. In this paper, we will present the assumptions that there are needs for an environmentally friendly way of doing business. Environmental entrepreneurship can be a driver of change that will create a better environment, and thus bring benefits to the owners, as well as the people in whose environment such a company would operate.

Key words: green economy, entrepreneurship, business, environment.

INTRODUCTION

In the second decade of the 21st century, global business as a form of new geoeconomic order bases its critical factors on a diametrical approach: business indicators such as locations, investors, clients, talent, education systems and economic development are analyzed as business-friendly barriers. Modern business

is no longer just international but necessarily global, because it encompasses the local, national and supranational economy. Doing business in global conditions dictates new competencies for entrepreneurs, such as a clearly defined goal in the global environment, intensive cooperation with the competition, competitive advantage in global distribution and creating a multinational climate in the organization is imposed as a global business imperative. In other words, entrepreneurship is a mechanism of modern business created to support economic parameters such as development, prosperity and innovation, with the proviso that in modern conditions this applies to both developed and underdeveloped countries.

The modern type of business initiative is not a new category of economic activity, but what makes it distinctive in relation to other types of business is the phenomenon of globalization, which has provided "fair conditions" in the world market for all, ie the indication of effectiveness no longer refers only to the one "who has the most" than the "one who is the best", ie. which is able to connect more interactive elements into a productive model of improving the lives of millions of populations.

STRATEGIC FEATURES OF GLOBAL ENTREPRENEURSHIP

Well-known elements that a potentially sustainable (successful) company should effectively connect are: expertise, technology, infrastructure, consulting support, financial approach, business premises, legal regulations. However, as the main feature of globalization, the author (Altagić, 2010, p. 40a) states "unification of national systems in all segments of social life (social, political, economic, social, cultural and scientific). Also, the author (Altagić, 2010, p. 40b) states that "modern society requires different behavior, ie constant behavior, which means appropriate management in the context of global change." Etymologically, the word globalization originates from the Latin word globus, which means ball, which the author (Ghemawat, 2007a) refers to as a model of already contradictory interpretation of the phenomenon by economists who are pro or contra liberalization of the market. While globalization in all aspects of society is generally seen as merging, integrating vital parts of national economies, some authors such as (Ghemawat, 2007b) point out that managers "should pay serious attention to significant and lasting differences between countries in development and Although the global strategy from the organizational spectrum is oriented towards globalization, for the creation of global value it is very important to adequately understand local and cultural differences by a company that really

wants to justify its global presence not only by necessity but also by competitive advantage. But often globalization from the aspect of entrepreneurship diverges even more in interpretation, e.g. when the author (Rugman and Verbeka, 2004, pp.3-18) clearly distinguishes between the so-called "New globalization" and "conventional (mainstream)" globalization, distinguishing them from the perspective of the 2002 United Nations World Investment Report, which reads: "the new perspective focuses primarily on growth patterns at the macro level in trade and foreign direct investment and compares these data with national GDP growth rates, but without any analysis of equivalent data on the growth of multinational enterprises at the micro level responsible for trade and foreign direct investment "

The role of entrepreneurship in economic development

Research has shown, and statistics have confirmed, that small business has not lost its dynamics in development. Today, there are about 300 million companies in the world (Miltchemore and Rowley, 2015, p. 20). Of that, the share of small companies is over 70%, which means that there are over 210 million small companies. (Vossenberg, 2015, pp. 1-27). In the European Union alone, 1.2 million new companies are registered annually. This is an extremely large potential that is expanding more and more. About 23 million people in the United States run their own businesses. From 1990 to 2005, 13.5 million new jobs were created in the United States. About 92% of all companies in the European Union are micro-enterprises with an average of two employees per company. About 90,000 new companies are opened in Germany every year. In Finland, where there is almost no unemployment, 96% of the total number of companies are small business organizations and thanks to them there are no unemployed. According to some statistics, 45% of people in the European Union and the Circular Economy - an opportunity for sustainable development PIM8 164 61% in the US want to run their business. The question is where is the activity of small businesses moving? It is moving towards services, ie intellectual jobs: 60% employ intellectual services, 14% production, 4% agriculture, and the rest goes to all other industries. (Wahba, Bridwel, 2015) In order to monitor the real situation of entrepreneurship it is necessary is to have sufficiently reliable data in the country, which can be compared with similar environments.

ENTREPRENEURIAL ECOSYSTEM - APPLICATION OF GREEN ECONOMY

There is no single definition or model of a green economy in the literature, but there is a general belief that a green economy should improve human well--being and restore, maintain and promote a healthy natural environment that humans and other living species should use and promote. The green economy is a means to achieve sustainable development and should therefore be based on the principle of equality within and between generations. Global goals of sustainable development are needed to build a common understanding of the results that the economy needs to achieve, in terms of improving human well-being and maintaining natural systems.

Entrepreneurship ecosystem and business ecology

(Moore, 1993) in his article from the Harvard Business Review introduces ecological terminology for the first time in scientific and professional use, combining hitherto strictly economic categories such as "market", "business" and "business entities in one dimension applicable in all spheres of sustainable development where he says: "The economic community, basically supported by the interaction of organizations and individuals, is an organism of the business world. The economic community produces services and products of value to customers, who are themselves members of the ecosystem. Member organisms also refer to suppliers, leading manufacturers, competitors and other stakeholders. Over time, they co-evolve in their capabilities and roles and seek to comply with the instructions of one or more central enterprises. Leading companies can change over time, but the ecosystem leader role is valued by the community because it allows members to move toward shared visions to align their investments and find mutually supportive roles." One thing is for sure, modern business is characterized by very complex relations between companies, which the authors (Townsend, 2010) and (Marshall, 2012a) state that they rightly refer to the necessity of new subdisciplines such as business ecology, further explaining that business ecology study of reciprocal links between businesses and organisms and their environment and that its goal is "sustainability through complete environmental synchronization and business integration through all aspects that it inhales, uses or affects." While through the so-called attitude. environmentalism (Marshall,

2012 b), openly suggests that government interference in business should be as discreet as possible because business itself operates on "natural principles".

Eco-efficiency

Eco-efficiency is recognized as a form of transformation from unsustainable development to sustainable development. It should represent a balance between ecology and economy, where business activities do not destroy the environment. The green economy itself is essentially the responsibility of producers of goods and services, and the responsibility refers to the overall human impact on the environment. Businesses, governments, business associations, research organizations, as well as customers and suppliers are the pioneers of this business concept. Eco-efficiency has been recognized as a significant business approach by "global players" such as the Organization for Economic Co-operation and Development (OECD) and the European Environment Agency (EEA).(https://www.worldatlas.com/articles/the-concept-of-eco-efficienty-why-is-it-so-important-for-the-modern-world.html)

The impact of the green economy on entrepreneurship

We can say that the Serbian economy is coming out of the recession, and it is focusing more on encouraging entrepreneurship and, with the growth of GDP, the unemployment rate is slowly falling. It is important to note that there is still a noticeable shortage of vocational educated workers in Serbia, and there is an obvious shortage of jobs for classically educated staff. This data can lead to the conclusion that in the Serbian education system, profiles of workers are created that do not meet modern business trends, and, despite the high unemployment rate, the market is dependent on imports. The growth of total investments has recorded a positive trend in the last five years, however, the strategic commitment to improve modern systems generally does not exist. (Geissdoerfer, et al., 2017) Thus, for example, there is no infrastructure for creating a stimulating environment, which promotes investments in "green" technologies, waste management, as well as investments in production systems that generate energy from renewable energy sources (RES). Although Serbia is quite energy independent (only 27.6% of energy is imported), we cannot come to the conclusion that we generate enough energy within the country's borders, since industrial activities

are still very weak. (Manyika, 2015) An increase in industrial activity would potentially lead to an increase in energy use; Given that Serbian entrepreneurs do not currently pay too much attention to energy efficiency, a gradual increase in energy needs is quite expected. On the other hand, only 25-30% of renewable resources are used for energy generation, while the energy use profile shows a low percentage of energy use from RES (about 21%). (Morabito, 2017) This leaves a lot of room for business improvement in that market, which has two visible benefits: increasing the energy independence of the state and increasing energy capacity while ensuring cleaner production. There was an increase in industrial production, as well as entrepreneurial activities. The growth and development of the predominantly process industry is represented by the circular economy.

CONCLUSION

The transition to a green economy is no longer just a question of a cleaner environment, a test of responsibility for states, companies and citizens, but also the sustainability of every business and new opportunities that thus open up to the economy. The new business model means that we deal not only with how to dispose of and dispose of what we have used, but also how to preserve the environment in which we live, create new products and value, create new jobs for companies and people. Transition to models of green economy and innovative, modern, clean technologies that are energy and resource efficient, good for the environment, and useful for the economy and society. Entrepreneurship is often seen as a "youth economy" and given that the green economy is a measure of sustainable development aimed at both developed and developing countries, it remains to be seen whether the rate of low economic growth will reciprocally affect individual responsibility countries are encouraged by the fact that self-initiative is the main stabilizer of national economies, given that the green economy is a powerful instrument in the hands of a responsible business entity.

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MORE EFFICIENT EFFORTS TO FIGHT ENVIRONMENTAL CRIME IN THE REPUBLIC OF SERBIA

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Abstract:

As ecology is an increasingly important area of civic activism that is based on the human need to provide viable living conditions, both now and in the future, the authors will try to emphasize the importance of recognizing environmental crime as one of major security challenges and threats, turning the environment into a reference social value. The complexity of the area itself, the number of people involved in such criminal activity and their subordinarity, as well as the tempting potential illegal property gain define a number of environmental crimes as organized crime. It is assumed that environmental crime, especially large-scale crime, which accordingly poses a significant security threat, requires the involvement of an organized criminal group, and the prosecution of a larger number of such crimes by the Prosecutor's Office for Organized Crime can provide better results. However, the specifics that characterize certain forms of criminal offenses in the field of environmental crime also condition the change of domestic legislation.

Keywords: environmental crime, organized crime, Prosecutor's Office for Organized Crime, organized crime group, Republic of Serbia, *Lex Ferenda*

INTRODUCTION

The environmental awareness of the citizens of Serbia is strengthening, as indicated by the growing number of environmental movements that have managed to bring together prominent personalities and individuals from a broad political spectrum, united by a joint idea. This idea, which has been achieving significant effects in the political sphere in Europe for several decades, is slowly becoming acceptable to a larger number of citizens of our country. There have been no armed conflicts in Serbia for two decades and the country is making

more and more progress towards achieving sustainable conditions necessary for military neutrality, and social issues and the mere material survival of citizens are emerging from public discourse. As a result, ecology is increasingly emerging as an important area, because it is based on efforts to give better nature and an unchanged quality of life to future generations.

Different forms of environmental crime generate different levels of risk, the possibility of their manifestation as well as harmful consequences. Although potential adverse effects such as a possible environmental catastrophe caused by illegal and / or inadequate storage of hazardous waste can cause dramatic consequences, the likelihood of this risk is relatively small. On the other hand, incidents of minor individual damage such as illegal logging, illegal hunting or fishing, but which recur frequently, cause significant environmental problems globally. Bearing in mind that the Republic of Serbia is predominantly an agricultural country, where the export of agricultural products in recent years is measured in billions of dollars, environmental pollution, in addition to environmental pollution, also has a pronounced economic dimension.

Previous research in the field of environmental safety and environmental protection in our country is recognizable (Popovic, 2015; Blagojević & Simić, 2012), while the works of foreign authors are mainly based on foreign experiences, i.e. in accordance with the subject of this paper, regarding policies and state legislation (Hunter, ect. 2006; Shover and Routhe, 2005; Abdenur, ect. 2020; Ayling, 2017).

Changes in global conditions

Since China banned the import of twenty-four types of waste for recycling in 2018, for political reasons, there have been significant changes at the global level (Qu et al., 2019). All developed and highly industrialized countries, and from the point of view of ecological security of the Republic of Serbia, especially significantly - almost all countries of Western Europe, are starting to accumulate their waste, failing to find an adequate and sustainable solution. It is important to point out that China, with the imported 51% of the total amount of plastic waste in 2016, was the largest importer of waste in the world, while at the same time the European Union is the largest exporter of such waste (Zero Waste Europe, 2018). The effects of this change are already visible, but it is estimated that the crisis will deepen in the coming period, since the existing solutions

between waste storage and recycling do not give the desired results. Especially since certain types of waste, and especially hazardous waste for which there is no technologically adequate method of recycling, can only be stored in a more or less efficient, i.e. safe way. It is a waste that is flammable, explosive, corrosive or toxic and that can cause death or serious injury, i.e. environmental pollution if it is handled inadequately (EPA, 2005).

Southeast European countries, especially those in transition and with a high level of corruption, in other words - a low economic standard, are potentially at risk of illegally storing hazardous waste on their territory. In particular, the lack of capacity reflected in poor law enforcement, lack of accountability at various levels of government, the prevalence of illegal landfills and infrastructure that is not in line with EU recycling standards affects almost all Western Balkan countries (Hogg and Vergunst, 2017). In that way, the entire society in our country, and potentially in the region as well, can become a victim of organized criminal groups in the field of environmental crime. Although there has been a noticeable improvement in domestic legislation on this issue, both in the region and in the world, there is clearly a lot of room to evade current regulations, since the total financial turnover, based on some form of environmental crime worldwide, is estimated between $ 20 billion and $ 40 billion (Brack 2004).

Difficulties in declaring environmental crime as an activity of organized crime

Modern OKG (organized criminal group) in Serbia, but also in the world, are mostly engaged in illegal trade and smuggling of narcotics, weapons, people and excise goods. Tendencies suggest abandoning activities that rely heavily on the use of violence, such as extortion or robbery, as organized crime activities are slowly moving into the domain of internet crime (Tropina, 2013) and money laundering, with the most common combination of legal and illegal activities.

The Criminal Code of the Republic of Serbia envisages several criminal offenses (a total of 18) in the field of environmental crime. Although crimes such as Forest Devastation (Article 274), Forest Theft (Article 275), Illegal Hunting (Article 276) or Illegal Fishing (Article 277) involve the illegal activities of a large number of individuals, and often organized groups, in exceptional cases it is about an organized criminal group. In order to meet the requirements for a given classification, it is necessary that the organized criminal group has a classical hierarchical structure, durability of the criminal organization, professionalism

and division of labor, and the existence of internal rules of the criminal organization (Škulić, 2008). The nature of the mentioned criminal offenses, as well as the criminological profile of the people who deal with the mentioned offenses, indicate that they are usually not persons from a criminogenic environment, and the existence of internal rules of a criminal organization cannot be confirmed with certainty. The very existence of the group requires membership of at least three persons (one of whom is the leader of the group) as well as a larger scope of criminal activities and larger amounts of illegal property gain.

On the other hand, the specificity of the activity and the wide range of environmental crime, especially the one on a larger scale, point to the fact that a complex organization is necessary for the performance of such an act. Criminal offenses such as Environmental Pollution (Article 260) and Importation of Hazardous Substances into Serbia and illicit processing, disposal and storage of hazardous substances, potentially meet the conditions to be categorized in certain cases as offenses in the field of organized crime. However, the permanence of a criminal organization points to the fact that the OKG is not composed *ad hock* and that there is a clear intention to commit crimes over a longer period of time (Chitadze, 2016). This to some extent determines the next characteristic, and that is professionalism, where OKG members choose crime as a life profession. This specifically means that OKG members in the field of environmental crime in Serbia would have to earn a living dealing with the mentioned illegal activities. Everything leads to the conclusion that the OKG in the field of environmental crime in Serbia most likely does not deal exclusively with criminal acts in this area but is also active in other spheres of illegal activity. It has been noticed that perpetrators of environmental crimes are active in other areas of crime as well, which is why environmental crime is seen as a type of criminal activity in most cases related to blood crimes, forgery of documents, use of forged travel documents, corruption, illegal possession and illegal use of weapons, piracy, drug smuggling and illegal migration (Uljanov, 2012).

Lex Ferenda - Prosecutor's Office for Environmental Crime

In the Republic of Serbia, the public prosecutor's office system includes the Republic Public Prosecutor's Office (RJT), the Appellate Prosecutor's Office, the Higher Prosecutor's Office, the Basic Prosecutor's Office and two special purpose prosecutor's offices. The current organization in our country indicates the existence of an organization that is relatively flexible and in line with the characteristics of current crimes. For that reason, two special purpose prosecutor's

offices were established, the Prosecutor's Office for Organized Crime (Informator, 2018) and the Prosecutor's Office for War Crimes, which, due to the specific gravity of criminal acts and the danger to society they bring, require increased observation. In this regard, within the Higher Court in Belgrade, there is a Special Department for Organized Crime, a Special Department for the Suppression of Corruption and a Department for War Crimes, and a Special Department of the Court of Appeals and a Special Detention Unit have also been established.

Having in mind the social significance of ecology as well as the current situation in that field, a more efficient fight against crime in the field of environmental protection is a real need. Therefore, considering the mentioned facts, the authors of this text find it necessary to propose possible changes in relation to the organization of the prosecutorial system in our country, which would include the Department of Environmental Crime - a kind of *lex ferenda*. Since the Higher Public Prosecutor's Office in Belgrade includes a Department for High-Tech Crime, which acts on the entire territory of the Republic of Serbia in cases within its competence (RJT, 2021), it is suggested that a new department should be opened.

The effects of the eventual Department for Environmental Crime are reflected primarily in the specialization of the prosecutor, whose further instructions are to be followed by the police officers, especially because the internal organization and systematization within the Ministry of the Internal Affairs and the Security Intelligence Agency (BIA) envisage and establish working units that deal with the investigation of criminal acts in the field of environmental crime. Also, the prosecution of those cases from this activity that have elements of organized crime by the Prosecutor's Office for Organized Crime (TOK), will certainly lead to a more efficient fight against such forms of crime.

CONCLUSION

It seems that only the knowledge from a few years ago about illegally stored toxic waste, as well as high concentrations of polluting particles in the air in the cities of Serbia, has awakened the awareness of our citizens to a greater extent. Presuming that the Constitution of the Republic of Serbia, as well as laws that more closely define the field of environmental protection, represent normatively regulated areas, the conclusion is that the laws have not been applied fully. In other words, stricter control of regulations is needed.

Taking into consideration certain specific characteristics of criminal offenses in the field of environmental crime, it can be concluded that they can be seen as the activities of organized criminal groups. If a large number of criminal offenses in this area is recognized as the activity of organized criminal groups, followed by their processing by the Prosecutor's Office for Organized Crime, it might enhance the capacity of efficient crime prevention in this field. For criminal offenses in the field of environmental crime, which are not suitable for the activities of organized crime groups, the authors find that they can be more efficiently investigated and prosecuted if the Department for Environmental Crime is formed within the Prosecutor's Office.

Ecology, economy and security of the Republic of Serbia are interdependent. Since our country is predominantly agriculturally oriented, the export of agricultural products is constantly increasing. Therefore, potential environmental incidents on a larger scale, illegal storage of hazardous waste or pollution of water, land and air, that is, disturbance of the natural balance, will greatly affect the economic situation, and eventually – our national security. The relationship between economic stability and national security is twofold, in such a way that a strong economy can provide sufficient expenditures for the security system, while safe working conditions provide stable business opportunities. In other words, the national survival formula is an economically stable, healthy and safe environment.

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POSTMODERN THOUGHT AND MODERN WORLD

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Abstract:

In this paper authors examine the postmodern thought and the ability of postmodern theories to understand the great issues of modern world. Postmodern thought is understood as a reaction to progressivism and it stands against the belief in objective and scientific truth. In philosophy, it represents mistrust in *grands recits* of modernity: great justifications of the West and the faith in its progress evident in Kant, Hegel and Marx, ideas that emerge in utopian visions of perfection reached by evolution, social improvement, education and development of science. As a notion, postmodernism was introduced in the beginning of the XX century, but gained its full meaning in the '70s, when it reached popularity that it still enjoys in the first decades of the XXI century. Instead of epistemological absolutism (only one truth) based on scientific knowledge, postmodern thought introduces a multitude of truths. Scientific, objective and general truth is replaced by relative and subjective truths. A common value system is pushed back by a large number of value orientations – workings of axiological relativism. Certainty of truth is lost along with certainty of moral evaluation. Postmodernism lost its foothold of moral evaluation. Authors consider postmodernism to be an expression of primarily liberal and neoliberal ideology which cannot grasp the tremendous problems of the global world, such are poverty, devastation of nature, demographic explosion, international terrorism, global inequality, perils of nuclear catastrophe, etc. We need to strive to all-encompassing and holistic theories which will not be exclusively West-centric, and redirect our scientific thought towards a "bold synthesis".

Keywords: postmodern theories, modern world, globalism, global challenges and crisis

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POSTMODERN – WHAT DOES IT ACTUALLY MEAN?

The notion of postmodern is an important and complex notion which yields no concurrence nor unanimity[2]. This is nothing out of the ordinary in social sciences, where diversity of thought is even desirable to some extent. Notions "Postmodern" and "Postmodernism" imply a social reality that comes *after* what is modern. They signify the existence of intellectual currents which explain the postmodern reality. Therefore, they denote a philosophical, scientific, and artistic movement based on the critique and rejection of modern *weltanschauung*. As a notion, postmodernism was introduced in the beginning of the XX century, but it got its contemporary meaning in the '70s. In this period, it gained a lot of popularity which stuck with it even in the first decades of the XXI century. According to postmodern thinkers, sociologists ought not be concerned with theories developed by Marx and Weber, especially their understanding of social change. "In culture, postmodernism is perceived as the acceptance of superficial style, self-conscious referencing and parody… along with the glorification of the ironic, transient, and trendy. It is usually understood as a reaction to naïve and serious conviction in progress, and against the faith in objective and scientific truth… In philosophy[3], it implies mistrust in the *grands recits* (great tales) of modernity: justification of the western society and conviction in its progress, evident in Kant, Hegel… Marx… In post-structural aspects, it encompasses denial of every determined meaning or any congruence between language and world, or any reality truth or fact which would be the object of examination." (Блекбурн, 1999, 325.). Some argue that Nietzsche was the harbinger of postmodernism, as he disputed all "objective knowledge". Objectivity was debunked as a disguise of power and authority. "Logical or rational thought[4] was debunked as imposition of suspicious dichotomies to the event-flow. Postmodernists differ in regards

2 "Not even the name **Postmodern** is commonly accepted. Americans think that postmodernism was initiated by the Argentinian writer and thinker Borges with his "fantastic realism"… Perhaps Nietzsche's "non-modern considerations" and his conception of "joyous science" really foreshadowed postmodernism." (Коларић, 1998, 270).

3 Roots of postmodernism in philosophy are found in neoclassical philosophy, existentialism, phenomenology, structuralism, neo-Marxism, game theory, post-Saussure linguistics… Therefore, some rightly view postmodernism as a "conglomerate of all ideas at the end of the XX century". (Узелац, 2004, 593.)

4 "Instead of logocentrism and eurocentrism, Postmodern introduces globalization of provincialism, marginality, contingencies and micrologies ("small" instead of "grand" tales…). Postmodernists highlight differences rather than identity, differentiation rather than repetition, discontinuity rather than continuity, pluralism rather than monism, heterogenous rather than homogenous, coincidence rather than necessity… Instead of "historical though" which

to the consequences of such discoveries… While for some disintegration of objectivity represents a path towards a liberating political radicalism, for others it allows for… seductive understandings like denial of (objective) existence of events… Second World War or the Holocaust. For some… like Rorty (*Contingency, Irony, and Solidarity,* 1989) it enables deviations from aesthetic, ironic, indifferent and casual relation with one's personal beliefs and… events… It may seem as though the postmodern framework… expressed in 1984 in Jean-Francois Lyotard's *Postmodern Condition*... depends on the arrogant belittling of scientific success… exaggerating the fallibility of every attempt of knowledge in all disciplines, and ignoring… the truth that human history and law recognize some reliable descriptions, despite the fact that they recognize none as final… just like landscape allows for no sole map, but still there are some more or less reliable ones." (Блекбурн, 1999, 325-326.). Poststructuralism[5] is a variant of postmodernism determined by reaction against structuralism and it is associated with authors like Derrida[6], Foucault… Habermas reacted to Bernstein's description of the crisis of our age: "… we live in an age in which there is doubt in reason and the very idea of universal value judgments which can be confirmed by arguments. There is genuine rage against humanism and succession of enlightenment[7]… We hear voices from everywhere telling us about the "end of philosophy", "end of individuals", "end of western philosophy"". (Bernstein, 1985, 25.). Postmodern even starts resembling antihumanism and posthumanism

dominated the XIX century and modern philosophy… **language** becomes the basic transcendental of the postmodern, post-metaphysical, and post-Heideggerian." (Коларић, 1998, 270.)

5 "The expression *postmodern*... is used to describe the latest movement in thinking: structuralism and post-structuralism. Historians of ideas view this movements as markings of a deep rejection of humanistic tradition which emerged in the renaissance and reached its full expression in the enlightenment. This tradition… is now questioned. As Silvio Gaggi pointed out, postmodernism can also mean *posthumanism*… Postmodern radical critique… of scientific objectivity, universal norms and reason driven progress represents… condemnation of tradition of the enlightenment." (Пери, 2000, 638.)

6 Jacques Derrida (1930-2004) is the most prominent postmodern hermeneutic.

7 "Postmodernists claim that modernity is based on the heritage of enlightenment, which was perceived as… a progressive force… which transformed into a source of repression with the help of its own creations: technology, bureaucracy, consumer mentality, materialism, nation-states, ideologies… Postmodernists express their… contempt of western humanism… Postmodernists claim that humanism failed: humanistic vision of communism ended up with Stalinism, while liberal humanism… and Christianity… failed to prevent Nazism. Glorified western ideals… are but a cape of hypocrisy hiding, rationalizing and legalizing power, privileges… of white European male elite. Postmodernists… question the worthiness of the entire tradition of humanist teachings and culture. They point out… misuses… of the West – slavery, imperialism, racism, ethnocentrism… class exploitation and destruction of nature…" (Пери, 2000, 651-655).

– "When postmodern is used in such a way, it suggests that… fundamental premises of humanistic tradition – confidence in reason as the ability of humans to understand the Universe, the belief in the existence of "self" and acceptance of individuals as a primary existential entity – are rejected as indefensible." (Gaggi, 1989, 18-19).

Šušnjić underlines three major theoretical-methodological postmodern ideas. First, instead of ontological monism which observes the world as a whole with science searching for general principles, postmodern offers ontological pluralism[8] insisting on particularities. "We should no longer observe the world as a whole, but as consisting of different segments" (Шушњић, 2015, 138.). Secondly, instead of epistemological absolutism which presupposed the existence of only one truth which can be grasped by scientific knowledge, postmodern introduces a multitude of truths: relative and subjective truths take place of scientific and general truth. "Postmodernists assert that all different opinions… are equally valuable, and no that no single one has any epistemological advantage… epistemological individualism is increasingly discussed – attributing importance to personal experience and truth criteria" (Шушњић, 2015, 141-142). Scientific truths, which are now said to be non-existent, are replaced by momentary impressions. Thirdly, a universal, absolute value system is repressed by a multitude of value orientations; axiological relativism at play. "Not only certainty as a measure of truth has been lost, but also certainty of moral evaluation" (*Ibid*).

Postmodernism confronts modern values, scientific comprehension of the world, and rationalism. Vaclav Havel sees the end of modern western thought in the downfall of communism – society can no longer be explained and organized according to a theoretical model striving for scientific accuracy. Reflecting the postmodern perspective, Havel considers the aspect of modern thought to be dangerous: "Modern age is characterized by a domination of belief that culminated… that the world… in an entirely comprehendible system governed by a final number of universal laws which can be grasped and rationally used by humans for their own advantage. This age, starting with the renaissance and developing in the enlightenment was marked by a rapid progress of rational, cognitive thin-

8 American philosopher of pragmatism, William James (1839-1914) considers the universe to actually be a multiverse. "It was the famous ontological thesis on pluralism of truths and utility as a criteria of knowledge truthfulness. Namely, as James puts it, monism is an "innate illness of philosophers" who are neither hungry nor thirsty for the truth (as they claim) but rather for unity and harmony". George Santayana (1863-1952) continues on the similar path of pluralism, and asserts the principle of tolerance: "I ask no one to think in my terms if he prefers other term, and if he can clean the window of his soul in a better way…"

king. This, in turn, sparked the development of an arrogant view that man, a pinnacle of all existence, is capable of objectively describing, explaining and controlling all things in existence and owning the one and only truth about the world… It was a time of ideologies, doctrines, interpretations of reality, a time in which the goal was to find a universal world theory and thus find a universal key that would ensure its prosperity… The fall of communism can be seen as a sign that the modern idea… of an objectively comprehensible world… reached its final crisis… It is a signal that the period of arrogant, absolutistic reason has come to its end" (New York Times, 1992, 15.). It was the end of grand stories and great ideologies.

"In his work *The Third Wave,* Alvin **Toffler** differentiates… three civilization waves: agricultural, industrial and the 'third wave' (electronic, computer)… After 10.000 years of agricultural rule and 300 years of industrial civilization… we now have a civilization and culture of the 'third wave'… preindustrial and industrial civilization is substituted by postindustrial civilization, while premodern and modern culture is substituted by postmodern culture… the central institution of the third wave (epoch of computerization, IT and cybernetics)… is the **human home**… historical experience of the heavy clash of the I and II wave warns us of… the dramatic consequences of the postindustrial wave, Postmodern and a global order based on it." (Коларић, 1998, 270.)

Philosopher Agnes Heller (1929-2019) claims that "the postmodern articulates the conscience of the threshold of the enlightenment, conscience of the 'death of mind' and… West-European civilization. It stands for 'self-understanding of contemporaries who take part in contemporaneity in a cognitive, effective and volitive manner' and advocates 'pluralism of all live forms'… Postmodernists reject the idea of progress[9] which is viewed by Heller as a 'cruel Captain Progress', indifferent to common mortals. Progress is… just a myth, (uber)ideology of industrialism and modernism… in contemporary society there is no genuine progress… except the idea of progress. Heller… finds that human beings still treat other human beings as means. Our 'History' is not a laudable one, as wars and monstrous crimes rendered progress a laughing stock" (Коларић, 1998,

9 "According to postmodernists, not only is there no general concept of progress… but there is no history… Postmodern society is very pluralistic and diverse. World is full of scenes from countless movies, videos, TV programs and websites. We come into contact with many ideas and values which have little to do with the history of the part of the world we live in, as well as our own history. Everything changes so quickly that we are not sure how tomorrow will look… World in which we live is in constant rebuilding. Mass production, mass consumers, huge cities, 'Big Brother' state, generic blocs of buildings and nation-states – everything is slowly collapsing: flexibility, diversity, differentiation and mobility, communication, decentralization and internationalization are increasing…" (Гиденс, 2006, 639.).

271.). Faith in eternal progress has been lost in postmodern, in which social movement is characterized by disorder, instability and unpredictability. "The idea of continuity is replaced by the idea of discontinuity – society is characterized by a state of sudden transition, shifts and collapses, unpredictable changes during which society transitions into a new state" (Печујлић, Милић, 2005, 42.). Postmodernism is critically oriented towards the foundations of western civilization. The Greco-Roman and Judeo-Christian value tradition if abandoned and destroyed – the truth about a phenomenon is crushed into multifold different interpretations, totality is striped of its purposefulness and structure and its parts become individual, universality is pushed by diversity, cosmos becomes chaos. "Meaning decreases with the increase of information, which leads to a 'catastrophe' (implosion) of meaning (Baudrillard)" (Узелац, 2004, 593).

Michel Foucault was the first figure of postmodern social theory and an obvious example of postmodern philosopher (Рицер, 2012, 344). Foucault's understanding of history as a discontinuous process of dispersion of power across a large number of points which can stand in mutual opposition and as a process of human management via rules (Стоиљковић, 2013, 24) served as a foundation of poststructuralism, but also postmodernism. "Michel Foucault (1926-1984)… claims that modern philosophy fell into a 'slumber of anthropology'… in anthropocentrism as narcissism. Therefore, postmodern episteme of the XX century brings the 'death of human' (not individual, but the idea or 'human form') foreshadowed by Nietzsche and Dostoyevsky. **Words and things** end in sinister presage: 'we can bet that humans too will perish just like sandbanks perish on see shores'" (Коларић, 1998, 272). Jean Baudrillard (1929-2007) is undoubtably the most popular and most productive postmodernist philosopher[10]. Baudrillard demonstrates and proves in a very striking manner that media simulation and event staging are the key for the "historical western triumph". "The main prerequisite and the effect of a simulation is the loss of any reference, illusion and chaos. Simulation is chaining things as if they have some meaning, but which are actually stages, artificially assembled. These are events that never happened, but were staged and faked which leads to the inversion of cause and effect. Mass-media image becomes the cause of events, it provokes and conditions them – not the

10 "One of the most important theoreticians of postmodernity is… Jean Baudrillard who thinks that electronic media destroyed our relation with our own past and created a chaotic, empty world… In the age of media domination… meaning is created through a series of images, like in a TV show. Most of the world has become some sort of a pseudo-universe in which we react to media images, not real persons… When Lady Diana, Princess of Whales was killed in 1997… people from all around the world felt sadness for her death… However, did people mourn a real person? Baudrillard would say no… Therefore, Baudrillard speaks of 'dissolution of life into TV". (Гиденс, 2006, 693-694).

other way around. A huge quantity of information goes about the modern world, but there is less and less meaning. Possibilities of manipulation of humans and nations are terrifying. In order to establish the balance of fear and absolute control, a virtual catastrophe is simulated instead of a real one. The alleged "security" suppresses all human liberties. Personalities are unwanted, while 'clones' are. Baudrillard proclaims that there is no hope for *meaning*… Acceleration and extermination of meaning occurs… Baudrillard writes of the **end of history**… and our time as a postapocalyptic time" (Коларић, 1998, 274).

Postmodern society is a *postindustrial society.* In a postindustrial society, production of goods is replaced by production of services, importance of physical labor is decreasing while the importance of theoretical and scientific, primarily technical knowledge is increasing (Рицер, 2012, 339-342). Postmodern society is a *consumer society,* eloquently described by Jean Baudrillard, and it rests upon significantly altered habits of modern man: he does not consume for the sake of his needs, but to distinguish himself from other people. "Production and consumption have become the meaning of life. By forming a new, consumer, society, the ideal of life has become to earn and spend as much as possible… man's spare time is completely controlled… By offering him meaningless and cheap consumer content, in large malls, man is distracted from… essential content of his life… and distanced from essential and most valuable issues of meaning…" (Чупић, 2019, 128). Political aspect of postmodernism is generated in order to move as far away as possible from totalitarianism which marked the XX century in Europe. Postmodernism rises when western Europe is faced with testimonies of dissidents from totalitarian real-socialism which crushes human rights. Ruling holistic social theories of the time, like scientific structuralism (negates human role) and Marxism which has been historically compromised, fall back before new humanism and its banner of human rights. In his study of Auschwitz, Jean-Francoise Lyotard[11] (1924-1998) linked totalitarianism with European ideas (Узелац, 2004, 597). Activation of diversity is one of the central themes in postmodernism: the world (society) consists of fragments which cannot be united in a universal whole without violating the right to diversity. Postmodernists think and claim that fragments are superior to the whole. Disqualification of the "grand tale" and "activation of diversity" causes a major shift in the way we think and define society. Đuro Šušnjić notes that western culture's obsession with diversity led to the rise of individualism as a mode of behavior which cau-

11 Lyotard thins that striving for objective truth and totality leads into a political state in which metanarratives and grand stories aim to legalize and adjust reality in order to fulfill their own fanatism at the cost of terror. "We paid dearly for our nostalgia for universality and totality". Lyotard calls for a "war on totality" and "activation of diversity". (Lyotard, 1995,24).

sec the breakdown of society (Шушњић, 2015, 144). Lyotard (1995, 27). wishes for grand stories to disappear and make place for a multitude of small stories of everyday life. Despite all the diversity, postmodernism still managed to create a total world view.

MODERN WORLD

Modern world introduced a new understanding of time and space. Paul Virilio (1932-2018) remarked that the age of space colonization has passed, and that we now live in the age of time colonization. He introduces the notion of *speed distance* which, he claims, "eradicates the notion of physical distance" (Вирилио, 2011, 13) and becomes more important than space and time. Modern technologies accelerated the world by negating the significance of spatial distance and by eliminating temporal distance. All this affects many aspects of human and social life – from city architecture, choice of living space to wars and ways of global management. Modern technologies and automatization of labor go in favor of multinational corporations, but weaken the working class and local society (Вирилио, 2011, 86-91). New technologies also aim to internally control people. However, technology it self has no inherent blame, it is but an instrument in human hands.

Zygmunt Bauman's insights into contemporary social phenomena are particularly valuable. This sociologist's arguments are presented in his several books, which are all titled with the adjective "fluid"[12]. He thinks that modern society has lost its solid form and clear direction under the influence of powerful forces. Fear of death is one of these forces. However, unlike the old world, modern world marginalizes the concern about human mortality by devaluation of all things which tend to last, which transcend human personal existence. Modern world negates the value of lasting existence and concern about eternity; it focuses on the current and transient as valuable, truthful and useful. Modern world deconstructs death and banalizes it. Death is banalized as something common, simply, explainable as a physiological cessation with clear causes which can be evaded and protected from. Man of our age wishes to try out everything in his limited human life and compresses impressions and pleasures in an attempt to

12 Bauman's books: "Fluid life", "Fluid love", "Fluid fear" and "Fluid evil". These books explain his concept of fluid modernity. According to Umberto Eco, it was precisely Bauman who best explained modern society. Grand words from a great man about the great and significant Bauman's work.

convince himself that he lived more lives in one. To satisfy all the urges, to try all desires and pleasures, to live a life full of new beginnings quickly and effortlessly. "Consumer syndrome"[13] took rule over the cultural space. Identity stops being a life project which implied continuity and coherence. "Hybrid culture" (Bauman, 2009, 78) emerges as a result of modern times. Man loses his foothold in tradition and customs.

Second powerful force is globalization which, for Bauman, is negative, imbalanced and unjust: "it is the highest level of exterritorial capital, trade, information, crime, and terrorism" (Bauman, 2010, 78). Globalization is a process of increasing interdependence and global interconnection but, according to Bauman, it lacks a "cosmopolitan conscience" and political institutions which can effectively regulate the new exterritorial space in which capital and global market shifted into (Bauman, 2018, 63). Neoliberal capitalism created concentration of capital but also a sea of rejected people, "global lowest class". A powerless state stands between them, which gives ground to the market, leaving new spaces and citizens without protection[14]. This makes human life even more uncertain in fluid modernity - people fear failure. Society becomes "a factory of mutual suspicion and competition" (Bauman, Obirek, 2016, 51). Solidarity is undermined and xenophobia and the sense of vulnerability is strengthened (Bauman, 2010, 119). Fear and insecurity, caused by uncertain future, makes people focus on "living in the present". Bauman notices that anxiety and fear of the subjected are a permanent element of power in modern democratic rule, like in totalitarian states.

13 In his famous work, *Revolution of Hope,* glorious Erik Fromm claims that our technological and bureaucratical society "reduces a man to an accessory to machines, governed by its own rhythm and demands. It transforms him into *Homo Consuments,* a total consumer whose sole goal is to *have* more and *use* more. This society produces useless stuff and with it, useless people. Man as a sprocket in the production machine becomes a thing and stops being human. He spends his time doing things he is not interested in, with people who are not interesting to him, making things which are not interesting to him. And when he is not producing, he is consuming…" (Fromm, 1968, 39-40).

14 American-German independent author, journalist and researcher of geostrategic economic issues, Frederick William Engdahl, when asked in an interview who he sees as the biggest evil, the largest threat, the most harmful and dangerous person in the world, replied: "It is clearly us… humanity, because we let a small group of people destroy lives in ways we all saw – Yugoslavian war in the 1990s, war in Ukraine, wars in Iraq, Libya, Syria… all across Latin America. Internal war in the United States, orchestrated race war… global financial crisis controlled by Wall Street, oil wars… Us, the 99,9% of humanity are not a part of this clandestine group. If we saw this, wars would immediately stop, and peace would rule everywhere… we are hypnotized be the perception of their power… we are the ones that empower them. Without our sense of their power, they would be… powerless, ridiculous oligarchs which they are."

Fluidity of modern society is reflected in the fact that social conditions change in a time shorter then necessary to create new habits and routines (Bauman, 2009, 9). Modern man's life takes place in conditions of permanent uncertainty, which causes the sense of insecurity[15]. Man fears losing pace with times, his skills becoming obsolete, himself becoming superfluous to his identity and culture. In fluid modernity, all the things that provided stability[16] to human life and identity changed its form: old-fashioned job is transformed into a series of flexible working hours and odd jobs, while the traditional marriage is replace by a "let's see how it works" relationships (Bauman, 2009 a, 53). In fluid modernity, human relationships become temporary, loose, and fragile. Instead of love which tends to possess, loose relations are established; they replace the old fashioned "until death do us part" marriages (Bauman, 2009 a, 53, 109). Modern man faces a problem as a firm and traditional foothold is nowhere to be found. Human identity[17] is fluid in new modernity, his life consists of new beginnings and rejections

15 "Old industrial society is replaced by a 'society of risk'. What postmodernists see as chaos or lack of pattern, Beck sees as risk or uncertainty. Risk management is the fundamental characteristic of global order. Risk is in the focus of attention for several reasons. Progress of science and technology created new risky situations which differ from those from previous epochs. Obviously, we benefit greatly from scientific and technological breakthroughs, but at the same time they pose a tremendous risk. This means that no one knows with certainty what type of risk does genetically modified food bring. Many attributes of everyday life are also filled with risk… Beck doesn't consider modern world to be riskier than before, but sees a different nature of risk. In today's times, risk of natural perils is much lesser than the insecurity brought upon by social development and progress of science and technology" (Gidens, 2006, 696-697).

16 "Castells… like Habermas… thinks that we no longer have full control over the world we created. This Castells' assertion… reminds of Weber's view… that the increase of bureaucracy will imprison us all in an "iron cage". Or, as Castells puts it, „humanity's fear of machines taking control of the world is on the verge of becoming reality – not in the sense that robots will eliminate jobs or that government's computers will start controlling our lives as police, but in the sense that an electronic system of financial transactions will be created" (Gidens, 2006, 698).

17 The Russian Jewish Congress, along with the international debate club "Valdaj", held a debate within the celebration of the 75th anniversary of Victory in WW2, on the subject "How and why speak of war in the language of culture?". Director Andrei Konchalovsky expressed his opinion: "Everything is becoming relative. Therefore, I am concerned about what is happening with the new generation… Such a generation is very easily led towards evil… And having in mind that greed, will for power, and fear are inseparable from man, we can become witnesses of catastrophes no lesser than WW2… Now the battle takes place in the field of education, where meaning is founded…. Civilization is becoming less human. How to stop it?... I have some serious questions for the wester Judeo-Christian civilization. Changes happen which draw people from their roots. Take not that this doesn't happen as much in China and Muslim countries as in Europe. This break with tradition is even seen in the state of theaters in the world, in the number of people who read books. I have a feeling that something

of former choices. Man becomes an isolated individual[18] and all responsibility for both failures and success is transferred to him. Consumerism and conformism become basic elements of identity formation. Identity institutions from the previous phase of modernity (families, schools, and churches) are undermined in order to be replaced by commercial brands. In such society children are taught to observe others through the prism of "market generated perceptions and judgments", they are groomed to be consumers (Bauman, 2009, 139). Western civilization in on the wrong path, especially western man's egoism, pragmatism and individualism. We must be reminded of the wisdom of Marcus Aurelius, philosopher and Roman emperor, who underlines just how crucial community is for humans: "Even if you wanted to, you cannot separate your life from humanity's life. You live in it, by it, and for it. And because you live among people, you cannot renounce yourself, for we are all born for mutuality… and mutuality is impossible without abstinence". Wisdom of centuries past ought to be read.

CONCLUSION

Postmodern theoreticians have been heavily criticized for inconsistencies of their theories, their complexity and incomprehensibility, as well as for the inadequate (sometimes inaccurate) transfer of knowledge from natural and technical sciences into social sciences. To be frank, this isn't a *specificum* of postmodern thought, as many earlier sociological theories (positivism, structuralism) shared such exaggerated ambition. Particular objection to postmodernism is its rejection of truth, totality and grand narratives[19]. Postmodernists demonstrate no ambition

is reaching its end, that we are in danger of losing the next generation, because we no longer nourish neither teachers nor parents. If there are no teachers or parents left, then everything else is useless."

18 Someone wrote that Eugene Ionescu's drama of absurd, *The Bold Soprano,* is still very relevant, despite being written in 1948, and first played in 1950. People today speak a lot, despite having little to say. Words lose their meaning, and people become more alienated and lonelier. There is less empathy. A lot is spoken of humanity and moral, but in practice things are often the opposite. Media easily forms opinions, creates norms and trends, and it is very difficult to resist it. Every deviation is a risk. Education is available to all today, but does this guarantee educated people? The play *Bold Soprano* speaks of hopelessness and entrapment of people who are not even aware of it. They only see what they want to see, only what they like, and speak in order to prove their existence. Their words are not products of their actual minds. Emotions are minimized.

19 Šušnjić writes: "Illness of our time is… rejection of absolute values! When… universal meaning is rejected… than everyone turns to himself… hence we see supremacy of group and individual over general and universal, diversity over homogeneity, private over public – all

to understand social processes, let alone to change them. Many contemporary sociologists and philosophers disagree[20]. Along with many justified objections and criticism of postmodernism, it needs to be said, for the sake of justice and truth, that postmodernism provided some important and astounding explanations of social phenomena in modern world. An important legacy of the postmodern is Baudrillard's understanding of the modern world as a world without genuine culture, without originality. Modern world is filled with simulations, i.e., false things. Such a world in which places and communities lost its authenticity is constructed for tourists and consumers. Baudrillard sees amusement parks, like Disneyland, as great simulations, but also entire cities or parts of them (Las Vegas or Times Square in New York). He notices that there are simulation centers and considers the largest and most important of them to be in the United States of America – TV, film and internet content production centers. The result of simulation multiplication in the world is hyperreality – a simulated world governed by technology which seems more real and more beautiful than the real world[21]. Continuing Baudrillard's ideas, Ritzer notices that cyberspace simulations can generate a new hyperreality, because they are not physically limited: cyberspaces have the potential of becoming new fantastic and spectacular worlds, based on simulations and created for the sake of consumption (Рицер, 2012, 369-379).

characteristic of relativism and individualism of postmodern time… By entering the age of relativism… each one of us becomes more aware of our own limitations… and feels the need for others…" (Шушњић, 2004, 234).

20 "Most contemporary… theoreticians concur that information technologies and new communication systems, along with other technological inventions, lead to radical social transformations. However, most disagree with Foucault's key ideas, and ideas of other postmodernists who think that we are uncapable of understanding general processes in the social world or changing the world for the better. Authors like… Manuel Castells… Jurgen Habermas and Ulrich Beck… and Giddens claim that wee need general theories about the social world, because they can help us introduce positive change to it… Beck agrees with Habermas that the new society means not the end of attempts to conduct social and political reforms… We witness the emergence of a new area, dubbed by Beck as "sub-politics". This notion referees to activities o groups and societies which act outside formal mechanisms of democratic policy… Responsibility for risk management cannot be places solely on politicians and scientists…" (Gidens, 2006, 696-697).

21 We think that hyperreality is incapable of solving real world problems and real human problems. It can only postpone the solution, making it less likely and less possible, because this fabricated reality will eventually burst like a bubble, like every fiction does. At that point, man will be faced with tremendous and insolvable problems because he treated himself and the world and nature surrounding him in an artificial, fabricated and embellished manner. Our wester civilization is on a slippery and dangerous slope, and it is questionably if we have already past the point of no return. Postmodern theories aid in this decadence, because they do not observe the totality or form a bold synthesis. They reject the holistic approach and all the collected wisdom of centuries.

However, "humanity has met the four horsemen of apocalypse a long time ago (Death, Famine, War, Sickness) and is aware that the final outcome depends of humans themselves. Nevertheless, the apocalypse (downfall) has already started a long time ago in desolated human souls and spiritual abysses and chasms… Baudrillard sees postmodernism as tired and nearing its end. No one knows what will come after it in the XXI century. Perhaps a spiritual renaissance driven by eastern philosophy… or eco-philosophy created by the rising threat of biocide, homicide and ecocide will emerge in the XXI century to replace the forthcoming decline of the west and its logocentrism, Eurocentrism, and anthropocentrism, instead of the American "radical modernism" and "now world order"… Jean Baudrillard speaks of accelerated eradication of meaning and categorically claims that there is no hope for meaning…" (Коларић, 1998, 275-276). Postmodernism proves that the imperfect Man is incapable of grasping the Totality and full Meaning, because he sees only his partial perspective in everything. When a scientist or a philosopher shine light on one aspect of a social phenomenon, they still remain blind for all other vitally important aspects and social dimensions of it. In that sense, postmodernism is no exception and it is precisely this that represents its biggest historical flaw and weakness.

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SOLAR RADIATION ENGINEERING DATASET REPRESENTATION: A METADATA APPROACH

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Abstract:

In the near future, Web 3.0 will come true and semantic metadata are crucial to enable it. That is why it is important to annotate and standardize existing web material. In 2013, we developed SOLAR as web application software for meteorological data processing. The main goal was to provide the community with easier access to different thermotechnical variables and parameters. Now, we upgraded our software with semantic metadata. We created Solar Radiation Engineering Application Profile as a robust application profile that can be extended to annotate any similar meteorological and thermotechnical research. Also, we upgraded our software with Solar Radiation Engineering Application Profile which promotes opening and reusability of data produced by SOLAR software.

Keywords: metadata schema, application profile, dataset representation, meteorological data processing, solar data software

INTRODUCTION

Over the years, SOLAR software (Dudic et al., 2014) has been mainly used by students of the Faculty of Mechanical Engineering, although it can be useful to a broader community. Our aim was to annotate output dataset of SOLAR software in order to make clear and concise machine-readable dataset representation. In that manner, we structured output dataset and made it usable for further processing because data gathered by one researcher, may also be beneficial to other researchers.

Most researchers do not describe data they have acquired in any way, mostly because the lack of time and knowledge. Furthermore, there is no guarantee that two related studies would be described similarly. In the era of web of data there are tremendous amount of ontologies, metadata standards, other vocabularies and thesaurus. All of them are available for different domains and it is difficult to find appropriate resources and determine which should be used for particular purpose. Although it is easier to create a new resource with problem specific characteristics, further consumption of such data silos is restricted. This may be resolved by reusing, combining and extending existing resources by application profiles (AP).

APs present mixing and matching elements from different and potentially diverse metadata schemas in order to describe mostly digital resources from a specific domain. Moreover, APs enable opening the data in a structured way (Dudic et al., 2020). APs are used in different domains: biology (ISA-tab Format, MIBBI Profile, NeXus Standard), geography (ANZLIC AP, FGDC Digital Geographical Metadata Standard, INSPIRE Metadata, AGM AP, CF Metadata, WMO Climate Metadata), economics (DDI AP), statistics (GESMES Metadata, SDMX Profile) and agriculture (Agricultural AP, AGMES, AGRIS AP, Ag-LR AP, AgRES AP, TrAgLOR). There is no widely used AP in engineering disciplines. Usually, engineering datasets are annotated using schemas for annotation of data in general, like Dublin Core Metadata Standard, DCAT vocabulary and DataCite Metadata Schema. Without domain specificity, dataset stays only partially annotated and thus disabled for further consumption. Recently, EngMeta AP has been developed for annotation of computational engineering data and it can be used as a starting point for more specific APs in engineering domain.

In this paper, we present Solar Radiation Engineering AP, metadata element set for describing meteorological and thermotechnical datasets as a combination of several general and domain specific semantic metadata schemas. We strive to establish a standard for annotation of solar radiation engineering datasets on the Web.

MATERIALS AND METHODS

The Dataset

The input dataset consists of typical meteorological year (TMY) data - experimental measurement results for several meteorological parameters given in Table 1.

Table 1.List of TMY parameters

Input parameter	**Unit**
Dry-bulb temperature	$°C$
Relative humidity	%
Total solar radiation	Wh/m^2
Diffuse radiation	Wh/m^2
Atmospheric pressure	Pa
Wind speed	m/s
Wind direction	$0 \div 360°$

SOLAR software takes TMY data in CSV format as input and based on user selected parameters (Table 2) computes new thermotehnical parameters and variables (Table 3) by using well known formulas from literature.

Table 2. List of mandatory user selected spatiotemporal parameters

	User selected parameters	**Unit**
Temporal	Month of the year	$1 \div 12$
	Day of the month	$1 \div 31$
	Day of the year	$1 \div 365$
	Hour of the day	$1 \div 24$
Spatial	Reflectance of the foreground	$0 \div 1$
	Latitude	degrees
	Surface azimuth	$0 \div 360°$
	Tilt angle	$0 \div 90°$

Table 3. List of computed thermotechnical parameters and variables

Thermotechnical parameters	**Unit**
Water vapor saturation pressure	Pa
Water vapor partial pressure	Pa
Air humidity ratio of saturated air	kg_w/kg_{da}
Air humidity ratio	kg_w/kg_{da}
Enthalpy of the moist air	kJ/kg
Wet-bulb temperature	$°C$
Dew-point temperature	$°C$
Declination	$0 \div 90°$
Hour angle	$0 \div 90°$
Solar altitude	$0 \div 90°$
Solar azimuth	$\pm 90°$
Surface-solar azimuth	$0 \div 90°$
Angle of incidence	$0 \div 90°$
Reflected radiation from the foreground	Wh/m^2
Direct radiation on surface of any orientation and tilt angle	Wh/m^2
Direct radiation on horizontal surface	Wh/m^2
Direct radiation on vertical surface	Wh/m^2
Diffuse radiation on tilted surface	Wh/m^2
Reflected radiation from the foreground	Wh/m^2
Total solar radiation on tilted surface	Wh/m^2

Application profile

The term 'application profile' was introduced by Heery and Patel (Heery and Patel, 2000). They defined an application profile as a type of metadata schema which consists of data elements drawn from one or more namespaces, combined together by implementers, and optimized for a particular local application.

APs are particularly interesting to us because they promote reusing instead of reinventing. This is significant because numerous metadata schemas are available but very few are widely used.

In order to annotate all aspects of data and to propose an adequate AP needed for data querying and searching, the following issues must be addressed:

- What to annotate in order to preserve the nature and relations among data in a SDS?
- Are all of metadata equally needed for each dataset?

- Is there any metadata set or an application profile that can be directly used?
- Is there any controlled vocabulary or an ontology to be used for the sets of values of metadata elements?

Answers to these and similar questions that may arise in the process of creating an application profile depend on the specific domain and particular application.

Metadata categories

The elements used for metadata and annotation should be defined to satisfy the following principles:

1. universality – the elements must be universal enough to annotate any solar radiation dataset;
2. intuitiveness – elements should be named intuitively, so their meaning is clear to any researcher;
3. unambiguity – the researcher must have no dilemma about how to annotate some feature of data.

In the case of engineering data, it is very difficult to be confident what metadata elements to choose, due to heterogeneity of engineering datasets. Metadata elements sets that tend to preserve the nature of data are very likely to be complex, extensive and numerous, all of which we are trying to avoid.

The aforementioned problem can be overcome by classifying metadata elements into one of the following groups:

- Mandatory – metadata elements or refinements that must be provided.
- Recommended – valid reasons must exist not to provide these metadata elements and refinements.
- Optional – permitted metadata elements and refinements.

Some of the metadata elements can occur just once and others can occur frequently.

RESULTS AND DISCUSSION

One goal of this research is to establish some paradigms and standards for annotating solar radiation engineering datasets on the web through semantic web concepts and techniques.

There is no agreed definition on what a "dataset" is. A very broad definition is the one from W3C Government Linked Data Working Group: *"Dataset is a collection of data, published or curated by a single source, and available for access or download in one or more formats"*. We further define a structured dataset (SDS), in order to distinguish the data in free textual format from the structured data we are interested in:

"Structured data set is a collection of structured data, published or curated by a single source, and available for access or download in one or more formats".

An SDS can be seen as a simplified relational database, not necessarily in tabular format, but having some kind of strict structure that explains the meaning of each piece of data. It could contain one or more tables (spreadsheets), but also XML files and the like. It is also possible that data in different tables are somehow related, as it would be in a relational database.

Although engineering studies differ in many aspects, such as subjects or methods, there are several features that almost every engineering SDS shares. Those features should be a starting point for defining categories of the annotation schema for data labeling. In the thermotechnical research, each SDS is characterized by the following:

- General information (dataset authors, contact person, dataset maintaining persons, institutions from which they came, belonging project, etc.)
- climate attributes (listed in Table 1);
- time attributes (listed in Table 2, section Temporal);
- spatial attributes (listed in Table 2, section Spatial);
- observed thermotechnical attributes (listed in Table 3);

According to this characterization, we have created Solar Radiation Engineering AP as a combination of elements from several metadata schemas: Dublin Core (Caverlee et al., 2009), DataCite (Robinson-Garcia et al., 2017), WMO Climate Metadata (Aguilar et al., 2003), FGDC Digital Geospatial Metadata (FGDC, 1998) and EngMeta (Schembera and Iglezakis, 2020). Dublin Core metadata standard and DataCite metadata scheme are widely adopted generic metadata element sets and we used them to describe general information about SOLAR SDS. Additionally, Dublin Core is used to annotate temporal parameters because of their general nature. Climate and spatial parameters are annotated with adequate elements from well-known metadata schemas from domains of their origins, WMO Climate Metadata and FGDC Digital Geospatial Metadata, respectively. Strictly engineering domain specific elements are annotated with

appropriate EngMeta elements. Solar Radiation Engineering AP is expressed as XML DTD file, available at: http://solar.mas.bg.ac.rs/solar.dtd. A brief description of used metadata elements is given in Table 4.

Table 4.Solar Radiation AP metadata elements. Referenced metadata schemas: dc: Dublin Core, dtc: DataCite, climate: WMO Climate Metadata, fgdc: FGDC Digital Geospatial Metadata, em: EngMeta

Title	Element name	Metadata schema	Status
Author	author	dc:creator	Mandatory, Repeatable
Contributor	contributor	dc:contributor	Optional, Repeatable
Contact person	contact	dc:publisher	Mandatory
Institution	institution	dc:creator	Mandatory, Repeatable
Project	project	em:project	Recommended
Title	title	dtc:title	Mandatory
Description	description	dtc:description	Optional
Keywords	keywords	dtc:keywords	Optional
Version	version	dtc:version	Recommended
Date created	date	dtc:date	Mandatory
Climate parameters	climateParams	wmo:elements	Optional, Repeatable
Temporal parameters	temporalParams	dc:date	Mandatory, Repeatable
Spatial parameters	spatialParams	fgdc:geography	Optional, Repeatable
Thermotechnical parameters	thermotechParams	em:parameter	Optional, Repeatable

Solar Radiation Engineering AP is used to annotate the resulting SDS of SOLAR software. In this way, all data used and produced by SOLAR software are fully opened and structured to make easier further reusing.

CONCLUSION

Many metadata sources are available online: application profiles, schemas and standards. APs are especially interesting because they promote reusing instead of reinventing, and it is definite that using metadata is standard on the Web nowadays and reusing of metadata will be standard of the Web 3.0. Structured format of APs makes them suitable for data opening, which makes reusing of APs possible. In conjunction with aforementioned, it is clear that APs promote further consumption of the data in structured way and extensive use of APs leads to data exchange in the Web more widely (Dudic et al., 2020). In order to anno-

tate solar radiation SDS, we considered different metadata approaches and we found that AP is an adequate solution for annotation, opening and interlinking of SDSs. Solar radiation SDS contain data from several domains: meteorological, geographical and thermotechnical. We considered different metadata element sets and chose ones that best fitted our SDS, but not over-representing it. In that way, we left space for adjustment of APs to similar domains.

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THE REVIEW OF FOREST AREAS IN THE TERRITORY OF THE REPUBLIC OF SRPSKA BY MEANS OF GIS

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Abstract

This paper will be describing Geographic Information Systems and their application in forestry, i.e., the review of forests and forest areas by means of GIS, managed by Public Forest Enterprise *Forests of the Republic of Srpska*. It will be shown how spatial data related to the display of forests and forest areas by Geographic information systems.

Keywords: GIS, Forest, Forest areas

INTRODUCTION

This paper will be describing Geographic Information Systems and their application in forestry, i.e., the review of forests and forest areas by means of GIS, managed by Public Forest Enterprise *Forests of the Republic of Srpska*.

As a part of Public Enterprise, the following organizations operate:

- 27 forest holdings
- Center for karst management
- Center for seed-nursery production
- Research-Development and Project Centre

- Public Enterprise Directorate
- Forester's house "*Ognjište"*

Geographic information systems and their components will be described in the first part of this paper. Furthermore, you will be presented the ways they can be used in different areas of application. The coverage in forests and forestry land in the Republic of Srpska will be described hereafter. The data that will be used for the needs of this paper are the data taken from the cadastre of the Public Enterprise, concerning the areas of forests and forest land, and the data taken from the Republic Institute of Statistics of the Republic of Srpska. The data from *CORINE Land Cover 2018* (Copernicus, 2021) will be used for review of the data through GIS, as well as the spatial data taken from the Public Enterprise. All the above-mentioned data will be statistically processed, both tabulated and shown by GIS, which will enable us to gain knowledge of the forest coverage of the Republic of Srpska territory (Statistics, 2020).

GEOGRAPHIC INFORMATION SYSTEMS

Geographic Information System GIS is a system for management of spatial data and their associated characteristics. Strictly speaking, it is a computer system capable of integrating, storage, editing, analyzing and review of geographic information.

Technology of geographic information system can be used for scientific research, resource management, property management, development planning, spatial planning, cartography and infrastructure planning. GIS is often used for the needs of marketing research, geology, civil engineering, forestry, and also in all areas using the data related to maps (Jovanović, Đurđev, Srdić, & Stankov, 2012).

Components of geographic information systems

Put simply, geographic information systems include: hardware, software, people, spatial data and processing and analysis of data.

Hardware

Computer systems that are used to operate with geographic information systems are composed of computer hardware and an appropriate operating system such as Windows, Linux or MacOS. The main elements of the computer

system that run GIS are: the computer, memory devices, printers, plotters and the computer network.

Software

There are different types of GIS software, i.e., programs that differ according to their functionality. Programs for work with geographic information systems can be divided as follows: Desktop GIS, Spatial Databases, Web Map Servers, GIS Servers, Web, GIS clients, GIS libraries and accessories, Mobile GIS.

Spatial data

It has been mentioned earlier that spatial data are one of the basic components of GIS, and their basic feature is to provide the information on the location, in relation to the other details in the area, which are connected with direct data (Usmani, Hashem, Pillai, Saeed, & Abdullahi, 2020).

DATA PROCESSING AND ANALYSIS

Functions provided by GIS are: entry, storage, processing, transformation, analysis and creating maps. Data entry is the process of entering data into GIS in a way that GIS can use them. Data entry and their maintenance is generally the most expensive part of the job which takes most of the time in GIS project. On average, 80% of time spent in the work on each GIS project goes to data entry and processing.

Data processing is one of the basic elements of GIS. Storage of data, their organization and search are achieved by using the database management system (DBMS).

Transformation is a process in which the presentation of an element or groups of elements is changed. Transformation is the element of GIS that distinguishes it from other types of information systems. That ability of GIS makes it possible to transform the spatial data, for example from one type of entity (point, line, polygon) into another, and to do spatial analysis of the same.

Spatial data analysis is characterized by classifying the GIS data into layers. For example, one map can be digitalized whereby several layers would be created in a way that one layer would show the roads, the other on rivers, then the facilities, population and the like. Each layer respectively contains data shown

with only one type of the entity, point, line or polygon. GIS enables the analysis of only one layer, and it can also perform the analysis of the data sets from more layers.

Maps are made in several ways depending on the needs. They can be digital or printed, and their content itself depends on the needs for details and descriptions. Maps in digital forms can be created in a way that they can be used in some other GIS.

People

Not one GIS system can function without organization, i.e., it always involves people who will plan, perform, maintain GIS, and make decisions on the basis of output data from geographic information system.

FORESTS OF THE REPUBLIC OF SRPSKA

Forests present the most important source of biological diversity and have the key role in maintenance of ecological processes and ecological balance at the local, regional and global level, protecting the sensitive ecosystems, water basins and sources, and presenting the ''storage'' of biological resources and genetic material necessary for biotechnology products.

Due to the specificity and the importance of forests and forest land, as well as the public forest functions, forestry should not be treated as other industry branches. Forest products are not the goods in the classical sense, so forestry as a whole cannot be considered to be the classic producer of goods, which defines an industry branch. If we treat the forestry as a classical industry branch, following only the principle of profitability and cost-effectiveness, there is an objective risk of neglecting the necessary interventions in the forests, which further leads to decline in balance and value of the forest in the future. Forestry as an industry branch is also characterized by, among other things, a long process of production, whose successful implementation depends on the work of several generations of forest workers. Its successful management also requires a continuous process of planning the forest management, which constantly runs changing the character by detail and obligation of implementation of the planned measures (JŠP RS, 2021).

Forests and forest land in Bosnia and Herzegovina cover the area of 2 709 800 ha, which is 53% of the total area of the country. 20% of that area is in pri-

vate ownership. High forests, high degraded forests and coppices cover the area of 81,5%. Of that area, 33,9% goes to coppices which resulted from large-scale clear-cutting in high forests at the time of Austro-Hungarian Annexation and frequent wars in these territories. It was not only the wars that harmfully affected the devastation of the forests, but it was more the post-war periods when the forest was exploited with great intensity. Of the total area of the territory covered with forest and forest land, 1 100 268 ha goes to the territory. A more detailed review of the forest areas was shown in the table below, while the second table shows the data taken from the cadastre of PFE *Forests of the Republic of Srpska* on forest areas as of 31 December 2019 (Forest of RS, 2020):

Table 1: Forest areas in the territory of the Republic of Srpska

	Forest areas (ha) by type of ownership		
	TOTAL	In state ownership	In private ownership
TOTAL	1100268	801900	298268
Pure stands of	369910	297255	72655
Broadleaves	333213	266629	66584
Conifers	36697	30626	6071
Mixed stands of	730357	504645	225712
Broadleaves	416727	211570	205157
Conifers	87492	83524	3968
Broadleaves – conifers	226138	209551	16587

Review of distribution of forests and forest land in the Republic of Srpska territory by means of GIS:

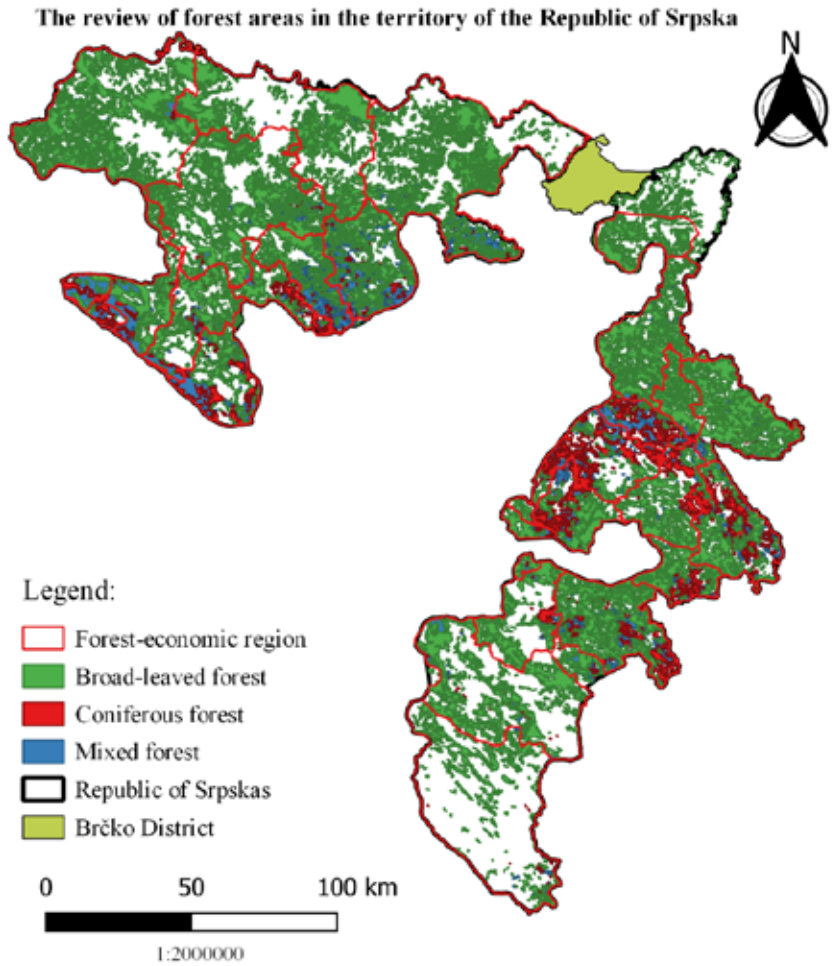

Figure 1: The review of forest areas in the territory of the Republic of Srpska by means of GIS

CONCLUSION

Based on everything presented in this paper, one can see that the data relating to forestry are of spatial character. It is obvious that the review of data related to forests and forest land can be most clearly presented by using geographic information systems. Likewise, the administrative boundaries, features of the terrain, area of forest land, as well as all other spatial data can also be clearly shown by means of GIS. In that way of data presentation one can get a faster and clearer insight into spatial distribution of data, and in this particular case, get a clearer picture of forest distribution in the territory of the Republic of Srpska.

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MODERN TEACHING MATERIALS IN INFORMATICS COURSES

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Abstract

The educational process at higher education institutions implies following the most modern technological trends. This paper offers a framework for the application of modern educational tools in educational institutions.

The proposed teaching materials represent an excellent experimental basis in the educational process of informatics or robotics studies and are based on many years of work and research.

Keywords: robot, robo platform, education

INTRODUCTION

The use of multimedia technologies (synthesis of audio and visual communication), enables the presentation of educational content in a dynamic and explicit way. In order for a student to get involved in the modern technological world, it is necessary to provide modern educational resources. It should be noted that future industrial production will increasingly be based on robotic machines (T. Balch, 2008). This is more of a reason for students to get acquainted with robotics from the earliest days and prepare for new technologies in an appropriate way.

What is gained by introducing a modern educational teaching tool? The first and most obvious benefits are:

- the presence of modern technologies in teaching using modern robotic means,
- students and lecturers find it easier to cope with obvious examples, by applying the latest obvious teaching aids,

- introducing students to real environments.

In addition to these general advantages, we can see many advantages and benefits for students:

- flexible approach to the use of the programs offered,
- simultaneous advancement in several areas - use of mobile information technologies, understanding and programming skills,
- increased level of motivation and engagement,
- development of new approaches to learning through groups or discussion forums dedicated to the subject.

The remaining significant elements for solving in order for new technologies to be of full use in teaching are:

- affordable price of teaching aids,
- raising the level of pedagogical quality of teaching aids,
- availability of electronic materials that follow new technologies in a practically usable way.

Many academic institutions have already made a smaller or larger step in the application of modern teaching aids by equipping classrooms for their students. In parallel with the new equipment, a virtual cabinet is being introduced, which enables the dislocated student to do the planned exercises in the e-learning education system (Lamb, Lin, & Firestone, 2020)**.**

The results of the research show that modern information and communication technologies implemented in modern teaching aids can help improve teaching strategies in several ways. Some of these ways are:

- make complex ideas more understandable, by explaining concepts in multiple ways and through obvious examples;
- offer students the opportunity to re-study certain topics, using modern teaching aids - another teaching medium;
- give students ways to test their different ideas, to form and test hypotheses that will help them understand abstract concepts;
- offer the possibility of effective group work, quality response to questions and requests of students, cooperation and support outside the classroom;

- increase students' motivation through their increased engagement and increased control over their own learning process;
- shorten the time students spend on low-level activities, increase their commitment to tasks and encourage them to invest more time in understanding the materials they create;
- provide better learning through intensified thinking and immediate apparent feedback;
- provide access to the opinion of experts precisely when the student needs it;
- provide students with direct access to richer and more attractive original teaching materials, as well as the opportunity to participate in authentic and collaborative solutions to individual tasks and problems.

The research framework can be most precisely defined as the desire to offer a completely new concept of a modern teaching aid that would differ in its characteristics and price from the existing sets.

By observing and recognizing the framework and characteristics of today's robotic modern teaching aids, the desired characteristics that robo teaching aids should have were noticed (Dorouka, Papadakis, & Kalogiannakis, 2020):

- modularity,
- compact dimensions,
- the ability to communicate with mobile devices,
- dynamic software adaptation to teaching goals,
- interaction that is software supported.

THE STATE OF THE ART

Contemporary theories of teaching gradually changing and increasingly adopted the idea that education should be organized so as to emphasize the cultivation of students' abilities, rather than on simply amassing the learned words (Jester, 2020). Therefore, the role of the lecturer passes to the next, advanced phase in which they get a more active professional role. At the same time, the lecturer is increasingly expected to be the creator of teaching materials, an assessor of their importance and impact on students, and a scientist who innovates

both his knowledge and the curriculum of the subjects he teaches. (Horlacher, Tröhler, & McCulloch, 2020).

MODERN EDUCATIONAL TOOLS

Educational robots have long proven to be an effective pedagogical tool for improving the efficiency of teaching physics, engineering and computer science.

A market that is extremely large (over 136 robotic platform and every day appear new products) offers a variety of teaching kits and other educational items (Sapounidis & Alimisis, 2020).

Selection sets is possible on the basis of several criteria:

- the age for which the set is intended,
- assembly set or assembled robot,
- possibility of robot programming,
- the ability to connect to a computer.

In this paper, we will mention several robo platforms that represent modern teaching aids that we have developed over the years, looking for platforms that will support curricula and at the same time be inspiring and attractive to students. Those are:

- CD robi, differential robo platform,
- Omni platform,
- Robo hand,
- Simulation platform.

Cd robi

CD Robi is a platform is a robo set intended for ages 9 and up. The first retail version was released in 2005 (Figure 1). The software is free.

Figure 1 CD Robi platform

CD Robi platform components: plastic computer case, two motors with reducers, control panel with USB interface, Bluetooth connection, ultrasonic sensor, modular, (country of origin Serbia).

QUAD platform

QUAD is an educational robot intended for the university level. It is easy to assemble. It was first realized in 2014 (Figure 2).

Figure 2 QUAD platform

QUAD platform components: plastic computer case, two motors with reducers, UNO control panel with USB interface, Bluetooth connection, ultrasonic sensors, modular (country of origin Serbia)..

Robo hand

The platform of this type is intended for ages 9 and up. Assembling the platform is relatively easy. It was first realized in 2016 (Figure 3).

Figure 3 Robo hand

Robo hand components: plastic computer case, four servomotors, UNO control panel with USB interface, country of origin Serbia.

Simulation platform

The simulation platform (washing machine) is intended for computer science students. The platform housing is realized on a 3D printer. It was realized for the first time in 2019 (figure 4).

Figure 4 Simulation platform

CONCLUSION

In a brief overview of the existing educational tools on the market, it is possible to see that they are efficient and good educational tools. We also see that the user, whether a professor or a student, using these means leaves a lot of room for creativity and expression.

Most of the educational tools arrive on the market as a finished product (they are not intended for assembly). There are gaining in quality because it did not need some prior knowledge but it is a finished product, ready for immediate operation.

Creativity is imperative and a lot is left to the user to define in their work through software packages.

To increase student motivation, cognitive indicators are often in the form of competition. Thanks to these competitions, students often achieve very good solutions to given problems.

With the development of educational robotic means, promotions began, and later competitions in robotics (Murphy, 2001). Local competitions have gradually grown into national and eventually into world competitions. There are several dozen very serious competitions, mostly organized by manufacturers of robotic devices.

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THE IMPORTANCE OF ADEQUATE APPLICATION OF ELECTRONIC LEARNING IN CRISIS SITUATIONS

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Abstract:

In recent times the world has faced a global problem. The whole society stopped for a moment. Noone could escape the crisis that ensued. In a number of segments, the population has abandioned their daily activities. Both education and companies had to access new methods of work, and one of them was to redirect education from the non virtual to a virtual approach. If there is a desire of the company to stand out in the market and stand out from the competition, employees must possess advanced knowledge and skills in order to successfully solve work tasks. This is far more important in the post-crisis times, in which it will be clear which companies have managed to respond to new market demands.

Key words: knowledge, education, learning, pandemic, efficiency, human resources, crisis situations.

INTRODUCTION

E-learning is a significant support to both employees and managers in the implementation of business processes in companies. Thanks to the ever-present free services on the Internet, managers can prepare and organize employees relatively quickly, and models are becoming more and more available. These resources can be easily changed and supplemented, updated and harmonized with educational regulations and the needs of performing work tasks. The basic philosophy of e-learning is to deliver the right materials, to the right people at the right time and in the right place and the right quantity in the right context using the most appropriate media.

The University of London was the first university to offer a degree or rank of distance learning training, based on its external program in 1859. Another

initiator in the institutionalization of this type of education was the University of South Africa, which introduced Correspondence Education courses before 1946. The largest Distance Education University in the UK, Open University, has existed since 1969. A similar one was opened in Germany in 1974. Fern Universitat in Hagen. Today, there are more than 90 institutions around the world, most often called Open University, in English or translated into one of the local languages, modeled on the long-established Open University in England, which primarily emphasize the importance of distance learning (Brkić et al., 2009).

Employee education has so far been focused in the traditional way. As e-learning systems developed, so did companies focus on new modules. The focus shifts to the intellectual needs of the individual employee. The digital age will have a significant impact on education and will radically change the existing process of employee learning and teaching. In many countries, initiatives have already been launched or are being launched that will mark a revolution in the use of new technologies in both large and small and medium-sized enterprises. However, the pandemic caused by COVID 19 forced companies to accelerate the application of new technologies. Costs increased, and the changes affected employees. Many felt that they would not do well enough. It was thought that the innovations would be drastic and that business processes would suffer because of them, and that there would be a halt in production and that dissatisfaction would be created among employees.

COST-EFFECTIVENESS OF ONLINE EDUCATION IN THE REPUBLIC OF SERBIA

The education of employees in the Republic of Serbia has not yet been raised to a satisfactory level. Employers most often apply traditional ways of educating employees, believing that in this way better efficiency is achieved and also in this way the costs are significantly lower compared to the application of online educational content.

For the purposes of distance learning, the institution is obliged to form, administer and maintain appropriate infrastructure, which ensures: availability of learning materials, synchronous and asynchronous communication between all actors involved in the learning and teaching process, monitoring student progress and implementing other activities that are important for the success of di-

stance learning. It is necessary for the infrastructure to follow modern technical standards, to be modular, flexible and scalable (in line with the increase in the number of users) and in line with the needs of the target group of users (Milićević, 2014).

The new way of doing business has conditioned the company to view the human resources sector as a separate organizational unit and to constantly improve its operations. However, since the emergence of the knowledge economy, traditional categories of knowledge have been both imprecise and difficult to operationalize for management purposes, leading to a number of new classifications (Blumentritt, R., Johnston, R, 1999).

Small and medium enterprises were included in the research. Respondents were of different age groups and qualifications. Heads of organizational units and sector directors were involved.

The sectors involved were: stock control sectors, the financial sector, the occupational health and safety sector, the general legal affairs sector, the human resources sector, and the quality control sector.

The profitability of investing in the education of employees in relation to the interest of the employed staff (for a certain type of education) was measured.

The first group of respondents	The second group of respondents
Managers and directors of different sectors	**Employees**

Table 1. Respondents divided into groups

Respondents were divided into two groups in order to facilitate data processing and obtain as accurate data as possible. The first group of respondents consisted of managers and directors of the sector, while the second group consisted of employees.

The planned costs of investing in online education of employees were 780,000 dinars annually, while the real costs are 635,000 dinars.

Graph 1. Planned and real costs

The costs include:

Lecture costs	25,000.00 Din.	
Rent space	30,000.00 Din.	
Catering	0.00 Din.	Sponsorships
Certificates after the seminar	25,000.00 Din.	
Accompanying gifts for participants and lecturers	20,000.00 Din.	Cooperation with business partners
Equipment rental	50,000.00 Din.	
Opening and closing conference	25,000.00 Din.	
In total	**175,000.00 Din.**	

Table 2. Basic costs of the organization

Leaflet printing	25,000.00 Din.	
Media advertising	50,000.00 Din.	
Accompanying material	100,000.00 Din.	
Promotions on social networks	0.00 Din.	Posts were not sponsored
In total	**175,000.00 Din.**	

Table 3. Marketing costs

Lecturer's travel expenses	50,000.00 Din.	50,000.00 Din.
Lecturer's per diems	60,000.00 Din.	60,000.00 Din.
Lecturer's personal income	125,000.00 Din.	125,000.00 Din.
Material needed for the lecturer's work	50,000.00 Din.	50,000.00 Din.
In total	**285,000.00 Din.**	**285,000.00 Din.**

Tabea 4. Lecturer costs

The total costs are 635,000 dinars, compared to the planned ones, which means that the project is profitable.

Project profitability: 780.000 - 635.000 = 145,000 dinars

One hundred employees were participating, of which 70 employees stated in the affirmative that they wanted to participate in any type of education. They were offered educations in various areas related to marketing, management, application of health and safety measures at work, marketing, economics.

A positive example from practice where one state institution implements one education program is:

The Faculty of Electronics of the University of Niš is involved in several e-learning projects. One of the biggest projects is in-service teacher training, which the faculty works with Microsoft, in which multimedia educational materials are distributed and learning outcomes are monitored in the Learning Management System, with the possibility of asynchronous learning. An important thing that was conducted at the Faculty of Electronics in Niš is a video conference with the University of Maribor and the University of Kragujevac within the subject of multimedia (Devedžić, V. et al., 2011). The development of these non-traditional methods of education and the use of information technologies in education can significantly contribute to the transformation of education through faster access to information and an accelerated process of knowledge sharing (Nguyen, Chung, 2020). This is exactly the great potential of the application of online learning in education and business.

ELECTRONIC LEARNING IN CRISIS SITUATIONS

A crisis is a disturbance in the normal state and functioning of a person or a certain situation. A crisis arises in situations when a person is faced with serious obstacles in achieving both important life goals and goals at work, but also such obstacles that are insurmountable by using the usual ways of problem solving in the life or business environment. The past period of the pandemic disrupted daily business activities. Companies instructed by the problems caused by the current situation have greatly increased online education for employees. Trainings refer to the application of various programs used in business, to the application of new content. Managers have realized that higher costs are caused by poor training of employees in relation to the costs that need to be set aside for investing in staff education. One wrong action can cause a thousand different problems in busi-

ness. Special attention must be paid to the training of employees who have been given assignments to perform work tasks in new job positions. When planning the application of knowledge management in companies accompanied by a quality system, all sectors in the company must be covered. In addition to the quality sector, the sectors of maintenance, procurement, marketing, human resources, health and safety at work, production must be included. Employee education should be viewed as a set of all knowledge that is based on certain experiences. In recent years, the company has been required to provide continuous training.

The research from 2015. shows that regarding the age of the respondents and the years of work experience, it depends which factors define their satisfaction. Younger respondents believe that intangible stimulation factors are extremely important, while older respondents are of the opinion that the reward of a material nature is a factor of satisfaction. In this regard, it can be concluded that the younger category of employees in relation to the older group of employees will opt for online education. Respondents with up to 10 years of work experience believe that the possibility of training, additional education in the company is a sufficient stimulus that defines job satisfaction. Zaposlena lica sa više radnog iskustva na nižim pozicijama u organizaciji radije se opredeljuju na tradicionalni način usavršavanja. Ova grupa zaposlenih edukacije zamenjuje novčanim stimulansom ako postoji mogućnost odabira. Smatraju da su njihova trenutna znanja dovoljno kometentna.

CONCLUSION

There is an increasing lack of recognition of the need to introduce knowledge management accompanied by a quality system. The importance of non-verbal communication, which is extremely important for the application of business education, was also poorly recognized. Clear communication is considered to be extremely important for business, especially in multinational companies. It is for these reasons that quality management is extremely important because leaders must recognize this need of employees and provide them with adequate support for additional training. Awareness of the need for knowledge and the two previous factors point to greater trust with respect between people who are referred to each other through the processes, functions and sectors of which they are members. Through well-designed strategies and trainings, employees will develop a

strong connection with the company, they will feel valued because it is invested in them and their values of organizational commitment will be at a higher level. Increased investment in quality education of employees will increase the value of companies.

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ДОБРОТОЉУБЉЕ, БЕОГРАД

Tiraž 50

ISBN 978-86-89529-33-3

CIP - Каталогизација у публикацији
Народна библиотека Србије, Београд

502/504(082)

INTERNATIONAL Conference on Sustainable Environment and Technologies "Creating sustainable commUNiTy" (1 ; 2021 ; Beograd)
Proceedings / The First International Conference on Sustainable Environment and Technologies [«Creating sustainable commUNiTy»], 24-25 september 2021, Belgrade, Serbia ; [editors Sanja Mrazovac Kurilić, Ljiljana Nikolić Bujanović] ; [organizer University «Union Nikola Tesla», Belgrad, Serbia]. - Beograd : University «Union Nikola Tesla», 2021 (Beograd : Dobrotoljublje). - 378 str. : ilustr. ; 25 cm

Tiraž 50. - Napomene i bibliografske reference uz radove. -

Bibliografija uz svaki rad.

ISBN 978-86-89529-33-3

a) Животна средина -- Зборници

COBISS.SR-ID 46182153

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