UNIVERSITY "UNION - NIKOLA TESLA"

Nikola Tesla

THE THIRD INTERNATIONAL CONFERENCE ON SUSTAINABLE ENVIRONMENT AND TECHNOLOGIES

PROCEEDINGS

22-23 SEPTEMBER 2023
CARA DUŠANA 62-64, BELGRADE, SERBIA

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ARCHITECTURE AS AN ENVIRONMENTAL INDICATOR BETWEEN TECHNICS AND CIVILIZATION:ONE INTRODUCTION

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ABSTRACT

The situation of humanity has entered a whirlwind of changes due to COVID, the evident climate change, and the spectacular development of sciences in a digitized and global world. Texts and technological advances are becoming obsolete before they can be taught or disseminated. No one has time to read scientific advances The physical world is connecting with less physical time every day, and mental time is becoming more capable of symbolically reaching more virtual spaces. The threat of a catastrophic implosion between the two space-times, physical and virtual, is increasing every day. The danger of volatility is increasing day by day.

If in the biblical Tower of Babel the condition for the physical survival of humanity was dispersal throughout an empty world, now the condition for survival is the opposite. We must unite in a world capable of communicating between languages to build a habitable land , not with towers of increasing height, as the Bible accuses. The biblical curse still stands, if we do not know how to react and each one continues to build their towers in their own way and according to their language, either climate, war, plagues, or a mix of everything will end with all of humanity.

What can we do in order that architecture and urban planning arrive to be environmental indicators between technics and civilization?. This text attempts an answer that, as H.G. Gadamer claimed in one of his last texts, is now fundamental, (1) However, I will answer the question on a short scale, as an introduction .

INTRODUCTION TOWARDS AN ARCHITECTURE AS AN ENVIRONMENTAL INDICATOR BETWEEN TECHNICS AND CIVILIZATION

This introduction is based on the previous work of many thinkers, such as P. Ricoeur, Pierre Kaufmann, L. Mumford, M. Bajtin, H. G. Gadamer, E. Husserl, J. Piaget, R. Sennett, S. Giedion, R. Poggioli, R.E Zimmermann, A. Rapoport, A. Salama, K. Friston, and many others. It also draws on the work of many architects who will form the backbone of other responses, as the verbal description of architecture is long and detailed, or else it is useless. In this short response, these architects will be present, often in their absence, as HG Gadamer indicated in his observations.

In my recent work (2), it is clear that in the last twenty-five years the earth has changed and so has its architecture. As happened at the time of the technological change that propelled the architecture of avant-garde art (3), styles were copied with new materials, often forcing the constructive reality. Today the same thing happens with the use of artificial intelligence in buildings and cities that change their image, but not the architecture that underlies them, thus ridiculing scientific advances of all kinds under an epidermal advance that does not impact social and cultural change in depth.

Here, linking to one of HG Gadamer's last writings, to which I have already referred, published at the age of ninety-three, one can trace the origin of the architecture of the end of the world in Goethe's phrases in the seventeenth century about a dialogue between the different creative literatures in the world, as a sign of hope for a new innovative global culture. Gadamer indicates that the plastic arts and music do not need translation and can therefore build imaginary bridges between different cultures. Although we may not be able to imagine this world in order, we must continue to think. He concludes by saying that as long as we are able to ask questions, we will be able to think; otherwise, humanity will have come to an end.

Therefore, this statement is based on questions, assuming that if one can ask, one can also respond through intelligent human conversation. In this way, and taking as reference, besides my own work, the doctoral thesis of Johan Nielsen recently read at the KuLeuven School of Architecture in Brussels (4), I wonder and ask: Why doesn't architecture serve to communicate architects, users, and owners, turning projects into conversations between deaf and/or mute people, instead of being supports for a new place, with a „grammar of coexistence," as a social forum (5) capable of peacefully translating the cultures and

intentions of its different inhabitants? A longer, „interlocutive" verbal response (between words) (6) is already available in the books of Richard Sennett (7), but the „interlocutive" responses (between bodies and places), despite the excellent „conversations" initiated by Antoni Gaudí and Enric Miralles, are still very weak responses.

Sennett's latest book as a question must be read carefully, and the conclusion that the capitalist system is not a response to either social or climate needs is globally accurate. However, neither the „interlocutive" examples in his book nor the theoretical arguments contain enough questions to start a critical and intelligent conversation. Regarding the theoretical aspect, I have already expressed my opinion (8) that his response with respect to Heidegger is correct, but substituting him with Levinas avoids better answers to the reasons for the failure of architecture in cities as a conversation between cultures.

Walter Benjamin, H.G. Gadamer, Paul Ricoeur, or Mikhail Bakhtin, the latter well defined by Sennett in one of his previous books, are surprisingly absent in his latest book to date, and they were much better prepared candidates to answer why our cities fail as a conversation between cultures than Levinas.

Here, one must ask, for example, about the importance of Bakhtin's concept of the „unsaid," as a fundamental part of a conversation in which nobody knows what the agreement will be at the end, but in which everyone can participate from a human presence that is difficult to predict, but that exists and cannot be identified with the algorithmic consciousness of artificial intelligence because it is much more than this. Let us answer more clearly. The moral weakness with which Sennett ultimately concludes his book is not a sufficient response. Architecture and urban planning pose a conversation that is going beyond, towards a possibility of celebration and peaceful truce between those who converse in the place, whether it is ancient, modern, lived, or represented virtually.

Here, Lewis Mumford, accused of moralism for years, is still the best when he indicates that architecture has always been abstract, always posing a conversation, between those who stroll and those who live within ,through geometries built as possible „grammars of coexistence" and „survival" between diverse subjects and cultures. This is why the „abstracted" works of art by Picasso, Miro, Miralles or Dali, are capable of posing a conversation between future experiences beyond the legal, ethical, and technological limitations of their time, projecting a better future, potentially providing a better response, as Mumford described for thirty years in his contributions to THE NEW YORKER.(9)

Paradoxically, Sigfried Giedion also gave similar responses (10), but in his case, to take away their critical capacity, the meaning of his last book has been misinterpreted so that it could never be read as a criticism of the subsequent development of the modern movement, of which he was a great defender.(11) In Mumford's case, the opposite happened, he was criticized as an attacker of architecture and modern art when he criticized the architecture of the International Style in New York, precisely based on his loyalty and defense of modern art. Once again, the conversation between them was, between Switzerland and the USA, a conversation between the deaf when both were convinced anti-fascists and defenders of the deep social dimension of architecture and urban planning. They asked and answered in unison, but the flute did not sound. We must ask why.

The easy answer is that both Giedion and Mumford were filled with mutual prejudices and saw each other as potential aggressors, without making any effort to find common ground. Despite both being knowledgeable about modern art and its history, there was no deep conversation. This was a shame, not just for them, but for humanity as a whole.

A more in-depth answer is harder to come by. Perhaps neither of them considered having a deep „interlocutory" conversation. If they had, they could have linked FLL Wright to the origins of the Modern Movement in Europe or to Russian Constructivism, which traveled to Chile via Uruguay and landed in the Open City in Valparaiso. I am proposing a deep conversation between the Bauhaus, Taliesin, and the Open City. The immediate and angry response of Enric Miralles to the Open City and its buildings, outraged that they had copied him when it was impossible because they predated his own works, was a response to this deep conversation that Gadamer defined in his last and premonitory texts. Here is the germ of the answer. That is, the answer was here, but it was never formalized in either interlocution or interlocation explicitly, although it was implicit in texts and works.

Gadamer's opinion is important here again. Although there could not have been a better response, we must continue to think, that is, we must continue to ask questions. For example, why did the deep conversation between these three schools not happen to understand how intercultural places and translation between languages, as defined by Walter Benjamin, work?

We are at a very central point in architecture as a conversation, a point that would find in Bakhtin perhaps the most aware author of what happens here(12). Essentially, they did not really believe in coexistence but in an agreement from a „balance of powers." Miralles feels threatened, Mumford and Giedion feel

threatened mutually, Wright feels weak in the face of the abstraction of art in Europe on the one hand, and on the other, he feels threatened by the arrival of the Bauhaus in the USA. Politics and morals work against a deep human conversation. The fascist power game hovers over Philip Johnson and H.R. Hitchcock's New York, and the important thing here is that everyone feels threatened, but no one really knows why. They feel threatened by the different forms of architectural schools and their factual powers. When they should have asked themselves why their art had been reacted to in each case, in search of a meeting point in the deep difference between the starting positions, here the interlocutory and unfinished debate between Derrida and Gadamer, and which continued interlocatorily between Derrida and Peter Eisenman, is the best reference.(13)

As Bakhtin, Goethe, and Gadamer proclaimed, despite not being able to imagine an order, we must continue to think, think and think, and ask the right questions: Why does Mumford criticize the New York of the Big Towers? Because the buildings in the Ciudad Abierta resemble those of Miralles? Why is Wright at the forefront of European architecture and vice versa? Why does Mumford defend Wright when the Bauhaus enter into the USA? Why do Gropius and Mies not defend them? The correct question, therefore, is how to teach to design a new place of coexistence and to what extent Taliesin, La Ciudad Abierta, and the authentic Bauhaus (old or new, it doesn't matter) are capable of teaching it in the digitized world of the future to new architects and designers, with the essential and necessary specificity in each school, but accepting that ideas are also essential. Here, Paul Ricoeur's latest book on „The Becoming of Social Recognition" is a first step (13). But architects and urban planners should also have a say with a fundamental experience that should be able to combine the inner and outer worlds in a social and physical, spatial and temporal investment that supports this social recognition, chrono topically, materialized in innovative architecture and urban planning, and therefore theoretically consistent.

And here again Enric Miralles and his urban proposals in Barcelona, designed but not built, constitute the questions that must be answered, because not only verbal language is capable of asking, but also, and with great strength, projects and built cities can do so interlocatively. Goethe answered these questions in his famous Journey to Italy, which Bakhtin included in the introduction to his book on the history of poetics in Western literature, a book that was burned in Hitler's bonfires in Berlin and of which Bakhtin, an unflappable smoker, smoked page by page until only this introduction remained, published in many languages thanks to the dedication of his students (14). Fortunately, artificial intelligence is only capable of answering more or less interesting questions, but it is not capa-

ble of imagining innovative questions, and when it does, there will be thinking and living brains to answer and engage in a conversation between machines and brains that already exists in the real professional life of architects but that no one wants to investigate and explain for fear of revealing the true reasons for the questions and answers, both interlocutively and interlocatively. And, without further ado, let's start asking.

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BUILDING ENVIRONMENTAL SUSTAINABILITY USING OSTROM FRAMEWORK: TECHNOLOGY-ENABLED GLOCAL APPROACH

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ABSTRACT

This paper proposes using the Ostrom framework to implement a sustainable environmental approach on addressing climate change and posits that Information and Communication Technologies (ICTs) can play a crucial role in many aspects within the framework. The Ostrom Framework consists of a set of variables that help in examining the institutional rules and interactions that influence the sustainable use and management of common pool resources (CPRs). Along with this framework the paper proposes a glocal approach to environmental sustainability that involves integrating global and local perspectives. In the proposed approach, the role of information networks is essential, enabling small- to medium-scale governance units to interconnect through monitoring systems. In addition, the paper showcases various successful examples based on the Ostrom framework, along with instances of maladaptation and unintended consequences in climate adaptations. It highlights the potential of ICTs as valuable tools to support collaboration, information dissemination, governance, and enforcement within the Ostrom-based framework for sustainable climate adaptation. It provides several illustrative examples of how these tools could be harnessed to improve the effectiveness of the environmentally sustainable approach.

Keywords: sustainability; Ostrom framework; glocal; ICT

INTRODUCTION

Data from The World Counts forum (2023) reveals that human current resource consumption and waste production require approximately 1.80 Earths, with projections that if we continue at the current rate by 2030, we will need the resources of 2 planets the size of Earth. In addition, a study by the World Wildlife Fund (WWF, 2018) highlights the destructive impact of human activities, with over a third of Earth's natural resources depleted within the last thirty years.

These facts highlight an urgent need for a broadly accepted environmentally sustainable plan to limit further destruction.

Sustainable development has gained widespread recognition as a crucial objective for human society in the 21st century. The term sustainability has evolved over the past several decades (Hajian & Kashani, 2021). In 1972, the emphasis was on restricting ecological systems to functions like waste recycling, while also addressing social, educational, health, and employment issues. In 1987, sustainable development was defined as meeting present needs without compromising future generations' ability to meet their own needs. In 2019, it was further defined as satisfying the needs of both current and future generations by considering the appropriate circumstances of human, natural, and economic capital to ensure human welfare (Hajian & Kashani, 2021).

Many research studies that incorporate the term sustainability in their titles fail to provide a clear definition, which is a methodological error (Salas-Zapata & Ortiz-Muñoz, 2019). In this paper, we adopted the latest definition of sustainability and propose using Elinor Ostrom's framework to define and build environmental sustainability. The frameworks have a significant role in the analysis of systems as they provide concepts and variables that facilitate the comparison and accumulation of knowledge (Ostrom, 1990).

In addition, we incorporate in the present analysis the term „glocal" coined by the sociologist Roland Robertson in the 1990s (Robertson, 1990). He coined the concept to describe the interplay between global and local dynamics in various social, cultural, and economic contexts. The term „glocal" combines „global" and „local" to emphasize the interconnectedness of global processes and their impact on local communities and vice versa. Soon after Robertson introduced the term, Elinor Ostrom and her colleagues used it in "Revisiting the Commons: Local Lessons, Global Challenges" (Ostrom et al., 1999), claiming that institutional diversity is as important as biological diversity for long-term survival. In Ostrom's later work on climate change, she proposes a polycentric approach because it encourages efforts at multiple levels (Ostrom, 2009).

In this paper, we will provide a background on the Ostrom framework while positing that information and communication technologies (ICTs) can be a valuable tool for collaboration, distribution of information, governance, and operation in a glocal Ostrom-based framework for sustainable adaptation to climate change.

The paper is structured in the following manner. The subsequent two sections provide background on the glocal approach and the Ostrom framework.

Following that, two sections outline examples of both successful and less successful attempts at implementing the Ostrom framework. Section 6 offers an overview of prior literature on digital transformation and environmental sustainability, while Section 7 discusses the role of ICTs in supporting elements within the Ostrom-based framework for addressing climate change. Finally, Section 8 presents the concluding remarks.

GLOBAL APPROACH

The glocal approach in environmentally sustainable policy refers to a strategy combining both global and local perspectives and actions to address environmental challenges and promote sustainability. It recognizes that environmental issues are interconnected and requires both global cooperation and local implementation to achieve meaningful and lasting solutions (Robertson, 1990).

The term „glocal" is a combination of „global" and „local," emphasizing the need for a holistic approach that considers the broader global context while acknowledging the specific needs, conditions, and capacities of local communities. The glocal approach recognizes that environmental problems often have global causes and impacts, such as climate change, deforestation, or pollution, but their solutions require tailored actions at the local level, considering local ecosystems, cultures, and socio-economic contexts.

This approach recognizes the significance of global agreements, such as the Paris Agreement, in establishing targets, fostering cooperation, and providing overall guidelines to address pressing issues like climate change. However, it also highlights the critical importance of translating and implementing these global goals and policies into actions that are context-specific and relevant at the local level. This involves considering local knowledge and practices while involving stakeholders in decision-making processes.

A local government, which can refer to a town, province, or any subnational unit of government, plays a pivotal role in this context. In the literature, local government encompasses various administrative levels, with substantial variations across different countries. For instance, in Russia, even enormous regions are considered „local," whereas, in most of the United States, municipalities and counties are entities referred to as local governments. Such variations can lead to confusion and complexity in defining what constitutes „local."

Ostrom envisioned „local" as geographically close to a specific natural resource, so much so that it became an integral part of daily life for the local

communities inhabiting that area. This understanding underscores the deep connection between people and their environment, emphasizing the significance of grassroots involvement in resource management and sustainability efforts.

The glocal approach promotes the idea that environmentally sustainable policies and practices should not be implemented in isolation but should be adapted to local realities while aligning with broader global objectives. It recognizes the interconnectedness of environmental, social, and economic dimensions, aiming for solutions that balance ecological integrity, social equity, and economic development in a locally relevant and globally responsible manner.

THE OSTROM FRAMEWORK

The Ostrom Framework, also known as the Institutional Analysis and Development (IAD) Framework, is a conceptual tool developed by Elinor Ostrom, a renowned political economist and Nobel laureate. It is designed to analyze and understand the governance and management of common pool resources (CPRs). CPRs are resources collectively used and managed by a group of individuals, such as fisheries, forests, or irrigation systems. They share certain important characteristics: they are rivalrous (if you use more, there is less for me); and they are not exclusive (it is difficult/impossible to keep people from using the resource). These characteristics make CPRs especially vulnerable to overuse.

The Ostrom Framework consists of a set of variables and concepts that help in examining the institutional arrangements, rules, and interactions that influence the sustainable use and management of CPRs. It provides a systematic approach for studying how communities, organizations, and societies develop and maintain effective governance systems for these common pool resources.

Ostrom's research identified eight design principles for the sustainable management of local common pool resources:

- Clearly defining the boundaries of the group and effectively excluding external parties who are not entitled to access the common pool resource.
- Developing appropriation and provision systems for common resources that are tailored to local conditions.
- Establishing collective-choice arrangements that allow most resource appropriators to participate in decision-making process.
- Implementing effective monitoring by individuals who are either part of the community or accountable to the appropriators.

- Implementing a system of graduated sanctions for those who violate community rules regarding resource appropriation.
- Establishing accessible and cost-effective mechanisms for resolving conflicts that may arise.
- Recognizing and supporting the self-determination of the community, as acknowledged by higher-level authorities.
- In the case of larger common-pool resources, organizing them into nested enterprises with multiple layers, where small local common pool resources form the foundation.

The Ostrom Framework is widely used in the field of commons and resource governance research to analyze and understand the conditions that lead to successful collective action and sustainable management of CPRs. It provides a valuable tool for examining the complexity of resource governance and informing policy interventions.

To support the Ostrom approach to sharing CPRs, governments can take the following actions:

Establish Data Recording Systems: prioritize the establishment of comprehensive data recording systems that document resource availability. This information, not always readily accessible to local residents, can provide a foundation for informed decision-making and a better understanding of ecological patterns.

Create Conflict Resolution Platforms: facilitate the creation of designated spaces or platforms for low-cost conflict resolution. These neutral grounds will allow community members to address disputes peacefully, fostering understanding and cooperation among stakeholders.

Foster Peaceful Information Sharing: to enhance community cohesion, governments should actively promote the design of mechanisms that enable local residents to share information with each other peacefully. Open communication channels facilitate the exchange of knowledge and ideas, contributing to more collaborative resource management.

Disseminate Successful Collaboration Examples: play a crucial role in spreading information about successful collaborative efforts and the strategies employed. By sharing such success stories, they can inspire other communities and provide practical examples for achieving collective goals in resource management.

Support the Creation of Organizational Institutions: aid local residents in establishing organizational institutions that empower them to effectively or-

ganize and address collective issues. By enabling communities to build their own governance structures, governments contribute to sustainable solutions for shared challenges in resource management, following the principles advocated by Ostrom.

In her arguments, Ostrom emphasized that addressing global warming requires more than just global-scale policies. She contended that trust among citizens and businesses is crucial for fostering comprehensive and transparent collective action. While existing initiatives like the Carbon Development Mechanism (CDM) and Reducing Emissions from Deforestation and Forest Degradation (REDD) have been put in place, they are not without their vulnerabilities and free-rider issues.

Instead of relying solely on these global mechanisms, Ostrom advocated for a polycentric approach that involves collaboration among various stakeholders at the local, regional, and national levels to tackle greenhouse gas emissions. This approach promotes experimentation with different strategies across diverse ecosystems and encourages individual commitments to emission reduction (Ostrom, 2009). A key aspect of this approach is the significant role played by small- to medium-scale governance units, which are connected through information networks and monitoring systems. This role of information networks serves as the main motivation for the analysis presented in this paper.

It is essential to understand that the polycentric approach is „nested," meaning it assumes that local-level institutions are integrated within higher-level and broader institutions. For instance, towns are nested within counties, which are, in turn, nested within states, and so on. This concept differs from „glocal," which primarily focuses on the ends of these nested units—the global and the local—without addressing the in-between connections that are crucial in the polycentric model.

In the recent study by Lofthouse and Herzberg (2023), the authors build upon Ostrom's approach to climate change and propose several advancements in the form of at least six advantages associated with polycentric systems for addressing climate change. These advantages include competition and cooperation among decision makers, fostering perceptions that encourage coproduction, facilitating mutual learning through experimentation, enhancing institutional resilience and robustness, and yielding socially desirable outcomes that are not centrally planned.

EXAMPLES OF ENVIRONMENTAL ADAPTATIONS

Ostrom's framework is rooted in the principle captured by Lee Anne Fennell's succinct statement: „A resource arrangement that works in practice can work in theory" (Fennell, 2011). This implies that Ostrom formulated her framework and design principles by observing successful real-world practices. The following examples highlight environmental adaptations that have achieved success by employing polycentric approaches, in alignment with Ostrom's principles.

The TURF-Reserves (Territorial Use Rights for Fishing) system has been implemented to manage marine resources in three coastal communities in Mexico (Villaseñor-Derbez et al., 2019). This approach involves allocating exclusive fishing rights to specific coastal communities, who then collectively manage and protect their designated fishing areas. Through local governance systems and clearly defined rules, communities have successfully improved fish stocks, reduced destructive fishing practices, and increased their economic well-being (McDonald et al., 2020).

Nepal has implemented community-based forest management programs, where local communities are granted rights and responsibilities for managing forest resources. This approach has led to improved forest conservation and sustainable utilization of forest products. Local institutions, such as Forest User Groups, have been formed to govern forest use and establish rules for resource allocation, protection, and revenue sharing (Ghimire & Lamichhane, 2020).

India has implemented Joint Forest Management (JFM) programs, where local communities collaborate with state and national government agencies to manage forest resources (Elias et al., 2020). Through JFM, communities have gained rights and responsibilities to protect and manage forests, including regulating timber extraction, preventing encroachment, and promoting afforestation efforts. This approach has shown positive outcomes in terms of forest regeneration, biodiversity conservation, and livelihood improvement for local communities.

Indigenous communities in Australia have traditional conservation practices that align with the principles of the Ostrom Framework. For example, Indigenous Protected Areas (IPAs) are managed by Indigenous communities to conserve biodiversity and maintain cultural heritage. These areas involve indigenous-led governance, traditional knowledge systems, and collaborative decision-making processes, resulting in effective conservation outcomes and cultural sustainability (Ens & Turpin, 2022).

The communities identified by Ostrom, which adopt the polycentric approach based on her framework for environmental adaptation, are predominantly found in low-resource settings. Surprisingly, there is a considerably smaller number of Ostrom-based CPR solutions employing the approach in the developed world. Blomquist and Schlager (2005) discuss some of the obstacles related to political issues in a small Southern California community that attempted to use the polycentric approach in watershed management.

On the other hand, numerous authors have observed that the UN 2030 Agenda for Sustainable Development adopts a polycentric approach that prioritizes the inclusion of people in its operations. These authors include Biermann et al. (2017), Goegele (2020), Niestroy (2014), and Weiss and Carayannis (2017).

MALADAPTATIONS TO CLIMATE CHANGE

While numerous adaptations are successful, not all attempts yield the intended outcomes. Planning for adaptation is inherently uncertain and reliant on imperfect information, resulting in the failure of many strategies. In fact, some strategies can exacerbate the situation, leading to what is known as maladaptation (Schipper, 2020). Apart from the wasted resources and time, maladaptation intensifies vulnerability to climate change. The primary cause of maladaptation lies in inadequate planning, although identifying its various complex manifestations in advance with certainty proves challenging.

A case study in Fiji highlights the unintended consequences of seawalls built to protect against rising sea levels (Piggott-McKellar et al., 2020). Contrary to their intended purpose, these seawalls have increased the vulnerability of nearby communities by obstructing stormwater drainage. The presence of such infrastructure often leads to a false sense of security, encouraging people to remain in vulnerable areas. Furthermore, in the Fiji case, the seawalls caused shifts in vulnerability along the coast due to changes in sediment deposits and posed threats to the marine ecosystem (Piggott-McKellar et al., 2020).

Similarly, in Bangladesh, a study examined the gendered impacts of flood control measures (Sultana, 2014; 2018). These measures had numerous negative consequences, including the elimination of floodplains that served as important sources of income and food. The measures also resulted in reduced soil nutrients derived from floodwaters. Most importantly, women were disproportionately affected, as landless and impoverished women lost opportunities for food and resource gathering when the flooded areas disappeared. This significantly undermined their livelihood security (Sultana, 2018).

Adapting to climate change also requires changes in attitudes and behavior. These behavioral changes often play a crucial role in successful adaptation strategies. Some of them are effective and positive, however, not all behavioral changes lead to positive outcomes.

A study conducted in northern Ghana examined how farming communities were responding to climate change. It was found that farmers were resorting to temporary migration away from rural areas in search of employment due to the insecurity caused by inadequate rainfall. While this strategy diversified their incomes and reduced pressure on food reserves, it also resulted in labor shortages during periods of favorable farming conditions. Therefore, when there are sufficient resources for a successful harvest, there is a lack of available manpower. Consequently, the act of migrating complicates farming further and introduces new dynamics and challenges to societal structures (Antwi-Agyei et al., 2018).

DIGITAL TRANSFORMATION AND ENVIRONMENTAL SUSTAINABILITY

According to the United Nations Environment Programme (UNEP), climate change efforts can be categorized into two main approaches: mitigation and adaptation (UNEP a, nd). Mitigation focuses on actions aimed at reducing greenhouse gas emissions or addressing factors that contribute to the global rise in temperatures. On the other hand, adaptation involves acknowledging that climate change is already occurring and making plans to adjust behaviors and systems to cope with the resulting changes. An example of adaptation can be seen in Fiji, where the population developed strategies to meet the challenges posed by climate change (UNEP b, nd).

Resilience is a concept often linked with adaptation. It goes beyond mitigation and is considered one step closer to disaster management. Resilience refers to the ability of communities and ecosystems to withstand and recover from the impacts of climate change and other disturbances. It emphasizes the importance of building adaptive capacity to effectively respond to and bounce back from the consequences of climate-related events.

The concepts of sustainability, digitalization, resilience, and agility have become buzzwords for organizations seeking to navigate the challenges of environmental degradation. However, the relationship between sustainability and resilience lacks clarity, particularly related to factors that contribute to greater resilience in times of crisis and disruption. Miceli et al. (2021) address this gap by constructing a conceptual model to explore how these dimensions interact, with

a focus on leveraging digitization and agility as enablers to achieve strategic resilience. The research offers a new perspective on resilience, moving beyond its traditional understanding as the ability to withstand or adapt to adversity. It introduces a strategic attribute that empowers companies to develop innovative approaches to conducting business under stressful circumstances.

Frameworks have a significant role in the analysis of social-ecological systems (SESs) as they offer concepts and variables that facilitate the comparison and accumulation of knowledge across diverse cases. The Ostrom framework comprises a collection of concepts and variables structured across multiple tiers. It has demonstrated its relevance in explaining outcomes through numerous case studies in the realms of fishery, water, and forestry common-pool resources (Hinkel et al., 2014).

Specific studies such as Eizenberg and Jabareen (2017) proposed a conceptual framework for social sustainability. The authors argue that risk is an inherent component of sustainability, and in today's context, the risks primarily emanate from climate change and the associated uncertainties. These risks pose substantial challenges to contemporary societies in social, spatial, structural, and physical dimensions. Within the broader context of sustainability, the concept of social sustainability emerges as a response to these risks while simultaneously addressing social concerns. Another study by Feroz et al. (2021) introduces a comprehensive framework outlining the necessary transformations in four critical domains: pollution control, waste management, sustainable production, and urban sustainability.

THE ROLE OF ICTS IN GLOCAL OSTROM FRAMEWORK APPROACH

Information and Communication Technologies hold significant potential as valuable tools for implementing the environmentally sustainable glocal approach within the framework proposed by Ostrom. They can provide essential support for various actions, including the establishment of data recording systems, the creation of conflict resolution platforms, and the dissemination of information and success stories. Below are some examples of how ICTs can facilitate and enhance these efforts.

Collaboration

Collaboration is critical for addressing complex environmental challenges, as they require the collective efforts of diverse stakeholders on all levels of government and society. Within Ostrom framework ongoing communication and col-

laboration between different communities using the same resource is essential. ICTs can enable collaboration by providing platforms for virtual communication, knowledge sharing, and coordination among stakeholders. For instance, online forums, video conferences, and collaborative workspaces facilitate the exchange of ideas, expertise, and best practices. By transcending physical boundaries, ICTs promote global collaboration while also empowering local communities to participate actively in sustainable initiatives.

One example of ICTs as a collaborative tool is the Global Biodiversity Information Facility (GBIF). GBIF is an international network and research infrastructure that uses ICTs to facilitate the sharing of biodiversity data among various stakeholders. It acts as a platform for data publishing, accessing, and integrating biodiversity information from different sources, including museums, research institutions, and government agencies (GBIF, nd). Through GBIF's online portal, researchers, scientists, policymakers, and conservationists collaborate virtually. They can access vast amounts of biodiversity data, ranging from species occurrences to distribution maps and ecological information. This information exchange fosters cooperation in understanding biodiversity patterns and trends.

Distribution of information

ICTs have the potential to act as powerful tools for disseminating relevant information to a wide range of stakeholders, including policymakers, communities, and individuals. Through websites, mobile applications, and social media platforms, ICTs enable efficient and widespread sharing of environmental data, policy guidelines, and educational materials as well as success stories. Accessible and up-to-date information empowers individuals and organizations to make informed decisions and take proactive measures toward sustainability. Furthermore, ICTs facilitate real-time monitoring and reporting of environmental indicators, enabling prompt actions and adaptive management strategies.

For example, one platform for sharing success stories implementing the environmentally sustainable approach is the „Climate Champions" (Climate Champions, nd). It is an online initiative that individuals, organizations, and communities from around the world use to share their success stories and best practices in implementing environmentally sustainable projects and initiatives. It serves as a virtual hub for showcasing inspiring success stories, innovative solutions, and impactful projects that have contributed to climate change mitigation and adaptation.

Governance

The Ostrom framework emphasizes the importance of local self-governance and the involvement of communities in managing common resources. ICTs support this aspect by enabling transparent and participatory governance processes. Online platforms, such as citizen engagement portals and collaborative decision-making tools, allow stakeholders to contribute to policy development, provide feedback, and engage in dialogue with decision-makers. By enhancing transparency, accountability, and inclusiveness, ICTs strengthen the governance mechanisms required for sustainable resource management.

Enforcement

Enforcement of environmental regulations and policies is essential to ensure compliance and prevent harmful practices. ICTs contribute to effective enforcement mechanisms by enabling real-time monitoring, reporting, and data analysis. For example, satellite-based remote sensing technologies could be employed to regularly monitor large, forested regions. High-resolution satellite imagery captures detailed snapshots of the forests at regular intervals, allowing authorities to detect changes in land cover and identify potential areas of illegal deforestation. Advanced data analytics algorithms are then applied to process the vast amount of satellite imagery data. These algorithms can detect changes in forest cover, and distinguish between natural disturbances and human-induced deforestation. Furthermore, ICTs could support efforts to enhance transparency and traceability in supply chains. By implementing digital tracking systems and blockchain technology, the sourcing and trading of forest products can be closely monitored.

CONCLUSIONS

The Ostrom Framework is widely employed in the field of commons and resource governance research to analyze and comprehend the factors that contribute to successful collective action and sustainable management of CPRs. The framework serves as a valuable tool for understanding the intricacies of resource governance and guiding policy interventions.

This paper explores sustainability within the Ostrom framework, particularly focusing on the application of the glocal approach. The glocal approach emphasizes that environmentally sustainable policies and practices should not be implemented in isolation but rather adapted to local realities while aligning with broader global objectives.

Throughout this paper several highly successful examples based on the Ostrom framework have been presented, along with some adaptations to climate change that did not yield positive outcomes, resulting in maladaptation with unintended consequences.

Moreover, the paper highlights the potential of Information and Communication Technologies (ICTs) as valuable tools for collaboration, information dissemination, governance, and enforcement aspects within the Ostrom-based framework for sustainable adaptation to climate change. ICTs offer powerful means to advance environmentally sustainable practices within the glocal approach, guided by the Ostrom framework. By promoting collaboration, facilitating the distribution of information, strengthening governance, improving enforcement mechanisms, ICTs can empower stakeholders to actively participate in sustainability initiatives. Harnessing the potential of ICTs in conjunction with the Ostrom framework can lead to more effective and inclusive environmental management, paving the way for a sustainable future.

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SORPTION AND TRANSPORT PHENOMENA OF HAZARDOUS CHEMICAL ENTITIES ON SUSPENDED PARTICLES

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Abstract:

At the beginning of 21st century focus of the environmental protection of atmosphere shifted towards the interaction between hazardous chemical entities and suspended particles representing a critical aspect of environmental science, contamination of ambient air and determining the real concentration level of polluting substances. The airborne pollutants and particulate matter correlation significantly influences the fate, transport, and subsequent impacts on ecosystems and human health. The paper illustrates sorption and transport phenomena of hazardous and emerging substances in the gaseous phase of the ambient air with particular focus on the specific free gas molecules that could be sorbed on suspended particles.

The sorption process phenomenologicaly observe the interface and the interaction between solid and gas phase. Very often the scientific and experimental approach does not differentiate free gaseous toxic molecules within gaseous phase. Sorption processes are based on the very complex inter / intra bond correlation between ad/ab sorbents and hazard substances (free gas emerging organic and inorganic molecules that are sorbed on the suspended particles).

The paper describes the long-range transport phenomena link with persistence and pseudo persistence, taking into account the fundamental physicochemical characteristics of hazardous emerging chemicals entities.

Key words: Sorption, transport phenomena, suspended particles.

INTRODUCTION AND THEORY

In the intriguing mosaic of atmospheric chemistry, the sorption and transport phenomena of hazardous chemical entities on suspended particles in ambient air stand as key determinants of environmental quality and human well-being. The very complex interactions (primary and secondary chemical bonds and intermo-

lecular bonds) between airborne contaminants and particulate matter introduce a dynamic dimension to the understanding of pollutant behavior, dispersion, diffusion and final impact (Weber, McGinley and Katz, 1991; Chen *et al.*, 2018; Sadeghalvad *et al.*, 2021). Emerging environmental substances are not necessarily new chemicals, often they have been omnipresent in the environment whose presence and significance are scarce, now being elucidated (Cohen *et al.*, 2017; Loos *et al.*, 2017; Yu *et al.*, 2020).

Sorption (ab and ad), the adhesion of hazardous chemical entities onto suspended particles, is a multidimensional bond process governed by surface properties, molecular interactions, and environmental conditions (figure 1.). As these entities become complex associated with atmospheric aerosols, the resulting composite structures contribute significantly to the overall composition of ambient air. The reciprocity between hazardous substances and airborne particles holds crucial implications for the dispersion, transformation, and gravitational deposition (dry and wet) of pollutants in the environment. In the chemistry, no process is one dimensional and excluding. One process is dominant, while the others are found in active thermodynamically equilibrium.

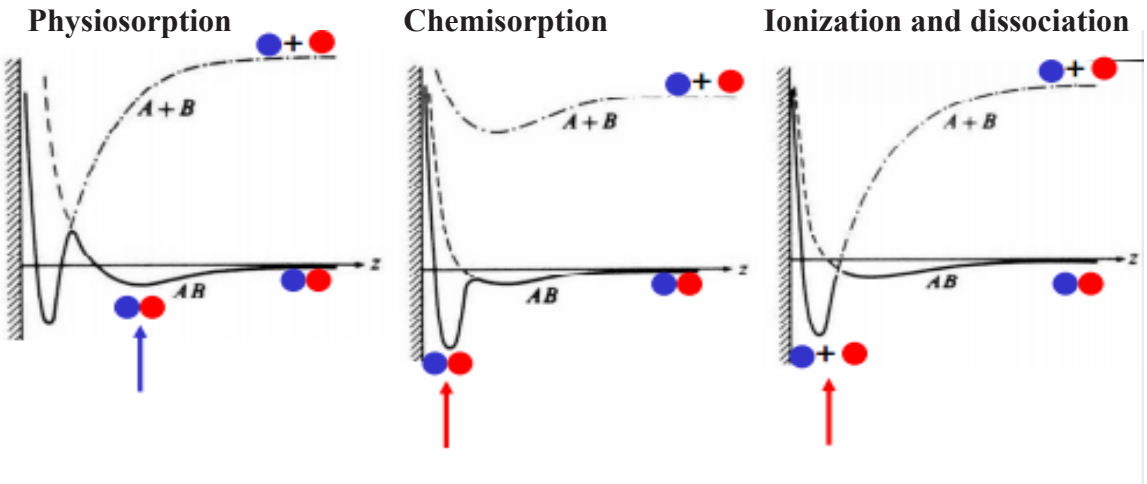

Figure 1. Simple scheme of sorption processes.

Transport phenomena further complicate this dynamic system by elucidating the pathways and mechanisms through which particle-bound contaminants move through the ambient air. Gravitational settling, diffusion, and atmospheric dynamics collectively influence the spatial and temporal distribution of hazardous and emerging substances(Selemenev, Chilrin and Khokhlov, 1999; Bilton *et al.*, 2000; Dunitz and Gavezzotti, 2005; Noy and Friddle, 2013). Understanding

these transport dynamics is imperative for predicting pollutant concentrations, assessing exposure risks, and regional variations in air quality, as well as long range transport.

The inter/transdisciplinary research integrates general principles from atmospheric science, chemistry, and environmental physics to unravel the high complexity of sorption and transport phenomena in ambient air. Advanced analytical techniques and modeling approaches are employed to examine the molecular-level interactions between hazardous emerging entities and suspended particles (Sahimi, 1995; Weiss *et al.*, 2010; Sirtl *et al.*, 2013).

The research goal is to enhance our comprehension of the processes shaping air quality, with practical applications ranging from pollution control strategies to refined risk assessments and targeted environmental adoption processes.

The complex molecular interactions (figure 2.) in the sorption processes create the clouds of the following chemical bonds:

- Dipol-dipol H bond – H+ and OH- group on the surface of SP – donor and electro negative oxygen/N - H-acceptor, eDA;

- Yoshida H bonds - interaction between –COOH/-OH from the surface of SP - H-donor and frequently C aromatic carbon rings of emerging and other organic substances;

- Self-organisation, Jean-Marie Lehn Supramolecular bonds.

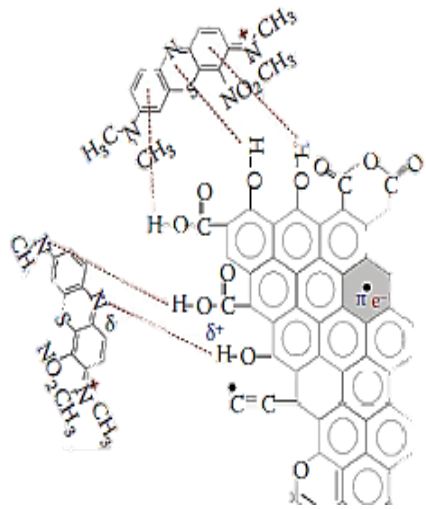

Figure 2. The complex bond interactions

MATERIALS AND METHODS

Suspended particles characterized by differentiated in size fractions, enable a detailed understanding of size-dependent sorption and transport phenomena. Understanding the physicochemical characteristics of the suspended particles provides the insights into the sorption phenomena in coordination with transport processes. Advanced models for the transport dynamics of particle-bound haz-

ardous substances in ambient air provide the necessities for simulation incorporating the atmospheric conditions, wind patterns, and particle characteristics to predict the dispersion and movement of contaminants.

The particle characterization data, sorption studies, and transport dynamics were observed in the comprehensive models. Integration facilitates a holistic understanding of the sorption and transport phenomena of hazardous chemical entities on suspended particles in ambient air.

RESULTS AND DISCUSSION

The reciprocity between sorbents and hazardous substances in sorption processes is a multifaceted phenomenon, governed by complex inter/intramolecular bond correlations. The nature of interactions is fundamental to understanding how free gases, organic compounds, and inorganic molecules associate with suspended particles. The sorbents, represented by airborne particulate matter, serve as dynamic carriers that influence the fate and transport of hazardous entities in the environment.

The diverse physicochemical characteristics of both sorbents and hazardous substances contribute to the complexity of these interactions. Surface properties, such as charge and composition, play a crucial role in determining the extent and nature of sorption. The specificity and strength of bonds formed at the molecular level influence the sorption capacity and, consequently, the persistence of these chemicals on suspended particles.

Unique Physicochemical characteristic of Emerging substances:

- Low doses occurrence and specific effects - ppm, ppb, ppt and lower, NMDR, Chemical Cocktails
- Pseudo persistency / persistency
- Stability low/non degradability
- Hydro/lipophilicity - (Log Kow = - 4.76 – 9.48)
- Bio concentration/accumulation/magnification
- Binding to proteins – (biological properties)

- Toxicity with hazardous and rather chronic effect
- Endocrine modulating/disruption, with teratogen and carcinogenic consequences within low/sub low doses
- Non - or semi volatile compounds, (volatile, D5cyclic siloxane)
- Water/lipid soluble molecules (0.06-3.1 104 mg/L)
- Polar/nonpolar molecules, Neutral, acidic, basic,
- Ionic or zwitter ionic chemical species.

The research develops the compelling link between long-range transport phenomena and the persistence of hazardous substances on suspended particles. Understanding the transport dynamics of particle-bound contaminants over extended distances is essential for comprehending regional pollution patterns and assessing the potential for exposure in diverse environments.

The concept of pseudo-persistence is particularly intriguing in this context. It recognizes that while sorption may lead to an apparent persistence of hazardous entities on particles, the reversible nature of some sorption processes suggests that these chemicals may be released under specific environmental conditions. This dynamic equilibrium between sorption and desorption contributes significantly to the behavior of contaminants during long-range transport.

The consideration of fundamental physicochemical characteristics extend of hazardous chemical entities include the molecular structure, volatility, solubility, and reactivity collectively shaping behavior in the environment. These characteristics influence sorption affinity, transport pathways, and the potential for transformation or degradation during transport.

The diverse environmental matrices, encompassing air, water, and soil, pose unique challenges in predicting the fate of particle-bound contaminants. The integration of physicochemical characteristics into models enables a more accurate representation of the environmental fate of hazardous substances during long-range transport - LRT.

The consequences of long-range transport of air pollutants are far-reaching and multifaceted, exerting significant impacts on both the environment and human health(Giona, Brasiello and Crescitelli, 2017). As pollutants travel extended distances through atmospheric fluxes contributing to the degradation of air quality in regions far removed from their original sources. LRT plays a pivotal role in the global dispersion of pollutants, contributing to trans boundary air pollution.

The deposition of contaminants onto land and water surfaces can have detrimental effects on ecosystems, including soil acidification, water pollution, damage to vegetation, and destroy biodiversity. A certain pollutants undergo chemical transformations during transport, giving rise to secondary pollutants that could have more hazardous and toxic environmental and health impact.

Understanding the sorption and transport phenomena of hazardous chemical entities on suspended particles has significant implications for environmental management. Strategies aimed at mitigating the impact of pollutants must consider not only the source and type of contaminants but also their behavior during transport. This insight becomes especially critical in designing pollution control measures and formulating policies that address the persistent nature of contaminants over varying spatial scales.

CONCLUSION

The complex nature of sorption processes, emphasizing the bond correlations between sorbents and hazardous emerging substances are highlighted as the crucial in the environmental understanding of sorption and transport phenomena. The paper defined long-range transport phenomena, persistence, and pseudo-persistence contributes valuable insights into the environmental fate of particle-bound contaminants.

The fundamental physicochemical characteristics of hazardous emerging entities posse the potential to impact the sustainable environmental management practices and enhance our ability to address the challenges defined by these complex interactions.

The fate and behavior of sorbed hazardous emerging substances onto the suspended particles are not well known, while the eco and nano toxicological effects are very dangerous. The omnipresence of these highly bioactive emerging molecules underlines the importance to understand the fate and the behavior of sorption and transport processes. The new strategic imperative is the shifting environmental protection processes toward future vision and application of advanced mitigation measures, circular economy, and development of the sustainability in society.

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DIGITAL TRANSFORMATION AND ECO-INNOVATIONS

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ABSTRACT

The paper analyzes the impact of digital transformation on eco-innovation. Significant progress in digital technologies has contributed to the birth of Industry 4.0, i.e. the Fourth Industrial Revolution. Digital transformation is the company's response to the rapidly changing business landscape in the digital age, enabling companies to remain competitive and improve their performance. It refers to the integration of digital technologies in all aspects of the organization, reshaping or replacing the business model. Previous industrial revolutions achieved an enormous rate of economic and social progress, but had a negative impact on the environment. Eco-innovations are companies' response to environmental problems: they refer to innovations that improve environmental performance, helping companies to balance profitability and environmental responsibility and to increase prospects for long-term survival. The focus of the work is on eco-innovations of products, processes and organization. The accumulation of digital technologies and the development of digital capabilities in an organization can induce all these categories of eco-innovation. The work is theoretical, the impact of digital transformation on eco-innovations can be empirically tested, it can be extended to other types of eco-innovations and it can also include the value chain and business ecosystem.

Key words: digital transformation, eco-innovation, digital technologies, sustainability

INTRODUCTION

The rapid development of digital technologies has led to large-scale quantitative and qualitative changes in both industries and society. The term Industry 4.0 originally emerged in Germany in 2011 as a vision of the future manufactur-

ing system, including not only a technological platform for the manufacturing industry, but also a social program aimed at major economic and social challenges in the 21st century (Michelsen, 2020). Schwab (2017) promotes the term Fourth Industrial Revolution which is characterized by a series of new technologies that connect the physical, digital and biological worlds, affecting all disciplines, economies and industries. These concepts, which have largely become synonymous, began to be accepted in the business world and introduced into the strategic documents of corporations that were seeking ways to increase competitiveness and improve performance. Digital transformation in Industry 4.0 integrates digital technologies into all spheres of business, changing business models and bringing unprecedented opportunities and challenges to economic and social development.

Digital technologies enable digital transformation. The plethora of digital technologies can cause confusion, so it is important to categorize them. Culot et al. (2020) classify digital technologies into four quadrants: physical-digital interface technologies – high share of hardware components/extended network connectivity; network technologies – high share of software components/extended network connectivity; data-processing technologies – high share of software components/low network creativity; and physical-digital process technologies – high share of hardware components/low network creativity. The Internet of Things, cyber-physical systems and extended reality (virtual, augmented and mixed reality) are classified as physical-digital-interface technologies; cloud computing, mobile technologies, blockchain and cyber security are in the category of network technologies; big data and real-time analytics, simulation, machine learning and artificial intelligence are part of data-processing technologies; 3D printing, robotics and energy management solutions are classified as physical-digital process technologies (Culot, et al., 2020; Zhou & Zheng, 2023).

As digital technologies are constantly evolving, it is necessary to understand the various concepts that arise when the analog and digital worlds intersect. Digitization, digitalization and digital transformation, which are often confused, are distinctive concepts related to each other. Digitization is a component of digitalization and digitalization is, in turn, subsumed under digital transformation (Saarikko et al., 2020). Digitization is the process of transformation from analog to digital form, enabling the creation of a digital version of physical information carriers. Digititalization represents the integration of the analog and digital worlds with new technologies that improve user interactions, data availability, as well as business processes (Eling & Lehmam, 2018). Digital transformation deals with the changes that digital technologies can bring to a company's busi-

ness model (Hess, et al., 2020). The main purpose of a business model is to define how a business delivers value to customers, entices customers to pay for value, and turns those payments into profit (Teece, 2010). Digital transformation requires companies to develop different capabilities, formulate an appropriate strategy and review and redefine business model in order to maintain or gain a competitive advantage.

The progress achieved by previous industrial revolutions, unprecedented in human history, has had its price embodied in long-term unwanted consequences for the environment. The fourth industrial revolution has the potential to be different. According to Javaid et al. (2022) Industry 4.0 technologies and key interrelationships through advanced technologies should positively impact the environment and sustainability. One of the important research questions in this context is the relationship between digital transformation and eco-innovation. When faced with global environmental crisis, the competitiveness of organizations is not possible without taking into account environmental impacts. The concept of eco-innovation is developed as a response to the connection of innovation with environmental protection, preservation of natural resources and improvement of the quality of life and is in accordance with the concept and philosophy of sustainable development. Eco-innovations have positive effects on the environment while generating economic returns, contributing to companies to engage in value creation activities in an environmentally sustainable and economically sustainable manner. Eco-innovations have also benefits for the national economy and society by increasing competitiveness and economic development, creating new sources of value for productivity growth, reducing environmental and health risks (United Nations Environmemt Programme, 2017). Some studies report positive effects of digital transformation on eco-innovation (Li & Shen, 2021; Xue et al., 2022) but research evidence is still insufficient.

This paper is structured as follows: Two sections following the introduction describe digital transformation and eco-innovation focusing on definition, context (external and internal factors), content, process and performance. After that, the impact of digital transformation on eco-innovation, namely product eco-innovation, process eco-innovation and organizational eco-innovation is discussed in the following section. The last section of the paper is the conclusion.

DIGITAL TRANSFORMATION

Digital transformation is changing the way companies do business, value chains, industries, economy and society as a whole. At the company level, dig-

ital transformation leads to changes in business models, processes, structure, culture, collaboration (Kozanoglu & Abedin, 2020; Warner & Wäger, 2019). Digital transformation also creates changes in consumer behavior, transforming their experiences in using the products and services of a company. According to the definition given by Ismail, et al. (2017) digital transformation is a process through which enterprises converge multiple modern digital technologies with the intention of achieving superior performance and sustainable competitive advantage by transforming multiple business dimensions including business model, user experience, processes and decision-making, influencing people (skills, culture) and networks.

According to Verhoef et al. (2021) key external factors of digital transformation are: digital technologies, digital competence and digital consumer behavior. Managers need to understand the potential of existing or emerging digital technologies, stay abreast of technology trends, proactively explore the ways in which digital technologies can contribute to business, as well as the challenges they face. Competition is intensifying as more and more companies adopt digital technologies, innovate their business models and processes, and companies that do not do that risk falling behind in the market competition and eventually disappearing from the market. Digital technologies change the behavior, interactions and expectations of consumers (Ejbari & Bouali, 2022), and if companies do not adapt to these changes, they become less attractive to customers who are likely to turn to the products and services of digitally advanced competitors.

According to Luo & Yu (2022) the internal factors of digital transformation are: digital strategy, internal resources and capabilities and leadership. Digital strategy is formulated and implemented with the aim of creating new forms of value, for the organization, its customers and partners, through combinations of digital technologies (Wielgos et al., 2021). When formulating a digital strategy, it is necessary to identify the elements of the business model that must change in accordance with the new strategy, along with the scope of the digital transformation (Correani et al., 2020). Organizations need to develop resources and capabilities to deliver digital strategies, including technological, human and organizational aspects. It is especially important that organizations have people with the right skills and competencies to use digital technologies effectively and efficiently. Digitally advanced companies develop strong leadership capabilities for digital transformation. To be successful, digital leaders should have the competencies and behaviors needed in the digital age, as well as the competencies necessary to lead digital transformation including strong leadership skills (Zeike et al., 2019).

The literature points out that the content of digital transformation derives from how companies integrate technology to transform their business, which emphasizes the formulation of an appropriate strategy and leadership that will lead the digital transformation (Kane et al., 2015). Digital transformation affects the entire company and way of doing business, leading to the development of new business models (Verhoef et al., 2021). According to Ismail et al. (2017) the business level of the content of digital transformation consists of vision, goals and strategic decisions about reviewing and changing business models, introducing technologies necessary to achieve the set goals, and creating benefits for customers through expanding the user experience and anticipating and satisfying their needs; the functional content level refers to managerial decisions about financial and other performance, changes in the organization and collaboration with external stakeholders, as well as changes in business processes.

Digital transformation is a continuous process of change. The literature emphasizes the perspective of episodic changes, which refer to non-frequent, discontinuous and intended changes, and the perspective of continuous changes, which refer to constant ongoing, evolving and cumulative changes (Weick, & Queen, 1999). In modern conditions, organizations must be able to continuously adapt to a rapidly changing environment in order to achieve and maintain business success (Hinsen et al., 2019). Hanelt et al. (2021) argue that digital transformation corresponds to the perspective of continuous changes, but it can be initiated and shaped by episodic changes, while further continuous changes are induced later. This means that the perspective of episodic changes can also be useful for digital transformation but with adaption, not assuming an end state or a freezing period (Hanelt et al., 2021).

By reviewing several studies on the process of digital transformation, Zaoui & Souissi (2020) summarize many activities that are in the focus of researchers, including the assessment of digital maturity, defining strategic guidelines for digital transformation, defining the implementation strategy, digital transformation of customer experience, digital transformation of the product and service offer, digital transformation of value creation, digital transformation of business processes, building skills, financial support, etc. It is very important for organizations to assess the degree of digital maturity achieved because progressing on the digital path increases the likelihood of achieving high performance. Many models of digital maturity can be found in the literature (e.g. Schumacher et al., 2017; Blatz et al. 2018; Pulkkinen et al., 2018 et al.) in which different dimensions are evaluated including strategy, business model, processes, products,

customers, performance indicators, interfaces, leadership, people, technological infrastructure, etc.

Digital transformation is associated with an increase in various dimensions of performance including, among others, competitive advantage (Adamik & Novicki, 2018), innovation (Lobejko, 2020), user involvement and experience (Schneider & Kokshagina, 2021), user satisfaction (De Miguel et al., 2022), improvement of business processes (Kubrak et al., 2023), operational efficiency (Zhai et al., 2022). Regarding its impact on the financial performance of companies, some studies find positive relationships between digital transformation and financial performance (Nasiri et al., 2020; Zeng et al., 2022; Zhai et al., 2022), however some other studies report that there is no significant increase in financial performance or that the effects are negative (Chen & Srinivasan, 2019; Guo et al., 2023). Researching companies in Sweden, Jardak & Hamad (2022) conclude that the negative impact of digital transformation on financial performance can be explained by the fact that it takes time for investments in digital technologies to materialize, and partly the negative effects are due to inappropriate management of digital transformation. According to Chen & Srinivasan (2019) digital technologies require high costs, but if digital investments are successful, positive effects will be seen in the long term. Nasiri et al. (2020) find a key mediating role of digital maturity for financial success in digital transformation, emphasizing the need to develop a continuous process of adoption of digital technologies.

ECO-INNOVATIONS

According to Rennings (2000) eco-innovations represent all the efforts of relevant actors who develop, apply and introduce new ideas, behavior, products and processes, and which contribute to reducing the burden on the environment or ecologically determined sustainability targets. Kemp & Foxon (2007) define eco-innovation as the production, assimilation or exploitation of a product, production process, service or management or business method that is new to the organization (develops or adopts it) and that results, during its life cycle, in the reduction of environmental risks, pollution and other negative impacts of resource use (including energy use) compared to relevant alternatives. Eco-innovations reduce the use of natural resources and reduce the release of harmful substances during the entire life cycle, bringing benefits for the economy - saving costs and energy, the realization of new products and services, new markets and business opportunities; environment - sustainable management of natural resources, im-

provement of biodiversity and ecosystems; and society - improving the quality of life, new and sustainable jobs (Malega et al., 2021).

The external factors of eco-innovation are political-regulatory, economic-market driven and cooperation-networking (Ćurčić & Zakić, 2021). Political-regulatory factors include market-based instruments (eg environmental taxes, subsidies, tradable permits, etc.) and command and control instruments (laws, standards, technical requirements, etc.). Among the economic-market driven factors stand out the influence of competition, the increase in consumer awareness of eco-friendly products (Aibar-Guzman, 2021) and saving costs, which, among other things, refers to the reduction of material and energy consumption (Horbach et al, 2012). Economists favor market-based instruments for their economic efficiency as they lead to cost-effective decisions and encourage technological progress in efforts to prevent environmental degradation (Pereira-Sanchez & Vence-Deza, 2015). Networking and cooperation with partners is important for the realization of eco-innovations due to their systemic and complex characteristics (De Marchi, 2012).

The internal factors of eco-innovation are environmental strategy, internal resources and capabilities and absorptive capacity (Mady et al., 2021). Environmental strategies can be reactive and proactive. Reactive strategies are typically applied by companies that strive to adopt regulations and a minimum level of eco-innovation practices (Delgado-Ceballos et al., 2012). In contrast, proactive strategies refer to the development of environmental goals and practices, top management support and investment in environmental initiatives beyond the requirements of regulations and standards (Das, 2023). Adequate physical and financial resources, human capital, reputation, technological and organizational capabilities can determine the adoption and development of eco-innovations (Kiefer et al., 2018; Cai & Li, 2018). Researchers emphasize the importance of absorptive capacity in terms of eco-innovation, i.e. the ability to recognize the value of external information and knowledge, assimilation and application (Arfi, 2018).

The content of eco-innovations is diverse. Numerous studies with typologies of eco-innovations and their characteristics can be found in the literature. Kemp & Foxon (2007) provide the following typology: environmental technologies, organizational innovation for the environment, product and service innovation with environmental benefits and green system innovations. Target, i.e. the basic focus of eco-innovation according to Organisation for Economic Co-operation and Development (2009) includes products, processes, marketing methods, organizations and institutions; the first two categories are primarily

technological in nature and the other categories are primarily non-technological. Hojnik (2017) lists the following categories of eco-innovation: product eco-innovation, process eco-innovation, organizational eco-innovation, marketing eco-innovation, social eco-innovation (they consider the human element as an integral part of any discussion about consumption resources, include changes in behavior and lifestyle, ensuring demand for eco-friendly products and services, innovative green life concepts, etc.) and system eco-innovation (a series of related innovations that improve or create new systems with new functions, reducing the overall impact on environment). In the literature, the most represented is the research of product eco-innovations, process eco-innovations and organizational eco-innovations (Triguero, et al., 2013; Medina et al. 2022).

The eco-innovation process is systematic and complex, it differs according to the nature of the innovation, the degree of novelty (incremental/radical innovation), the implementation of environmental practices (proactive/reactive environmental strategy) and other criteria, and requires internal and external collaboration, diversified knowledge and analysis of various impacts (economic, ecological, social). Different models of the innovation process can be applied according to different eco-innovation projects depending on the contingencies and uncertainties of a project. In addition, due to the complexity of eco-innovations, collaboration may be more important for their realization than in the case of other types of innovations (De Marchi, 2012). Evaluating the achieved level of maturity in terms of eco-innovation is more difficult for companies due to the lack of appropriate models in the literature, but in recent years, attempts have been made to bridge the gap. Xavier et al. (2020) develop an eco-innovation maturity model whose dimensions are: strategy, structure, resources and culture and which includes five levels of maturity, from the first level (unfinished) where the company does not yet apply eco-innovation practices, continuing with ad-hoc, operational and strategic levels, up to the fifth (holistic) level when eco-innovation practices are applied and strategically integrated in all sectors in a systemic, harmonious and collaborative way.

Eco-innovations contribute to the improvement of company performance in multiple directions, among which are the creation of new business opportunities, increasing market share, improving image and reputation, increasing customer satisfaction, increasing sales, improving operational performance and reducing costs, etc. (Pujari, 2006; Cheng et al., 2014; Ryszko, 2016; Yao et al., 2019; Yurdakul & Kazan, 2020). Some studies find that there are no significant effects of eco-innovations on financial performance (Li, 2014; Putri & Sari, 2019) or that the effects are negative (Driessen et al., 2013). The literature states that invest-

ments in eco-innovations at the start carry high costs and payback periods can be long (Ghisetti et al., 2016). Meta studies show positive correlations between eco-innovations and economic, environmental and social performance, with the highest correlation coefficient in the case of environmental performance (Hizarci-Payne et al., 2020; Liao et al., 2021). In a meta study based on 33 studies involving 7,300 companies, Liao et al. (2021) find a significant positive correlation between eco-innovations and financial performance and state that studies on the negative impact of eco-innovations on financial performance focus on the generation of additional costs for companies, but ignore the benefits that eco-innovations can bring them. And the meta study of Hizarci-Payne et al. (2020) based on 70 studies involving more than 25,000 companies indicates that companies that introduce eco-innovations can expect higher financial returns and other benefits, which shows that eco-innovation practices lead to a win-win situation (fulfilled economic, environmental and social goals).

IMPACT OF DIGITAL TRANSFORMATION ON ECO-INNOVATIONS

Digital transformation is a strategic initiative in an enterprise that can reshape the entire business model. Redefining the business model enabled by modern digital technologies should be seen as a continuous process that encompasses all core aspects of business, including environmental sustainability. According to Gomez-Trujillo & Gonzalez-Perez (2022) by adopting sustainability and digital transformation, companies should increase their digital capabilities and balance economic, environmental and social impacts. Digital capabilities are among the key ones for companies to gain competitive advantage through digital transformation, as well as the main source of sustainable competitiveness (Annarelli, et al., 2021). As eco-innovations are of great importance for improving economic, environmental and social performance, and contribute to the goals of sustainable development, it is important to look at the impact of digital transformation on different types of eco-innovations (eco-innovations of products, processes and organization).

Product eco-innovations. Using big data technologies, organizations can collect, analyze, visualize and interpret large amounts of data from external and internal sources in real time, on the basis of which they come up with valuable ideas for developing new products that are favorable for the environment and customers, and generate revenue for companies. Digital platforms, cloud technologies, automation, machine learning, artificial intelligence, smart connected devices and other technologies help optimize product development, shortening

the life cycle, improving productivity and efficiency while maintaining high functionality and quality requirements, optimizing the types and quantities of materials that need to be processed. and reducing waste, energy requirements and other environmental burdens. Digital design and simulation technologies, including digital twins (He & Bai, 2021), can help designers and engineers create, visualize, test, and modify environmentally friendly products in a digital environment by reducing the need for physical prototypes and materials, saving costs and time. Co-creation in a B2C and B2B contexts that is beneficial for the development of eco-innovative products (Shi et al. 2020) can be supported by many digital technologies, i.e. with the use of virtual reality technology co-creators can engage in practices that enable visualization of their preferences, comparing their expectations and integrating their views into the digital space (Kostis & Ritala, 2020). With advanced technologies like IoT and artificial intelligence, businesses can create products that enhance the user experience while minimizing environmental impact, such as smart connected vehicles that collect and analyze data to improve individual driving behavior, traffic route choices, and traffic management which contributes to the reduction of emissions and energy consumption (Dekeyrel & Fessler, 2023).

*Process eco-innovation*s. Companies in more mature stages of digital transformation have a much greater potential for the realization of eco-innovations compared to those that are just at the beginning - higher stages of maturity indicate improved capabilities in managing a specific domain (Hortovanyi et al., 2023). Organizations that adopt advanced digital technologies and practices have unique opportunities to implement eco-innovations of processes that would be impractical, expensive, unfeasible or unimaginable with traditional technologies. With digital technologies, various types of process-related data can be rapidly collected, stored and cleaned using a number of methods. For example, IoT devices with sensors, actuators and other components connected to the network, can monitor and control various aspects of the process and generate information in real time (Soori et al., 2023). The information obtained can be analyzed in various ways including machine learning algorithms and artificial intelligence (Mourtzis, et al., 2021). Using data analytics, organizations can gain valuable insights into the impact of their processes on the environment, resource consumption, and waste generation, which helps develop environmentally friendly processes. Digital transformation can improve efficiency and reduce material and energy consumption by optimizing workflows and automating manual processes. Robotization and intelligent systems improve efficiency, scalability, flexibility and sustainability (Xu et al., 2023). Technologies used in production such

as 3D printing save energy, minimize waste and reduce carbon dioxide emissions leading to sustainable manufacturing processes (Mallikarjuna et al., 2020).

Organizational eco-innovations. The perspective of socio-technical systems implies that changes in the technical system follow changes in the social system, or vice versa, therefore it is necessary to pay attention to both systems in order to function together and in an appropriate balance (Anzola-Román, et. al., 2018). In the context of eco-innovations, managers should also consider organizational eco-innovations, not only technological ones, if they want to take advantage of all the advantages of digital technologies. Research shows the existence of positive effects of organizational eco-innovations for generating process and product eco-innovations (Medina et al., 2022), which is in line with research on organizational innovations in general (Anzola-Román, et. al., 2018). According to Cheng et al. (2014) organizational eco-innovations not only directly contribute to environmental performance, but can be key to creating an organizational environment that encourages process eco-innovation and product eco-innovation.

Digital transformation leads to fundamental changes in the organization and its impact on the organization is far greater compared to the previously conducted IT-enabled organizational transformation (Koukouvinou et al., 2023). Digital technologies enable managers to quickly access a large amount of data generated inside and outside the organization, their processing and analytics, which leads to better decisions. Managers can more easily identify weaknesses and deficiencies in various organizational components related to the environment, which affects their review and identification of opportunities for innovation. Digital transformation makes many traditional tasks and positions unnecessary as they are performed more efficiently by digital systems and devices, on the other hand it creates the potential for new functions and tasks that are essential for success (Kretschmer & Khashabi, 2022), including those related to the environment and sustainability. Digital technologies open numerous opportunities for better communication between dislocated organizational units and teams, which affects the improvement of organizational performance in several dimensions, including reducing the impact on the environment. Companies can use digital tools and platforms to encourage knowledge exchange among employees; since this exchange generates knowledge and improves innovative performance (Liu, et al., 2023), it contributes, among other things, to eco-innovative projects and initiatives. Digital technologies enable remote work (e.g. from home), according to Loia & Adinolfi (2021) this is an eco-innovation that contributes to the environment by reducing energy consumption and carbon dioxide emissions. With digital technologies, organizations can implement strategies and practices to manage

talent with environmental knowledge and skills (Ghobakhloo, et al., 2021). The application of digital technologies in staff training, where different environments and scenarios can be simulated (Di Sabato & Savov, 2022), can help employees develop environmental skills and behaviors, which positively affects the culture of sustainability in an eco-innovation-friendly organization. (Galpin, 2015).

CONCLUSION

The rapid development of digital technologies has facilitated and accelerated the birth of Industry 4.0, or the Fourth Industrial Revolution, which has the potential to undo the damage that previous industrial revolutions have done to the environment. In this context, one of the important issues is the impact of digital transformation on eco-innovations. Digital transformation is a business imperative for businesses to remain competitive and relevant in the rapidly changing business landscape of the digital age. It requires the right strategy, strong leadership and the development of resources and capabilities, in order to transform business models and create new value for the organization, customers and other stakeholders. On the other hand, eco-innovations are one of the leading driving forces of the sustainable development of companies and provide important support for the sustainable development of the economy and society, contributing to the achievement of economic, environmental and social goals.

Some research studies conducted in the last few years indicate that digital transformation can promote eco-innovation (Li & Shen, 2021; Xue et al., 2022). The theoretical discussion in this paper focuses on the impact of digital transformation on product eco-innovations, process eco-innovations and organizational eco-innovations, from which it follows that the accumulation of digital technologies and the development of digital capabilities can induce eco-innovations of all three types. This is consistent with earlier findings of research studies that technological capabilities generally have a positive impact on eco-innovation (Cai & Li, 2018). The optimistic view of the possibilities that digital transformation offers for eco-innovation is not without constraints. Digital transformation and eco-innovations require investments and can compete for limited organizational resources, therefore it is necessary to conduct research on the possible negative effects of digital transformation on eco-innovations. Since the work is of a theoretical nature, the next step would be to empirically test the impact of digital transformation on eco-innovations of products, eco-innovations processes and organizational eco-innovation. Furthermore, the research can be extended to other types of eco-innovations. In addition, the paper focuses on the enterprise level and future research may cover the value chain or the business eco-system.

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POLYCHLORINATED BIPHENYLS CONTAMINATION HOTSPOT: A REVIEW OF THE ENVIRONMENTAL POLLUTION AT THE INDUSTRIAL SITE

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Abstract

The industrial zone of Incel in Banja Luka has been facing severe pollution issues, primarily due to the presence of polychlorinated biphenyls (PCBs) and other harmful contaminants. The contamination is believed to have stemmed from industrial activities, with the release of waste materials and improper disposal practices being the main culprits. PCBs are a class of synthetic organic chemicals that were widely used in various industrial processes such as electrical equipment, plastics, and rubber products. However, their use has been banned due to their potential to cause serious health and environmental problems. The contamination of the Incel industrial zone poses a significant threat to the environment and public health. Exposure to PCBs can lead to various health problems, including skin rashes, liver damage, and reproductive disorders. In addition, the toxic chemicals can accumulate in the food chain, leading to long-term

ecological damage. To address the pollution issue, there needs to be a concerted effort by the authorities and industries operating in the Incel zone. Measures such as stricter regulations, better waste management practices, and increased environmental monitoring can help reduce the release of contaminants and prevent further contamination of the area. Overall, the pollution problem in the Incel industrial zone highlights the importance of sustainable industrial practices and responsible waste management to protect both the environment and human health.

Key words: PCB, Incel, Banja Luka, pollution

INTRODUCTION

Polychlorinated biphenyls (PCBs) are a group of synthetic organic chemicals that were widely used in the past as coolants, lubricants, and insulating materials in electrical equipment. PCBs are highly toxic, persistent, and bioaccumulative, meaning that they can remain in the environment for a long time and accumulate in the food chain. Exposure to PCBs can have severe adverse effects on human health and the environment (Gašić et al., 2010; Ilić et al., 2020; Ilić et al., 2021c).

The pollution issue in the Incel industrial zone in Banja Luka (Republic of Srpska, Bosnia and Herzegovina) is a significant environmental and public health concern (Ilić et al., 2020; Stojanović Bjelić et al., 2022). Incel location (former cellulose factory, now industrial complex) 3 km from the center of Banja Luka – the second-largest city in Bosnia and Herzegovina (Ilić et al., 2020). Results indicate that the soils in the location Incel suffer different levels and other of dangerous and harmful substances and that: polycyclic aromatic hydrocarbon (PAH), Total petroleum hydrocarbons (TPH) and heavy metals. Soil was highly polluted (Ilić et al., 2020; Ilić et al., 2021a; Ilić et al., 2021b; Ilić et al., 2021c; Ilić et al., 2021d). The contamination of the area with PCBs and other harmful contaminants has led to the degradation of the soil, water, and air, posing a severe risk to human health and the environment. PCBs, in particular, are a class of synthetic organic chemicals that are known to cause serious health problems, including skin rashes, liver damage, and reproductive disorders. The sources of pollution in the Incel industrial zone are multifaceted and include industrial activities such as the release of waste materials, improper disposal practices, and lack of proper pollution control measures. Additionally, the industrial zone is located near a residential area, further increasing the risk of exposure to harmful pollutants for local communities (Lammel et al., 2010a; Lammel et al., 2010b;

Lammel et al., 2011; Gašić et al., 2010; Ilić et al., 2020; Ilić et al., 2021a; Ilić et al., 2021b; Ilić et al., 2021c; Ilić et al., 2021d).

The Stockholm Convention on Persistent Organic Pollutants (POPs) is an international treaty that aims to protect human health and the environment from highly toxic and persistent chemicals such as PCBs (Fiedler et al., 2019; Ilić and Maksimović, 2021). The problem of soil contamination with PCBs is directly related to the Stockholm Convention, as soil is a major sink for POPs. Contaminated soil can pose a risk to human health and the environment, as PCBs can enter the food chain and persist for a long time. The Convention provides a framework for addressing the problem of soil contamination with POPs, including PCBs, through measures such as risk assessments, soil remediation, and pollution prevention. By implementing the provisions of the Convention, countries can reduce the risks posed by soil contamination with PCBs and other POPs and protect human health and the environment (Lallas, 2001; Porta & Zumeta, 2002; Fiedler et al., 2019; Ilić and Maksimović, 2021).

When PCBs are released into the environment, they can enter the soil, water, and air, where they can persist for decades (Ododo et al., 2019; Hashmi et al., 2021). The main route of exposure for humans is through the ingestion of contaminated food, such as fish, meat, and dairy products, as PCBs accumulate in the fatty tissues of animals. In addition, PCBs can also enter the body through inhalation and skin contact with contaminated soil and dust. Exposure to PCBs can have several adverse effects on human health, including skin rashes, liver damage, and reproductive disorders. PCBs have been classified as probable human carcinogens by the International Agency for Research on Cancer (IARC), meaning that they can increase the risk of cancer. PCBs can also affect the immune system, leading to increased susceptibility to infections (Dorea, 2006; Srogi, 2008; EFSA et al., 2018). In addition to human health risks, PCBs also pose a threat to the environment. PCBs can accumulate in soil and sediments, where they can affect the growth and development of plants and microorganisms. PCBs can also bioaccumulate in aquatic organisms, such as fish, leading to ecological imbalances and disruptions in food webs (Gašić et al., 2010; Ilić et al., 2020; Ilić et al., 2021c).

MATERIAL AND METHODS

The materials used in this study included data and information obtained from sources such as academic journals, research reports, and online databases. We collected relevant data on the topic of interest to create a comprehensive overview of the subject matter.

The studies included in this review were selected based on the following criteria: (1) studies that reported the concentrations of PCBs and other pollutants in soil and other medium samples collected from industrial zone Incel; (2) studies that described the characteristics of PCBs; and (3) studies that reported the geographical location of the industrial zone.

RESULTS AND DISCUSSION

The presence of PCBs in soil in location Incel is a significant environmental and public health concern. Exposure to PCBs can have severe adverse effects on human health, and they can persist in the environment for a long time, posing a risk to the ecosystem (Dorea, 2006; Srogi, 2008; Gašić et al., 2010; EFSA et al., 2018; Ilić et al., 2020; Ilić et al., 2021c). Therefore, it is crucial to take measures to reduce the exposure to PCBs and prevent their release into the environment. Industrial sites that were in use prior to the introduction of regulations on the use and disposal of hazardous chemicals often pose a significant risk of soil contamination with PCBs and other pollutants. Old industrial sites, such as Incel, contaminated with heavy metals, PAHs and other hazardous materials can pose potential risks to human health and the environment. Heavy metals such as lead, cadmium, and mercury can accumulate in soil, water, and biota, leading to toxic effects on the ecosystem and human health (Ilić et al., 2020; Ilić et al., 2021a; Ilić et al., 2021b; Ilić et al., 2021c; Ilić et al., 2021d). PCBs were widely used in electrical equipment, such as transformers and capacitors, and in other industrial applications, until their production was banned in many countries in the 1970s and 1980s (Gašić et al., 2010; Ilić et al., 2020; Ilić et al., 2021c). The problem of soil contamination with PCBs and other pollutants is particularly acute in older industrial sites that have been abandoned or repurposed without proper clean-up. These sites can release toxic substances into the surrounding environment, including soil and groundwater, which can pose serious risks to human health and the environment. Industrial development in Bosnia and Herzegovina has led to the contamination of many sites with hazardous pollutants, including PCBs. PCBs were widely used in various industrial applications in Bosnia and Herzegovina (Ilić et al., 2020; Ilić et al., 2021c). Contaminated industrial sites in Bosnia and Herzegovina pose a significant risk to public health and the environment (Dorea, 2006; Srogi, 2008; EFSA et al., 2018). Location of the Incel industrial zone in Banja Luka has had a significant impact on the population and the environment of the city. The pollution caused by the release of hazardous substances into the soil and groundwater has raised concerns about the health effects on nearby residents, as well as the long-term environmental impact on the local

ecosystem. Efforts to address the issue are underway, but much work remains to be done to ensure the safety of the local population and the health of the environment.

Previous studies indicate that the level of PCBs on several sampling sites in industrial zone Incel in Banja Luka was as high as 400,000 ng/g (400 mg/kg) of the dry soil sample, which are two orders of magnitude higher than on any other investigated site performed by in the first investigations at the site (Apopsbal 2019). The additional pollution surveys (soil, air etc.) at the site were conducted in 2008 (Lammel et al., 2010a; Lammel et al., 2010b; Lammel et al., 2011; Gašić et al., 2010). Intensive soil testing for the presence of PCBs, PAHs, heavy metals and other pollutants continued in 2019 (Ilić et al., 2020; Ilić et al., 2021a; Ilić et al., 2021b; Ilić et al., 2021c; Ilić et al., 2021d). Total PCBs concentrations (∑PCB congeners: PCB28, PCB52, PCB101, PCB118, PCB138, PCB153 and PCB180) varied in range from 0.26 to 6,722 mg/kg in soil, with a median of 31.80 mg/kg (Table 1) (Ilić et al., 2021c). According to the national standards, all the concentrations of ∑PCB congeners found in this study were significantly higher than the permissible value of 0.02 mg/kg (Rulebook, 2021).

Table 1. Statistical summary of total PCBs and PCBs congeners (PCB28, PCB52, PCB101, PCB118, PCB138, PCB153 and PCB180)

	PCB total	PCB28	PCB52	PCB101	PCB118	PCB138	PCB153	PCB180
Valid	37	37	37	37	37	37	37	37
Mean	495.4	13.59	9.005	33.87	57.34	97.31	148.4	135.8
Median	31.80	0.65	1.52	1.47	1.67	2.77	3.25	2.44
Std. Deviation	1,238	31.12	14.83	83.92	140.5	236.1	375.4	420.8
Coefficient of Variation	249.95	228.91	164.70	247.74	245.09	242.63	252.91	309.78
Variance	1.533e+6	968.4	220.0	7,042	1.975e+4	5.575e+4	1.409e+5	1.771e+5
Skewness	3.952	2.945	2.193	3.677	3.455	3.371	3.554	4.632
Kurtosis	18.14	8.453	4.833	15.08	13.29	12.87	14.44	23.82
Range	6,722	139.8	61.64	434.7	709.3	1,190	1,933	2,385
Minimum	0.26	0.01	0.01	0.01	0.02	0.04	0.03	0.01
Maximum	6722	139.8	61.65	434.7	709.3	1,190	1,933	2,385

The government of Republic of Srpska (entity in Bosnia and Herzegovina) and City of Banja has recognized the need to address the problem of contaminated industrial sites and has taken some steps to address the issue. However, much more needs to be done to adequately address the risks posed by these sites to public health and the environment. International organizations, such as the United Nations Development Programme (UNDP), have also provided support for cleanup efforts in Bosnia and Herzegovina. It is made Project of remediation and recultivation for Incel zone (Project, 2021). The project envisages short-term measures. Short-term preventive measures are designed to immediately prevent contact of local employees, visitors and trespassers moving at the contaminated sites (hotspots) with contaminated soil and/or construction materials.

The pollution issue in the Incel industrial zone in Banja Luka is a complex problem that requires a multifaceted approach. Addressing the problem will require a concerted effort from all stakeholders, including the government, industry, and local communities. Implementing effective regulations, promoting sustainable industrial practices, and adopting better waste management practices will be critical in ensuring the long-term health and well-being of local communities and the environment (Ilić et al., 2020; Project, 2021).

To reduce soil pollution with PCBs)at the industrial zone several general measures can be recommended:

- Soil Remediation: One of the most effective ways to reduce soil contamination is through soil remediation, which involves removing the contaminated soil and replacing it with clean soil.
- Phytoremediation: Phytoremediation is a process that uses plants to remove pollutants from the soil. This method can be a cost-effective and sustainable way to reduce soil contamination.
- Containment: Another option is to contain the contaminated soil by using barriers, liners, or capping the soil with a layer of clean soil or impermeable material.
- Land Use Restrictions: The government can implement land use restrictions, which can limit access to contaminated areas and reduce the risk of exposure to harmful pollutants.
- Improved Waste Management: To prevent future contamination, improved waste management practices can be implemented, such as proper storage, transportation, and disposal of hazardous waste.

The best option would be Soil remediation, i.e. excavation of contaminated soil and construction materials and thermal treatment in incineration plant or thermal desorption plant abroad and replacing it with clean soil. This process can be expensive, but it is an effective way to reduce the risk of exposure to harmful pollutants.

CONCLUSIONS

The industrial zone of Incel, located in Banja Luka, Bosnia and Herzegovina, has been identified as a site of significant contamination due to the presence of PCBs and other hazardous substances in the soil. PCBs are known to be persistent organic pollutants that do not break down easily in the environment and can accumulate in the food chain, posing a risk to human health and the ecosystem. They are classified as a probable human carcinogen and have been associated with a range of adverse health effects, including developmental and reproductive disorders, immune system dysfunction, and neurological damage.

The contamination in the Incel industrial zone has been identified as a significant risk to human health and the environment, particularly due to the potential for PCBs and other hazardous substances to migrate from the soil into groundwater and surface water. The site is also a potential source of air pollution, as PCBs can volatilize and become airborne, posing a risk to the respiratory health of nearby communities. Efforts to address the contamination in the Incel industrial zone have been ongoing for several years, with measures including soil remediation, groundwater monitoring, and the removal of contaminated materials from the site. However, progress has been slow due to the complexity of the contamination and the high cost of remediation efforts. The contamination has also led to legal disputes between the authorities and the companies responsible for the pollution, which has further delayed progress.

The pollution issue in the Incel industrial zone has prompted concerns from various stakeholders, including local residents, environmental groups, and the authorities. There have been calls for stricter regulations to prevent the release of harmful contaminants, better waste management practices, and increased environmental monitoring to prevent further contamination of the area.

In response, the authorities have implemented various measures aimed at reducing pollution levels in the industrial zone. These include tighter controls on industrial activities and improved waste management practices. However, there is still much work to be done to address the pollution problem comprehensively.

The contamination of the Incel industrial zone is a stark reminder of the importance of sustainable industrial practices and responsible waste management. It highlights the need for industries to take a more proactive approach to environmental protection and to prioritize the health and well-being of local communities. Moreover, it underscores the importance of effective environmental regulations and enforcement mechanisms to ensure that industries operate in a way that is safe and sustainable for both people and the planet.

Overall, the contamination in the Incel industrial zone is a significant environmental and public health issue that requires urgent attention and long-term solutions to prevent further harm to the ecosystem and human health. The remediation of the site will require a multi-stakeholder approach involving government agencies, industry, and local communities to ensure effective and sustainable solutions are implemented.

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ARCHITECTURAL ELEMENTS AS A PART OF URBAN TRANSFORMATIONS AND MIGRATIONS AFTER COVID EPIDEMIC

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ABSTRACT

The global COVID-19 pandemic has triggered profound shifts in urban dynamics, requiring a reevaluation of urban spaces and their architectural elements. The research paper investigates the role of architectural elements in urban transformations and migrations processes after the COVID-19 epidemic.

The study recognized that the pandemic accelerated the embrace of remote work and digital communication technologies, influencing individuals' preferences for living environments. Urban planners and architects are confronted with the task of redefining public and private spaces to accommodate new patterns of work, leisure, and social interaction. The paper explores how architectural elements, such as flexible building designs, adaptable public spaces, sustainable infrastructure, and smart technologies, are responding to evolving necessities.

The research investigates the role of architectural innovation influence on the urban migration patterns. As individuals and families seek environments that offer enhanced safety, connectivity, and quality of life, cities are witnessing shifts in population distribution. The paper analyzes how architectural elements, including mixed-use developments, green and eco spaces, pedestrian-friendly designs, and resilient infrastructure, contribute to attracting and retaining residents.

The research data from surveys provides direct insights into public perceptions and necessities concerning architectural adaptations and innovations. By responding to the evolving needs of post-pandemic societies, architects and urban planners need to contribute to the creation of sustainable, environmentally friendly, inclusive, and vibrant cities.

Key words: COVID, urban transformation, migration processes, new paradigm.

INTRODUCTION

The aftermath of global pandemic has changed the urban and socio-economic way of human existence in societies. The COVID-19, the virus of still unknown and undefined geometric structure and source, has irrevocably challenged urban living on a global scale. The urban spaces have obtained vital role in societies renewal and regeneration (Jefferies, Cheng and Coucill, 2021; Abusaada and Elshater, 2022). The pandemic heavily impacted work dynamics, social interactions, and lifestyle preferences, and required architects and urban planners to reconsider the role of architectural elements in shaping the cities of the future (Garde, 2020; Alraouf, 2021; Jasiński, 2022). The research explores the intricate relationship between architectural elements, urban transformations, and migrations in the post-COVID era.

The pandemic served as a catalyst for changes that were already underway in urban design and planning (Simon, 2023). The unexpected shift to remote work, digital connectivity, and a sensitive awareness of public health has reflected a comprehensive examination of how cities function. The relationship with urban environment has evolved, a growing emphasis on spaces that accommodate both the need for social interaction and the imperative of personal safety (Graziano, 2021; Abdelkader, Khalifa and Elshater, 2023). The shift implicate that architectural design and urban planning must now strive and aspire to a gentle balance between the physical and the virtual, the communal and the individual.

Certain architectural elements have emerged as fundamental factors defining the direction of urban development, from flexible building designs that can swiftly adapt to changing demands, to public spaces that prioritize both recreation and public health (Rojas-Rueda and Morales-Zamora, 2021; Fricke and Brill, 2022). Furthermore, the interplay between architectural elements and urban migration patterns has gained importance, as individuals and families seek out environments that align with their evolving values and priorities.

Comprehensive approach to the subject demands a multi/intradisciplinary approach, soliciting insights from urban planning, architecture, social, economic and migration studies. Through a synthesis of existing literature and empirical case studies, the research sheds light on the dynamic relationship between architectural elements, urban adaptations, and migration trends.

MATERIALS AND METHODS

The research engages a combination of qualitative and quantitative research methods to reconsider the role of architectural elements in shaping urban transformations and migrations in the post-COVID era. Quantitative data was collected through surveys distributed to online freelancers' communities, as this group of people is always in the roaming processes searching for the better conditions. **Survey was designed to capture freelancers' perceptions, preferences, and behaviors related to architectural elements and urban changes in post-COVID period. The surveys sought to gather insights into how architectural adaptations influenced freelancers' decisions to migrate, stay, or alter their living arrangements.** The research was based on the interdisciplinary framework including the theories and concepts in urban planning, architecture, sociology, economic and migration studies. The interdisciplinary framework allows a holistic approach on the complex interactions between architectural design, urban dynamics, and societal shifts.

RESULTS AND DISCUSSION

The survey was focused on 3 essential components for the research: Architectural, Urban and Socio-economic elements. The findings of the research underline the pivotal role that architectural elements play in shaping urban transformations and migrations in the aftermath of the COVID-19 pandemic. The pandemic served as a catalyzing event that accelerated trends already underway in urban planning and architecture, propelling cities toward innovative solutions that prioritize adaptability, resilience, and the evolving needs of the inhabitants. Several crucial topics have emerged among which are: Architectural Flexibility and Adaptability, Public Spaces as Catalysts for Social Interaction, Sustainable and Resilient Infrastructure, Smart Technologies and Digital Integration, Impact on Migration Patterns, Policy Implications and Collaborative Efforts.

Architectural Flexibility and Adaptability is demanded by the shift towards remote work and virtual communication requiring the reevaluation of traditional office spaces and residential layouts. The adaptability of architectural elements was found to temporary bridge a transition between work, leisure, and public health considerations, enabling cities to remain functional and attractive in the face of uncertainty. Flexible building design, such as modular layouts and convertible spaces allows architects to provide for the fluctuating demands of residents, encouraging the environment beneficial approach.

Public Spaces as Catalysts for Social Interaction were for a while underestimated, and in the wake of the pandemic it has been reinstituted as a balancing element. The imperative of physical distancing with the human need for social interaction played the vital role. Adaptive public spaces that incorporated green areas, pedestrian-friendly designs, and digital connectivity developed as essential components of post-pandemic urban environments. These spaces not only facilitated safe social interactions but also contributed to improved mental well-being and a sense of community cohesion. Communities that embraced these design principles reported increased resident satisfaction and a stronger sense of belonging.

The pandemic has shown that the cities are prone to elemental disasters and other problematic situations, which requires the development of Sustainable and Resilient Infrastructure. Architectural elements prioritizing the sustainability and resilience, such as efficient waste management, renewable energy integration, and disaster-resistant structures, now play important role. The architectural elements not only addressed immediate health concerns but also positioned cities to mitigate and adapt to future challenges.

The digital and virtual transformation accelerated by the pandemic permeated urban design, leading to the integration of smart technologies. From contactless interfaces to data-driven urban management, technology-driven architectural elements emerged as powerful tools for enhancing urban efficiency, safety, and convenience. Considerations regarding data privacy and approachable access to these technologies remain critical in ensuring inclusive urban development.

The evolving preferences and priorities of individuals and their families played a significant role in shaping migration patterns in post-COVID era. Cities embracing the architectural elements supporting hybrid work models, outdoor recreation, and enhanced quality of life witnessed an influx of residents seeking environments that aligned with their shifting lifestyles. The migration, in turn, stimulated a reimagining of urban demographics and social dynamics.

The research emphasizes the need for urban policies that encourage and support architectural innovation. Governments and local authorities play a critical role in creating and enabling environment for architects, urban planners, and developers to implement forward-thinking design solutions. Policy frameworks that promote sustainable infrastructure, mixed land use, and participatory urban planning can enhance the effectiveness of architectural interventions.

Architectural elements

The research results determined that several architectural elements have significantly impacted urban transformations and migrations after the COVID-19 pandemic. The architectural elements play a fundamental role in reshaping cities to accommodate new lifestyle preferences, work dynamics, and health considerations. The survey results prioritize following elements:

- **Flexible Building Designs:** Architecture that allows for adaptability and multi-functionality has become crucial. Spaces that can easily transform from offices to living areas, or from public venues to medical facilities, have addressed the need for versatility in post-pandemic urban environments.
- **Adaptable Public Spaces and Green Infrastructure:** Urban planners and architects are rethinking public spaces to accommodate safe interactions. Parks, plazas, and pedestrian zones have been redesigned to ensure physical distancing while still promoting social cohesion. The use of movable furniture and modular designs allows these spaces to cater to different types of activities while maintaining safety. The pandemic highlighted the importance of outdoor spaces for physical and mental well-being. Incorporating green spaces, rooftop gardens, and outdoor recreational areas into urban designs has become a priority. These elements provide residents with spaces for exercise, relaxation, and socializing while maintaining a safe distance from others.
- **Digital Integration Virtual, Smart and Contactless Technologies:** Architecture incorporating smart technologies, touchless interfaces, and automation has reduced the need for physical contact. From touchless entry systems to voice-activated controls, these innovations enhance safety and convenience.
- **Sustainable Infrastructure:** Urban designs incorporating sustainable features such as green roofs, rainwater harvesting, and renewable energy sources align with the growing focus on environmental consciousness. These features contribute to long-term resilience and reduced ecological impact.
- **Remote Work Spaces:** As remote work becomes a lasting trend, home office spaces and communal work areas within residential complexes have become integral architectural components.
- **Pedestrianization and Cyclability:** Urban redesigns that prioritize pedestrians and cyclists over vehicular traffic promote healthier modes of transportation. Walkable cities have gained prominence as people seek alterna-

tives to crowded public transportation. Pedestrian-friendly designs, wider sidewalks, and enhanced pedestrian zones have been introduced to encourage walking and cycling, reducing reliance on shared transportation.

- **Digital Infrastructure:** The integration of high-speed internet and digital connectivity into urban design supports remote work, virtual education, telemedicine, and online commerce.
- **Adaptive Reuse of Spaces:** The repurposing of underutilized spaces such as vacant commercial buildings into housing or community centers showcases architectural adaptability while addressing changing needs.
- **Cultural and Artistic Expression:** Architectural elements that incorporate public art, cultural centers, and creative spaces contribute to community engagement and a sense of identity, drawing residents to urban areas.
- **Resilient Infrastructure:** The pandemic underscored the importance of resilient infrastructure to withstand shocks. Buildings and urban systems are being designed to be adaptable to future disruptions, whether they are health-related, environmental, or technological. The resilience also includes very complex contamination - mitigation processes.

The presented architectural elements are highlighted as essential in reshaping urban landscapes, influencing migration patterns, and support the evolving preferences and demands of residents in the post-COVID era. As cities continue to adapt to the new normal, the integration of these elements remains fundamental in creating vibrant, resilient, and people-centric urban environments.

Urban elements

The survey results distinct the most prominent urban elements that constitute and define transformations and migrations processes after the pandemic. The post pandemic period has shown that the most resilient cities are urban environments and agglomerations with the distinguished elements:

- **Accessibility and Connectivity:** Cities with well-connected transportation networks, including efficient public transit and digital infrastructure, have been attractive to individuals seeking a balance between remote work and in-person interactions.
- **Housing Affordability:** The cost of living, including housing prices and rental rates, has influenced migration patterns. Individuals and families may relocate to areas with more affordable housing options, especially because remote work allows for greater flexibility in choosing living locations.
- **Quality of Housing:** The quality and suitability of housing units have be-

come paramount as remote work blurs the lines between living and working spaces. Urban transformations have focused on creating comfortable, functional, and adaptable living environments.

- **Green Spaces:** Cities with accessible parks, green belts, and recreational areas have seen increased interest as people prioritize outdoor spaces for physical and mental well-being.
- **Healthcare Infrastructure:** Access to quality healthcare facilities has become a crucial factor in migration decisions, as individuals seek locations with prominent healthcare systems.
- **Digital Connectivity:** The availability of high-speed internet and digital infrastructure has influenced individuals' decisions to migrate to areas conducive to remote work and online learning.
- **Cultural Amenities:** Cities offering diverse cultural amenities such as museums, theaters, and entertainment options have retained their appeal, despite the challenges posed by the pandemic.

Socio-Economic Elements

The pandemic has influenced how people view their living environments, work opportunities, and overall well-being, leading to shifts in urban dynamics. The survey results indicate social and economic elements that have driven the changes:

- **Remote Work Opportunities:** The ability to work remotely has given individuals and families the freedom to choose their living locations based on personal preferences rather than proximity to workplaces.
- **Work-Life Balance:** Cities that offer a balance between work opportunities and quality of life, including access to outdoor spaces and recreational activities, have attracted individuals seeking enhanced work-life balance.
- **Economic Opportunities:** Urban centers with diverse job markets and industries have remained attractive to migrants seeking economic stability and growth.
- **Health and Safety:** Migration patterns have been influenced by perceptions of health and safety. Cities with effective pandemic responses and healthcare systems have been favored.
- **Cultural Diversity:** Urban areas known for their cultural diversity and inclusivity have attracted individuals and families seeking vibrant social environments.

- **Social Services:** Access to social services, including childcare, eldercare, and support for vulnerable populations, has influenced migration decisions.
- **Entrepreneurial Ecosystem:** Cities with thriving entrepreneurial ecosystems have attracted individuals and businesses looking to innovate and adapt to changing economic conditions.
- **Community and Social Networks:** The presence of strong social networks and communities has influenced migration decisions, as individuals seek connections and a sense of belonging.

A complex interaction of urban and socio-economic elements has driven urban transformation and migration patterns in the post-COVID era. The pandemic has prompted individuals and families to reconsider their priorities, leading to shifts in how urban spaces are used and valued. As cities continue to adapt and evolve, these elements will continue to shape the future of urban living and migration trends.

CONCLUSION

The post-COVID era has propelled cities into a transformative phase, where architectural elements have emerged as powerful agents in shaping urban landscapes, behaviors, and migration patterns. The research clarifies the intricate relationship between architecture, urban transformations, and migrations, providing insights into the ways in which cities are adapting to the evolving needs of a changed world.

The pandemic incited a reevaluation of urban design paradigms, challenging architects and urban planners to envision spaces that accommodate the diverse facets of modern life. The integration of architectural flexibility and adaptability has proven fundamental in creating environments that seamlessly transition between work, recreation, and community engagement. The flexibility of spaces not only supports the remote work revolution but also nurtures a sense of belonging and connection within communities. The public spaces are required to bridge the divide between physical distancing and human interaction. The infusion of green spaces, walkable designs, and digital connectivity into urban fabric demonstrates an astute understanding of the importance of communal spaces in promotion of well-being and collective identity.

The architectural elements embracing the sustainability and resilience has laid the foundation for cities to withstand and recover from future shocks. This commitment to eco-friendly infrastructure and disaster preparedness speaks to

a forward-thinking approach that recognizes the symbiotic relationship between urban environments and their inhabitants.

Technology's essential role in the post-pandemic urban narrative is evident in the seamless integration of smart elements. The infusion of data-driven decision-making and innovative technologies has redefined urban management, enhancing efficiency, safety, and convenience.

The migration patterns that have emerged post-COVID are illustrative for people seeking environments that align with their evolving values and aspirations. As architectural elements guide these migrations, they play a central role in reshaping demographics and social dynamics. The phenomenon emphasizes the critical role of design in determining the purposes of cities and the communities.

The need for collaboration and inclusive approaches in shaping urban futures, demands that the architects, urban planners, policymakers, and citizens must associate in constructing resilient, sustainable, and livable cities. The lessons learned from the pandemic and the historical moment is depicted in the capacity of architectural innovation to not only respond to crises but also to initiate positive change that transcends immediate challenges.

Clarifying how architectural innovation can meet the evolving needs of societies navigating the complexities of a post-pandemic world, the study contributes to the ongoing discourse on resilient and sustainable urban futures. The paper offers a comprehensive understanding of how cities are redefining themselves in response to the challenges and opportunities posed by the COVID-19 pandemic, and provide resilience to future crises elevating the overall quality of urban life.

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SEASONAL VARIATIONS OF ^{3}H IN SAVA RIVER

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ABSTRACT

This paper presents distribution and seasonal variations of tritium, radioactive isotope of hydrogen, in Sava River in Belgrade. Tritium besides its natural origin also has an artificial origin, through human activity including the operation of nuclear power plants, nuclear weapons manufacturing and atomic bomb tests. Knowing the concentration of tritium in the Sava River in Belgrade is important because it is located downstream from the Krško Nuclear Power Plant in Slovenia. Analysis of tritium concentrations in surface water samples were done in composite monthly samples during 2017-2022. Tritium activity was determined by liquid scintillation spectrometer using electrolytic enrichment. Seasonal variations were estimated by determination of average monthly concentrations and seasonal indices.

Key words: tritium, surface water, seasonal indices

INTRODUCTION

Tritium is widely used in the field of hydrogeology for its tracing properties which enable to estimate origin, residence time, dynamic, mixing, storage volumes of groundwater and their zone of discharge in surface waters [1]. Various studies were performed in order to investigate the radiological impact of tritium releases from nuclear facilities on the environment referring to pre-testing base-

line levels and also various studies presents long time investigations of tritium concentrations at the downstream part of rivers [1]. It is useful to identify potential sources of tritium other than nuclear facility discharges. It is known that tritium baseline (HTO form) in rivers varies according to physical, climatic and geographic parameters spreading from regional to global scales within the hydrosphere [1]. The water in a river is collected from two sources: recent precipitation through surface runoff, channel precipitation or by rapid flow through the shallow subsurface, and groundwater recharge [2]. Long-term monitoring studies for radioisotopes are essential for understanding hydrology of rivers and to assess impacts on river discharge. Global Network of Isotopes in Rivers (GNIR) managed by International Atomic Energy Agency (IAEA) has been available since 2007. GNIR began as a pilot project in 2002–2005 and focussed on the stable isotopes and tritium content of various world river catchments [2,3]. The aim of the GNIR programme is to collect and disseminate time-series and collections of riverine isotope data from the world's rivers and to inform a range of scientific disciplines including hydrology, meteorology and climatology, oceanography, limnology, and aquatic ecology [3].

Nuclear power plant KrškoNPP in Slovenia is located on the Sava River. Sava River passes through Croatia and Serbia. Based to the fact that this river is transboundary, it is necessary to assess the radiological safety of water. The cities supplied with drinking water from water reservoirs which are close to the river. The primary task is environmental protection and sustainable use of water resources that requires continual environmental monitoring.

The aim of this work is to assess seasonal indices based on the obtained tritium concentrations in Sava River in order to estimate if there is some impact of the nuclear facility or, whether the origin of tritium is stratospheric.

Long-term isotope river data record climatic trendsand human impacts within a watershed. Differences in the timing and mixing of winter and summer precipitation runoff can be observed in the variation of the river isotopic values over time [3]. Long-term isotopic time series providing scientific information for researchers to gain insights to study hydrological processes and better focus integrated water management strategies.

In the literature data, there are publications related to the topic of tritium determination in Sava River: in Slovenia [4,5], Croatia [6,7], Serbia [6,8-10].

MATERIAL AND METHODS

The surface water was sampled several times a month at Belgrade during 2017-2022. Analysis was performed in a composite monthly sample. For sample preparation, validated method with electrolytic enrichment was used [11,12]. Measurements were done by liquid scintillation spectrometer Quantulus 1220. For counting efficiency determination, reference standard tritium solution ^{3}H 9031-OL-548/13 Czech Metrology Institute Type: ER X with activity 5.060 MBq on day 1.10.2013. which has traceability to the BIPM, was used, according to method ASTM D 4107-08 [13]. The counting efficiency was from 25.7 to 29.2 %. According to the quality control plan, the efficiency check of the detector is done on a monthly basis, before measurement of samples. Together with the samples, background sample was also measured (tritium free water), as well as sample with known tritium concentration, for enrichment factor determination. After electrolytic enrichment, samples were mixed with scintillation cocktails ULTIMA GOLD LLT or OptiPhase Hisafe 3 in relation 8:12 in 20 ml polyethylene vial. Measurement time for samples and the background was 18000 s.

RESULTS AND DISCUSSION

Tritium activity concentrations obtained in surface water samples from Sava River, in the investigated period 2017-2022 ranged from 0.51 Bq/l (January 2022) to 5.69 Bq/l (July 2018). Figure 1 presents average monthly concentrations for tritium in Sava River for period 2017-2022. The highest average monthly concentration was obtained for July, 2.52 Bq/l, the lowest average monthly concentration was obtained for April, 1.33 Bq/l.

The seasonal variations of ^{3}H could be analyzed by seasonal indices. A monthly seasonal index represents the ratio of the monthly mean value and the overall average concentration for the examined period. The quarterly seasonal index represents the ratio of the average monthly concentration for the respective season, i.e., December, January, and February for winter, March, April, and May for spring, June, July, and August for summer, and September, October, and November for autumn, and the total mean concentration values for the whole period tested [14]. Table 1 presents the calculated values of monthly and quarterly seasonal indices over the investigated period for ^{3}H. Monthly seasonal index and quarterly seasonal index is the highest in summer indicating seasonal variations of ^{3}H and stratospheric origin of this radionuclide [15].

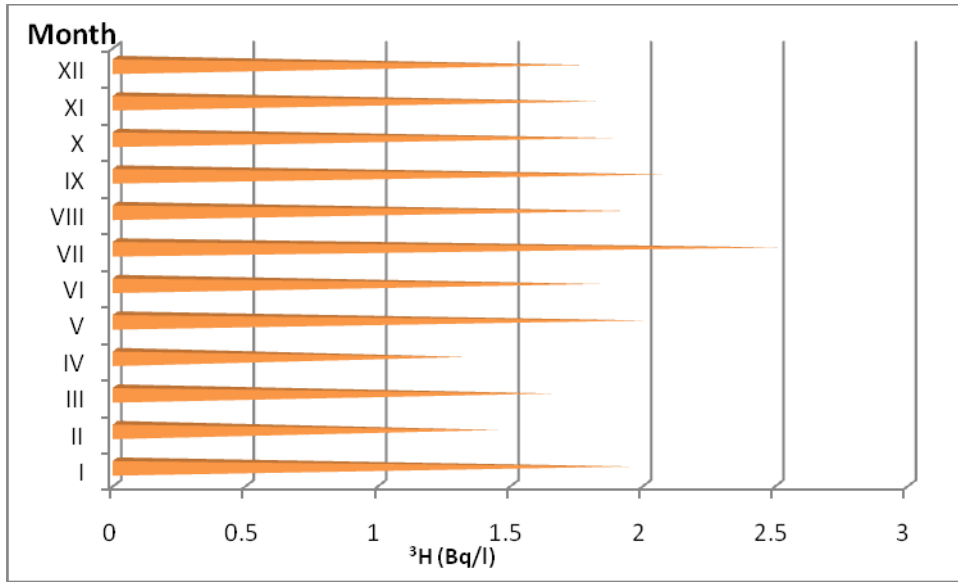

Fig. 1. Average monthly concentrations of tritium in Sava River for period 2017-2022

Table 1 Seasonal indices of ^3H in Sava River in Belgrade (2017-2022)

Monthly	**XII**	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**
	0.96	1.05	0.78	0.89	0.71	1.08	0.98	1.35	1.04	1.12	1.01	0.98
Quarterly	**Winter**			**Spring**			**Summer**			**Autumn**		
	0.93			0.89			1.13			1.04		

Tritium was emitted into the atmosphere also as a result of nuclear tests in the 1960s, but its existence in the environment waters as a consequence of these tests is decreasing. The isotopic content of the river water also depends on temperature, elevation of the recharge area and amount of precipitation. In the north hemisphere activity concentrations of cosmogenic tritium in precipitation follow characteristic seasonal variations. The spring/summer maximum, referred to as spring leak, is explained by the exchange of tropospheric and stratospheric air masses occurring mainly during late winter and spring. At this time is the border layer between the stratosphere and troposphere lowered due to the heating of the continents and this decline is followed by a release of tritium from the stratosphere into the troposphere and thus increases the flux of tritiated water to the ground by precipitation [16]. As can be seen at Figure 1, in investigated surface water samples there is no ^3H pronounced maximum in spring as is the case with precipitation. There is a pronounced maximum in summer.

The KrškoNPP does not release tritium into the Sava River continuously. It operates in intermittently at certain times of the month [6]. Therefore, tritium activities in the river water are monthly average values. The influence of NPP on tritium concentration in Sava River in Croatia can be seen in references [6,17]. Reference 6 shows the analysis of cross-border flows through Croatia and Serbia (Sremska Mitrovica). The results for tritium concentrations in Sava River in Slovenia can be seen in references [4,5], in Croatia [6,7,17]. In Serbia there are data for the long time investigations of tritium distribution in Sava River in Belgrade: for period 1976-1984 [8,9], 1985-2009 [10].

CONCLUSION

Distribution of tritium in Sava River in Belgrade was determined during the period 2017-2022. If the entire examined period is observed, analysis showed maximum average monthly concentration of tritium in summer. Based on the obtained tritium concentrations, monthly and quarterly seasonal indices were calculated. The highest values, monthly and quarterly, were obtained for summer. Summer maximum can indicates seasonal variations of tritium. But pronounced maximum in spring was not obtained as is the case with precipitation, when we can claim that the origin of tritium is stratospheric. Constant monitoring of tritium in river water is necessary due to the existence of a nuclear power plant in Slovenia on the Sava River. All obtained values of tritium concentration in Sava River in this study were far below the permissible values for tritium in drinking water [18].

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SELECTION OF SOIL REMEDIATION TECHNIQUE USING AHP METHOD

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Abstract

Preserving and protecting the environment is crucial for urban ecological sustainability and is essential in reshaping people's surroundings. Contemporary engineering practice is more intensively concerned with the issue of neglected and inactive, previously built areas and the possibilities of their sustainable redevelopment. Given that abandoned areas were burdened by industrial and military plants, removing the pollutants from the soil is necessary to create opportunities for reuse. Technological development has enabled the modern application of various soil remediation techniques, classified into biological, physical, and chemical methods. When choosing the most optimal plan for soil remediation, decision-makers should consider the applied technique's impact on the environment, the cost, the complexity of performing the method, the degree of efficiency in removing pollution, and the time needed for soil decontamination. The paper deals with applying multi-criteria analysis in selecting the technique for soil remediation. The research aims to use the Analytical Hierarchy Process (AHP) method to rank 18 types of biological, physical, and chemical remediation techniques concerning various influencing factors (impact on the environment, cost, complexity, degree of effectiveness, and time). The conducted results ultimately aim to identify the most optimal soil remediation method in the context of ecological sustainability.

Keywords: Soil Remediation, Remediation Technique, Brownfield Regeneration, Analytic Hierarchy Process, Multi-Criteria Decision-Making

INTRODUCTION

After facing the energy crisis, followed by climate changes, in recent decades, the world has been more intensively concerned with establishing a balance between nature, man, and society, putting sustainability in the foreground as an essential prerequisite for development and conservation. The concept of sustainable development is one of the critical principles in building design. Among other things, it actively advocates the orientation towards adaptation of abandoned built-up areas while minimizing demolition and new construction procedures. Given that preserving and protecting the environment is one of the primary components of ecological sustainability, modern construction tends to suppress negative impacts on the already-built structure and natural environment (Kosorić, 2012). Special attention is directed toward implementing the brownfield restoration process, which creates opportunities to reuse these abandoned and devastated areas through regeneration.

Brownfield's redevelopment creates a quality environment, increasing security and preserving the city's identity. Although the driving force behind renovations is primarily economic interest, they increasingly arise from demands for environmental protection (Perić & Maruna, 2012). Considering that brownfield areas also include former industrial complexes, military zones, and landfills, these locations are characterized by a certain degree of soil pollution resulting from the previous way of use (Milošević et al., 2018). Due to outdated production technologies and the lousy handling of harmful substances, there is a high level of soil contamination in former industries, with the most dangerous waste and chemicals from the chemical and oil industry, metallurgy, and paint and varnish industry. Research has shown that the content of heavy metals in the soil around these plants is up to 10,000 times higher than natural (Marković et al., 1996). At the locations of industrial brownfields, we come across old infrastructure installations, underground and above-ground tanks, fuel storage, and transformer stations. Harmful substances are often present in the constructions themselves in the form of asbestos and various coatings (Perović & Kurtović, 2012).

Contaminated brownfield land requires the application of decontamination methods or remediation technologies, which are used to remove pollutants that negatively affect human health and degrade the environment. This way, the land is freed from the burden and accessible for future investments and construction. Today, geotechnics offers many remediation technologies divided into thermal, physical-chemical, and biological methods according to their nature (Kisić, 2012). The selection of the appropriate way depends on a large number of influencing factors, primarily on the type of pollutant in the soil, and then on the

efficiency of the applied method, the complexity of the implementation of the procedure, the price, the available time for decontamination, and the impact that the decontamination procedure itself has on the environment (Milošević et al., 2017).

In deciding which remediation technique is most convenient, a multi-criteria approach can significantly help. The paper deals with selecting soil remediation techniques for industrial brownfield sites using multi-criteria decision-making. Given the impact on the environment, cost, complexity, degree of effectiveness, and time, the research aims to rank 18 remediation techniques applying the Analytical Hierarchy Process (AHP) method to find the most optimal procedures for soil remediation of former industrial sites.

TYPES OF SOIL REMEDIATION TECHNIQUES - THEORETICAL OVERVIEW

Soil remediation is a set of different methods and techniques used to treat polluted land to remove or reduce pollution to a level that will not threaten the environment and people (Prokić et al., 2012). Identifying spilled pollutants precedes the selection of the appropriate remediation method, that is, determining the degree of soil contamination and its impact on the environment. Appropriate chemical analyses of laboratory soil samples and physical measurements determine soil contamination. The primary soil pollutants are heavy metals, aromatic hydrocarbons, polycyclic aromatic hydrocarbons, and pesticides. Although the choice of remediation technique is greatly influenced by the nature and degree of pollution and the characteristics of the soil, it also depends on the future way of using the ground, the spatial extent of the corruption, and the limited concentrations prescribed by legal regulations.

All soil remediation methods can be classified into two primary groups based on criteria related to the place of their implementation (Beškoski et al., 2012):

- **In-situ methods** - include technologies that remove pollutants from the soil on the spot, without or with soil excavation;
- **Ex-situ methods** - include technologies where the soil is excavated and transported to the place intended to remove pollutants.
- According to their character, soil remediation methods are classified (Kisić, 2012):
- **Physico-chemical remediation methods** - This group of methods is most

often used. By applying the physical laws of nature (volatility, solubility), chemical principles, and conversions, pollutants are removed from the soil extremely fast. The price varies with the specific type of technology, and many of them create by-products that harm the environment.

- **Thermal remediation methods** - This group of methods is considered the most effective due to the extended processing period. They use the principles of thermals and heating, burning, and melting processes. On the other hand, they are costly and pollute the environment with by-products that arise in the thermal processes themselves.
- **Biological remediation methods** - They function according to the principle of applying natural biological processes, most often using plants, oxygen, and adding microorganisms. Remediation processes take a long time, but the procedures are simple, cheap, and effectively remove pollution. An essential feature is that by-products are not created by applying this type of method, which does not further damage the quality of the environment.

Each of the groups of soil remediation methods includes several separate technologies. A comparative view of selected types of remediation methods is given in Table 1.

Table 1. Overview of the most used soil remediation methods (Singh et al., 2014; Virkutyte et al., 2002; Dimović, 2004)

P	**Physico-chemical methods**
P_1	chemical extraction - adding organic compounds to remove toxic substances
P_2	chemical oxidation - adding oxidants to remove toxic substances
P_3	soil leaching - adding water to remove toxic substances
P_4	electrokinetic remediation - contamination is removed using electricity
P_5	solidification & stabilization - immobilize contamination by adding the mineral/cement
P_6	steam extraction - using vacuum pressure to remove contamination
T	**Thermal methods**
T_1	thermal desorption - a process of heat used to increase the instability of pollutants
T_2	thermal steam extraction - improved physical method of extraction by vapor
T_3	pyrolysis - using heat to break down complex compounds into simpler one

T_4	incineration – using heat to destroy pollutants completely
T_5	gas decontamination - injecting hot gas into the excavated soil
T_6	vitrification - heat used to melt pollutants
B	**Biological methods**
B_1	phytoremediation - using plants, fungi, and algae as agents for absorbing pollution
B_2	bioremediation - using microorganisms as agents for absorbing pollution
B_3	bio-ventilation - introduction of air into the soil to accelerate the microorganisms
B_4	bio-pile - mixing the excavated soil with the soil of good quality
B_5	landfarming - mixing the soil through agricultural activities
B_6	bioreactor - land is mixed with water to the separation of sand and slurry

Physico-chemical methods provide the most opportunities for technology selection, and some have no restrictions regarding the place of implementation. Thermal procedures are often carried out off-site, but some have recently been developed to enable on-site application. Regarding biological methods, in-situ technologies lead to efficiency, cost, and easy application.

MATERIALS AND METHODS

The Analytic Hierarchy Process (AHP) is a technique that measures through pairwise comparisons and relies on expert opinions to derive priority scales (Saaty 2008). It is one of the most popular tools for multiple-criteria decision-making. The AHP methodology's hierarchical structure makes it easy to put the elements of a complex decision-making process together as a whole by measuring and synthesizing a range of aspects in a hierarchical manner. There are six phases in this method: 1) Define the issue and decide what knowledge is needed; 2) Establish the decision-making hierarchy with indicators; 3) Build matrices to do a series of pairwise comparisons; 4) Determine the indicators' relative weights for each level; 5) Decision-making is checked and balanced; 6) Decision documentation. AHP structure is displayed in Figure 1.

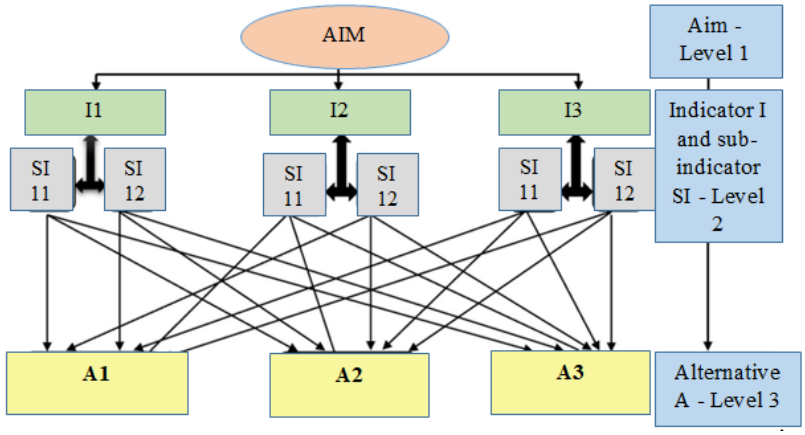

Figure 1. The Hierarchical structure of AHP method

The comparison matrix will be 'translated' per pair into problems of determining their eigenvalues in order to obtain normalized and unique eigenvectors, as well as the weight of all the indicators on each level of the hierarchy with the weight vector. Any comparison between two elements of the hierarchy is made using Saaty's scale in Table 2.

Table 2. Adopted scale of importance

Intensity of importance	**Degree of Preference**
1	The criteria are equally important
3	Medium importance of one factor over another
5	Strong or essential
7	Crucial importance
9	Extremely important
2, 4, 6, 8	Intermediate values

At any point during the process of comparing pairs of options, the AHP technique allows for evaluating the consistency of assessments. The ratio of consistency CR = CI/RI is determined using the index consistency formula: , where λ_{max} is the highest eigenvalue of the matrix comparisons. The value of the consistency ratio CR is less than 0.10. The possibilities for applying the AHP method are many and significant (Stanojević et al. 2019, Selim et al. 2018)

RESULTS AND DISCUSSION

The overall synthesis is realized in the following way: the participation of each alternative is multiplied by the weight of the observed indicator , and then these values are summed up for each alternative separately and the result is the weight of the observed alternative in the model. In the same way, the weight is determined for all other alternatives, after which the final ranking of alternatives in the model are determined. The weight of the indicator is denoted by wI.. The results of ranking the indicators relevant to selection of soil remediation technique are presented in Table 3.

Table 3. Ranking of indicators

	A1	A1 w_I	A2	A2 w_I	A3	A3 w_I	A4	A4 w_I	A5	A5 w_I	Final
T2	0.3547	0.6370	0.1192	0.1020	0.0808	0.7334	0.1197	0.1220	0.2071	0.0633	0.1135
B1	0.1210	0.1047	0.3853	0.7258	0.0354	0.0675	0.2712	0.5584	0.3853	0.7429	0.1047
T4	0.1197	0.6370	0.4010	0.1020	0.3737	0.7334	0.3547	0.1220	0.0509	0.0633	0.0979
T3	0.1197	0.6370	0.2712	0.1020	0.2390	0.7334	0.2184	0.1220	0.0509	0.0633	0.0749
T5	0.2184	0.6370	0.0530	0.1020	0.0808	0.7334	0.1197	0.1220	0.1262	0.0633	0.0739
B3	0.2029	0.1047	0.2534	0.7258	0.1139	0.0675	0.1192	0.5584	0.1633	0.7429	0.0710
F4	0.4115	0.2583	0.2760	0.1721	0.1112	0.1991	0.0789	0.3196	0.2449	0.1939	0.0668
B2	0.1210	0.1047	0.1633	0.7258	0.0712	0.0675	0.4010	0.5584	0.2534	0.7429	0.0614
T1	0.1197	0.6370	0.1192	0.1020	0.1448	0.7334	0.1197	0.1220	0.4387	0.0633	0.0579
F3	0.0435	0.2583	0.4055	0.1721	0.1112	0.1991	0.3432	0.3196	0.3777	0.1939	0.0385
B6	0.4355	0.1047	0.0463	0.7258	0.3980	0.0675	0.0365	0.5584	0.0463	0.7429	0.0367
F5	0.0994	0.2583	0.1908	0.1721	0.3350	0.1991	0.1244	0.3196	0.1528	0.1939	0.0363
B5	0.0725	0.1047	0.1054	0.7258	0.2678	0.0675	0.1192	0.5584	0.0463	0.7429	0.0338
F1	0.1732	0.2583	0.0360	0.1721	0.1976	0.1991	0.2074	0.3196	0.0916	0.1939	0.0334
F2	0.1732	0.2583	0.0360	0.1721	0.1976	0.1991	0.2074	0.3196	0.0916	0.1939	0.0334
T6	0.0678	0.6370	0.0365	0.1020	0.0808	0.7334	0.0678	0.1220	0.1262	0.0633	0.0315
B4	0.0471	0.1047	0.0463	0.7258	0.1139	0.0675	0.0530	0.5584	0.1054	0.7429	0.0177
F6	0.0994	0.2583	0.0555	0.1721	0.0474	0.1991	0.0387	0.3196	0.0413	0.1939	0.0166

The key indicators are thermal steam extraction - improved physical method of extraction by vapor, phytoremediation - using plants, fungi, and algae as agents for absorbing pollution, and incineration - using heat to destroy pollutants completely.

CONCLUSION

In this paper, by applying the AHP method, the ranking of soil remediation techniques for industrial brownfield regeneration in the context of ecological sustainability is carried out. The research rank 18 types of biological, physical, and chemical remediation techniques concerning various influencing factors. Environmental impact, cost, complexity, degree of effectiveness and time were considered.The conducted results identify the most optimal soil remediation methods in the context of ecological sustainability. It is most optimal to use thermal steam extraction and phytoremediation. The applied methodology can be practically used in decision-making processes in various aspects of environmental protection

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ETHICAL PRINCIPLE DURING GREEN PROCUREMENT IN SUSTAINABLE BUSINESS

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ABSTRACT

The paper analyzes green public procurement as an important tool in achieving the goals of sustainable development, which are becoming increasingly important due to efforts to reduce resource consumption and reduce negative impacts on the environment. The subject of the paper is in the form of a question: whether and to what extent green public procurement has been implemented in Serbia, but also in the world? What is the role of green public procurement in achieving sustainable development and improving competitiveness and innovation? The aim of the paper is to present the importance of conducting public procurement according to the principles of green public procurement by looking at the data on the representation of public procurement in GDP, as well as to present the contribution of green public procurement in the development of sustainable production and consumption and the development of competitiveness and innovation. The contribution of this paper is reflected in the overview of theoretical facts specific to green public procurement, in the overview of the degree of application of green public procurement, including the legal regulations related to green public procurement and the formulation of conclusions on green public procurement, as well as indicating the necessity for the public sector to implement green public procurement, so that they become practice. Appropriate legal regulations, the level of management awareness and understanding of consumer attitudes and needs towards green products and services are necessary items in achieving sustainable development.

Key words: green public procurement, sustainable production and consumption, law on public procurement, National Action Plan

INTRODUCTION

Green public procurement is considered an important policy instrument on the way to achieving the goals of sustainable development. The work is divided into thematic units. An analysis of the representation of public procurement in GDP was made, in order to further clarify the positive impact of green public procurement on society. The existence and application of appropriate legal regulations contributes to the implementation of green public procurement, and also the public sector, given that it has great purchasing power, contributes to the implementation of green public procurement. The contribution of green public procurement was presented:

- innovativeness, given that they provide the industry with incentives for the development of green products and services,
- competitiveness, because green public procurement encourages the competitiveness of products that have less negative impact on the environment
- sustainable production and consumption through the rational use of resources, contained in the green public procurement tender documentation.

MATERIAL AND METHODS

The research method used in this work is:

- collection and systematic analysis of available data on the representation of public procurement in GDP
- analytical approach to the importance of green public procurement through the prism of competitiveness and innovation, as well as sustainable production and consumption
- data were reviewed and analyzed, data extraction and integration were carried out in order to process *the topic of green public procurement in the function of sustainable development*.

RESULTS AND DISCUSSION

Public procurement - representation in GDP

Public procurement refers to the procedure in which public contracting authorities, such as ministries, regional or local authorities or bodies operating in accordance with the law on public procurement, procure works, goods or services from companies.

Based on the report on public procurements, the registered value of public procurements in Serbia in 2019, was 440.5 billion dinars, the number of registered public procurement contracts was 122 066, while the representation of public procurements in the gross domestic product was 8.14%. (Annual report on public procurement in the Republic of Serbia for the period 1.1.2019-31.12. 2019, 2020). In 2020, a decrease in the share of public procurement in the gross domestic product was recorded to 6.88%, due to the increased value of procurements that are exempt from the application of the Law on Public Procurement, due to the unfavorable epidemiological situation. The number of registered public procurement contracts was 135 022, the registered value of public procurement was 376.1 billion dinars. One of the reasons that in the following period, i.e. in 2021 and 2022, the increased number of public procurements, the value of public procurements, as well as the introduced ecological criteria, is the promotion of the so-called „green procurement" that takes into account the ecological aspects of procurement.

The value of public procurement contracts, the number of registered contracts, as well as the percentage of public procurement in GDP increased significantly in 2021, while a more significant jump occurred in 2022, based on the following indicators: In 2022, the total number contracts amounted to 251 949, the registered value of public procurement was 662,7 billion dinars, while the representation of public procurement in the gross domestic product was 9.34%.

„In 2022, contracting authorities declared that they applied environmental aspects in 1111 public procurement procedures, which accounts for 0.44% of the total number of public procurement procedures. Compared to the previous year, there was a significant increase in the number of procedures in which ecological aspects." (Annual report on public procurement in the Republic of Serbia for the period 1.1.2022-31.12. 2022, 2023).

Significant progress in promoting the so-called of „green procurements" that take into account the ecological aspects of procurement, which resulted in an increase in the number of public procurements that include an ecological aspect by almost 100% in 2022 compared to 2021.

Table 1 Tabular presentation of significant indicators of public procurement for the period 2019-2022, Source: author of the paper according to annual reports on public procurement in the Republic of Serbia

Year	*No. of registered public procurement contracts*	*The value of public procurement*	*Share of public procurement in GDP (%)*	*Number of procedures in which ecological aspects were applied*
2019	*122.066*	*440.5*	*8,14*	
2020	*135.022*	*376.1*	*6,88*	
2021	*182.998*	*559.7*	*8,93*	*650*
2022	*251.949*	*662.7*	*9,34*	*1111*

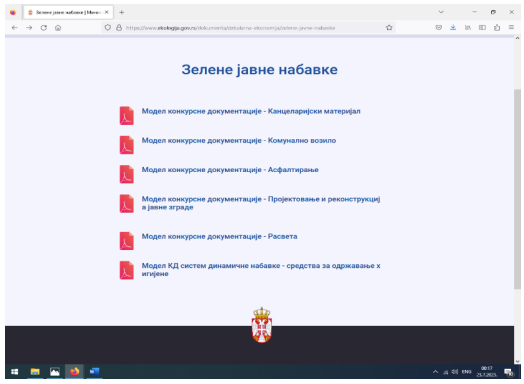
The percentage of public procurement in GDP is much higher at the level of the European Union and amounts to 15% for 2020.

Green public procurement - concept and importance

Based on the data on the significant share of public procurement in GDP, it is concluded that if public procurement were carried out in accordance with the principles of sustainable development, i.e. if the procurement of goods, services or works was carried out with a reduced impact on the environment, i.e. the use of green public procurement would have a positive impact on society. Green public procurement is one of the instruments that can significantly contribute to the achievement of sustainable development through more efficient use of natural resources and stimulating the economy. Through the process of green public procurement, goods, services or works are procured with an additional sustainable element, because the impact on the environment is actually taken into account. This is confirmed by the definition of green public procurement by the European Commission. According to the definition of the European Commission: „Green public procurement is a process in which the contracting authorities buy such goods, services and works that have a lower negative impact on the environment in the entire life cycle compared to the goods and services that we would otherwise buy, which have the same functions. „ (COM, 2008).

Legislation and the public sector - contribution to the implementation of green public procurement

The new law on public procurement was adopted in 2019, but the above mentioned law does not prescribe the mandatory application of criteria other than price, but rather the authority of the contracting authority depending on the subject of the procurement. The application of green public procurement, although recognized in domestic legislation, is not binding. It is recommended that each country have a National Action Plan (NAP) in which the criteria for green public procurement (GPP) will be defined during the public procurement procedure. „A total of 23 EU member states have adopted National Action Plans (NAP) for green public procurement: Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Lithuania, Malta, Netherlands, Croatia, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, while Estonia, Hungary , Luxembourg, Romania do not have NAP. (Green public procurement in Serbia - situation and perspectives, 2022). The public sector, as a large buyer, has great purchasing power and can play a leading role in promoting green procurement. Public institutions can provide real incentives for the industrial sector, for the development of green technologies and products, by announcing green public procurements, on the other hand, those who announce procurements are not stimulated to announce green procurements, because it is important for them that the procurement goes as cheaply as possible, so that is the criterion of the lowest price and is still dominant when calling for tenders.



The Office for Public Procurement publishes models of tender documents for green public procurement on its website.

Figure 1 Models of green public procurement, Source: https://www.ujn.gov.rs/strucna-pomoc/modeli-dokumenata-zjn-2019/

The top management of the contracting authorities is a key link in the promotion and tendering of green public procurements, and it is very important that the management has a high level of awareness in relation to green procurements. Also, understanding the needs and attitudes of consumers towards green products is the starting point for planning the sustainability of producers of green products and services. By adopting and implementing green public procurement, the state shows responsibility and contributes to the development of the green economy. According to the available data from the Report on Public Procurement for 2021 in Serbia, the most common items of procurement in which ecological aspects were used are the procurement of vehicles, procurement of office supplies, computer equipment, laboratory materials, lighting, construction materials, cleaning services and chemical agents. (Green public procurement in Serbia - an exception or is there hope that it will become the rule?, 2022).

The established hypotheses

Bearing in mind the above mentioned analysis of the green public procurement model and the possibilities of application, the following hypotheses were set:

H1: Green public procurement-contributions to innovation and competitiveness

H2: Green public procurement-contributions to sustainable consumption and production

Analysis and proof of hypotheses

In the analysis of the first hypothesis *H1: Green public procurement - contribution to innovation and competitiveness*, it starts from the clarification that Green Public Procurement (GPP) is a powerful instrument for encouraging innovation and encouraging companies to develop new products with improved environmental performance. This is confirmed by the following statements: „Green public procurement can be a major driver of innovation, providing industry with incentives to develop green products and services. It can also be a source of significant savings for buyers as they look beyond the immediate purchase price and the cost of the entire contract life cycle. For example, buying energy-efficient or water-saving products helps to significantly reduce utility bills". (European Commission, 2021). Also, encouraging innovation contributes to increasing the competitiveness of a country. By using green public procurement mechanisms and appropriate criteria, the competitiveness of products that have less negative impacts on the environment is encouraged. Products that have less negative impacts on the environment are the basis of the future and sustainable

development, and that is why the purpose of green public procurement is to start the market of innovative products and services, because innovation is the basis of modern business. The goals of environmental policy can be met through green public procurement. This is confirmed through the following: „GPP can affect the environment:"

- Directly – through improving the environmental performance of purchased goods, services and works
- Indirectly – using this market leverage to encourage companies to invest in cleaner products and services" (Green Public Procurement, An introduction, 2019).

In order to achieve this, the procurement system should be shifted from finding the lowest price to procurement that takes environmental criteria into account.Thus, the hypothesis *H1: Green public procurement - contributes to innovation and competitiveness is proven*.

In the analysis of the second hypothesis H2: *Green public procurement-contributions to sustainable consumption and production*, we started from the point of view that the basic idea of sustainable consumption and production is that the social cycle of production and services is such that the needs of future generations are not threatened. According to the 2030 Agenda for Sustainable Development, one of the 17 goals is goal 12, which refers to sustainable production and consumption. As part of the Earth Summit [1)] in 2015, 15 principles of green economy were adopted, among which is the principle of sustainable production and consumption: „It is necessary to ensure sustainable production and consumption with rational use of resources, reduce unsustainable production practices, encourage reuse, renewal and recycling of materials in order to reduce the use of limited natural resources". It is green public procurement that can make a great contribution to sustainable production and consumption, through special ecological criteria contained in the tender documentation. Green public procurement is considered an important policy instrument on the way to achieving sustainable consumption and production.The above statements confirm our hypothesis H2: *Green public procurement - contribution to sustainable consumption and production.*

[1)] Earth Summit is the name of the United Nations conference that has been held since 1972, a which gathers world leaders whose goal is to develop a sustainable development plan on a global level

CONCLUSION

Green public procurement is considered an important segment on the way to achieving the goals of sustainable development, contributing to competitiveness, innovation with simultaneous sustainable production and consumption. The public sector, as a large buyer, has great purchasing power and can play a leading role in promoting green procurement. As public procurement represents a significant share of GDP, the implementation of green public procurement would have a positive impact on society, and the adoption and implementation of legislation, with defined environmental factors, contributes to the development of the green economy. The top management of the contracting authorities is a key link in the promotion and tendering of green public procurements, and it is very important that the management has a high level of awareness in relation to green procurements. Also, understanding the needs and attitudes of consumers towards green products is the starting point for planning the sustainability of producers of green products and services. . Green public procurement is already an established practice in the member states of the European Union, and there is a noticeable increase in the number of procurements with environmental criteria included in public procurement.

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DIGITAL COMPETENCES OF TEACHERS IN SECONDARY SCHOOL

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ABSTRACT

The events that happened in the previous three years had a significant impact on the development of teachers' digital literacy. The Covid-19 virus pandemic affected all aspects of life, including education. Unaccustomed to a situation in which teaching took place mainly online, teachers were forced to further improve their digital competences and thus increase the quality of online and hybrid teaching. This paper analyses digital competence of teachers in the period from 2020 to 2023. The research was conducted in three phases. The first phase refers to the digital competence of teachers before the crisis situation, the second phase to the digital competence of teachers immediately after the crisis situation, while the third phase follows the progress of literacy concerning the period in which teachers return to traditional classroom teaching. The aim of the paper is to compare the digital competencies of teachers through the previously listed periods.

Keywords: digital competence, crisis situation, crisis, online teaching, hybrid teaching

INTRODUCTION

Improving the digital literacy of teachers is a constitutive element of their professional development. Informatics and digital literacy is a very long-term and slow-moving process. In 2017, the Ministry of Education, Science and Technological Development of the Republic of Serbia published the Framework for Teachers' Digital Competences. The framework was revised in 2019, and that was the time when teachers took this issue more seriously. Professional development largely enables teachers to educate themselves digitally.

BASIC TERMS

Digital literacy is a set of knowledge, skills and behaviors related to the use of digital devices and a set of human abilities to find, evaluate, analyze, create and transmit information in digital format (Bjekić, 2013). **Digital devices** include desktop computers, laptops, tablets, smartphones and similar devices. **Digital competences** of teachers represent the digital literacy of teachers that ensures a thoughtful, safe and flexible improvement of the process of traditional, online and hybrid teaching (Bjekić, 2003). Online and hybrid classes take place in crisis situations. **Crisis situations in education** means teaching during some intense disaster that has hit the community (Basilaia, 2020). In this case, online and hybrid teaching is a consequence of the crisis situation caused by the Covid-19 virus pandemic.

WORK METHODOLOGY

For the purposes of this work was used a survey which teachers filled out in three phases. The survey was anonymous and identical in all phases. The first phase referred to the period before the crisis situation (June 2019), while the same group of teachers filled out the survey after the crisis situation (June 2022).

In May 2023, a third survey was conducted with the same number of teachers but with a slightly changed structure. The survey was filled out by teachers of general education and professional subjects of the Technical School of Architecture (a sample of 69.23%). The questions in the questionnaire stem from the definition of digital literacy and the framework of digital competences of teachers, which was adopted by the Ministry of Education, Science and Technological Development. The aim of the paper is to compare the digital literacy of teachers before online and hybrid teaching, immediately after these types of teaching, and one year after the crisis.

RESULTS

General data

General data refer to gender, seniority work, teacher's education and the type of subject they teach at school (general education or vocational).

Table 1 General information about the teacher before the crisis situation, immediately after and 1 year after the crisis

		General data about teachers before the crisis	General data about teachers immediately after the crisis	General information about teachers 1 year after the crisis
Variable	Category	Percentage (%)	Percentage (%)	Percentage (%)
Gender	Male	20	20	17.78
	Female	80	80	82.22
Working experience in school	0-10 years	28.89	26.67	31.11
	11-20 years	37.78	40	35.56
	>20 years	33.33	33.33	33.33
Education	Undergraduate	64.44	60	62.67
	Master	35.56	40	33.33
Type of subject	General education subjects	31.11	31.11	31.11
	Professional subjects	68.89	68.89	68.89

The presentation of data before, immediately after and one year after the crisis is given in Table 1 and has not changed significantly in four years.

Computer skills

The analysis of the survey related to teachers' computer skills shows that teachers have significantly improved in handling hardware, software and the internet after crisis situations (table. 2.).

Table 2 Teachers' computer skills

	Before the crisis		Immediately after the crisis		1 year after the crisis	
Question::	**Yes (%)**	**No (%)**	**Yes (%)**	**No (%)**	**Yes (%)**	**No (%)**
Do you know the basic difference between hardware and software?	71.11	28.89	84.44	15.56	94.34	5.66
Can you turn on/off the computer properly?	95.56	4.44	97.78	2.22	100	0
Can you run the program properly?	95.56	4.44	95.56	4.44	100	0
Can you minimize, maximize and move windows around your desktop?	86.67	13.33	95.56	4.44	95.56	4.44
Can you work with folders and files (delete, rename...)?	71.11	28.89	97.78	2.22	97.78	2.22
Can you install/uninstall the program?	40	60	62.22	37.78	70.22	29.78
Can you save/transfer files, folders and documents to various devices?	53.33	46.67	91.11	8.89	91.11	8.89
Can you scan your computer for potential threats/viruses?	55.56	44.44	62.22	37.78	70.22	29.78
Can you create a simple document in MS Word?	93.33	6.67	97.78	2.22	100	0
Can you create a simple document in MS Excel?	42.22	57.78	62.22	37.78	83.56	16.44
Can you create a simple document in MS PowerPoint?	68.89	31.11	80	20	83.56	16.44
Can you copy, cut and paste content within a document?	46.67	53.33	77.78	22.22	83.56	16.44
Can you format a text document?	75.56	24.44	93.33	6.67	93.33	6.67
Do you know how to use a photo program (change size, content...)?	64.44	35.56	80	20	80	20
Can you record and add sound?	35.56	64.44	55.56	44.44	55.56	44.44

Do you use email?	95.56	4.44	100	0	100	0
Can you download a material/ document from the Internet?	68.89	31.11	86.67	13.33	86.67	13.33
Can you use any online video conference calling tools?	13.33	86.67	91.11	8.89	100	0
Can you use any digital online learning platforms?	13.33	86.67	95.56	4.44	95.56	4.44

Use of digital devices

Teachers owned digital devices before and after the crisis. 25 teachers in both cases used mostly desktop computers. Before the crisis situation, laptops were used by 28 teachers, and after 42 teachers. Tablets and other devices were used in approximately the same percentage, and smartphones are used by all teachers (Figure 1.)

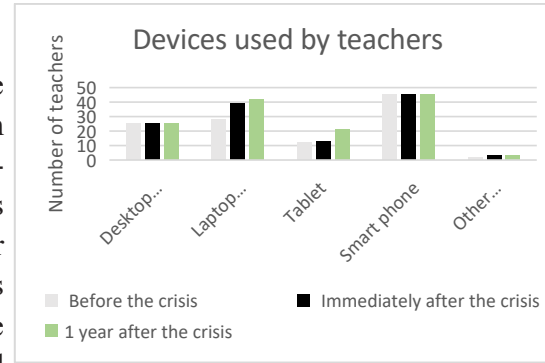

Figure 1 Digital devices

The survey analysis showed that the percentage of computer use for the purpose of education and knowledge transfer increased from 26.67% to 63.15%. Also, teachers devoted less time to entertainment after the crisis situation, namely 12.42% of teachers, while before the pandemic that percentage was slightly higher and amounted to 20% (Figure 2).

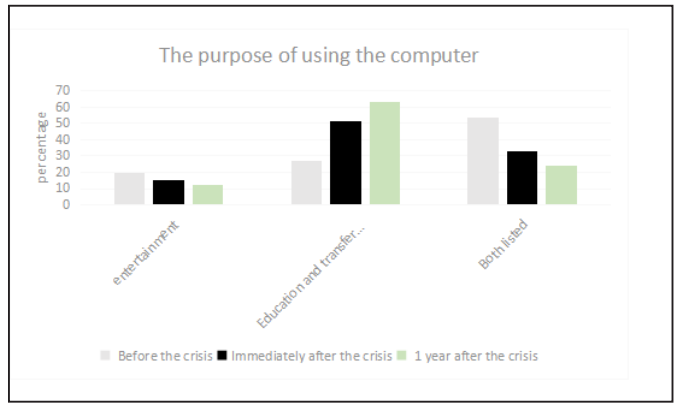

Figure 2 The purpose of using the computer

The frequency of using digital devices 1 year after the crisis has changed significantly. Today, teachers use digital technologies to a greater extent. 51.11% of teachers spend more than four hours a day working on a computer or other digital device (Figure 3). This situation can be related to the daily use of an electronic diary.

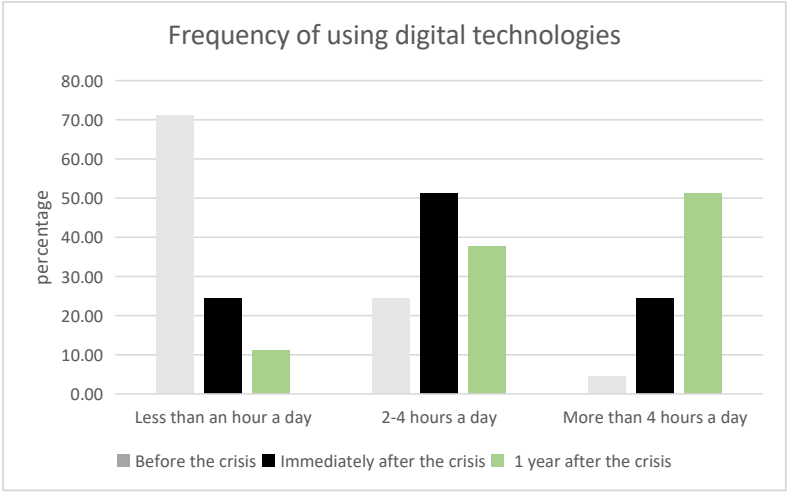

Figure 3 Frequency of using digital tehnologies

Digital competences of teachers related to the digital environment

The paper analyzes some of the digital competencies set by the Ministry of Education, Science and Technological Development of the Republic of Serbia (https://mpn.gov.rs/wp-content/uploads/2019/08/2019_ODK_Nastavnik-za-digitalno-doba.pdf.).

a. **Internet browsing**: The analysis of the survey shows that the level of digital competences of teachers related to internet browsing has increased (Table 3).

Table 3 Internet search

Levels of digital competence: Internet search	Before the crisis		Immediately after a crisis		1 year after a crisis	
	Frequency	%	Frequency	%	Frequency	%
Basic: I use browsers for basic searches.	36	80	23	51.11	19	42.22
Medium: I define search keywords. I use search engines, forums, open educational resources.	7	15.56	19	42.22	21	46.67
Advanced: I use advanced search techniques.	2	4.44	3	6.67	5	11.11

b. Precaution on the Internet: After a crisis situation, teachers behave more cautiously in the Internet environment (Table 4).

Table 4 Precaution on the internet

Levels of digital competence: Internet security	Before the crisis		Immediately after a crisis		1 year after a crisis	
	Frequency	%	Frequency	%	Frequency	%
Basic: I behave with caution on the Internet.	35	77.78	24	53.33	15	33.33
Medium: Together with the students, I apply precautionary behavior procedures to maintain safety in online classes.	9	20	19	42.22	26	57.78

Advanced: I empower myself digitally and try to prevent digital bullying in order to preserve personal and student safety in online classes.	1	2.22	2	4.44	4	8.89

c. Ethics on the internet: The analysis of the survey showed that before the crisis, teachers mostly knew the types of ownership of digital products, but after the crisis they learned to use licenses of protected digital products with reference to the literature (Table 5).

Table 5 Ethics on the internet

Levels of digital competence: Ethics on the internet	Before the crisis		Immediately after a crisis		1 year after a crisis	
	Frequency	%	Frequency	%	Frequency	%
Basic: I know the types of ownership of digital products.	43	95.56	27	60.00	26	57.78
Medium: I use the license of protected digital products and cite data sources.	2	4.44	16	35.56	17	37.78
Advanced: I create an environment for myself and students where we can publish digital products protected by a license.	0	0.00	2	4.44	2	4.44

CONCLUSION

Based on the statistical data obtained from the analysis of the survey used for the purposes of the work, the following can be concluded:

- Teacher's computer skills of the Secondary Technical School of Architecture were satisfactory before the pandemic. After the pandemic, teachers showed a higher level of knowledge in handling hardware, software and the Internet.
- Before the pandemic, teachers used digital devices for entertainment purposes and spent significantly less time using them. After the pandemic, teachers used digital technologies for education and teaching most of the time.
- Teachers demonstrate higher levels of digital competencies related to Internet browsing, Internet safety, Internet ethics, protection and storage of data and devices, and health care after the crisis compared to the period before the crisis.

The teachers of the Secondary Technical School of Architecture have become digitally literate to a significant extent after the pandemic. However, it is necessary to work even more on professional development related to digital technologies and to increase the percentage of digital competences of teachers at an advanced level.

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ANALYSIS OF DATA ON FORESTS COLLECTED THROUGH REMOTE DETECTION AT THE TERRITORY OF THE REPUBLIC OF SRPSKA

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ABSTRACT

This paper presents data on forested areas at the territory of the Republic of Srpska, whose beneficiary is the Public Forest Enterprise „Sume Republike Srpske Forests of the Republic of Srpska „ JSC Sokolac using geographic information systems and data taken from the CORINE Land Cover program. The mentioned program shows the manner of forests and forest land utilization. Used data will be compared with the data recorded by the Public Enterprise within the cadastre, which are updated at the end of each fiscal year. By comparing the data taken from the CORINE program and the data recorded by the Public Enterprise, the accuracy of the data collected by the CORINE program will be determined.

Keywords: GIS, CORINE, Forests, analysis

INTRODUCTION

The paper analyzed data on forests and forested area taken from the CORINE Land Cover program as well as data from the cadastre of Public Forest Enterprise „ Sume Republike Srpske „ JSC Sokolac. The purpose of the analysis is to determine the accuracy of the data collected by satellite imagery by the European Environmental Protection Agency (EEA). Data on forests, i.e. polygons of deciduous, coniferous and mixed forests, which are displayed using geographic information systems, were taken from the mentioned program. Surface area measured in hectares was obtained using these data, and data on forested area

surface were then compared with data from the cadastre of the Public Enterprise in order to check its accuracy (Milanović and Filipović, 2017).

METHODOLOGY

For the purpose of this paper, data on forested areas at the territory whose beneficiary is the Public Forest Enterprise „Sume Republike Srpske" JSC Sokolac was analyzed as well as data taken from the CORINE Land Cover 2018 database which are available by the European Environmental Protection Agency (EEA). CORINE Land Cover maps the landscape pattern, while the data used were obtained by interpreting multispectral satellite images which are publicly available (Milanović, Valjarević and Lukić, 2020). The CORINE program includes five segments of collected data (Novaković, 2022):

- Artificial surfaces
- Agricultural areas
- Forests and semi-natural areas
- Wetlands
- Water bodies

This paper shall cover in detail the data from the segment "Forests and Semi-natural areas", i.e. class 300. Polygons with the codes: 311 deciduous forests, 312 coniferous forests and 313 mixed forests have been singled out. Also, all polygons that are located within the area whose beneficiary is a Public Forest Enterprise were emphasized. The above-mentioned polygons were lined out depending to which group of forestry-economic area each of them belongs and out of them the areas belonging to national parks, rainforests and plantations were excluded. In accordance to the previously collected data, the result was that the data regarding landscape areas were identical as the data recorded by the Public Forest Enterprise within the Cadastre.

DATA ANALYSIS

The cadastre of the Public Forest Enterprise is created for the entire surface area that includes forest-economic areas, and the data refer both to national and privately owned forests. All data in the Cadastre are presented in table by separate forest category:

- High forests with natural renewal - 1000
- High forests - degraded condition- 2000
- Forest crops - 3000
- Coppice forests - 4000
- Landscape suitable for reforestation and management - 5000
- Landscape unsuitable for reforestation and management – 6000

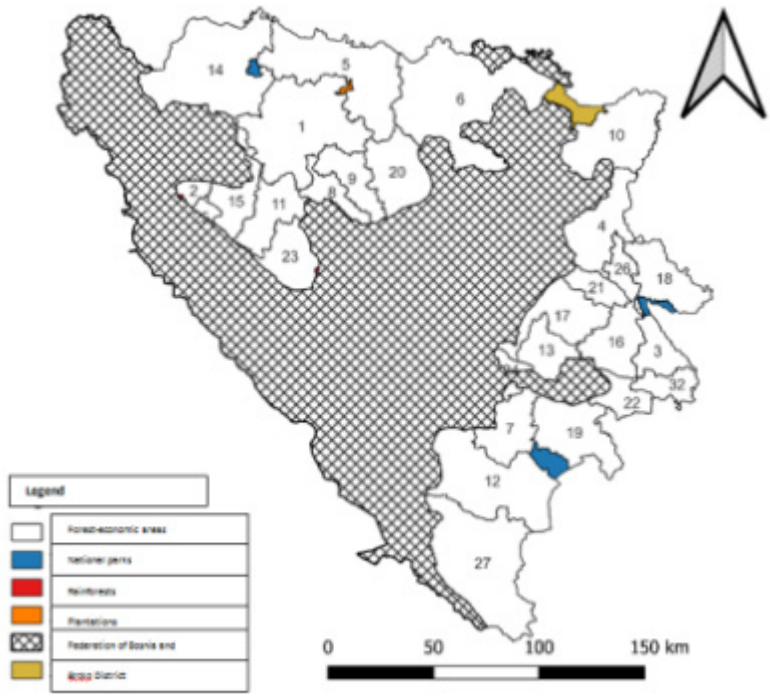

Figure 1 Forest-economic areas of Public Forest Enterprise „Sume Republike Srpske" JSC Sokolac

Due to the fact that the grouping of forest types was carried out in a different way by the CORINE program, this paper included the data from the Cadastre which were grouped in such a way that all areas of deciduous, coniferous and mixed forests were summed up together. This way, all gathered data were grouped according to the previously mentioned groups and presented in hectares. Data including surface area were recorded in the Cadastre of the Public Forest Enterprise, and

Geographic Information System (GIS) was used for collection of data regarding subject polygons from the CORINE program. Besides the tools for obtaining data regarding polygon surface area, GIS also enables a graphical representation of the distribution of forests and forest land within forest-economic areas.

As the last database available through the CORINE program was the 2018 edition, the data from Cadastre of Public Forest Enterprises from the year 2018 was also used during this analysis. In addition, data from the Cadastre of the Public Forest Enterprise until the year 2022 were included in the analysis, in order to gain insight into the condition of forested areas within forest-economic regions per year (Public Forest Enterprise „ Sume Republike Srpske „ JSC Sokolac, 2018-2022).

In accordance to data shown in Table 1, it can be seen that the CORINE program presented larger areas covered by forests than the identical areas recorded by the Public Forest Enterprise. According to the above, it can be concluded that the forested areas were approximately the same, and these data can be used for general analyses only and they cannot be used as accurate and precise data due to a deviation of 8%. When comparing the data by each year after the year 2018, it is evident from the Cadastre of the Public Forest Enterprise that there were no significant deviations in the areas recorded as forests, and also compared to the CORINE program, the ratio is approximate.

Table 1 Data overview of CORINE and cadastre of Public Forest Enterprise „ Sume Republike Srpske „ JSC Sokolac

Forest type	CORINE 2018	Public Forest Enterprise 2018	Public Forest Enterprise 2019	Public Forest Enterprise 2020	Public Forest Enterprise 2021	Public Forest Enterprise 2022
Deciduous forest	843600.42	542173.76	544332.73	544681.68	541854.05	539715.77
Coniferous forest	123852.95	85013.10	83991.98	82698.42	32944.66	81435.93
Mixed forest	183002.85	432705.89	434934.10	435268.58	484287.77	437958.40
Total	1150456.22	1059892.75	1063258.81	1062648.68	1059086.48	1059110.10
% CORINE		92,13%	92,42%	92,37%	92,06%	92,06%

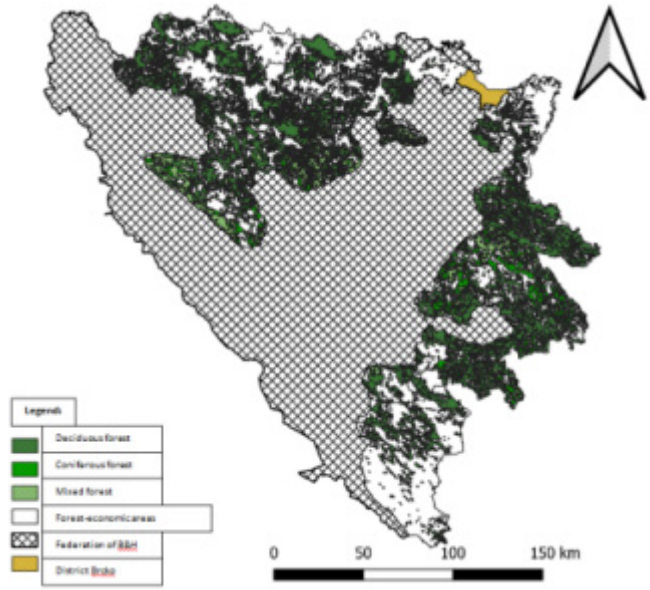

Figure 2 GIS representation of forest cover according to Forest-economic areas

CONCLUSION

In accordance to the analysis results, we can conclude that the difference between the data on forested surface areas which were collected using the CORINE program and the data from the Cadastre of Public Forest Enterprise „Sume Republike Srpske" JSC Sokolac was 8%. The area recorded using the CORINE program was 1,150,456.22 ha, while the records of the Public Forest Enterprise showed 1,059,892.72 ha of forested areas. Three groups of data were recorded regarding the mentioned areas by the CORINE program: deciduous forests, coniferous forests and mixed forests. The public company keeps records through six groups, i.e. forest categories: high forests with natural renewal – 1000, high forests - degraded condition- 2000, forest crops – 3000, coppice forests – 4000, landscape suitable for reforestation and management – 5000 and landscape unsuitable for reforestation and management – 6000. During the analysis, only data from the first four categories were used, and data were separately grouped for both the national and privately owned forests. The difference in data accuracy of 8% is due to insufficiently recorded data on privately owned forests, parks and other landscape areas which are not categorized as forests, which clearly indicates a large deviation from the real situation within the analyzed area. It is clear that the data from the CORINE program cannot be used as accurate and relevant

data. They can be used for student research work and graphic representation of forests and forested areas.

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POSSIBILITIES OF APPLICATION OF INNOVATIVE SUSTAINABLE TECHNOLOGIES USING THE ASPECT OF HOUSING COMFORT IN RESIDENTIAL BUILDINGS IN BELGRADE BUILT DURING THE 1970s

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ABSTRACT

About 40% of the total housing stock in Belgrade was built between the 1960s and 1980s. From today's aspect of construction sustainability, the rapid development of technology and the great need for apartment construction led to the fact that certain aspects of sustainable construction were not accomplished. Urban projects formed settlements that followed the traditional rules of sustainable construction, while respecting the well-known methods among designers of the time, which related to good lighting and airiness of residential spaces. However, thermal comfort was not taken much into account, therefore residential buildings from that time period are still large consumers of thermal energy. Modern innovative sustainable technologies and a new approach to the design of residential buildings enable practical solutions to this problem, but also the re-examination and application of all principles of sustainable construction. As we once did, we should again look into the world-wide examples that deal with such demands. Regarding the application of new sustainable technologies in favor of improving the comfort of existing buildings, it should be approached with careful and studious research, because the application of technologies in construction that were applicable and innovative around the 1970s are responsible for the current residential housing problems in terms of sustainability. It is necessary to consider the impact on the users, what are the advantages and disadvantages of new technologies and whether they provide an adequate solution for achieving comfort in existing residential buildings. The conclusions of this research will provide a basis for further research and implementation of sustainable technologies in the design and construction of future residential housing.

Keywords: innovative sustainable technologies, residential housing, users of residential housing, comfort condition-internal environment

INTRODUCTION

The focus in the traditional construction was about passive architecture that implies renewable energy sources, such as solar, geothermal energy and wind exploitation. With the arrival of new technologies, the term bio-architecture was born, which focuses on the functions of the building but also on its users. Therefore, it is not only important how to make the building as efficient as possible and that it last as long as possible with minimum investment and minimum costs, but the emphasis is again placed on the users of the space, on applying aspects of comfort in housing.

During the past few decades, the term sustainable architecture has mainly been understood as energy saving, but it includes much more than that. Therefore, the interpretation of sustainable architecture should be renewed and its basic characteristics should be recalled. The current interpretation needs to be broadened because the term sustainable architecture has a much wider application than most interpret. The traditional style of construction is a good teacher in this sense, because the experience gained in traditional construction dealt with overall comfort in housing with the aim of creating a healthy and pleasant residential space.

It is necessary to adjust the rules with reference to traditional construction. Acquired knowledge from traditional contruction should be applied in future buildings in order to be in the domain of sustainable architecture. When planning an urban site, it is necessary to observe the location as a whole and strive to build according to local conditions, but with the implementation of advanced knowledge and methods in construction.Bottom of Form

USING URBAN PLANNING TO GET TO SUSTAINABLE ARCHITECTURE

The first step in achieving sustainable architecture is the urban planning of a giving area. Each area planned for construction has individual conditions that should be taken into account.

Recent researches showed that there are three basic rules for the positioning of buildings that were applied in the traditional style of construction and those locations were built according to local conditions. These principles include:

„climatic-ecological, socio-cultural and socio-economic conditions"[2]. The application of these basic principles in the existing urbane spaces produced a safe space, comfortable for living and working, economically accessible, aesthetically pleasing and socially acceptable.

During urban planning, the first priority is the suitability of the terrain for residential space, that is, the orientation and position of the building in relation to the movement of the Sun, then in relation to the flow of the wind, as well as the architectural design of interiror and exterior of building.

Residential buildings with 3-4 floors proved to be the most convenient for living. Locations where the emphasis was on planning the city in width, are favorable for the development of the urban environment, rather than striving for the highest possible population density. By designing not very tall residential buildings, constant events were encouraged, also it is noticeable the existence of greater interaction among the population, the environment was more humane, adapted to people, and easy accessibility within walking distance.

Emilijan Josimović, who in 1860 wrote a series of instructions that were a trace of the traditional style of construction, had a great influence on the way residential buildings were later designed. That text gave instructions related to rational energy consumption, moisture protection measures, good lighting and ventilation, use of double windowing, selection of high-quality, local materials for construction, design of minimum room heights, and etc.

When the industrial (modular) construction began, the basics of urban planning were somewhat neglected. By using new materials and technologies in all locations intended for construction, the emphasis was placed on fast and economical construction. Gradually, locations and facilities began to resemble each other, in the desire to rationalize consumption and economic profitability.

ASPECTS FOR ACHIEVING SUSTAINABLE ARCHITECTURE

In the Law on housing and maintenance of buildings („Sl. glasnik RS", no. 104/2016 and 9/2020 - dr. law) comfortable housing is described as sustainable housing. The goal was to improve residential conditions, as well as to preserve and innovate the existing residential fund. Fulfillment of energy efficiency requirements, reduction of environmental impact and rational use of resources are important.

[2] Achenza M, 2016, p.167

Overall, comfort in housing means that everything is about how to make living and working comfortable, easy and healthy in the residential space.

According to current domestic regulations, there are several ways to achieve comfort in residential space. Thus, in the official and mandatory legal act – Rulebook of achieving energy efficiency („Sl. glasnik RS No. 61/2011) it is defined that there are four types of conditions for achieving residential comfort, which must be met in order for the building to be energy efficient. These are: thermal, air, light and sound comfort.

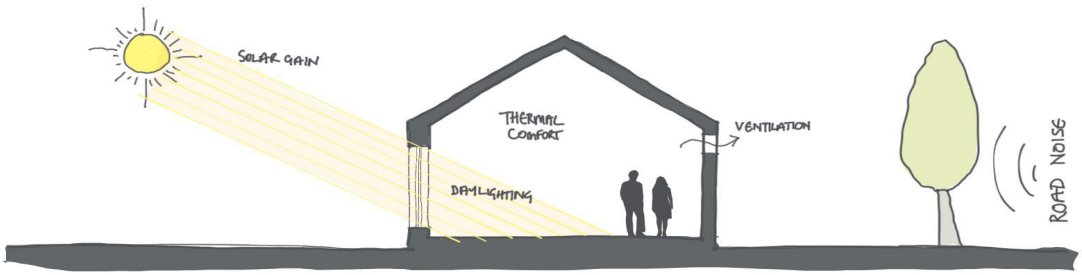

Figure 1 Graphic image of the application of four types of comfort in a residential building

Thermal comfort

Thermal comfort can be explained as personal feeling about the comfortable temperature when being inside a certain room. Since that feeling is individual, Rulebook of achieving energy efficiency from 2011 introduced specific parameters for determining thermal comfort, which are based on average, medium values. Those parameters are: „temperature, humidity and air flow in the room and radiation of the surrounding surfaces" [3].

The goal of introducing rules on how and how much a building should be protected, is to limit the excessive use of energy. With these limits buildings can be easily classified within thermal comfort norms. When making designs for buildings, it is very important to include natural characteristics of the terrain on which it is being built. Therefore, the first step is the application of all available architectural and construction specifications, such as the size and shape of the object, its orientation in relation to the movement of the Sun and in relation to the wind, than thermal zoning of the object, the choice of appropriate insulation layers and materials, the application of other elements on the facade that provide

[3] mr Đukanović Lj, 2015, p.126

protection against excessive heating in summer and cooling in winter, and etc. After the application of such rules when it comes to building design, next step would be use of artificial methods for heating or cooling the object, in accordance with the existing infrastructure of the location.

In our legal act, the thermal protection of buildings is mentioned for the first time in the Rulebook on minimum technical conditions for the construction of residential apartments ("SFRJ", 45/1967), where the maximum values of the heat transfer coefficient are defined in a few sentences. After that, as industrial construction takes off, legal acts become more and more detailed and strict.

Airflow comfort

Airflow comfort can be defined as a condition that must be met in order to ensure the necessary amount of fresh, quality air in the room.

In order to achieve the appropriate inflow of clean air and the expulsion of unhealthy, polluted air, during the design it is necessary to enable natural ventilation throughout the year, taking care at the same time not to affect other factors for the realization of comfortable housing.

High-quality ventilation of the building can be achieved through facade openings (doors and windows), ventilation ducts and infiltration through facade elements.

In domestic legal acts, air comfort, i.e. ventilation, was mentioned for the first time in the Rulebook on technical measures and conditions for ventilation in residential buildings from 1970. ("SFRJ", 35/70), and before that it was part of traditional construction.

On old domestic houses, you can often see small openings just below the roof plane or on the gable wall of the houses. These small fasade openings had the purpose of natural ventilation but also of maintaining the temperature inside the house. With the advent of the construction of multi-storey residential buildings, this element loses its importance, and different ventilation systems are used, modern technical solutions that act as a supplement to natural ones.

Figure 2 An example of a ventilation opening, above a window, on an old Vojvodina house

Visual comfort and lighting

In the Rulebook on Energy Efficiency of Buildings from 2011, visual comfort is defined as a minimum condition that should be met to enable a quality visual moment for achieving accurate and quick perception within the average human field of vision, with minimal eye strain. In doing so, the goal is to find a balance that should allow enough, but not too much, natural light indoors, for as long as possible during the day, and avoid the use of artificial lighting, in accordance with the room's purpose. Also, it is important to take into consideration the impact on the overall health benefits for the people who stay in closed rooms, where daylight has great advantages.

A well-designed use of daylight also affects rational consumption, that is it contributes to the system of sustainable architecture. Detailed procedures related to light restrictions are mentioned for the first time in the instructions written by Emilijan Josimović, from 1860, where he explained hot to design residential units so that they would be healthy. But these instructions were not mandatory. Since 2011, within the Rulebook on Energy Efficiency of Buildings, the concept of visual comfort and lighting has taken the form of a legal act and a binding character.

Acoustic comfort

Acoustic comfort represents an acceptable level of noise that does not disturb the daily activities of the people inside a residential apartment. It is necessary to satisfy the criterion that unwanted sounds coming from outside are

imperceptible and to establish a certain level of privacy which implies privacy protection, that is, that mutual activities cannot be heard from two different residential units.

The conditions for achieving acoustic comfort were first mentioned in the Rulebook on minimum technical conditions for the construction of apartments from 1967, very generally, as was the case with the conditions for thermal comfort.

A few years later, a separate rulebook was created that dealt with technical measures and conditions for achieving sound protection of buildings.

The turning point occurred during the 80s, when the first domestic standards in the field of building acoustics were formulated. Furthermore, the regulations in this area developed along with the new methods of constructing and the usage of new materials.

RESIDENTIAL BUILDINGS BUILT IN BELGRADE DURING THE 1970s

The development of construction technology and the use of new, innovative materials practiced during the 70s created ground for the formation and development of legal regulations. The conditions of comfort in housing were also part of these innovations, and were applied even when there were no official legal regulations. Those were mainly methods used in traditional construction. That proved to be insufficient considering the factors applied to create residential comfort that were in use before and after modern materials and modular construction.

During the 1970s, the largest percentage of residential units were built in Belgrade, which is a turning point in the domestic history of construction and the development of construction technology. However, legal acts that related to the standards and conditions for comfortable living were written immediately after construction, and were already applied to the next buildings. But there is still a large number of residential buildings built from the 70s, which are not covered by those more demanding construction standards and legal acts.

Applied methods of sustainable construction

In the 70s, when mpodular construction was at its peak and when it was necessary to build apartments for the incoming population in Belgrade as soon

as possible, there was no time for the construction industry to devote itself to residential comfort, but certain rules were not completely absent.

In order to limit energy consumption, the first legal acts that had the character of sustainable construction dealt with thermal and air comfort.

Legal acts were developed in the following decades, but there were no detailed considerations until the appearance of the first domestic standards in the 80s, when the concept of acoustic comfort was introduced. Domestic standards and regulations had a voluntary character, unless they were part of a secondary legal act (rulebook, regulation).

Since 2011, within the Rulebook on energy protection of buildings, visual comfort and lighting has been mentioned as a binding condition. After several decades since the construction of the mentioned residential buildings in Belgrade, it became clear that it is necessary to carry out certain reconstructions in order to improve energy consumption and provide better living comfort for the existing residential fund.

Possibilities of applying new methods to achieve sustainable architecture on existing buildings

The method of thermography provides insight into how unprotected a certain building is, that is, to what extent it is necessary to proceed with reconstruction in order to make it sustainable. This method deals only with the thermal aspect of sustainability, but it is useful because it provides accurate data on the occurrence of condensation in the building, leakage of the heating system and other installations, on the temperature variation between the structure and the facade.

One of the ways to reconstruct existing buildings, which would contribute to improving the sustainability of the building, is the application of new technologies and new building materials.

In Europe, a non-invasive method is applied related to the replacement of finishing materials with a new type of material containing phase-changing particles. This is in the experimental stage for now. Phase-changing materials have the ability to change their own structure, that is, to change from one aggregate state to another, phase-wise and in accordance with external conditions. This way of functioning of phase-changing materials enables the maintenance of a constant temperature.

As this method is still in the research phase, the question is how much it would contribute to the specific problem, how profitable it is, whether it is necessary to renew the installed materials more often, and whether it has been tested medicaly.

CONCLUSION

The difference between the use of the term sustainable architecture is noticable, because until recently, the focus has been on passive architecture, which includes renewable energy sources, such as solar, geothermal energy and wind exploitation. With the arrival of new technologies, the term bio-architecture arises, and again focuse is on the functionality of the building and comfort for its users. Therefore, it is no longer important just how to make the building as efficient as possible and that it last as long as possible with minimum investment and minimum costs, but rather about the users of the space and to meet the requirements of comfort in housing.

When it comes to urban planning, the space should be approached in such a way as to primarily aplly as many natural features as possible that help create sustainable architecture. The most efficient are settlements that have buildings with fewer floors, because it creates an opportunity for easier application of architectural and construction features to achieve sustainabilty. Residents of such a settlement are more active, they have more easily accessible facilities in their surroundings.

When designing residential units, it is necessary to harmonize all aspects of comfortable housing so that the residential units are healthy, pleasant and desirable for people to stay in. This is achieved by designing in accordance with the natural characteristics of the environment in which the object is located. And when that is not enough, artificial methods are applied.

Given that there is a large number of residential buildings in Belgrade built in a time frame when legal regulations on sustainable architecture were not as detailed as they are today, these buildings are now large consumers of energy. In order to change that situation, it is necessary to reconstruct them.

In order for the reconstruction of buildings to be sustainable, with all the features of comfort housing, it is necessary to look at tested and approved examples in Europe, follow their regulations and gradually apply them to the domestic market. Taught by experience from the 70s, new technologies in the production

of materials, the so-called bio-architecture, should be applied after surveying the impact and durability on reconstructed buildings in Europe.

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FIGURES

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BUSINESS MODELS IN THE CONDITIONS OF THE COVID-19 PANDEMIC

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ABSTRACT

Pandemic of the COVID-19 virus affected the existent business models all over the world and exhibited the degree of uncertainty affecting various business models. Numerous companies were forced to constantly change their business models, to adapt to times of crisis and provide a chance for existence and growth. Companies that chose, created, developed, and implemented business models based on digitalization and e business had significantly higher chances to survive. Digitalization of business proved to be the most effective tool in the fight against the negative impacts of the pandemic. Countless companies had to collaborate with external partners to innovate business models and survive. Many companies were forced to radically accelerate business model innovation processes to face the threats posed by COVID-19 and to prosper.

Keywords: Business models, innovations, Covid 19 pandemic.

INTRODUCTION

On December 18, 2019, the first case of a disease accompanied by atypical pneumonia was recorded in a patient from the city of Wuhan in the central Chinese province of Hubei. In January 2020, the new virus that caused a whole series of cases in China was named 2019-n CoV. The virus started to spread outside of China. On January 30, the World Health Organization (WHO) declared a Public Health Emergency of international importance in 19 countries. On February 11, the virus was named Sars-cov-2, while the disease it caused was named Covid-19. On March 11, the WHO declared a pandemic Covid-19 and the disease was registered in 114 countries and already caused 4,000 deaths (Duffin,

2022). Since then, humanity's battle has been going on with both the health and economic consequences of the pandemic.

The economic consequences of the COVID-19 pandemic were devastating and, above all, widespread (Cortes & Forsythe, 2023). Global economic growth fell by 4%, while world trade was tremendously shaken. There was an increase in deficits and debts, which inevitably led to a spiral of inflation (Martin, Sanchez & Wilkinson, 2023). Some business models have performed better during the pandemic, while others have undergone dramatic changes. The world simply had to adapt to the new circumstances.

MATERIALS AND METHODS

Covid-19 and business models in various sectors of human activity

In the market of American airlines in the conditions of the covid-19 pandemic, business models with financial and operational characteristics made a difference in terms of the immediate impact of the pandemic. Models that were based on lower costs and the lowest prices were incomparably more efficient than Full-Service Network Carrier (FSNC). Lean operations provide a significant advantage in a situation where externally caused lack of demand drastically reduces the possibilities for generation of income. This primarily refers to the costs intended to compensate for the structure and operating costs. Differences in business models became more pronounced during the crisis. In the pre-pandemic era, the rise in demand led companies to operating profitably and the differences that existed did not clearly indicate differences in the success of one model over another (Fontanet-Pérez, Vázquez, & Carou, 2022). COVID-19 has caused an unprecedented digital transformation by encouraging e-commerce and remote work. There are realistic expectations that despite the abatement of the pandemic, these trends will continue the tendency of growth, which will have an impressive impact on the way of conducting business and the resilience of businesses. Digital technologies enabled moving to radical rationalization and transformation of operational processes, thus encouraging growth through evidently improved access to the market itself and through the prism of improved employee motivation and productivity (Lashitew, 2023).

COVID-19 tasked organizations with looking for digital substitutes or to devising innovative ways of delivering their products and services with minimal

physical contact that would be considered safe for both the one who delivers and the one who receives the goods. Organizations were forced to be innovative in redesigning theirs products. They were also faced with the imperative of designing alternative digital products and services. They were forced to rethink the channels and methods of delivery of products and services and to strive to achieve strategic positions or new partners in an entirely new environment (Seetharaman, 2020). For example, the hospitality industry was the one of the hardest hit industries due to mass closures due to the global COVID-19 pandemic. Business Model Innovation (BMI) can be seen as a key solution for recovery and successful coping with the COVID-19 crisis. It was learned that BMI was applied during and after the crisis with the aim of creating innovative income streams and providing a higher level of liquidity (Breier et al., 2022). The gastronomy sector was among those particularly affected by the pandemic and the damage caused to the sector was reflected through the prism of loss of customers and regulatory uncertainty. When an established business under normal circumstances becomes unattainable, Business Model Innovation (BMI) is the one feasible solution to the potentially high level of uncertainty. Effectuation and causation are useful decision-making logics that can lead to BMI and help the organization survive under uncertain circumstances (Harms et al., 2021). Press & Brzeszczynski (2022) supported the view that when the performance of socially responsible investment SRI firms is investigated taking into account the domain of their specific business, a brokerage model based on matching buyers and sellers without taking ownership of the product has the potential to overshadow other models. COVID-19 also affected this kind of established model. At the same time, the companies that represent the Distributor's business model, that is, the companies that sell the products they bought and did not actually create. They did better in the conditions of the pandemic than before it. BM's affected by the COVID-19 crisis can provide an opportunity for new ways of thinking about risk exposure in different extreme scenarios.

RESULTS

Bilińska-Reformat & Dewalska-Opitek (2021) believed that e-commerce had a prominent role in modern retail, where it is special focus placed on an industry that requires dynamism in the supply. Digital businesses radically improved as a result of the pandemic, where many brands started their new lives online that accompanied companies using advanced IT technologies following the increased interest of producers and consumers in doing business online. As

virtual market entrance gained momentum, companies were forced to radically and urgently change their business models and to rely on omnichannel solutions. The study that was conducted, leads us to the conclusion that fast fashion as well as applicable retail chains must understand the growing expectations of customers regarding e-commerce solutions during the pandemic. In most cases, family companies are by their nature extremely resistant to the harmful consequences of the pandemic, since they are socially responsible and their stakeholders work consciously in their favor. Because of the strong ties families have in business, they have the ability to increase, to a considerable extent, human, financial, reputational, and relational capital that gives them the ability to survive in times of crisis. These companies have the ability to use their long-term orientation adapted to the needs of stakeholders and to outlast their non-family rivals. At the same time some of the worst lawbreakers during the pandemic were irresponsible family businesses that used abuse of secrecy and corrupt relations with the authorities to victimize the public during a pandemic (Breton-Miller & Miller, 2022).

In many countries, restrictions on mobility were introduced during the pandemic, and the situation escalated with the so-called lockdown regime. In response to the new situation, cities undertook appropriate management policies, but it should also be noted that private companies begun to provide innovative logistics services, and those that have proposed new business models for more efficient mobility stand out. Most business models focused on provisioning the security of its clients and directly in terms of business innovation from a management point of view. The biggest changes in business models were implemented within the car-sharing industry. From the safety point of view, during the pandemic, the biggest change was implemented in ride-sharing industry. It is interesting that the smallest number of changes regarding the model was carried out within the framework of bike-sharing sector (Turoń & Kubik, 2021).

The COVID-19 pandemic was more than a big challenge for micro, small, and medium enterprises in all branches of industry. Companies from the field of culture and creative industries were particularly affected. In order to survive in the challenging time of the pandemic, they were forced to propose redesigned business models that would bring new added value. Open innovation on the business model due to the availability of the network plays a primary role with the aim of understanding how adjustments of cultural and creative industries function. The solution is that politicians and decision makers, above all, should support closeness between innovation entities (Peñarroya-Farell & Miralles, 2022). It was observed that e-commerce in accordance with the accepted om-

nichannel strategy provides the company with the opportunity to operate more than efficiently in times of a pandemic. In such a situation, it will certainly not be missing positive financial results (Bilińska-Reformat & Dewalska-Opitek 2021).

DISCUSSION

Under great pressure from the reality of the world we live in, business models have changed their work format and approach depending on the „innovation" factor. Proactive use of the Internet positively supports companies to offer their products or services to a wider market with incomparably lower transaction costs and significantly reduced investments to reach new customers. In the world of business success, those companies that make abundant use of their innovative abilities and thus achieve better financial results are certainly leading the way. Seen through the prism of financial performance, management style, as well as a flexible business model should contribute to the „diffusion of innovations". This provides an opportunity for businesses to establish their position in the market and to more clearly define their goals so that they can position themselves where they want to be (Vangjel, 2021). As a rule, recovery in the conditions of a pandemic is more difficult for small businesses, which are largely exposed to the problems they encounter in the supply chain (Chang et al., 2022).

Based on the analysis of the literature in the field of business models, Montemari & Gatti (2022) intended to support companies in the construction of resistant and original BM's based on continuity innovation. This approach is gaining weightiness in very dynamic and unpredictable circumstances, such as the one that characterizes the COVID-19 pandemic. Based on the combination of the Canvas business model, BM measurements, BM pivots, and BM configurations, the authors of this study wanted to provide a structured approach to defining the main BM features, to proactively assess the impact of new scenarios on the BM, to carefully and in detail identify the areas that require innovation and, based on all of the above, to choose the correct position regarding the course of action for adapting BM to new scenarios in the future, especially in conditions similar to the COVID-19 pandemic.

Li (2022) showed in his study that during the COVID-19 pandemic, the fashion industry faced with a pronounced problem of supply and demand, having limited management tools available at the mentioned moment. The state of emergency caused by the pandemic led to fundamental changes in both the functioning of the economy and society as a whole. He is the author who developed a framework for approaching the assessment of a new business model aimed

at sustainability and transparency in terms of economic efficiency indicators. Jabeen et al. (2023) reached the following conclusions during their research. First, their research implied how the COVID-19 pandemic caused traditional SME's to reassess their value creation, configuration and mechanisms, thereby contributing innovations of the traditional business model. Consequently, during challenging times, such as the COVID-19 pandemic, smaller firms have higher bankruptcy rate compared to their counterparts. That's why it's important for these companies to collaborate with external partners to innovate business models and survive. Companies are forced to radically accelerate business model innovation process to face the threats posed by COVID-19. The authors supported an attitude that emphasizes viewing open innovation as a continuous process that needs to be managed through decisions concerning open innovation practices, acquiring knowledge, pushing boundaries activities and choice of partners. Press & Brzeszczynski (2022) demonstrated in their study that the dramatic change in social patterns greatly affects BM in considerably different ways. BM under the influence of the COVID-19 crisis can point to new ways of thinking regarding risk exposure in numerous and above all different extreme situations. The BM perspective by its very nature represents a completely new strategic approach to investment analysis that affects the perception of the game among BM's as well as performance and risks in the BM and management literature. Furthermore, gaining insight into the relationship between BM and inventory performance provides incentives for managers to sense selection that BM will develop from the point of view of financial performance and resilience. Strategic decisions can contribute to the development of those aspects of business that focus on the differences between brokers and distributors in these business models.

CONCLUSION

The aforementioned studies regarding the position and role of business models in the conditions of the COVID-19 pandemic clearly indicate the degree of uncertainty brought about by the pandemic, which killed more than 6 million people globally to date. We can rightfully create a paradigm that business systems are always there, they just constantly change their appearance, adapt to times of crisis and provide companies with a chance for survival and development. This is neither the first nor the last pandemic to hit humanity. What has brought salvation to humanity and recovery to the economy is the ability to adapt to new circumstances. Digitalization of business proved to be the most effective tool in the fight against the negative impacts of the pandemic. Pandemics do not

exist in the virtual world. That door is closed until there is the last networked company and the last client.

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METHODOLOGY OF RESEARCHING SMART CITIES AND SMART PEOPLE - A REVIEW

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ABSTRACT

Scientific and professional research of smart cities has been on the rise in recent years. The research is followed by the application of the concept in the development of various cities around the world. However, the research is accompanied by disagreements about the definition of the concept, the exact and precise dimensions of the smart city, as well as the way of researching smart cities. Particularly, research is not sufficient when it comes to people as a key element of a smart city. This paper has studied the scientific research methods of smart people and smart people that are currently most used in published research. The most frequently used methods, in addition to literature research, are: SWOT analysis, and SWOT analysis in combination with MCDM.

Keywords: Smart City, smart people, research methodology.

INTRODUCTION

Academic research into the smart city concept has gained momentum in recent years in various scientific communities and are present in Q1 scientific journals. This concept is gaining significance in professional research and practical implementation in cities all over the world. However, there is a lot of disagreement in scientific research, starting with the very dimensions of the smart city. One of the dimensions of a smart city that is particularly important and less often researched is the so-called smart people, i.e. people who contribute to smart cities in every sense (as creators, as users, as stakeholders). This paper will

investigate which methods are most often used in the scientific research of the smart city and smart people.

MATERIALS AND METHODS

Smart City Concept

There are numerous definitions that attempt to fully define the term *smart city*. All of them have a different perspective on the existence of a smart city (Marek, Campbell and Bui, 2017). There are two basic approaches to the problem. One is essentially techno-centric while the other is human-centric. The technology-centric approach includes terms such as Big Data, cloud computing, AI, robotics, virtual reality (VR), 3D printing, satellite communication and navigation, etc. The human-centric approach incorporates terms such as community education, learning, online education, smart healthcare, industrial poverty alleviation, etc. (Hu, Wang and Zhai, 2023). In fact, the mentioned two domains can be materialized in the form of hard and soft domains. Hard domains incorporate buildings, water and waste management, mobility, energy networks, etc. Soft domains are primarily those where the application of ICT technology is not considered crucial and they include education, culture, government, etc. (Albino, Berardi and Dangelico, 2015). Perhaps the most appropriate and comprehensive definition of a smart (and sustainable) city is embodied in the one proposed by The International Telecommunication Union (ITU): "A smart sustainable city is an innovative city that uses information and communication technologies (ICTs) and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social and environmental aspects" (ITU, 2014).

Dimensions of smart city

In addition to the countless differences expressed regarding the definition of a smart city, there is also an ongoing disagreement on the number of dimensions that make up a smart city. Both origins have an impact on the methodology and approach to the study of smart cities. Giffinger et al. (2007) proposed a model according to which a smart city incorporates six basic characteristics, i.e. dimensions: Smart Economy, Smart People, Smart Governance, Smart Mobility, Smart Environment and Smart Living. Camboim, Zawislak and Pufal (2019) in their research outlined four dimensions of a smart city: City governance, Environ-ur-

ban configuration, Socio-institutional structure and Techno-economics dynamics. In their analysis, Deloitte singled out 6 key initiatives within the smart city: economy, mobility, security, education, living, and environment (Deloitte, 2018). Bibri and Krogstie (2017) analyzing enabling technologies of ICT proposed 11 domains of a smart city: Smart transport/mobility, Smart energy, Smart traffic, Smart planning, Smart environment, Smart buildings, Smart healthcare, Smart education, Smart grid, Smart safety and Smart design.

RESULTS

In their study of smart cities Yigitcanlar et al. (2019) relied on conceptual explorations and empirical case investigations. In this way, they gained an insight into whether cities can be considered smart cities without being sustainable. To address business modeling to smart cities Schiavone, Paolone and Mancini (2019) use integrative literature review to identify the most important drivers of *smartization*. In analyzing how a smart city deals with imperfect information, Abdel-Basset and Mohamed (2018) applied the concepts of *neutrosophic* and rough set theory. In an effort to analyze the use of Big Data within smart cities, Lim, Kim and Maglio (2018) used multi-case analysis with the aim of analyzing a reference model for data use, while the action research method was used to identify different challenges regarding the use of Big Data within smart cities.

In an attempt to delve deeper into the effects that a smart city has on the peri-urban parts of the city de Falco, Angelidou and Addie (2018) successfully applied a SWOT analysis. Kasinathan et al. (2022) used SWOT analysis to evaluate the proposed approach regarding the sustainable development of urban areas. Urdabayev and Utkelbay (2021) used SWOT to analyze smart city projects in Moscow, Nur-Sultan and Almaty. SWOT analyses took into account the following characteristics of a smart city: innovation, maintenance of improved living environment, efficient resource management of technological solution, and delivery of high-quality services. SWOT analysis can also be used to examine the readiness of adoption of smart services in cities.

Vershitsky et al. (2021) applied the aforementioned approach to cities within the Russian Federation. Calzada (2023) dealt with rural development programs with the aim of creating smart rural communities. The SWOT method was used in the research in order to arrive at a solution regarding the applicability of the most effective strategy. Gotlib et al. (2019) in their research focused on the possibilities of applying SWOT analysis for the purpose of transforming the city of Warsaw into a smart city. The SWOT analysis proved to be a very suitable

method for choosing a strategy for the application of smart services in the event of a pandemic, as was the case with the Covid-19 pandemic. It was shown that smart services contribute to greater resilience and the provision of better quality health services (Rohmah, Rachmawati & Mei, 2023).

DISCUSSION

The research of smart tourist destinations has been gaining more importance in recent years. Vardopoulos et al. (2023) showed with the help of a SWOT analysis on the example of the four cities Amsterdam, Barcelona, Seoul, and Stockholm, in which direction the government should move with the aim of improving smart services both for the local population and for tourists visiting the mentioned destinations. Motevalli and Seyedian (2022) dealt with the implementation of smart houses with a special focus on infrastructure and on that occasion they used a SWOT analysis to analyze the environment within four aspects that include urban infrastructures, domestic appliances and equipment, urban residents' attitude, and urban management and government policies. Jelenski et al. (2020) focused in their research on renewable energy sources (RES) with the aim of reducing air pollution applicable to the city of Krakow in Poland. For this purpose, a SWOT analysis was used to identify the full potential of renewable energy sources

In some cases, the proposed frameworks tested through SWOT analysis required additional quantification, and multi-criteria decision-making methods or other methods were used for this purpose. Pazzini et al. (2023) dealt with the problem of urban regeneration that specifically concerns Rimini Canal Port in Italy. SWOT analysis was used in combination with the ANP-BOCR method in order to get a clearer picture regarding possible scenarios. Batmetan and Kainde (2022) selected an approach where SWOT analysis was combined with the McFarland Strategic Grid model. A SWOT analysis was conducted to define the appropriate strategy for each of the dimensions of a smart city: SWOT smart governance, SWOT smart economy, SWOT smart branding, SWOT smart living, SWOT smart society, SWOT smart environment. The prioritization of the defined strategies for the smart city was then carried out using McFarland Strategic Grid analysis. Prioritization through McFarland Strategic Grid analysis was carried out taking into account the proposed strategies for each of the six dimensions of the smart city. Demircan and Yetilmezsoy (2023) used fuzzy multi-criteria decision-making (MCDM) methods, more precisely hybrid fuzzy AHP-TOPSIS approach with the aim of implementing long-term smart sustainable waste management strategies in the context of applying smart city tech-

nologies. Radziejowska and Sobotka (2021) used a combination of SWOT and DEMATEL methods, where SWOT analysis was used to analyze the factors characterizing smart sustainable buildings, while through the DEMATEL method establish relationships between the mentioned factors are observed through the prism of the social aspect of smart cities. Lyu et al. (2023) dealt with the application of multi-criteria decision making (MCDM) methods for the purpose of flood risk assessment of the metro system. The authors of the research came to the conclusion that MCDM in combination with the GIS method can serve as a useful tool for the purpose of creating a flood risk assessment model.

In addition to researching overall smart city dimensions, people as a key factor of smart cities are starting to be significant topic for research. Rijavec, Marsetič and Strnad (2023) in their research dealt with a sustainable transport system with the aim of creating an optimal traffic management system (TMS). In the aforementioned research, the TMS scenario is based on SWOT analysis and human resource management. Amiruddin et al. (2021) studied how smart people can contribute to the development of a more attractive tourist offer. A SWOT analysis was used to see which factors influence the creation of smart people who contribute to the tourism offer. Alternative strategies were then defined through TOWS analysis. In their study, Kim, Lee and Kim (2023) dealt with the possibilities of better utilization of the infrastructure of a student campus through the prism of sustainable development of the University and communities. Infrastructure is viewed as a trinity of space, equipment, and human resources. SWOT analysis was used to look at appropriate indicators, while TOWS analysis was used to define appropriate alternative strategies. Li et al. (2023) used the SWOT-AHP-TOWS approach to adopt the best strategy with the aim of improving citizens' sense of well-being in Smart Cities. In his empirical study, Nilssen (2019) claims that technology, human resources and governance occupy a very prominent place in the context of smart urban development.

CONCLUSION

Academic research of smart city concept is gaining momentum and it can be expected that with the implementation of various smart cities undertakings, it is going to be central issue of many academics in social, technical, and environmental sciences. The meticulous and specific dimensions of the smart city is an ongoing process, with the expectation that the research of smart people is going to be more interesting in the following years. Currently, the most of the literature is researching dimensions of smart cities using SWOT analysis s or the combination of SWOT analysis with MCDM.

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CAUSES AND CONSEQUENCES OF SHADOW ECONOMY IN SERBIA

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ABSTRACT

Shadow economy produces numerous, diverse and often very deep and negative consequences for the economy and society. It is a global phenomenon, as it is present in both highly developed countries and developing and transition countries. Key consequences of the shadow economy are unfair competition to the healthy economy, reduced budget revenues and increased fiscal deficits, decreased investments and consequently, the overall economic growth of a country. Since 2015, the Republic of Serbia has begun a systematic fight against the shadow economy by adopting national programs and action plans to combat it, as well as legal regulations adapted to modern economic environment demands, such as the Law on Fiscalization and Electronic Invoicing, software for lump-sum taxation, interconnectivity of key state institutions, etc. Only by planning and implementing systemic solutions can the long-term reduction of the shadow economy and its negative consequences be influenced.

Key words: shadow economy, tax evasion, tax administration, factors of the shadow economy

Introduction

Shadow economy represents a societal challenge, which by its nature is extremely complex and multidimensional. The consequences of the shadow economy are numerous, with the most significant ones being unfair competition, diminished trust in the institutions of the system, slowing economic growth, reduced efficiency in the collection of public revenues, and consequently, a lower quality of public services provided by the state to the economy and citizens. Therefore, addressing this societal challenge requires the use of active and systemic measures of a large number of public policies and their coordinated action.

In 2015, the Government of the Republic of Serbia initiated a systematic fight against the shadow economy by adopting the first National Program for Combating the Shadow Economy, followed by an identical program for the period 2019-2020, and a program for the period 2022-2025 is being prepared. The causes of the shadow economy are numerous, ranging from economic, regulatory, and administrative to political and social factors. In addition to penal policy and the efficiency of the tax administration in detecting tax evasion, as well as changes in the level and structure of tax rates, it is essential to raise awareness among citizens and businesses about the importance of combating the shadow economy.

FACTORS CAUSING THE EMERGENCE AND SPREAD OF THE SHADOW ECONOMY

Shadow economy represents a complex phenomenon that has a negative impact on numerous areas in society, manifesting itself in the form of tax evasion, unreported employment, disregard for intellectual property rights, unfair market competition, etc. Successful containment of the shadow economy can be achieved by planning and implementing public policy measures, through public policy documents, in areas such as the tax system, judiciary and legal system, public administration, employment, and social protection, as well as in construction, transportation, agriculture, and other sectors.

However, in order to establish a comprehensive and coordinated approach to combating the shadow economy, it is necessary to adopt a unified public policy document of an intersectoral nature, which will contain clearly defined and harmonized measures, along with indicators based on which their impact will be measured during implementation in all relevant areas.

Combating the shadow economy depends on legal solutions and the application of numerous regulations from different areas, including regulations governing the establishment and operation of economic entities, labor relations, inspection supervision, tax system, etc. Of particular importance in this area is the implementation of regulations contained in the Law on Inspection Supervision, Law on Tax Procedure and Tax Administration, Law on Payment Operations, Law on Payment Services, Law on Interbank Fees and Special Rules of Business for Payment Transactions Based on Payment Cards, Law on Electronic Invoicing, Law on Business Companies, Law on Registration Procedure in the Business Registers Agency, and other legislative and sub-legislative acts that, among other things, deal with this matter.

Shadow economy represents a multidimensional phenomenon that inevitably accompanies and exists alongside the formal economy in every country in the world. Despite its ubiquitous and inevitable presence, its scope and structure vary significantly - from relatively benign to distinctly negative, large, and damaging forms present in individual economies. Its expansion and worsening structure undoubtedly indicate deep, structural challenges in an economy.

The growing needs of the state for financing the fiscal deficit can lead to an increase in the fiscal burden on citizens and the economy, which results in further expansion of the fiscal deficit. This can also lead to a weakening of both the quantity and quality of public services, and consequently, lower economic growth rates. In this way, a negative spiral is formed, where gross domestic product and formal employment continuously decrease, and resources are inefficiently allocated.

As this is a complex phenomenon, there is a wide range of definitions in the literature that describe the shadow economy. Some definitions focus on concealing the scope of economic production (Gerxhani, 2004), while others concentrate on hiding the extent of employment (Hussmanns, 2004; Perry, 2007). Smith (1994) defines it as the market value of goods and services, both legal and illegal, which are not detected and recorded during the official estimation of GDP. Del'Anno (2003) considers it to be economic activities and the income derived from them, which bypass state regulation, collection, and recording.

One of the more comprehensive definitions is the one offered by Schneider et al (2010), who believe that: „The shadow economy represents the sum of all market and legal production and service activities that are deliberately concealed from state authorities for one or more reasons: to avoid paying income tax, value-added tax, or taxes based on other grounds; to avoid certain requirements arising from labor legislation; and to avoid certain administrative procedures."

Economic activities that are legally permitted but take place outside registered flows, i.e., are not included in the calculation of gross domestic product, and are therefore not regulated and taxed by the state, constitute the shadow economy (Arsić, Ranđelović, 2017).

Shadow economy - in its broadest theoretical scope - includes all unregistered income from the production of legal goods and services, whether resulting from monetary or non-monetary transactions. As such, it encompasses all productive and legal economic activities that would generate tax revenues if they were properly and fully reported to state authorities.

The scope and structure of the shadow economy are influenced by a large number of factors, and according to Schneider et al (2010), the following determinants of the shadow economy should be considered: an increase in tax and contribution burdens; the quality of state institutions; fiscal transfers; specific regulations in the field of labor legislation; the quality and availability of public services; and tax morale.

In their research, Arsić et al (2014) state that factors of the shadow economy include: the size of the tax burden, fiscal labor burden, social security system, efficiency of the Tax Administration in collecting taxes, penalties for tax evasion, probability of sanctions imposition, structure of the tax system, complexity of the tax system, compliance costs with tax obligations, and labor market-related institutions.

Sarac and Basar (2014) point out the following factors as causes of the shadow economy:

1. Economic causes - unfair income distribution, inflation, unemployment
2. Fiscal causes - high tax rates, oversight failures
3. Regulatory causes - complexity of the legal framework, frequent changes in regulations
4. Administrative causes - organization and technical structure of the Tax Administration and other supervisory authorities
5. Social causes - tax morale, behavioral patterns of taxpayers' behavior, historical context
6. Political causes.

As a result, the shadow economy produces numerous, diverse, and often very profound and negative consequences for the economy and society. Unfair competition caused by entities operating in the shadow economy leads to the closure of businesses that comply with regulations or their transition to the shadow economy, layoffs, and reduced investments.

Lower budget revenues reduce the quality of public services such as education, health care, security, social protection, utilities, etc. On the other hand, the rights of employed persons, safety, and health are jeopardized (lack of contributions to pension and disability insurance, health insurance, and unemployment insurance, insurance in case of work injuries for students engaged through student or youth cooperatives), and the quality and health safety of products are at risk.

The shadow economy is thus an obstacle to the development of businesses, and consequently to new investments and economic growth, and ultimately to building a better quality of life for every individual. Although it represents a „safety net" for many individuals and households in Serbia, it means much more than just uncollected taxes, as it leads to job losses, business closures, smaller budgets for healthcare, education, culture, social benefits, and all other services provided by the state to citizens, which are financed through taxes.

According to the neoclassical model of tax evasion, states have three instruments at their disposal to directly influence the level of tax evasion - penal policy, the efficiency of the tax administration in detecting tax evasion, and changes in the amount and structure of tax rates (Arsić, Ranđelović, 2017).

MEASURES FOR SUPPRESSION AND REDUCTION OF THE SHADOW ECONOMY

In 2015, the Government of the Republic of Serbia launched a systematic fight against the shadow economy by adopting the first National Program for Combating the Shadow Economy, which over a five-year period contributed to a 3.1 percentage point reduction in informal employment and positive overall shifts in reducing the shadow economy. Namely, a survey on citizens' attitudes conducted at the beginning of 2020 showed that more than ¾ of respondents (significantly more than in previous studies) believe that the shadow economy is not justified, while slightly more than half believe that the scope of the shadow economy has decreased.

Since the expiration of the previous National Program for Combating the Shadow Economy, the volume, structure, and forms of the shadow economy have somewhat changed, which imposes the need for a new Program for Combating the Shadow Economy, with a planned duration from 2022 to 2025. A survey conducted to examine the attitudes of businesses about the impact of the crisis on their operations showed that the majority of respondents think that every fifth economic entity in their sector is unregistered, then that 10% to 30% of turnover is untaxed, and that taxes and contributions on wages are not paid for all employed persons (National Program for Combating the Shadow Economy 2022-2025, proposal).

Within the National Program 2019-2020, five specific goals were defined (National Program 2019-2020):

1. More efficient control over the flows of the shadow economy,

2. Improvement of the Tax Administration's work for more efficient tax assessment and better tax collection,
3. Incentive measures for fair competition, legal entrepreneurship, and employment,
4. Reducing administrative and parafiscal burdens,
5. Raising awareness of citizens and businesses about the importance of combating the shadow economy.

The feasibility of specific measures largely depends on the capacity of the state administration to implement the necessary activities for their successful application in practice. One group of measures is related to another group, and often the implementation of one measure is a prerequisite for the successful implementation of another measure. The direct impact of individual measures to combat the shadow economy is measurable through financial indicators, i.e., the effects on public revenues and expenditures. Measures also contribute to reducing the operating costs of companies and increasing their competitiveness in the market.

Shadow economy is contributed to by tax burdens as well as complicated procedures for completing and submitting tax returns and other documentation. Therefore, the role of the Tax Administration in combating the shadow economy is crucial and goes far beyond controlling the implementation of regulations. Therefore, it is necessary, on the one hand, to reduce the administrative burden on the Tax Administration wherever possible, and on the other hand, to enable the further strengthening of administrative, technical-technological, and other capacities to improve its efficiency.

Within the previous National Program, in December 2020, the Law on Fiscalization was adopted („Official Gazette of the Republic of Serbia", No. 153/2020), which created the conditions for the introduction and transition to a new fiscalization system, in which it will be possible to monitor turnover in real-time. With the amendment and supplement to the Law („Official Gazette of the Republic of Serbia", No. 96/2021), a transitional period was introduced from November 1, 2021, to April 30, 2022, during which taxpayers will be obliged to switch to the new method of fiscalization. By adopting the Decree on determining activities in which there is no obligation to record retail turnover through an electronic fiscal device („Official Gazette of the Republic of Serbia", No. 32/2021), it is estimated that the number of newly covered taxpayers for fiscalization is about 100,000, of which over half are entrepreneurs. To assess the effect

of the new fiscalization on small and micro-enterprises, an ex-post analysis is also planned.

At the beginning of 2021, the Law on Electronic Invoicing was adopted („Official Gazette of the Republic of Serbia", No. 44/2021), whose application begins on May 1, 2022. This created the legal conditions for the transition to an electronic system of issuing and sending invoices, so a special measure will be dedicated to the implementation of this system. Training is planned for public sector entities, private sector entities, and the establishment of an automated communication system within the Contact Center for electronic invoicing. Also, the expansion of the scope of this system to sectors and areas not currently covered by the Law on Electronic Invoicing is planned.

There is a need for strengthening the IT sector and the analytical capacities of the Tax Administration in collecting and processing data relevant for more efficient implementation of inspection supervision, alongside enhancing the advisory function. This implies, among other things, establishing a minimum standard for data exchange with other registries (Central Registry of Mandatory Social Insurance, National Bank of Serbia, Business Registers Agency, Ministry of Internal Affairs, Cadastre) to ensure data usability within the Tax Administration, as well as strengthening the Risk Management Unit within the Tax Administration.

Although the previous National Program enabled consolidated tax collection for certain groups of taxpayers, the same option remains to be introduced for entrepreneurs. To explore the possibilities for implementing consolidated collection for this group of taxpayers, an analysis for introducing a single payment account for entrepreneurs is planned, along with the implementation of recommendations from the analysis.

Calculating tax liabilities poses a significant burden on tax inspectors, citizens, and the economy. By simplifying the calculation of tax liabilities, such as property tax, and analyzing the justification/purposefulness and manner of calculating tax reliefs, and possibly reducing the number of exemptions and reliefs that burden the work of tax authorities, greater predictability for citizens and the economy would be created, while relieving the administrative workload for employees in the Tax Administration.

In the previous period, the delivery of tax decisions to entrepreneurs in electronic form was enabled, and software for lump-sum taxation - the „Lump-sum Calculator" - was developed and put into use. This significantly reduced the administrative burden and increased business predictability for more than

110,000 lump-sum entrepreneurs. On the other hand, for issuing certificates of paid taxes at the republic and local levels, citizens and the economy still visit multiple counters, both in the branches of the Tax Administration and in local tax administrations. To further alleviate the burden on not only entrepreneurs but also other businessmen and citizens, it is necessary to ensure that a certificate of paid taxes is obtained at one place, both at the republic and local levels, and to enable instant tax payments and payments by credit cards.

Significant positive changes for combating the shadow economy since 2015 include (National Program 2019-20):

1. The business environment has improved as the economy of the Republic of Serbia has recorded continuous growth in recent years, a significant enhancement compared to the conditions when the first National Program was adopted. Simultaneously, the international economic climate has improved, further stimulating economic growth in Serbia, and the administrative burden of regulatory compliance has decreased, making business operations in the legal zone more affordable and profitable.
2. State capacities for monitoring shadow economy flows have been enhanced.
3. Public attitudes towards the shadow economy have improved, as the degree of justification for the shadow economy among the public has noticeably decreased.

Conclusion

Share of the shadow economy in developing countries is very high, with numerous causes ranging from heavy tax burdens, low tax culture, inefficient inspection oversight, high unemployment, and poverty, among others. The consequences of such a high share of the shadow economy include reduced budget revenues, unfair competition, poor quality of public services, compromised safety and health at work, violations of labor rights, and more. By adopting national programs for combating the shadow economy, the Republic of Serbia aims to reduce its share in the total gross domestic product and thus enable growth and increase competitiveness of the healthy economy.

Combating the shadow economy represents a key step in establishing a predictable and stable business environment and an equitable market competition, requiring coordinated efforts of public administration and market participants. Repressive measures yield short-term results and are insufficient. Only by planning and implementing systemic solutions can the long-term reduction of the

shadow economy and its consequences be influenced. To achieve these goals, appropriate preconditions exist as the business environment has improved, state capacities for monitoring shadow economy flows have been enhanced, and public attitudes towards the shadow economy have improved in the sense that the degree of justification for the shadow economy among the public has noticeably decreased.

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ECONOMIC SYSTEMS IN THE GLOBAL ECONOMY

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ABSTRACT

In the modern world, the predominant economic systems are those based on an open economy, implying a high level of rule of law, low corruption, export competitiveness, and acceptance of foreign investments and technology. Despite occasional global economic crises, these systems find ways to overcome the problems brought by crises and successfully return to their established development strategies. Contemporary practice has confirmed that market laws are a dominant factor of development, but the state also plays a crucial economic role. This is particularly evident after global financial crises and other worldwide disruptions that impact the global economy, like the COVID pandemic and so forth. Developing countries strive to establish market institutions and economic environments that will enable them to boost competitiveness and participate equitably in the open global market.

Key words: economic system, globalization, development strategies, market

INTRODUCTION

Economic systems burdened by corruption and a low level of rule of law achieve weak economic results and lag in their development compared to developed nations worldwide. Poor economic institutions hinder economic performance, while strong ones stimulate it, leading countries to face the need to transition from weak to strong economic institutions. Economic outcomes, gauged on criteria such as economic growth, living standards, employment, and other metrics, demonstrate the economy's effectiveness. These outcomes are also influenced by other factors, such as environmental conditions, economic policies, etc. The aim of economic policy is economic stability, which implies the absence of significant growth rate fluctuations, maintaining relatively low unemployment

rates, and avoiding high inflation rates. Economic instability differently affects individual population segments, and cyclical instability slows GDP growth. The long-term sustainability of an economic system is the dominant test of its success.

In the contemporary era, we can distinguish three models of capitalism, namely the Anglo-Saxon model, the European model, and the Asian model. The key questions concerning their differences lie in ownership structure, particularly in corporations, the way they are managed, the methods of capital collection, labor market functioning, the role of the state in the economy, income distribution and redistribution, the legal system, and economic institutions. Through the process of globalization, the world's economies are connected via the expansion of trade in goods, services, and capital. Thanks to technological advancements enabled by the revolution in the fields of information, telecommunications, and transport, some countries have achieved remarkable economic growth, especially export-oriented economies open for international trade and finance. The dominant developmental characteristic of the world economy in contemporary conditions is represented by globalization strategies and open economies, as well as a business environment attractive for the inflow of foreign capital.

ECONOMIC SYSTEMS AND THEIR EFFICIENCY

Economic systems are multidimensional by nature. According to Lindbeck (1977), an economic system is a set of institutions required for decision-making and implementing decisions concerning production, income, and consumption within a given geographic territory. In line with this understanding, an economic system, among other things, consists of mechanisms, conventions, organizational arrangements, customs, and decision-making rules. Each dimension of an economic system can vary, particularly its structure, functioning, and adaptability over time. This includes all institutions, organizations, laws and rules, traditions, beliefs, attitudes, values, and resultant behavioral patterns that directly or indirectly influence economic behavior and outcomes.

An economic system is defined by its institutions, which encompass numerous elements – the legal system, business organization, customs, conventions, norms, informal practices, etc. Institutions represent the rules of the game in a society, i.e., the constraints that humans have imposed to shape their interactions. Accordingly, they regulate incentives in political, social, or economic relations among individuals (North, 1990). Political, social, and economic institutions are broadly interpreted to include customs, voting procedures, legislation, organiza-

tions such as unions and corporations, or any other political, social, or economic rules that influence how people treat each other when exchanging private or public goods.

Differentiating economic systems is important for five general types of institutions (Gregory, Stuart, 2015). These are:

1. property rights
2. decision-making methods
3. market versus plan - institutions for providing information and coordination
4. incentive mechanisms for setting goals and motivating individuals to achieve these goals
5. procedures related to public choice.

It is undeniable that economic systems influence countries' economic performance. Economic systems burdened with corruption, a low level of the rule of law, etc., yield weak economic results, and vice versa. As weak economic institutions hamper economic performance and strong ones stimulate it, states face the need to transform weak economic institutions into strong ones. An unreasonable choice of economic institutions can impoverish countries otherwise rich in natural resources. There are many such examples, starting from Africa, Latin America, the Middle East, Central Asia, and other regions worldwide.

Economic outcomes show the success of an economy based on criteria such as economic growth, standard of living, employment, and other measures. Other factors, such as environmental factors, policies, etc., also influence economic outcomes. Environmental factors represent the economic environment in which the economic system operates. They include natural resources, the accumulation of human and physical capital, education, the level of development achieved, and initial conditions for development. Policies imply trade policy, macroeconomic decision-making, regulatory environment, and other policies that change with the economic system itself.

To evaluate economic outcomes, usually five performance criteria are used (Gregory, Stuart, 2015), namely: economic growth, efficiency, income distribution, stability, and sustainability. In addition to these indicators, it is certain that the quality of the environment, military power, and others are also significant.

Economic growth is the most commonly used indicator of economic performance, representing the increase in real Gross Domestic Product (GDP) or real GDP per capita over a certain period. A growing economy means a growing

number of jobs, a greater ability to finance the non-productive sector, increasing population welfare, and more. Economic efficiency is the effectiveness with which a system uses available resources at a given time (static efficiency) or over time (dynamic efficiency). Static efficiency requires an economy to operate on the edge of its production possibilities, while dynamic efficiency represents the system's ability to increase the production capacity of goods and services over time without increasing capital and labor inputs.

Economies can grow thanks to increasing efficiency (by finding new ways to do jobs with the same resources) or increasing the amount of labor, but using it at a constant rate of efficiency. Intensive growth is growth based on increased efficiency in resource use, while extensive growth occurs based on increased inputs. An economic system operating below the limit of production possibilities is wasting its resources, and the economy operates below its potential. This can also produce inefficient political decision-making, such as political allocation of investments with lower rates of return compared to other projects based on economic parameters.

An important efficiency question is how fairly an economic system distributes household income. Measurement of income inequality is made by the Lorenz curve or the Gini coefficient. It is generally thought that income distribution is poor in those countries where a small percentage of the population controls a disproportionately large percentage of income. Differences in earnings reflect differences in effort expended (provision of labor services), differences in thrift (provision of capital), inheritance of capital, etc. On the other hand, the market distribution can be modified by the tax system and provision of social services. Moreover, one of the biggest problems in international trade is the growing protectionism of developed countries (Salvatore, 2009).

Economic stability implies the absence of significant fluctuations in growth rates, maintaining relatively low unemployment rates, and the absence of high inflation rates. Economic instability affects different segments of the population differently, and cyclical instability slows GDP growth. The long-term sustainability of the economic system is a dominant check of its success. All economic systems that have not shown long-term endurance are considered inferior to those that possess sustainability over a long period of time. Changes in the economic system are implemented through reform, which represents modifying the existing system and (or) transition, which denotes the transition of one economic system to another.

The basis for establishing efficiency criteria implicitly contains the possibility of evaluating the economic universe, the possibility of exerting a certain influence on it, and that the most favorable influence cannot be realized automatically. In itself, the concept of economic efficiency is by nature quantitative and, viewed broadly, can be measured by the relationship between achieved results and efforts made. Meanwhile, as there are many ways in which results and investments (costs) can be expressed, numerous interpretations of the concept of efficiency can be given. Efficiency is most often taken in the form of the highest possible level, so it is also called optimal efficiency or just optimum (Njegovan, Djuric, 2017).

Efficiency means that society gets the maximum from its scarce resources, and fairness means that the benefits from these natural resources are fairly distributed to all members of society (Mankiw, 2013). As one of the first definitions of efficiency, Vilfredo Pareto's rational resource allocation (the so-called Pareto optimum) can be mentioned, according to which the optimum - rational resource allocation in a society can be achieved only if the well-being of someone in society increases at the expense of the well-being of someone else. In this sense, the Pareto optimum defines a state of general equilibrium and not a state of optimum. This essentially qualifies it as a static approach.

Based on this, Schumpeter (2012) already noticed the necessity of distinguishing the static and dynamic approach to efficiency. He sees the static as the possibilities of influencing resource allocation at one point, and the dynamic, as the impact on potential development possibilities as a process unfolding in time and space. In this sense, the dynamic approach, as more complex and complicated, can be assessed as more desirable. It is based both on the qualitative and quantitative characteristics of the growth of productive forces, that is, on the continuous change of development based on the volume and structure of social needs. The dynamic approach promotes multidimensionality, and especially the aspect of movement and change in economic efficiency.

Considering these two concepts, many authors have tried to systematize this matter. For example, author Bela Balas (1964) introduces five indicators for measuring efficiency: (1) static efficiency of resource allocation, (2) dynamic efficiency, (3) the growth rate of national income, (4) satisfaction of consumer needs (living standard), and (5) income distribution.

ECONOMIC SYSTEMS ENVIRONMENT AND DEVELOPMENT STRATEGIES

In modern times, three models of capitalism can be distinguished (Gregory, Stuart, 2015). These are the Anglo-Saxon model, the European model, and the Asian model. The key issues of their differences are ownership structure, particularly in corporations, how they are managed, the way capital is collected, the functioning of the labor market, the role of the state in the economy, distribution and redistribution of income, legal system, and economic institutions.

The Anglo-Saxon model developed in accordance with the classical liberal ideas of Adam Smith and the constitutional rules of classical liberalism. It is based on common law which involves judge-juries, a jury, broader legal principles, oral evidence, and precedents, and according to which state intervention in the economy should be limited.

The European model is based on economic ideas in France and Germany in the 19th century and it does not rely solely on the invisible hand of the market but advocates greater state intervention in the economy. The European model envisages that the state be more active in the economy, pays greater attention to the „common good" as opposed to individual property rights, and envisages greater regulation of the private economy. It is based on civil (or Roman) law, which implies professional judges, codexes, and written records. Examples of the European model are present in a large number of countries, including Germany, France, and Sweden.

The Asian model is based on high rates of capital accumulation and other mechanisms, often with state support. It originated in the 19th century in Japan, and the best examples of this model are South Korea and Taiwan. Asian countries apply a mix of civil, common, and religious law. It is characterized by a high degree of business and trade freedom, which is understandable because in the global economy, countries must be open so as not to lag in development. In middle-income or poorer countries, there is a significantly higher degree of corruption compared to the other two mentioned models.

Globalization means increasing interconnection of world economies through the expansion of trade in goods, services, and capital. It affects the economic performance of countries and their economic institutions. It enables consumers to buy a wider range of goods and services at lower prices than they could if they were restricted to local markets. Companies face greater competition which drives them towards innovation and efficiency, legal institutions adjust to the

needs of international trade, and capital collection is possible from very distant destinations.

Thanks to technological advancements made possible by the revolution in information, telecommunications, and transportation, living standards have increased, although they are not evenly distributed around the world. The fastest growth is achieved by export-oriented economies, open to international trade and finance. A significant factor of progress is the process of deregulation in the economy, which allows companies to freely determine prices and product quality policy. The combination of globalization and deregulation has undoubtedly increased the degree of competition in much of the world. On the other hand, many opinions suggest that the severe economic crisis of 2008 resulted from excessively aggressive deregulation of financial markets in the US. Contrarily, excessive regulation leads to the spread of corruption in the system, a feature particularly characteristic of developing and less developed countries.

When economically analyzing the process of economic development in one economic system, several complex categories are most often used: capital accumulation, population growth, technical-technological changes and innovations, international trade and investments, as well as income distribution both within the country and with different countries. However, in addition to this, the market category and its functioning are increasingly taken into account as one of the factors of the emergence or absence of an accelerated development process. In this sense, the question often arises whether it is efficient or not? The analysis starts from the genesis of its creation and formation, whether it refers to its emergence as a spontaneous autonomous process or its creation through external linking.

Every exchange on the market implies a certain level of transaction costs that burden it. Accordingly, if there is a higher level of transaction costs in a certain market, the goods and services exchanged on it will be more expensive and less competitive in international exchange. In extreme cases, exceptionally high transaction costs will lead to a halt of any exchange on the market. Globalization is the intensification of social relations on a global scale that connects distant places in such a way that local events are shaped by events occurring miles away (Giddens, 1998).

It becomes clear that the regulation of market organization and functioning cannot be initiated by an external - exogenous factor, not even the state. The regulation of market organization arises evolutionarily. It is created and perfected over a number of years by market participants - both buyers and sellers. In the majority of today's highly developed countries, it has been shown that it was the

agricultural sector that crucially influenced the creation of institutional frameworks that later expanded as regulation to other, modern sectors.

Globalization strategies represent the dominant development characteristic of the world economy. The globalization process has been facilitated and practically enabled by reduced costs of integrating individual countries into global flows, based on rapid technological changes and changes in development policies in terms of their greater turn towards the operation of market laws and liberalization of economic flows. Today's globalization process differs in many of its characteristics from the process that took place during the nineteenth century. It was based on the imperial policy of the great powers, on colonization and exploitation of natural and other wealth of underdeveloped countries, and with high costs of transport and communication.

Today's processes are characterized by a high market orientation and market forces affect all parts of the world and all forms of human activity - political, social, even climate change. Globalization has imposed market liberalization in all countries that want to be part of global flows, both capital markets and goods and services. Unfortunately, today there has been a retrograde tendency only in one market segment and that is the labor market.

Indeed, this segment is highly limited by administrative, visa, and all other barriers, so that the market that used to be the freest, is now the most regulated. Decreasing costs of transport and communication have led to a decrease in the „natural" protection rate of certain markets. On the other hand, the participation of primary products in world trade is decreasing both in terms of quantity and value. Far greater importance in world trade is given to products of higher stages of processing and services, and modern technologies have practically made the globalization process irreversible. The world processes of globalization and liberalization have also caused significant changes in the development and development perspectives of many countries in the modern world.

In addition, the classification of certain development strategies can be based on three criteria (Njegovan Djuric, 2017):

1. The criterion of comprehensiveness, which implies complete and comprehensive development strategies instead of considering them by individual segments or sectors.
2. The criterion of providing the possibility of testing the results of applying a certain strategy at least by some of the most important variables.

3. The criterion by which strategies must be understandable and appropriate both for developed OECD countries and for underdeveloped countries, which provides the possibility of identifying potential effects of application in each group of countries.

Some countries are not in a position to independently choose their own development paths embodied in a complete strategy. Many restrictions are imposed by the size and level of development of individual economies, as well as the realistically available development resources. In the case of small countries, especially if it is associated with low purchasing power of the population, the only real option of the strategy appears to be an open economy and full integration into development flows. Closing such countries and their development under such conditions show suboptimal results. Also, it has proven unrealistic several times for a country to choose a „state-intensive" development strategy based on a strong and capable state administration without having a good and efficient state administration and institutional prerequisites for it. The choice of a development strategy is closely linked to the chosen ideology and the material interests of the group in power, specifically with the interests of those social strata whose government representative.

It is necessary to point out that there is a clear link between a country's ability to attract and effectively use foreign accumulation and the chosen development strategy. Socialist countries, despite the strict and centralized control of foreign accumulation flows by the state, were in a subordinate position for many years because their national regulations were restrictive to capital imports. Also, the export sector in these countries was relatively undeveloped and oriented towards trade, primarily with other socialist countries, so they did not generate a sufficient volume of foreign exchange inflows to be able to cover loan obligations and ensure the import of necessary goods and services. In contrast, countries that followed the strategy of an open economy or industrialization were far more open and attractive for foreign investors. In addition, they had access to new technologies or developed their own research and development sector that most effectively employed foreign accumulation. When looking at long-term growth rates of the domestic economy, they were highest in countries that followed a development strategy based on the growth of the export sector of the industry (an example is South Korea), countries based on income redistribution with an emphasis on the export economy (an example is Taiwan) as well as socialist-oriented countries, but only in a limited time period.

CONCLUSION

Economic systems with underdeveloped institutions burdened by corruption and a low level of the rule of law achieve poor economic results and lead to the underdevelopment of states in the long term and their lagging behind the developed part of the world. The goals of economic systems are stable economic growth, low unemployment rates, stable and low inflation, export orientation, and openness of the economy on a global scale. States that have developed such economic systems have gained developmental advantages and greater competitiveness in international frameworks. The key issues of economic system efficiency are ownership structure, especially in corporations, the way they are managed, the way capital is collected, the functioning of the labor market, the role of the state in the economy, distribution and redistribution of income, the legal system, and economic institutions. It is also necessary for developing countries to accept the principles of developed economic systems in order to successfully integrate into the international division of labor and world markets, which will be in favor of increasing their competitiveness and the living standard of the population.

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ELECTROCHEMICAL ENERGY STORAGE IN SUSTAINABLE MODERN SOCIETY

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ABSTRACT

This paper shows the momentum of the development in the use of alternative energy, as well as the needs of modern users for storage of excess energy, mobility, etc. and in connection with that, the modern development and use of electrochemical energy sources, especially in the light of ecological needs.

Key words: alternative energy, electrochemical energy sources, battery

INTRODUCTION

Energy is present all around us in various forms and in a philosophical sense it can be said that there is an equivalence of energy and life. Today, energy is the most represented, along with the economy and the environment, in discussions about the strategic directions of the development of each society. These three pillars of society are in such a sensitive cooperation that any progress must rest on the optimal management of all three segments, which is achieved by promoting energy efficiency, establishing free investment, avoiding trade restrictive measures, encouraging research, development and application of energy-efficient technologies, forcing international cooperation in the development of innovative technologies, encouraging mutual recognition of energy labels and standards, and finally, imposing rigorous and reliable measures in the field of environmental protection.

According to the first low of thermodynamics, during an interaction between a system and its surroundings, the amount of energy gained by the system must be exactly equal to the amount of energy lost by the surroundings. A closed

system it can change from one form to another, i.e. the amount of energy is always constant, which is known as the principle of conservation of energy.

The transition of chemical energy into heat and other forms of energy is found, for example, when burning fossil fuels in the form of heat that is converted into the kinetic energy of water vapor to start turbines and produce electricity in thermal power plants, or the released thermal energy is used to heat a fluid. which indirectly heats another system. Kinetic energy is recognized in wind and sea waves, while magnetic field energy and electrical energy are encountered in everyday life in many forms. Different energy sources have different energy values. Although we are surrounded by energy, we cannot always simply use it. We generally need it in a specific form and quantity at a specific place and at a specific time, which results in the need for energy to be stored in a portable form, ready for use. Electrical energy can be stored in the form of an electric or magnetic field, mechanical energy in devices such as a flywheel, and thermal energy in isolated solids or fluids, but their stored quantities are relatively small, and their conversion methods are complicated. A much larger amount of energy can be stored in the form of chemical energy that can be converted into electrical, mechanical, thermal or light energy at the moment of need. Most often, this energy is converted into thermal and mechanical energy by means of thermal power plants and internal combustion engines, but the modern way of life with the use of new technologies gives increasing importance to the conversion of chemical energy into electricity by means of electrochemical converters, electrochemical power sources (EPS). The biggest advantage of electrochemical converters is that they work isothermally, they are not limited by the so-called Carnot cycle, which achieves a much higher coefficient of useful conversion effect. In electrochemical converters, chemical energy is converted into electrical energy in the form of low-voltage direct current through the overall chemical reaction, which is a set of electrochemical reactions at the phase boundaries between electrodes and electrolyte, or vice versa, electrical energy is converted into chemical energy (energy conversion).

Recently, a huge increase in activities in the field of research and development of electrochemical power sources has been noticed. There are several reasons for this, and the foremost among them is the environmental reason. This is confirmed by numerous conventions, whose goal is to reduce global warming, signed on the basis of the Kyoto Protocol, which, along with the United Nations Framework Convention on Climate Change, is a basic international agreement aimed at reducing the emission of carbon dioxide and other gases that affect the destruction of the ozone layer. There is no doubt that the burning of fossil fuels

releases gases whose accumulation leads to global warming, which can be seen from the data that in 2011 the atmospheric concentration of carbon dioxide was 391 ppm, while the concentration of carbon dioxide was measured in old ice deposits whose origin was dated to 1750 a year, i.e. pre-industrial era, 278 ppm. To this should be added industrial pollution of the environment as well as the appearance of atmospheric smog in urban areas as a result of the huge increase in the number of cars with internal combustion. The use of internal combustion engines is strictly prohibited in enclosed spaces due to toxic exhaust gases. All these facts have contributed to the accelerated development of electric cars that use electrochemical energy sources. Their development, focused on obtaining a reliable source with high values of specific energy and working life, becomes imperative. Such an electrochemical source must enable the electric car to be competitive with existing internal combustion engines, from the point of view of performance as well as financially. That competitiveness has not yet been realized, so this intermediate space has been filled by the development of hybrid cars. In addition, in the automotive industry, there is a noticeable increase in the needs related to interior comfort in terms of installing electric motors for opening and closing windows, adjusting mirrors and seats, then for the use of higher power sound systems and small electrical accessories in the car cabin, which requires that the starter batteries in recently, they will switch from the current 12 V to 36 V. This requirement cannot be achieved only by simply connecting the existing starter EPSs in series due to their limited specific characteristics, but the replacement of the most commonly used lead acid batteries today with completely new electrochemical systems is being considered (Симичић, 2020).

NEEDS OF THE CONTEMPORARY WORLD FOR ALTERNATIVE ENERGY

An important reason for the great increase in interest in the development of new electrochemical systems lies in the increased awareness of the limited resources of fossil fuels, which encouraged the development and use of alternative sources of electricity, such as solar energy, wind and wave energy. From 2009 to 2018 alone, the produced capacities from wind generators increased from about 150 to 564 GW, while the capacities of using solar energy increased from about 23 GW in 2009 to 486 GW in 2018 (IRENA, 2019). It is a well-known fact that the application of alternative sources is not uniform over time, their availability and use depend both on the time of day and the season. Precisely because of this, the development of efficient reversible electrochemical systems for the storage

of excess alternative energy and its leveling have become a strong driving force for financing new projects in this area.

When considering the reasons for the increase in interest in the development of EPS, we should not leave out the dizzying growth in the sale of small electronic devices such as computers, tablets, mobile phones, cameras, wireless power tools and devices where energy density, their specific power and life span are of crucial importance for the consumer.

And finally, we should mention the application of EPS for backup power in cases of termination of the primary power supply of electrical consumers such as large computer systems, networks, telephone exchanges, lighting power, electric motors for powering elevators, etc.

The feeling of the importance of EPS research and development led to an absurd situation that Germany, with a once traditionally emphasized social-market economy, in its „National Industrial Strategy to 2030", accepted, in February 2019, that state interventionism is justified in innovative industries if it is in the interest of the competitiveness of the national economy and calls on politicians to constantly improve the framework conditions for the competitiveness of industrial production in important sectors, among other things, through research and technological innovation. Based on this strategy, a German-French initiative was created to create a consortium that would deal with the development and production of EPS for powering electric cars with a budget of 1,700,000,000 euros with the aim of catching up with Asian competitors.

OVERVIEW OF THE CHARACTERISTICS OF SECONDARY ELECTROCHEMICAL SOURCES OF ELECTRICITY

Secondary electrochemical power sources (accumulators) represent a very dynamic area that is difficult to present in one time section. We are witnessing the continuous improvement of existing systems, research and development of new systems, which results in constant changes in their characteristics, construction, application methods and market prices. In addition to the traditionally well-known starter batteries (for starting engines in vehicles) and industrial (traction) batteries for powering electric vehicles for internal, most often, factory transport and stationary batteries for auxiliary (reserve) power supply, there is a huge market of propulsion batteries of smaller sizes for powering portable devices such as tools, laptop computers, cameras, mobile phones, and for a long time, batteries for powering electric and hybrid vehicles have been winning an increasingly important market.

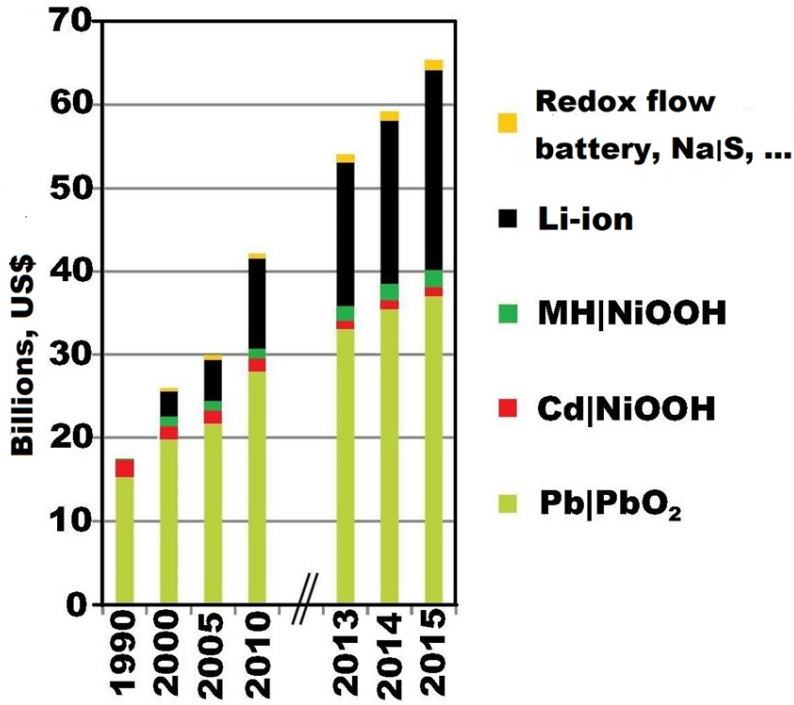

Figure 1: Global battery market in the period from 1990 to 2015

The dynamism of this area can best be seen from Figure 1, which shows the global battery market in the period from 1990 to 2015 (Pillot, 2016). According to estimates by the Bloomberg New Energy Finance agency, the total global battery production capacity will reach nearly 280 GW in 2021. Globe Newswire's latest forecast in the „Battery Market - Growth, Trends, and Forecast (2020-2025)" report provides a tentative estimate that the global battery market will grow at a compound annual growth rate (CAGR) of 12.31% between 2019 and 2024. The main drivers of this growth will be the decline in the price of lithium-ion batteries, which has fallen by almost 90% since 2010 from 1183 $/kWh to 156 $/kWh in 2019, then the growth in the production of electric and hybrid vehicles, the growing renewable energy sectors and portable electrical devices. This report also predicts that the mismatch between the raw material and battery manufacturing markets could potentially hinder this projected growth.

The characteristics of the batteries that are most common on the market are shown in Table 1. Data from the table should be taken with caution, as an orientation indicator of different electrochemical systems because they are collected from literature based on the characteristics of standard batteries of various commercial manufacturers. The characteristics of an electrochemical system depend

on many parameters, construction, composition and structure of active materials, separators, technological procedures, charging and discharging modes, and therefore it is very ungrateful to reduce them only to the characteristics shown in Table 1. Therefore, any serious approach to this complex matter requires a deeper and a more comprehensive analysis both from the electrochemical and technological aspects as well as regarding the categorization of batteries of the same electrochemical system and its basic purpose.

Table 1 Characteristics of some of the most common accumulators on the market

	Cd|NiOOH	MH|NiOOH	Pb|PbO_2 (vented)	Pb|PbO_2 (VRLA)	Zn|MnO_2	Na|S
Specific energy, Wh/kg	45-80	60-120	30-50	30-50	80	120-150
Internal resistance, mΩ	100-200 (6V batt.)	200-300 (6V batt.)	<100 (12V batt.)	<50 (12V batt.)	200-2000 (6 V batt.)	
Service life, number of cycles (80% of discharge)	1500	500	200-300	300-600	50 (до 50%)	>2500
Charging time, h	1-2	2-4	8-16	<1	2-3	
Overcharge tolerance	moderate	low	high	very high	moderate	
Self-discharge, %/ month at room temperature	20	30	5	1-3	0.3	low
Nominal cell voltage, V	1.25	1.25	2	2	1.5	2.08
Charging efficiency, %	70-90	65-80	50-92	98		85
Discharge peak	20 C	5 C	5 C		0.5 C	
mode standard	1 C	<0.5 C	0.2 C		0.2 C	
Operating temperature, °C (discharge)	from -40 to 60	from -20 to 60	from -20 to 60	from -40 to 0	from 0 to 65	from 280 to 350
Maintenance	moderately	moderately	moderately	not required	not required	moderately
Environmental impact	very high	low	high	high	moderate	low
In use since	1950	1989	the end of the 19th century	1985	1992	1960

Table 1 (continued): Characteristics of some of the most common accumulators on the market

		Li-ion (cathode $LiCoO_2$)	Li-ion (cathode $LiMn_2O_4$)	Li-ion (cathode $LiFePO_4$)	Li-ion (polymer)	$Na|NiCl_2$ (ZEBRA)
Specific energy, Wh/kg		150-250	100-150	90-120	150-250	100-120
Internal resistance, mΩ		150-250 (6.6/7.2 V batt.)			200-300 (7.2 V batt.)	
Service life, number of cycles (80% of discharge)		500-1000	500-1000	1000-2000	300-500	3500
Charging time, h		2-4	1-2	1-2	2-4	
Overcharge tolerance		low	low	very low	low	
Self-discharge, %/month at room temperature		<5			~5	no
Nominal cell voltage, V		3.6	3.7	3.2-3.3	3.6	2.58
Charging efficiency, %		80-90			>90	>90
Discharge mode	peak	2 C	>30 C	>30 C	>2 C	
	standard	< 1 C	<10 C	<10 C	≤ 1 C	
Operating temperature, °C (discharge)		from -20 to 60			from 0 to 60	from 270 to 350
Maintenance		not required			not required	
Environmental impact		low			low	low
In use since		1990	1996	1999	1999	2001

A comparative representation of the dependence of gravimetric (kW/kg) and volumetric (kW/dm3) energy density and Ragone's comparison plot for most accumulators are shown in Figures 2 and 3 respectively. Discharge curves in the discharge current regime of approximately C/5 of different batteries are shown in Figure 4, while the effects of temperature on the specific energy of different systems at the same regime of approximately C/5 are shown in Figure 5 (Reddy, 2011).

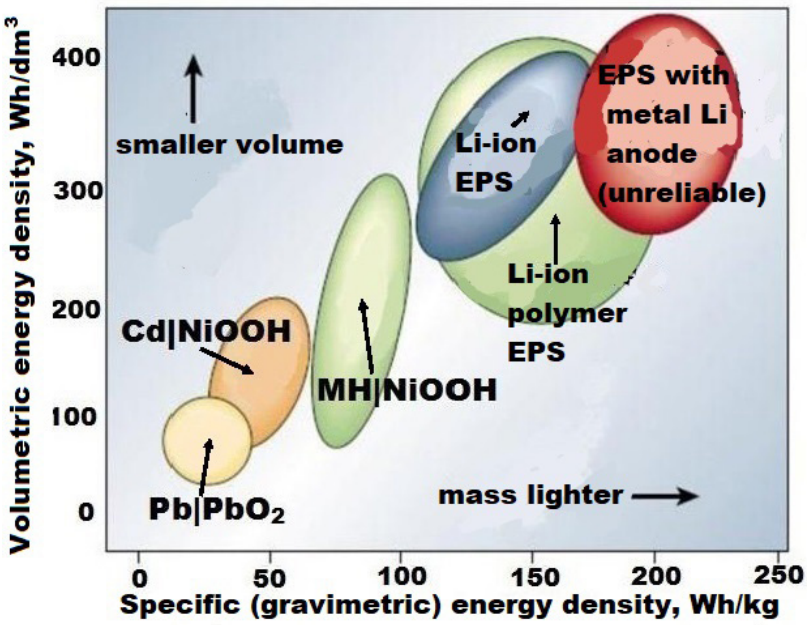

Figure 2: Gravimetric energy (Wh/kg) and volumetric energy density (Wh/dm³) for most secondary EPSs Plot

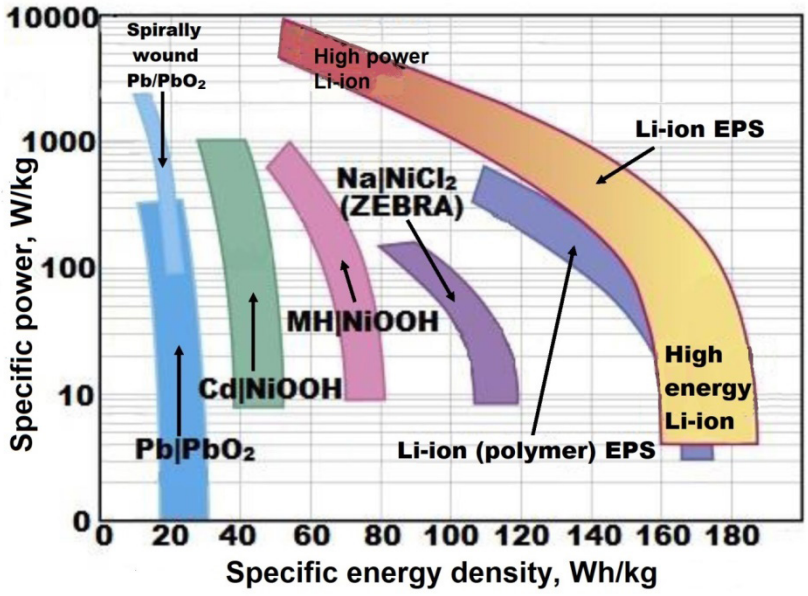

Figure 3: Ragone plot as a comparative representation of most secondary EPSs

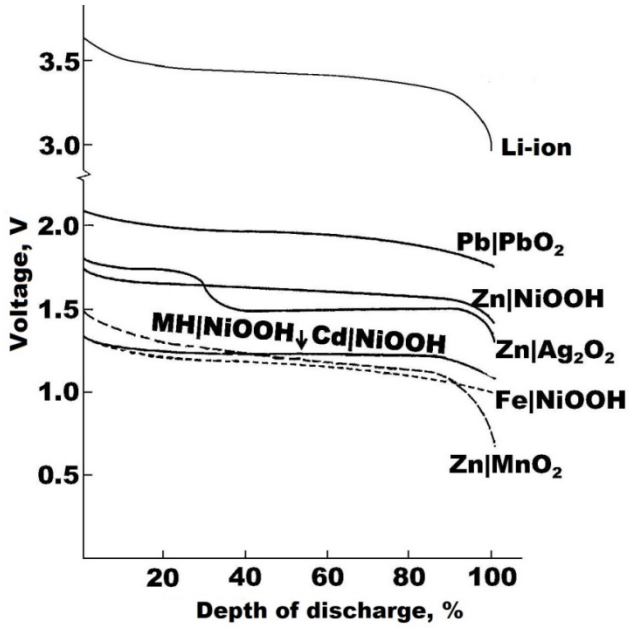

Figure 4: Discharge curves in the discharge regime of approximately C/5

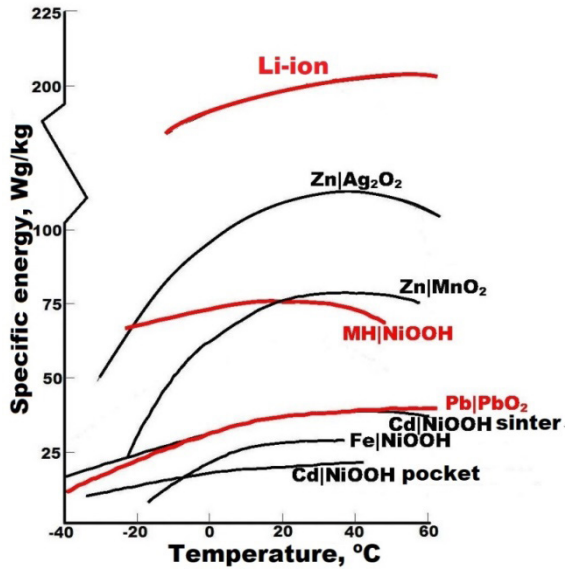

Figure 5: Temperature effects on the specific energy of EPSs at a regime of approximately C/5

CONCLUSION

At the end of the second decade of the twenty-first century, we are witnessing an extremely intense development and production of electrochemical energy sources. They are becoming an essential part of a large number of modern devices in the most modern technologies, and the huge interest in them stems from the increased ecological awareness. Apart from the presented modern electrochemical energy sources, in the near future it is possible to expect the appearance of possible electrochemical sources such as lithium|air, zinc|air, lithium|sulfur, sodium-ion and other systems that are still far from commercial use at the moment.

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THE CONTRIBUTION OF RADIONUCLIDES FROM BUILDING MATERIALS TO GAMMA DOSE RATES IN AIR

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ABSTRACT

Gamma radiation from primordial radionuclides ^{232}Th, ^{238}U and their decay products are the main source of external exposure to humans. These radionuclides are present in varying concentrations in all soils, rocks and building materials. Therefore, contribution to gamma dose rate in air strongly depends on the composition of radionuclides contained in the soil and various building materials used for construction. In this paper outdoor and indoor gamma dose rates were measured in two distant buildings. Radex 1503^{+} and Gamma-Scout radiation detectors were used for simultaneous measurements which included positions on the ground/floor and 1 meter above the ground/floor. The obtained values measured with the RADEX RD1503^{+} detector ranged from 0.08-0.24 μSv/h, and the GAMMA-SCOUT® values from 0.101-0.182 μSv/h. These values are higher than worldwide average indoor absorbed dose rate value of 0.07 μGy/h. Results were compared, and the contribution of different building materials to gamma dose rates were analyzed. It was concluded/confirmed that soil/ground and local stone mainly contribute to indoor gamma dose rates.

Keywords: gamma dose rate, air, building material, ground

INTRODUCTION

More than 2/3 of human exposure to ionizing radiation in the environment arises from natural sources which include terrestrial radiation in rocks/minerals of the Earth's crust, and cosmic radiation (UNSCEAR, 2000). Terrestrial gam-

ma rays derive essentially from potassium ^{40}K and the radionuclides of uranium ^{238}U and thorium ^{232}Th decay series. They are also present in air, water, building materials, food and human body itself. Cosmic radiation is mainly constant, and depends on the altitude, while terrestrial radiation varies depending on geographical location, meteorological conditions, geology of the terrain, content of radionuclides in the soils/rocks and building materials. Worldwide average value of annual dose from natural sources is estimated to be 2.4 mSv, of which a natural radioactive gas radon contributes 1.26 mSv, external terrestrial radiation 0.48 mSv and cosmic radiation 0.39 mSv.

The external and internal radiation exposure from building materials creates prolonged exposure situations as individuals spend more than 80% of their time indoors. The external radiation exposure is caused by the gamma emitting radionuclides, which mainly belong to ^{40}K and the decay of ^{226}Ra in the uranium series. The internal radiation exposure is due to inhalation of ^{222}Rn, and marginally to ^{220}Rn (thoron), and their short lived decay products, exhaled from building materials into the room air (Papastefanou et al. 2005). They are responsible for the high radiation health risk. The worldwide average indoor effective dose due to gamma rays from building materials is estimated to be about 400 μSv/y (UNSCEAR, 2000).

Radioactivity in buildings comes from radionuclides of the building soil, including radon emanation from the building soil and building materials. Most building materials of terrestrial origin contain varying amounts of radionuclides. Generally, buildings tend to have a slightly lower indoor air pressure compared with that in the ground, which allows infiltration soil gas from the ground into the building.

In Europe, the lowest outdoor gamma dose rate values (less than 40 nSv/h) are in Cyprus, Iceland, the Netherlands and the United Kingdom. However, Portugal had the values greater than 80 nSv/h. The lowest indoor values (below 40 nSv/h) were found in Iceland, and the highest values were found in Albania, Hungary, Italy, Portugal, Spain, and Sweden (greater than 95 nSv/h), probably due to the extensive use of stone or masonry materials in buildings (UNSCEAR, 2000).

Therefore, it is important and desirable to measure the gamma dose rates everywhere in human environment, where possible. This study deals with measurements of indoor and outdoor gamma dose rates in buildings and air at two distant locations in Serbia with the aim of comparing gamma radiation levels.

MATERIALS AND METHODS

Indoor and outdoor dose rate measurements were conducted in the middle of April 2023 in two locations in Serbia: Brus and Vrčin. The selection of locations was done in order to avoid geological and geographical similarities, and to compare/discuss the obtained results. The measurements were performed indoors (in selected house) and outdoor (in vicinity of the house) at the height of 1m above ground, or on the ground/floor in the middle of the day. Outdoor measurements were taken at points which are an open, undisturbed level ground surface free from vegetation sheltering and runoff during heavy rain and away from public roads. Indoor measurements were obtained on floor or other suitable surface.

Geiger-Müller counters, GAMMA-SCOUT® and Radex RD1503^{+} were used for measurements. GAMMA-SCOUT® device enable detection not only gamma radiation, but alpha and beta radiation as well. Detector is calibrated to measure across a wide scale from 0.1-1.000 μSv/h. The device is calibrated using isotope ^{137}Cs. The current radiation measurement reading is shown on display every 2 s. In this case, the measurement at each position lasted 5 min. Radex RD1503^{+} detector supplied by QUARTA-RAD operates in the range from 0.05 - 9.99 μSv/h with measuring uncertainty of ± 15% (Gulan & Spasović, 2017). It has been tested and calibrated using isotope ^{137}Cs. Due to low detector's response, detection of high energy particles from cosmic radiation was negligible. Two measuring cycles of 40 seconds at each position were performed using Radex RD1503^{+}.

RESULTS AND DISCUSSION

The results of gamma dose rate measurements at two distinct locations Brus and Vrčin are presented in Table 1 and Table 2, respectively. These values are within the worldwide average gamma dose rate, which is in the range of 20–200 nSv/h (UNSCEAR 2000). Minimum and maximum values are presented as representative of the numerous obtained values. The results revealed that values of indoor gamma dose rate were found to be higher than outdoor gamma dose rates (measured with Radex RD1503^{+} counter) in location Brus (Table 1); it was found that ratio of 1.25 and 1.17 are comparable with the world average ratio of 1.4 (UNSCEAR, 2000). Particularly, the gamma dose rate obtained for building built of the stone confirmed higher radioactivity than other positions in the locality. At the other hand, higher values in cellar (basement) are expectable, as soil is source of radionuclides. However, indoor/outdoor ratio of gamma dose rates

pointed comparable results in location Vrčin. This means that radionuclides contained in building materials insignificantly or slightly contribute to the gamma dose rates.

Table 1. Gamma dose rates measured in Brus

Brus	Counter location	Gama Scout (μSv/h)		Radex (μSv/h)	
		min	max	min	max
Indoor	Ground floor (parquet)	0.131	0.154	0.15	0.24
	Ground floor (wooden floors)	0.145	0.159	0.15	0.19
	Cellar (in the ground)	0.163	0.177	0.18	0.21
	Average	**0.146**	**0.163**	**0.16**	**0.21**
Outdoor	On the ground	0.154	0.165	0.13	0.19
	1 m above the ground	0.133	0.145	0.09	0.15
	Terrace (1m above the ground)	0.136	0.160	0.12	0.20
	Building of the stone	0.160	0.182	0.17	0.20
	Average	**0.146**	**0.163**	**0.128**	**0.18**
Indoor/outdoor		**1**	**1**	**1.25**	**1.17**

The floor type can also affect gamma dose rate due to presence of radon concentration. The higher values had wooden floors (with cracks) than parquet. This normally shows the radon buildup from soil into the building units. This results in accumulation of radionuclides inside the buildings, emerging from the floor materials, but depends on the house-to-house, even for areas with low exhalation rates from the ground (Gulan et al., 2013). The lowest value of gamma dose rate is obtained for ceramic tiles, which seem to be good choice in preventing exposure that comes from floors and walls.

Table 2. Gamma dose rates measured in Vrčin

Vrčin	Counter location	Gama Scout (μSv/h)		Radex (μSv/h)	
		min	max	min	max
Indoor	Ground floor (parquet)	0.101	0.144	0.09	0.14
	Ground floor (wooden floors)	0.130	0.145	0.14	0.20
	Ground floor (ceramic tiles)	0.101	0.115	0.08	0.16

	Average	**0.111**	**0.135**	**0.10**	**0.17**
Outdoor	On the ground	0.132	0.145	0.14	0.18
	1 m above the ground	0.130	0.142	0.10	0.13
	Garden (soil without fertilizers)	0.117	0.123	0.11	0.18
	Water source (in concrete)	0.123	0.145	0.09	0.14
	Average	**0.126**	**0.139**	**0.11**	**0.16**
Indoor/outdoor		**0.88**	**0.97**	**0.91**	**1.06**

The outdoor gamma dose rates are slightly higher in Brus in comparison with Vrčin; this can be consequence of local geology, since Brus is located in the foothill of Kopaonik Mtn., which originating from the granite rocks. In addition, the altitude of the measurement site may affect the difference in gamma dose rates; namely the Brus is located on 429 m a.s.l., while the altitude of Vrčin is 138 m a.s.l.

Lastly, the obtained results are in good agreement with the air monitoring in 2022 continuously performed in several towns of the Republic of Serbia: average values of ambient dose equivalent rate varied from 95 to 141 nSv/h (Serbian Serbian Radiation and Nuclear Safety and Security Directorate, 2023).

CONCLUSION

The radiation registered under normal conditions originates from cosmic radiation and terrestrial radionuclides, and depends on the geology of the terrain, the altitude of the measurement site, and characteristics of a specific area. In this paper, the values of gamma dose rate in the outdoor air and indoors (influence of building materials) in Brus and Vrčin were measured. It was obtained that the values do not exceed the world limits of 0.2 μSv/h, except for two indoor positions in Brus, where gamma dose rates were up to 0.24 μSv/h. The reason may be the diversity of the geological structure of nearby mountain terrain.

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SOCIO-MARKETING ASPECTS OF THE APPLICATION OF ARTIFICIAL INTELLIGENCE IN ENVIRONMENTAL PROTECTION AND PRESERVATION

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ABSTRACT

In this scientific paper, we investigate the socio-marketing aspects of the application of artificial intelligence in environmental protection and preservation. In today's world, an increasing number of companies and organizations recognize the potential of artificial intelligence in solving environmental problems, such as reducing greenhouse gas emissions, managing waste and using resources more efficiently.

The paper analyze how the application of artificial intelligence in environmental protection can contribute to the improvement of sociological aspects, such as greater information and engagement of the public in the preservation of the environment. We are also exploring how the application of artificial intelligence can improve environmental marketing strategies, for example through personalized marketing campaigns and targeted advertising.

Special attention is paid to the ethical issues arising from the application of artificial intelligence in environmental protection and preservation, as well as the possibilities for a regulatory framework that would guarantee that the application of artificial intelligence in environmental protection is responsible and ethical.

Through qualitative research and analysis, this paper points to the potential of artificial intelligence in environmental protection and preservation and offers guidelines for further research on this topic.

Keywords: Socio-marketing aspects, artificial intelligence, environmental protection, social responsibility, digital transformation

INTRODUCTION

With increasing attention focused on environmental protection, the application of artificial intelligence is becoming increasingly important in this area. Artificial intelligence (AI) can be defined as the ability of computers and software to perform tasks that typically require human intelligence, such as pattern recognition, prediction, and decision making.

In the field of environmental protection, VI has the potential to contribute to more effective monitoring of the environment, reduction of pollution, more efficient use of natural resources and prediction of climate change.

The very application of artificial intelligence in environmental protection deals with the basic concepts and principles of applying artificial intelligence in order to preserve the environment. It includes an overview of key areas where artificial intelligence can be applied in environmental protection, such as environmental monitoring, climate change prediction, more efficient use of resources and pollution reduction.

Also, within this scientific unit, different types of algorithms and artificial intelligence technologies that can be applied in this field are analyzed and discussed, such as machine learning, deep learning, neural networks, genetic algorithms, etc. In addition, the potential advantages and challenges of applying artificial intelligence in environmental protection, as well as its role in combating climate change and preserving natural resources, are explored and discussed. The goal is to provide users with a basic understanding of the application of artificial intelligence in environmental protection, as well as to emphasize its importance in the modern world where we are facing increasing challenges in the field of environmental protection.

Artificial intelligence (AI) represents one of the most significant technological innovations in the modern age. Its application is reflected in various areas, including environmental protection. The use of VI in this area is particularly important considering that we are facing increasing challenges in preserving the environment and reducing the negative impact of man on nature.

The application of VI in environmental protection refers to the use of algorithms and models that are used to analyze large amounts of data in real time, in order to make decisions and implement environmental protection measures based on it. For example, VI can be used to monitor air quality, detect water and soil pollution, and monitor and predict climate change.

One of the biggest challenges in environmental protection is monitoring and controlling the amount of greenhouse gas emissions that contribute to global warming. In this context, the application of VI can help in monitoring gas emissions, identifying sources of pollution and developing strategies to reduce emissions. For example, VI can use data obtained from sensors installed in large factories to monitor the emission of harmful gases and identify the parts of the production process that contribute the most emissions. In this way, more effective measures can be developed to reduce emissions and improve air quality.

Also, VI can help develop more efficient and accurate waste management systems. For example, VI can be used to identify locations where waste accumulates the most and develop strategies to reduce that waste. Also, VI can help monitor the amount of waste that is recycled, as well as finding ways to reduce waste that ends up in landfills.

However, the application of VI in environmental protection also carries certain risks and limitations. For example, there is a danger that AI will be used in a way that does not take into account ethical issues, such as privacy and animal rights. Also, the AI may rely on data that is not always accurate or complete, which may lead to erroneous decisions. That is why it is important that the implementation of VI in environmental protection is carried out with careful planning and with respect to certain principles.

One of the principles that must be respected in the application of VI in environmental protection is transparency. This means that it should be clear how the VI is used and how decisions are made based on the data obtained from the VI system. Also, care should be taken to protect data privacy and not use it in a way that could threaten the privacy of individuals or organizations.

Another important principle that must be respected is ethics. In the application of VI in environmental protection, ethical issues, such as animal rights and sustainable development, should be taken into account. For example, it would be unethical to use VI to monitor animals in their natural habitat in a way that would compromise their safety or their ability to perform natural functions in the ecosystem.

The application of artificial intelligence in environmental protection represents a significant step towards preserving the environment and reducing the negative impact of man on nature. However, we must be aware of the risks and limitations that the application of VI brings with it, and carefully plan and implement VI systems while respecting certain principles, in order to ensure transparency, ethics and protection of data privacy.

In this paper, the key aspects of the application of VI in environmental protection will be discussed in more detail.

- Environmental monitoring

VI can help in monitoring air, water and land pollution, as well as in monitoring the state of flora and fauna. For example, VI can be used to analyze data obtained from satellites and sensors, allowing faster and more accurate detection of pollution and other environmental problems.

- Forecasting climate change

VI can be used to analyze large amounts of climate change data, as well as to predict future climate conditions. This can be useful in planning long-term strategies to preserve the environment and reduce emissions.

- More efficient use of natural resources

VI can be used to optimize the use of natural resources, such as water, energy and forests. For example, VI can be used to optimize water distribution in an irrigation system, which can reduce water consumption and increase system efficiency.

- Reduction of pollution

VI can be used to reduce air and water pollution. For example, VI can be used to predict air quality in urban areas and manage traffic to reduce emissions.

In addition to the above examples, VI can be applied in other areas of environmental protection, such as waste management, sustainable agriculture, biodiversity protection, and others. However, despite the numerous advantages of applying VI in environmental protection, there are also certain limitations. Namely, AI can rely on data that is not always accurate or complete, which can lead to wrong conclusions and decisions. Also, there is a possibility that AI will be used in a way that does not take into account ethical issues, such as privacy and animal rights.

Nevertheless, with adequate implementation and use, the application of VI can contribute to a more efficient and sustainable management of the environment. In order to ensure the maximum benefit from the application of VI in environmental protection, it is necessary to develop adapted algorithms and models, as well as to work on reducing the risk of possible negative consequences of the application of VI.

The application of artificial intelligence in environmental protection has great potential to contribute to the preservation of the environment and the re-

duction of negative impacts of human activity on nature. However, further research and development is needed to ensure adequate application and use of VI in this area.

SOCIOLOGICAL ASPECTS OF THE APPLICATION OF ARTIFICIAL INTELLIGENCE (VI) IN ENVIRONMENTAL PROTECTION

The modern world is facing increasing challenges in the field of environmental protection, while at the same time technological progress, especially in the field of artificial intelligence (AI), offers new opportunities to solve these challenges. By exploring the sociological aspects of the application of artificial intelligence in environmental protection, the goal is to understand more deeply how AI is integrated into environmental initiatives, how it affects society and human interaction, and what implications it has for future environmental protection practices.

VI technologies offer three main advantages. First, it allows the automation of important but repetitive and time-consuming tasks, allowing people to focus on higher-value work. Second, it uncovers insights otherwise trapped in vast amounts of unstructured data that once required human management and analysis, such as data generated by videos, photos, written reports, business documents, social media posts, or email messages. Third, it can integrate thousands of computers and other resources to solve the most complex problems (Nishant, Kennedy, & Corbett, 2020).

It is necessary to create an introduction to the basic concepts of artificial intelligence and environmental protection, in order to consider how AI is applied in solving environmental problems, such as deforestation monitoring, waste management, climate change prediction and biodiversity conservation. The importance of social engagement in environmental initiatives is also highlighted here.

It is also necessary to investigate the sociological implications of the application of artificial intelligence in environmental protection, by analyzing how AI can change the way people communicate, cooperate and make decisions related to environmental protection. It also explores how the role of experts is changing with the ubiquitous use of AI, as well as its impact on public trust.

AI has enormous potential in environmental sustainability issues as it has capabilities in the field of natural language processing (speech recognition) or machine translation; either in computer form (image recognition and classification) or in the field of data analysis and pattern recognition, and the latest tech-

nologies used are sophisticated machine learning and „deep learning". Potential areas covered by the environment, in which VI can be applied, range from applications in energy and utilities, agriculture to environmental protection (Sharma, Yadav, & Chopra, 2020).

If we focus on the potential social division that can be caused by the application of VI in environmental protection, we will consider how access to VI technologies can be uneven between different social groups and regions, which can lead to inequality in access to environmental resources and information. In addition, the ethical framework for the use of VI in environmental protection is explored, including issues of privacy, transparency and accountability.

Today, without a doubt, we can say that consumer culture and the expansion of consumerism conditioned the formation of an individual's identity as a consumer. In the simplest terms, consumer society is a society whose values and norms are dominantly based on consumption, accumulation of material goods and use of services (Latinović & Ostojić, 2023).

There we have the future directions of application of artificial intelligence in environmental protection (Rauch, 2018). In addition to technical innovations, we emphasize the importance of an inclusive approach and education to ensure that all social classes benefit from these technological advances. A series of recommendations for decision-makers, experts and society as a whole, in order to responsibly use artificial intelligence in order to preserve the environment, should not be skipped either, because researching the key sociological aspects of the application of artificial intelligence in environmental protection, it is emphasized that technological progress should be followed with by understanding the social implications and ethical considerations. The integration of artificial intelligence into environmental initiatives can change the way society and institutions function, creating opportunities for more efficient and sustainable environmental protection.

MARKETING ASPECTS OF THE APPLICATION OF ARTIFICIAL INTELLIGENCE IN ENVIRONMENTAL PROTECTION

In today's global context, an increasing focus is placed on environmental protection and sustainability. At the same time, technological progress, especially in the field of artificial intelligence (AI), provides new opportunities to improve environmental initiatives. Investigating how artificial intelligence can be applied to marketing strategies in support of environmental protection, and focusing on the synergy between technology and marketing, it is analyzed how

AI can contribute to effective information, engaging target groups and encouraging positive changes in behaviour.

Artificial intelligence enables fast and accurate analysis of large amounts of data, which is crucial for informing the public about environmental challenges. Data processing algorithms can identify the most current environmental problems and generate relevant information for target groups. For example, personalized campaigns via social media or email can reach individuals with specific environmental interests.

The integrated application of artificial intelligence in the field of intelligent manufacturing can be evaluated by considering three aspects: application technology, industry and application effect. With application technology, it is necessary to assess the level and capacity of infrastructure construction, individual applications, synergistic applications and business development. The industry development evaluation covers intelligent products (products that can intelligently and autonomously perform their tasks) and intelligent connected products (intelligent products that can form an ecological network), intelligent industrial software, hardware development that supports intelligent design/manufacturing/ management/commissioning/ security, and the development and operation of intelligent production systems at different levels of the intelligent production unit, intelligent workshop, intelligent factories and intelligent industry. For application effects, it is suggested to focus the evaluation on changes in competitiveness and changes in social and economic benefits to measure the direct or indirect effects of the intelligent manufacturing system on increasing capabilities and economic benefits (Li, Hou, Yu, Lu, & Yang, 2017).

Personalization is a key element of modern marketing. VI enables the creation of personalized marketing messages that are focused on the individual preferences and needs of users. By analyzing data on user behaviour and interests, VI can provide relevant content, such as information on sustainable products, advice on reducing the ecological footprint or involvement in volunteer activities.

VI can also identify patterns in consumer behaviour and suggest specific steps toward green behaviour. Let's take for example that the analysis of consumer habits can lead to the recognition of key points, where the consumption of resources can be reduced or consumer habits can be changed (Zeynalova & Namazova, 2022). This approach allows marketers to tailor their messages and encourage positive changes in behaviour.

Transhumanism, in addition to being seen in future artificial intelligence, can systematically help humans overcome their own limitations. Technological solutions were a part of social development, because their use made everyday activities easier. The adoption of virtual reality can play an influential role in our ability to understand perspectives that we cannot currently reach. It is certain that the need for human labour will be drastically reduced, forcing humans to compete with artificial intelligence and at the same time forcing computational integration between the human brain and the brain of artificial intelligence (Latinović, Ostojić, & Krčadinac, The Sociological Perspective of Transhumanism Through the Prism of the Sports-Marketing Industry, 2023)

VI also contributes to better tracking and measuring the impact of marketing campaigns. By analyzing engagement, interaction and conversion data, marketers can more quickly identify what's working and adjust their strategies. This allows for more efficient allocation of resources and real-time optimization of campaigns.

The application of artificial intelligence in environmental protection brings the potential to revolutionize marketing strategies. Through effective information, personalization, analysis of behavioural patterns and better monitoring of campaigns, VI can help spread environmental messages, engage target groups and encourage positive behavioural changes. It is crucial that marketers recognize this potential and use artificial intelligence responsibly to support sustainability and environmental protection.

ETHICAL ISSUES OF THE APPLICATION OF ARTIFICIAL INTELLIGENCE IN ENVIRONMENTAL PROTECTION

Rapid technological progress in the field of artificial intelligence (AI) brings numerous advantages, but also creates deep ethical questions, especially when applied in the context of environmental protection. The complex ethical issues arising from the application of artificial intelligence in environmental protection are a sphere of our interest. While the technology has the potential to improve the sustainability, efficiency and monitoring of environmental processes, it also poses challenges that require careful consideration.

One of the key questions is whether artificial intelligence can surpass human knowledge and intuition in environmental protection. While algorithms and machine learning can analyze large amounts of data more quickly, the human ability to understand context, make moral judgments and consider complex fac-

tors often remains irreplaceable. An ethical dilemma arises when technology is used as a substitute for human engagement and decision-making.

The essential element of the ethical application of artificial intelligence in environmental protection must not be neglected - transparency. As algorithms are used to make decisions in areas such as monitoring climate change or identifying endangered species, it is important that the public understand how these decisions are made. A lack of transparency can lead to a lack of trust in technological solutions, which can undermine the legitimacy of environmental initiatives.

AI-based technologies are already being used to help people benefit from significant improvements and enjoy greater efficiency in almost all walks of life. But the great growth of AI also forces us to be careful to prevent and analyze possible direct or indirect disadvantages that the expansion of AI can generate (Janković, Gajdobranski, & Jović Bogdanović, 2023).

In order to solve the problem of climate change, it is proposed to establish a „Green Government" that, with the help of VI, can govern humanity and regulate countries and individuals to achieve climate goals. This seems like a direct threat to human rights and freedoms. However, there are examples of countries that have managed to introduce environmental regulations, which, to a certain extent, have introduced certain restrictions to improve the climate change situation, but at the same time leave enough freedom. Giving exact definitions for „to a certain extent", „enough" and „average" is a complicated issue when democracy determines the way of life. Especially at the global level, when it comes to significant differences in the understanding of fundamental rights and reference points for different countries. Thus, states will have to face the challenge of human liberties and learn to combine pressure and governance. However, it can certainly lead to a situation where some countries tackle climate change while others ignore the problem. This leads directly to global and intergenerational justice (Lozo & Onishchenko, 2021).

The application of artificial intelligence can reinforce existing social inequalities in environmental protection. If access to technology depends on economic power or access to education, a situation can be created where only certain sections of society benefit from progress in this area. The question is how to ensure that AI contributes to the universal good, instead of deepening inequalities.

Using large amounts of data to train VI models can lead to privacy and data protection issues. Collecting information about environmental processes and human behaviour for the purpose of advancing technology may conflict with the

need to protect personal data. It is important to set boundaries and establish ethical guidelines for the collection and use of this data.

The application of artificial intelligence in environmental protection brings with it numerous ethical challenges that require careful and comprehensive consideration. While technology has the potential to improve the sustainability and effectiveness of environmental initiatives, it is equally important that the progress itself is made in a responsible manner, respecting moral values, transparency, social justice and privacy protection. The integration of artificial intelligence into environmental initiatives requires a balancing act between technical capabilities and ethical principles in order to achieve environmental conservation goals.

REGULATORY FRAMEWORK FOR THE APPLICATION OF ARTIFICIAL INTELLIGENCE IN ENVIRONMENTAL PROTECTION

Contemporary challenges in the field of environmental protection require innovative approaches, including the use of artificial intelligence (AI). Here we are talking about the importance and complexity of the regulatory framework that should guide and control the application of VI in environmental protection. Through a review of existing legal regulations, standards and ethical guidelines, we explore the challenges and benefits arising from this combination of technology and environmental protection.

Today's world is facing increasingly serious environmental challenges, such as climate change, biodiversity loss and pollution. At the same time, technological progress, especially in the field of VI, provides new tools and opportunities to solve these problems. However, the application of VI in environmental protection requires careful alignment with the existing regulatory framework to ensure ethical and responsible use of the technology.

By analyzing the existing regulatory framework related to the application of VI in environmental protection, we study how different laws and standards, both at the national and international level, address issues related to the collection, processing and use of data for the purpose of environmental protection. Special emphasis is placed on the definition of key terms such as - environmental data, ecosystem monitoring and ecological analytics, which are essential for the application of VI.

The regulatory framework should reflect and regulate the ethical issues arising from the application of VI in environmental protection. Issues such as transparency in data collection, citizens' right to privacy, possible social inequalities

in access to technology and ethical use of data are becoming essential. Therefore, it is important to develop guidelines that will set boundaries and determine best practices in this area, taking into account the specificities of different ecosystems and cultures.

In recent years, concerns about global warming and resource depletion have led to increased awareness of the digital world's impact on the environment. This has become a topic of public debate in many countries. After years of denial, the impact of digital technology on the environment is now recognized as a significant research issue, including the environmental impact of technology production, and the energy required to use digital services and end-of-life analysis of equipment. The so-called „Deep learning" is no exception to these concerns. More precisely, due to the large amount of data and computing power required for „deep learning", which has a significant impact on the environment, these increasing demands on computing power also contribute to the obsolescence of hardware and software (Pachot & Patissier, 2022).

Future directions for the development of the regulatory framework should be aimed at a balance between innovation support and ecosystem protection. Properly defined guidelines will enable the achievement of that goal, while simultaneously supporting environmental goals and ethical implementation of VI. The implications of this regulatory framework include improving the monitoring of environmental processes, accelerating the response to environmental crises, and supporting sustainable technological innovation.

The regulatory framework for the application of artificial intelligence in environmental protection is a key factor in achieving a balance between technological progress and environmental responsibility. We will highlight the need for comprehensive and up-to-date guidelines that will guide organizations, researchers and practitioners towards the ethical and efficient use of VI in order to achieve environmental goals.

CASE STUDIES AND ANALYSIS OF THE RESULTS OF QUALITATIVE RESEARCH ON THE APPLICATION OF ARTIFICIAL INTELLIGENCE IN ENVIRONMENTAL PROTECTION

Today's world faces complex challenges in the field of environmental protection, requiring innovative and effective approaches to solving problems such as climate change, biodiversity loss and pollution. In this context, artificial intelligence (AI) provides significant opportunities to analyze and solve these problems. This scientific paper explores several case studies that illustrate the appli-

cation of artificial intelligence in environmental protection, analyzing how these innovations contribute to environmental conservation.

1. Monitoring of forest ecosystems

One of the key elements of environmental protection is the monitoring of forest ecosystems. Through the analysis of satellite images, deep learning techniques are applied to recognize changes in vegetation, detect deforestation and assess forest health. This enables a quick response to illegal logging and protects biodiversity. The case study illustrates how VI can improve the monitoring and response to changes in forests, thereby preserving a vital ecosystem component.

2. Prediction of natural disasters

Predicting natural disasters, such as floods and fires, is crucial to preventing loss of life and environmental damage. By combining VI and big data analysis, algorithms can identify patterns that indicate possible disasters. This technology enables early intervention and effective risk management, contributing to ecosystem preservation.

3. Preservation of biodiversity

Preservation of biodiversity is a key goal of environmental protection. VI is used to analyze genetic data and identify endangered species. In addition, machine learning techniques enable the identification of habitats that need to be protected. Through a combination of population and habitat data, VI helps make informed decisions about concrete measures to conserve biodiversity.

4. Effective use of resources

Optimal use of resources is key to sustainability. VI is applied in the analysis of consumption of water, energy and other resources. Algorithms analyze consumption data and identify areas where waste can be reduced and resources managed more efficiently. The case study illustrates how VI can help to use resources sustainably, thereby reducing the negative impact on the ecosystem.

The case studies we have presented clearly indicate a wide range of applications of artificial intelligence in environmental protection. Through techniques of data analysis, deep learning and machine learning, AI enables a better understanding of the ecosystem and a faster response to changes. However, it is important to point out that with technological progress comes the responsibility to use AI in an ethical and transparent manner, in accordance with laws and guidelines, in order to achieve sustainable environmental goals.

Contemporary challenges in the field of environmental protection require a comprehensive and innovative approach to solving problems such as climate change, biodiversity conservation and sustainable resource management. Artificial intelligence (AI) is increasingly recognized as a key tool for achieving these goals. It is primary to investigate and analyze the results of qualitative research, which deal with the application of artificial intelligence in environmental protection, in order to gain a deeper understanding of the effectiveness, challenges and implications of these innovations.

Analyzing qualitative research on the application of VI in environmental protection requires a variety of methods, including document analysis, case studies, and content analysis. Such approaches enable understanding of the context, in-depth exploration of experiences and perceptions, as well as identification of key challenges and benefits of VI implementation.

Qualitative research shows that the application of VI significantly improves the efficiency of monitoring ecological processes. Techniques of data analysis and image processing enable precise monitoring of changes in forests, assessment of water quality and identification of invasive species. Experts point out that AI is used to quickly identify samples that would take humans much longer to analyze, saving time and resources.

The results of the research highlight the challenges related to transparency and ethics in the application of VI in environmental protection. Experts point to the need for clear guidelines and an ethical framework for data collection and use. Issues of privacy, liability and the right to access information are becoming more complex with the ubiquitous use of technology.

The research itself also indicates that AI can improve decision-making and planning processes in environmental protection. Data analysis enables the identification of patterns and trends that help create effective strategies for resource management, habitat protection, and environmental disaster prevention.

Through the analysis of the results of qualitative research, the implications for the future of the application of VI in environmental protection are clearly recognized. There is a need for further research to understand the long-term effects and potential risks of using this technology. It is also important to develop educational programs to train professionals for the ethical and responsible application of VI in their fields.

The results of qualitative research emphasize that the application of artificial intelligence in environmental protection is crucial for the effective manage-

ment of environmental challenges. However, challenges related to transparency, ethics and long-term effects require careful consideration. Qualitative research plays a vital role in understanding how VI contributes to environmental conservation and how it can be improved to achieve sustainable and ethically responsible progress.

CONCLUSION

The application of artificial intelligence (AI) in the field of environmental protection has enormous potential to transform the way we face environmental challenges. This discussion segment explores the key points and implications of applying VI in environmental protection, including benefits, challenges, and ethical aspects.

Application VI brings a number of advantages in the field of environmental protection. Primarily, VI enables faster and more accurate analysis of large amounts of data. It is crucial for monitoring climate change, detecting deforestation, identifying invasive species and other ecological processes. Also, VI can improve the efficiency of resource use, enabling sustainable management of water, energy and other resources.

However, with this progress comes challenges. One of the key challenges is the issue of ethics and transparency in the collection and use of data. Unclearly defined ethical guidelines can lead to data misuse and compromise privacy. Also, there is concern that excessive use of VI could replace human engagement and decision-making, which could lead to the loss of the human dimension in environmental protection.

Despite the challenges, the potential of applying VI in environmental protection for the future is encouraging. VI can accelerate the identification of key issues, provide better predictions of environmental change and enable informed decisions. If applied ethically and responsibly, AI can be a powerful tool for achieving sustainability and environmental preservation.

Assessing the potential of artificial intelligence applications in environmental protection, AI has the ability to transform the way we collect, analyze and use data for environmental protection. However, it is crucial to approach it with responsibility and attention to ethical and transparent guidelines. The integration of AI with human knowledge, ethics and practices can create a harmonious relationship between technological progress and environmental protection. This

relationship is key to achieving a sustainable future and leaving behind a clean, healthy and prosperous planet for generations to come.

However, the application of artificial intelligence in environmental protection requires careful consideration of ethical issues, as well as the establishment of a regulatory framework that guarantees responsible and ethical application. This paper highlighted the need for further research and development of artificial intelligence technologies in order to improve the ecological situation.

Taking into account the positive and negative aspects of the application of artificial intelligence in environmental protection, we conclude that this technology will play a significant role in solving environmental problems in the future and that it is necessary to approach this topic in a systematic and ethical way.

The conclusion of this scientific work is that the application of artificial intelligence in environmental protection and preservation can have significant socio-marketing effects and the potential to accelerate the resolution of environmental problems. The sociological aspects of the application of artificial intelligence can contribute to greater awareness and engagement of the public in environmental protection, while the marketing aspects provide the opportunity for personalized campaigns and targeted advertising.

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FORMS OF THE PRESERVATION OF MARITIME HERITAGE: THE HOTEL AND PASSENGER SHIP "SVETI STEFAN"

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ABSTRACT

Maritime heritage, intertwined with maritime history, is deeply woven into the cultural identity of the peoples of the countries that safeguard the maritime tradition. This includes artefacts such as vessels, maritime archaeological sites, characteristic maritime routes, archival documentation of vessel construction, documents on the navigational skills of seafarers, ship logs, navigational autonomy, etc. Preservation of maritime heritage is of exceptional importance from an archaeological, cultural-historical, and socio-economic point of view. Maritime museums around the world represent cultural-historical, strategic, educational, and touristic elements in the milieu of various museum collections.

Possible forms of preservation of maritime heritage, as different architectural compositions that enable the lifespan of vessels to be extended, provoke unfettered design freedom when shaping the limited ship space, and come to the fore in contents such as an anchored hotel ship or a museum ship on land, as well as a ship with defined navigation autonomy.

This paper presents the following projects: *The hotel ship Sveti Stefan (anchored)* and *The interior of the passenger ship Sveti Stefan (with a 20 day autonomy of navigation)*. both created on the foundations of the bed of the eponymous ferry, which for decades connected the coasts of the SFRY and Southern Italy. Naval architectural compositions are based on shaping the form of ship elements in the function of the ship's interior, and the project of *the interior of the passenger ship* was carried out according to the valid rules and regulations in the shipping industry, SOLAS and Jugoregistar.

Keywords: Maritime heritage, hotel ship, maritime museum, naval architectural composition, ship interior.

INTRODUCTION

Maritime heritage presents an indispensable building block of the cultural identity of the people of those countries which have a maritime tradition. A large number of countries preserve their autochthonous cultural heritage assets on maritime archaeological sites, or the navigable objects themselves.

„Evaluation of architectural heritage (valorisation) is the definition of value based on criteria such as: cultural-historical, architectural (meaning the history of architecture) and independent visual-perceptual" (Ljubenov, 2020, p. 299). Thus, the preservation of maritime heritage, whether it is about navigation in saltwater or freshwater (river or sea navigation), is of exceptional importance from an archaeological, cultural-historical, socio-economic point of view. Traditional heritage also includes things such as certain shipping lanes, archival documentation from the very stage of ship construction in the shipyard to preserved documents on the navigational skills of seafarers, of ship's logs, on navigation autonomy, on the authority of the ship's captain, etc.

Types of preservation, i.e. the way in which the heritage will be preserved depends on the object of protection and the condition of the artefact. Preservation methods treat artefacts whether they are static or objects in a navigable state, in the form of: museum ships, hotel ships or ships that sail short distances. Such an approach guided the author in choosing the ferry *"Sveti Stefan"* , for which, during the last years of its navigation experience, feasibility studies were carried out with the aim of extending its exploitation. During the course of 1991, a solution was presented, first in the form of *The Hotel Ship Sveti Stefan,* where the object would be located on the berth in the port, and later through the study: *The Interior of the passenger ship Sveti Stefan,* a ship that sails short distances, with a maximum of 20 days of navigational autonomy.

EXAMPLES OF ARTEFACTS OF NAVAL HERITAGE

MARITIME MUSEUMS

Among the oldest maritime artefacts is the „Solar" ship from the period of the Egyptian pharaoh Cheops (2589 - 2566 BC), located in the Great Egyptian Museum in Cairo (Fig. 1). The boat „Nydam" (310 - 320 AD), one of the forerunners of Viking ships, found in 1863 at the site of Midam Mose - Denmark, exhibited in the Gottorf Castle in Schleswig, Germany (Fig. 2).

The Viking ships Gokstad (Fig. 3) and Oseberg (Fig. 4). are the national symbols of Norway, and housed in the Viking Ship Museum[4] in Oslo.

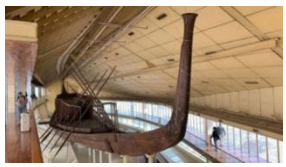

Figure 1 Solar ship of Pharaoh Cheops, Cairo

Figure 2 The boat Nydam, Gottorf Castle, Schleswig

Figure 3 Viking ship Gokstad, Oslo

Figure 4 Viking ship Ossenberg, Oslo

Among the most famous museums are the Titanic Maritime Museum in Belfast, Ireland, which preserves in its premises the story of the Titanic, which sank on its first voyage in 1912 in the Atlantic Ocean[5], as well as the Naval Museum[6] in Madrid from 1842, the national museum of Spain, which presents the history of the Spanish Navy from the 15th century to the present day. Like the Vasa museum in Stockholm, it was named after the Vasa ship of the same name (Fig. 5), which capsized and sank in Stockholm in 1628. on its first run 10 minutes after launch.

Figure 5 The ship Vasa, Stockholm

Figure 6 Cutty Sark, Greenwich

4 https://kasadoo.com/sr/norveska/oslo/muzeji/muzej-vikin%C5%A1kih-brodova; https://www.khm.uio.no/english/visit-us/viking-ship-museum/

5 https://www.titanicbelfast.com/

6 https://www.google.com/search?q=Mueso+Naval+u+Madridu&rlz=1C1GCEA_enRS887RS887&oq=Mueso+Naval+u+Madridu+&aqs=chrome..69i57j33i10i160l2j33i22i29i30l7.918j0j15&sourceid=chrome&ie=UTF-8

The National Maritime Museum from 1934, in Greenwich, United Kingdom[7], belongs to the group of Royal Museums, which, in addition to the Queen's House and Observatory, also includes the Cutty Sark, a tea clipper that transported tea from China to England in the mid-19th century. Since the middle of the 20th century, repaired and revitalised, it has been turned into a museum ship, so that the deck of the ship (superstructure) is free, and the ship's waterline is trapped in a metal and glass building, architecturally integrated around the ship's circumference (Fig. 6).

In the territory of Montenegro, Ex Yugoslavia, in Kotor, in the old town, in 1938, the notable Maritime Museum was established, and the Collection of Maritime Heritage, where the P-821 „Heroj" submarine is an open-air exhibit, is available for tourists to visit (Fig. 7)[8] in Tivat.

Figure 7 The submarine P-821"Heroj" Tivat, Montenegro

Figure 8 "Old Ironsides", the USS Constitution, USA

EXAMPLES OF MUSEUM SHIPS IN SEAWORTHY CONDITION

"Popularan pod nazivom "Old Ironsides", USS Constitution je stari brod, koji pripada mornarici SADa, najstariji je drveni brod na svetu, koji je još uvek u plovnom stanju (Sl. 8). Porinut je u vodu davne 1797. godine. Danas je ovaj brod školski, naučni, istorijski i muzejski brod,a njegov cilj je da učestvuje u javnim ceremonijama, gde za te prilike, demonstrira vožnju i naoružanje koje se koristilo nekada, da organizuje obrazovne programe, za decu, đake i student, ali i za

Popularly called „Old Ironsides", the USS Constitution is an old ship belonging to the US Navy, the oldest wooden ship in the world which is still in seaworthy condition (Fig. 8). It was launched back in 1797. Today, this ship is a school, scientific, historical and museum ship, and its goal is to participate in public ceremonies, where for those occasions, it demonstrates driving and weap-

7 https://sh.wikipedia.org/wiki/Nacionalni_pomorski_muzej,_Greenwich

8 https://www.portalanalitika.me/clanak/230474-zbirka-pomorskog-nasljeda-tivat

ons that were used in the past, to organise educational programs for children, pupils and students, but also for adults."[9]

A similar example is the ship „Galeb or the Ship of Peace, built in 1938, which served as a training ship of the Yugoslav Navy and the residence yacht of the President of the SFRY, Josip Broz Tito (Fig. 9a)." In October 2006, it was declared a cultural property of the Republic of Croatia, and in 2019 it is being renovated with the aim of creating the Peace Museum Ship, on the berth, with the purpose of a permanent museum with occasional exhibitions, and a cinema, but also for commercial purposes - a hostel, a bar/restaurant, a souvenir shop (Fig. 9b)."[10]

Figure 9a The ship Galeb, SFRY

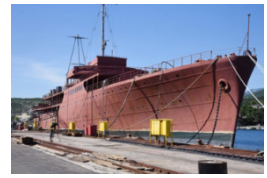

Figure 9b Galeb during restoration

Figure 10 River museum boat Sava, Serbia

The river monitor „Sava" was made for the Austro-Hungarian Navy (Fig. 10), and in the period from 1920 to 1941, it was owned by the Royal Yugoslav Navy. The turbulent history of the ship, which was sunk 3 times and during the First World War served in battles against the Serbian army, was decommissioned in the middle of the 20th century. It was listed as a natural asset of the Republic of Serbia in 2006, and after restoration, it was turned into a museum ship and open to visitors from 2021.[11]

9 https://en.wikipedia.org/wiki/USS_Constitution; https://kasadoo.com/sr/amerika/boston/muzeji/brod-muzej

10 https://www.fiuman.hr/otkriven-detaljan-plan-za-brod-galeb/

11 https://www.novosti.rs/c/beograd/vesti/1131999/brod-muzej-atrakcija-turiste-svedok-burne-istorije-monitor-sava-ukotvljen-ispod-brankovog-mosta-svakodnevno-docekuje-posetioce; https://sr.wikipedia.org/wiki/%D0%9C%D0%BE%D0%BD%D0%B8%D1%82%D0%BE%D1%80_%D0%A1%D0%B0%D0%B2%D0%B0

CASE STUDY

THE FERRYBOAT "SVETI STEFAN"

The trough of the Sveti Stefan Ferry served as an example for the preservation of maritime heritage.

The vessel Sveti Stefan was designed in 1954. in the Aalborg shipyard, Denmark, under the name Djursland, and it was laid down in 1957. In May 1965, it was transferred to the ownership of the Prekookeanska plovidba Bar company, where it will sail for about 30 years on the route between Yugoslavia and Italy, i.e. on the Bar-Bari ferry line. At the end of 1999, the ship ended its lifespan (it was turned into 1200 tons of scrap metal). Its technical characteristics are as follows: Overall length of the ship - 81.10 m'; Length of the ship along the waterline - 73.80 m'; Width of the ship along the main rib - 14.00 m′; Ship's draft - 3.80 m'; Performance: Movement speed -18 knots; carrying capacity-(1640) 1618 GRT. Ship capacity: 1100 passengers in local traffic, or 650 in international traffic. It had 130 beds with 95 spaces for vehicles.[12]

Figre 11 The Sveti Stefan ferry on the bert - Bar harbour, Montenegro

THE HOTEL SHIP "SVETI STEFAN"

Figure 12 Plan of the 2nd subdeck

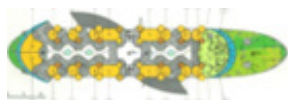

Figure 13 Plan of the 2nd deck

Figure 14 Side view of the ship

The functional organisation of the vessel is subject to the rules of designing hotel content on land, given that the hotel ship is not intended to be in a navigable condition (ie. to be on the berth). The two levels of the forecourt are designed as a space that serves and supports the ship's logistics: facilities for food preparation and storage, service activities, promenades with shops, pastry

12 Documentation taken from the Prekookeanska plovidba Bar company in 1989

shops, bars, etc. In the superstructure, on the level of the 1st and 2nd decks, there are residential units, i.e. apartments, of different structures, on the level of one deck, or duplexes on two decks. Since the ship has three decks, on the 3rd deck, there are recreational facilities, swimming pools, bars, as well as the existing command bridge. From an organisational point of view, the ship is serviced by the crew, which is stationed in the cabins of deck 1, as well as a large number of employees, who, on a shift basis, provide services to guests, while staying outside the ship.

THE PASSENGER SHIP "SVETI STEFAN"

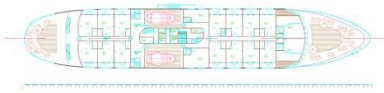

Figure 15 Basis 2.
Deck of a passenger ship

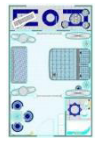

Figure 16 The basis of the Apartment

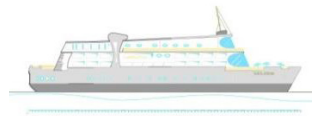

Figure 17
Side view of the ship

The passenger ship „Sveti Stefan" is intended for cruising in coastal and river waters. Travel autonomy ensures a pleasant stay on the ship for passengers, which implies that, when the ship is at full capacity, its survival on the water, without docking in the port, can withstand a period of time lasting 20 days.

The accommodation capacity of the ship is: 101 beds (32 apartments in total). The ship's crew consists of a total of 77 members. The total area of the ship - the net area is 3,640.53 m2, distributed over three decks and two levels in the ship's waterline. A functional organization is conditioned by the purpose itself. Taking into account that there are two groups of passengers: crew and passengers - guests, care was taken to ensure that the walking lines do not cross, especially those technical roads related to the maintenance of the ship's navigable functions.

DISCUSSION

These two variants of developing a vessel are used as examples of how to approach the preservation of maritime heritage while fulfilling the necessary measures that provoke the imagination of designers and builders. In the case of the hotel ship, the requirements were met that the ship be docked, that the total square footage be used to the maximum, and that it be used for everyday visitors,

as well as those who use hotel services. The command bridge with complete equipment, the devices on the ship are authentic, which represents a permanent museum display.

The requirements for a sailing ship are more substantive and expansive, so the second solution was made according to the rules and regulations in shipping (Solas, Lojd, Jugoregistar). With an acceptable level of depreciation, and looking at the further exploitation of the vessel, under the condition of passenger safety, the author saw the possibility of sailing St. Stefan on short distances for some time.

CONCLUSION

By creating the above-mentioned possibilities for further modifications to the vessel, whether the vessel is docked, in seaworthy condition or as a museum collection, the multifaceted importance of the sustainability of the cultural heritage for future generations is realised. One of the important motives is to save from oblivion one of the most famous vessels that represented the pride of Yugoslav shipping, and at the same time to bring engineering shipping closer to the future reader in the form of virtual waterborne compositions, which, with an accent on the interior design, establish a synthesis of the unity of the ship's space, through forms and shapes of ship elements.

Comparing maritime heritage with immovable cultural assets built on land, a conclusion emerges that points to the complexity of preserving vessels, which have an unenviable degree of depreciation or even damage (in relation to houses, buildings), considering that they are under the constant influence of water in which they sail. Masters, shipbuilders reach for new solutions, new technological achievements, building on the existing ones. In addition to the mentioned, cultural-historical point of view, and from the socio-economic aspect, this study would serve future generations of researchers to provide concrete examples, by revitalising old vessels into potential cultural assets, to provide affirmative tourist attractions at the national level.

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DETERMINATION OF TRACES OF PSEUDO-CONTENT OF THORIUM, URANIUM AND THALLIUM IN SOIL BY ICP-MS METHOD

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ABSTRACT

The contens of less abundant heavy metals such as thallium, uranium and thorium was examined in different soil samples of the northern part of Kosovo and Metohija. In this work the concentrations of Th, U, Tl in soil samples were determined by the ICP-MS metod. Range of concentrations of those determined toxic elements were: tallium (Tl) 0,96-23,86 mg/kg, thorium (Th) 8,25-18,89 mg/kg and uranium (U) 0,74-2,68 mg/kg. The samples were recorded on ICP – MS (ICP-MS, iCAP Qc, Thermo Scientific, UK) instruments. Elemental analysis of soils could provide information about the state of the pollution. 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: heavy metals, thallium, uranium, thorium, soil, pollution

INTRODUCTION

In the modern age, along with the development of nuclear technology and nuclear weapons, depleted uranium is becoming an increasing subject of discussion among scientists in the world whose activity is dedicated to this scientific field. *Uranium* (U) and *thorium* (Th) are naturally occurring radioactive elements widely distributed in the lithosphere as well as stratosphere. Their content in soils depends especially upon geological conditions, but may be influenced by nuclear accidents (Xu, 2002a) Uranium up-take is highly dependent on soil pH and depends on the content of organic compounds in soil because of their ability to influence the mobility of U in soil (Bednar, 2007). The most mobile are U(VI) salts, as predominantly UO_2^{2+} (Grenthe,1992) and carbonate complexes other

forms are less bioavailable and remain in bound to soil particles. The danger to humans from uranium and thorium is multiplied by the radioactive effects of their decay products, especially radium and radon. Uranium is very widespread in nature and is considered to be in the lithosphere on average, 0.5-5 g of elemental uranium comes to one ton of soil. It is present in various minerals and is also found in sea water. Uranium occurs in nature in the form of three isotopes - $_{92}U^{238}$ (99.28%), $_{92}U^{234}$ (0.006%), $_{92}U^{235}$ (0.72%). Its compounds, both highly mobile (soluble) and relatively inert (insoluble), are found in the environment and in very small amounts in the human body. The transfer factor depends on radionuclides, migration routes, metabolic, physical and chemical parameters, while the „dilution" factor includes both physical and biological half-life.

Research on the content of radionuclides in the environment, the environment and the organism, includes the collection of samples of air, water, soil, food, tissue and excreta, and the main ways of exposure of the population to the effect of radiation from the environment are inhalation and ingestion. Inductively coupled plasma mass spectrometry (ICP-MS) has the potential to be an ideal tool for precise, accurate, and rapid determination of REEs, Th and U, and much effort has been expanded recently in environmental analytical chemistry to optimise multi-element ICP-MS technique.

However, heavy metal pollution of the soil is caused by various metals, especially Cu, Ni, Cd, Therefore, heavy metals are considered as one of the major sources of soil pollution. 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).

Thallium (Tl) is a soft, bluish-grey, malleable heavy metalloid that was discovered in 1864 by Sir William Crookes. It is not a rare element; it is 10 times more abundant than silver. This metalloid occurs mainly in association with potassium minerals such as sylvite and pollucite in clays, soils and granites. Thallium minerals are well-known to they are rare, but a few are known, such as crookesite, lorandite, christite, avicennite, ellisite, or sicherite. They contain 16-60% thallium, namely as sulphides or selenides in complexes with antimony, arsenic, copper, lead and silver (Anderson, 1999). Thallium is not an ubiquitous element and is itself very toxic – its salts are considered to be the most toxic compounds known. Thallium sulfate is used for rodent control, but is banned in many countries due to its toxicity. However, it is still widely used in South America and Asia. According to estimates by the United States Geological Survey (USGS), based on research into the content of thallium in zinc and iron ores, the world's thallium resources for these ores are around 17 thousand tons.

Research and discovery of the beneficial properties of thallium further increased its use.

The results of a study on the spatial distribution of toxic elements in Kosovska Mitrovica region, in north Kosovo are reported,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 uncul-tivated soil was sampled. 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 systema- 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 obtai ned by wet acid decomposition in a closed system (reflux) with the addition of hydrogen-peroxide (30%) (USEPA 1996).

Instrumentation and Reagents

The samples were recorded on 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 Wasseraufbere-itungssysteme 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; Se- lenium 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 Table 1. Obtained concentrations of the elements determi-ned in the soil samples are presented in Table 2. The highest concentration of thallium is found in the Pirit- Žitkovac,the lowest concentration of this element is present in the Landfill-Lešak. The limit value of thallium in the soil is 1 mg/kg, and the remediation value is 15 mg/kg. We conclude that the obtained values are lower than the remediation values, which means that thallium is not present in a very large and critical quantity for the quality of the soil.

The highest thorium concentration present in the Pirit-Žitkovac, the lowest concentration of this element is present in the Landfill-Lešak. Also here, the concentration of thorium is very low, which does not pose a risk of large soil pollution with this element.

The concentration of uranium is the highest in the Pirit-Žitkovac while the lowest concentration of this element is present in the Landfill-Lešak. And here we see that the values of this element are low, which means that the soil in our area is not polluted by these elements to a large extent.

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

Element	**Tl**	**Th**	**U**
LOD (ppb)	0.00052	0.000561	0.00038
LOQ (ppb)	0.001732	0.00187	0.001267

Table 2 Concentrations of the elements determined in the soil samples

Samples	Tl (mg/kg) (RSD%)	Th(mg/kg) (RSD%)	U(mg/kg) (RSD%)
Trepča 1	5.47 (0.43)	10.29 (2.58)	0.75 (4.16)
Trepča 2	5.86 (2.51)	10.05 (1.94)	0.74 (1.89)
Pirit-Žitkovac 1	23.31 (2.23)	8.25 (2.19)	1.49 (0.17)
Pirit-Žitkovac 2	23.86 (2.97)	8.99 (3.83)	1.68 (2.39)
Landifill-Lešak 1	4.13 (1.90)	11.79 (2.37)	2.52 (0.94)
Landifill-Lešak 2	2.72 (1.24)	14.48 (0.91)	2.68 (1.37)
Road/Lešak-Kosovska Mitrovica	1.26 (3.96)	18.89 (2.15)	2.60 (1.46)
Road/Lešak-Kosovska Mitrovica	0.96 (2.07)	16.59 (1.28)	2.29 (1.51)

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

CONCLUSION

In this work, the content of thallium, thorium and uranium in soil samples from the territory of Kosovo and Metohija was determined. By comparing the obtained results, it can be determined that the concentrations of these elements vary depending on the sampling location. Based on the obtained results, it can be concluded that different types of pollution sources affect soil and environmental pollution, such as for example: industrial sources, mines, smelters and even man himself. It is necessary to constantly monitor the values of these toxic elements in order to improve the quality of the environment and to fully preserve the health of living beings, which is the contribution of this paper.

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ESTIMATION OF THE FOREST VEGETATION REFLECTANCE BASED ON SPECTRAL MEASUREMENTS

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Abstract

Monitoring forests with satellites, remote sensors, and terrestrial measurements is active due to the woods' considerable ecological and economic importance. Our study focuses on the reflectance of coniferous and deciduous forests using data from spectroradiometer measurements made in the electromagnetic spectrum (EMS). Cubic splines are used to create continuous, smooth curves that show the reflection of forest vegetation. The representation of the center reflectance values and comparison with the corresponding mean reflectance values provided by the spectroradiometer used interval mathematics. The correlation between the reflectance of forest vegetation was considered. This paper presents the results of measuring the ambient reflection of deciduous and coniferous forests with a spectroradiometer to present a mathematical model of forest reflection analysis that facilitates the classification of forests and, based on the range of reflection, assesses the forest health status.

Keywords: Spectral measurement; Reflectance; Cubic spline, Estimation, Forest

INTRODUCTION

The mapping of forests is done in multiple studies using digital data from satellite and aircraft sensors (Kraus 1993, 2007). The development of information and communication technology (ICT) over the past few decades has made it possible to map and categorize vegetation. The variety of tree species is an im-

portant aspect of describing forest ecosystems. Airborne laser scanning (ALS) and terrestrial laser scanning (TLS) received a lot of interest as quick and effective technologies for estimating forest structure attributes (Liu et al., 2017). An essential element in natural resources management, the vegetation of the terrain (landscape classification) varies in its reflection. There are a growing array of techniques (neural networks, artificial neural networks, support vector machines, and logistic regression) for automatically identifying the type of landscape (Stević et al., 2016).

The area where the forest reflection is measured is between 43°16'30'' north latitude and 20°00'00'' east longitude in the southwestern part of Serbia. This area is very heterogeneous, considering the influence of various natural conditions and historical factors. The wealth and diversity of flora are shown through the relation of flora and the surface of the territory and amounts to 0.993, which is significantly above the values for Serbia, Bosnia and Herzegovina 0.759, Montenegro 0.844, Albania 0.780, Bulgaria 0.704, Romania 0.657, Italy 0.684, and Britain 0.601.

Forest photoelectric processes and the growth and production of a particular kind of vegetation are impacted by solar radiation. The relationship of reflection degree $\rho(\lambda)$, the absorption degree, $\alpha(\lambda)$ and the transmission degree $\tau(\lambda)$ of the solar radiation is defined by the equation: $\rho(\lambda) + \alpha(\lambda) + \tau(\lambda) = 1$.

The thickness, spatial distribution, and orientation of leaves all affect how much light they reflect in the spectral range. Thick leaves in the EMS's visible region are better at absorbing solar energy. In damaged leaves, the visible part of the EMS (400-700 nm) exhibits a change in the degree of reflectance, and in particular, the red section of the EMS (620-700 nm) indicates an increase in the degree of reflectance. Understanding broad principles of solar energy assimilation and photosynthetic processes in forest leaves requires careful consideration of the optical characteristics of leaves and radiation absorptions. Most solar radiation that hits the leaf is reflected, a part passes through, and a portion is absorbed. Different spectral bands of light are absorbed in the leaf in different ways. The most significant impact on leaf pigments is caused by sun radiation's contact with forest leaves. TLS can enable the outstanding assessment of the three-dimensional structure of vegetation canopies. The techniques could help determine the health of the forest and map deteriorated trees based on TLS readings. To assess the effects of climate change on forest health and to provide training data for airborne or space-borne remote sensing measurements, more precise data on the condition of the forest should be made available and employed in

research (Ramirez et al., 2013; Garcia et al., 2011). Scientists and academics have been developing numerous precise methods for measuring reflectance for years (Olpenda et al., 2018).

MATERIALS AND METHODS

Focussing on the use of hyperspectral images in research, particularly on the classification and mapping of soil and vegetation use, the development in sensor technology over the past two decades has made it possible to collect several hundred spectral ranges.

Several steps make up the study: measuring reflectance, gathering discrete data, developing a mathematical model, and presenting the reflectance of the forest vegetation using a cubic spline, as in Figure 1.

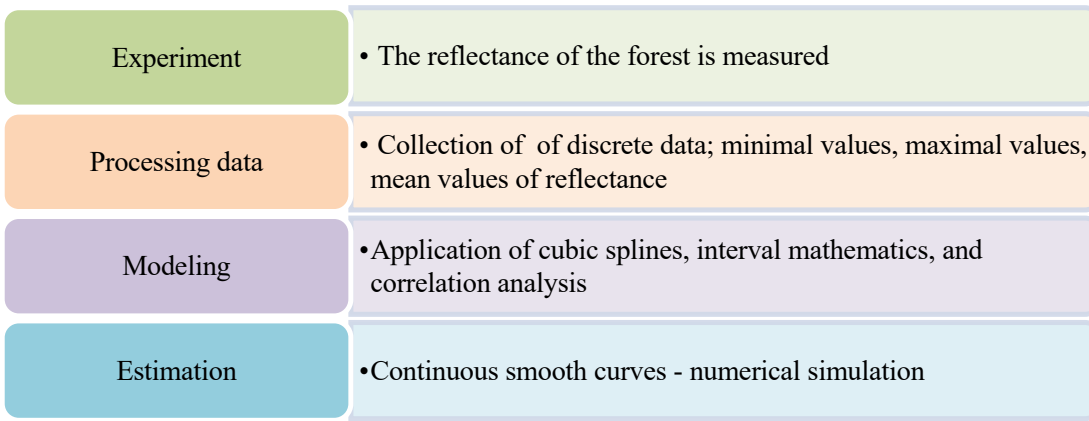

Figure 1. Research methodology

The study's objectives include determining a continuous smooth curve that passes to the discrete data acquired in the visible portion of the EMS, measuring forest reflectance using actual field measurements, and drawing inferences about the forest's health.

Since the data obtained by measuring are discrete, that is, given as an ordered pair of wavelength and reflectance values in percentages, to construct a continuous smooth curve, we assume that, for function f, we have values in points x_0 and x_1. Let us assume that for the function f in the points x_0 and x_1 ($h = x_1 - x_0$) the known values are:

$f(x_0) = f_0, f(x_1) = f_1,\ f'(x_0) = m_0,\ f'(x_1) = m_1,\ f''(x_0) = M_0,\ f''(x_1) = M_1.$

The cubic splines are used in the simulation of the reflectance curve forest derivated on the basis of equation:

$s_i(x) = f_{i-1} + (x - x_{i-1})\left(\frac{1}{h}(f_i - f_{i-1}) - \frac{1}{6}(M_i + 2M_{i-1})h\right) + \frac{1}{2}M_{i-1}(x - x_{i-1})^2 + \frac{1}{6h}(M_i - M_{i-1})(x - x_{i-1})^3$.

The reflectance values are measured at various intervals, and mathematical analysis of the derived mean reflectance value shows that the values are closer to the minimum. It is necessary to locate the center value as the center of the interval to find the central magnitude of the reflection. Interval on a real axis, with the center $c = \text{mid}\, I$ and the radius $r = \text{rad}\, I$, $I = \{x:|x - c| \leq r\}$, can be denoted symbolically with $I = \{c;r\}$. More about interval arithmetic properties can be found in (Petković et al., 2005, 2006, 2011). Using these properties, based on the given discrete values, we can find interval centers of minimum and maximum reflectance.

RESULTS AND DISCUSSION

Some of the results of forest reflectance measurements with a spectroradiometer are in Table 1. When measuring the reflectance, the weather was stable, without wind, and the intensity of natural light was uniform. The measurements were taken around noon, from 10 a.m. to 2 p.m., lasting 15 minutes. The spectroradiometer view of the forest is chosen so that the sun is behind the operator's back, so the view and the sun's rays are in one vertical plane (Mi lošević et al., 2020).

Table 1 involving: λ- wavelength (nm); measured reflectance values (%); Mean – the mean value of the forest (%); Max – maximum measured values of the forest (%); Min – minimum measured values of the forest reflectance (%).

Table 1. The measured reflectance values in percentages %, according to the wavelengths λ, for the forest environment of the EMS

	Beech			Oak			Birch			Acacia		
λ (nm)	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min
400	4.8	10.7	1.5	4.2	11.4	0.7	2.8	1.3	5.3	5.9	1.9	10.3
420	6.5	15.5	2.0	5.2	13.9	1.0	3.5	1.4	6.7	6.3	2.0	11.6
440	6.3	12.8	2.8	5.5	14.1	1.0	4.0	1.8	7.4	6.4	2.3	9.9
460	6.3	12.2	3.0	5.4	14.3	1.1	4.1	2.0	7.8	5.9	2.8	8.9
480	6.1	11.4	3.8	5.1	12.4	1.2	4.2	2.0	7.6	5.4	2.6	7.9
500	6.0	9.7	4.1	5.0	11.4	1.5	4.2	2.2	7.5	5.9	2.7	9.5
520	9.5	15.9	5.8	6.6	18.3	2.1	5.7	3.0	10.6	7.1	4.4	9.9
540	13.2	24.3	7.6	7.8	16.8	2.4	7.1	4.0	12.1	9.8	4.2	19.5
560	14.9	28.2	7.4	8.1	18.2	2.3	8.2	4.4	12.3	9.6	3.1	18.1
580	11.0	22.6	6.2	6.8	13.5	1.9	6.1	4.0	10.0	7.8	2.7	14.7
600	9.8	20.4	5.2	6.3	12.6	1.6	5.4	3.4	9.5	6.9	2.3	12.0
620	8.2	17.7	4.1	5.5	12.0	1.2	5.0	3.3	8.9	6.3	2.0	9.6
640	7.3	16.2	3.2	5.5	11.1	1.2	5.0	3.0	9.0	6.2	1.6	8.8
660	6.0	11.0	4.0	5.1	10.6	1.3	4.8	3.6	8.0	5.5	1.8	7.8
680	7.4	10.0	4.1	7.3	19.8	1.5	5.9	3.2	7.8	6.9	2.7	17.8
700	15.1	20.8	11.6	11.2	24.5	1.5	8.5	7.4	9.6	13.4	5.3	19.6

Based on the measured reflectance values, a cubic spline are constructed. Also, the central values of the reflectance are calculated, and the graphic curves of reflectance are drawn, Figure 2.

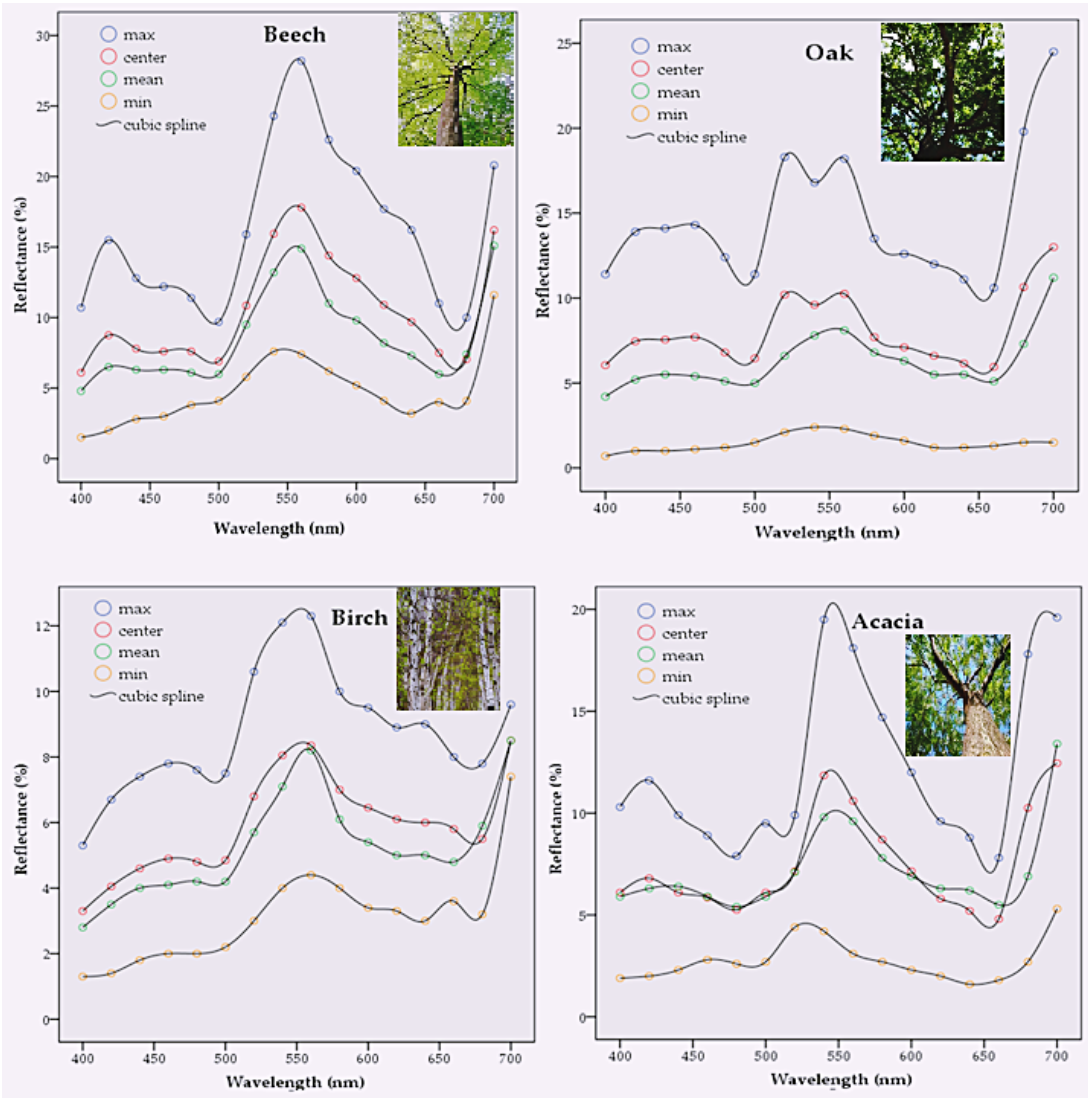

Figure 2. Approximation wave range of some forest vegetation reflectance by cubic spline.

The cubic spline yields a curve representing the central mean value meanings of the reflectance, central interpolation curve. We can see that there is little difference between the mean and center value curves. The mean reflection of the instrument has a lower value than the calculated center value because the reflectance measurement was performed in a wider time interval, while the curve of the central reflection divides the minimum and maximum range in half. The model makes it possible to monitor the health of forests by measuring reflection rather than viewing the natural environment. Healthy plants have a lower reflec-

tance in the visible part, unlike stressed ones. For wavelengths greater than 700 *nm*, healthy plants have a higher reflectance than diseased ones. Drawing a graph of the reflectance curve can thus answer the health status of the forest.

Table 2. shows the values of reflectance for some coniferous forest for visible part of the EMS.

Table 2. The measured reflectance values in percentages %, according to the wavelengths λ **(***nm***)***, for coniferous forest ambiences: black pine, fir tree, spruce for visible part of the EMS*

λ	**400**	**420**	**440**	**460**	**480**	**500**	**520**	**540**
Mean	2.6	3.3	3.7	3.7	3.5	3.7	4.8	5.9
Max	9.5	10.4	10.3	13	11.1	12	15.6	19.1
Min	0.1	0.6	1.0	1.0	1.0	1.2	1.6	2.0
λ	**560**	**580**	**600**	**620**	**640**	**660**	**680**	**700**
Mean	6.1	5.3	4.9	4.5	4.0	4.1	4.9	8.1
Max	20.5	18.5	18.1	16.5	16.6	14.5	14.2	28.3
Min	2.4	2.2	2.2	1.6	1.0	1.0	1.0	1.7

Healthy forests have less reflection in the visible part, unlike stressed forests (Figure 3, left).The corresponding range of reflectance is presented in Figure 3, right.

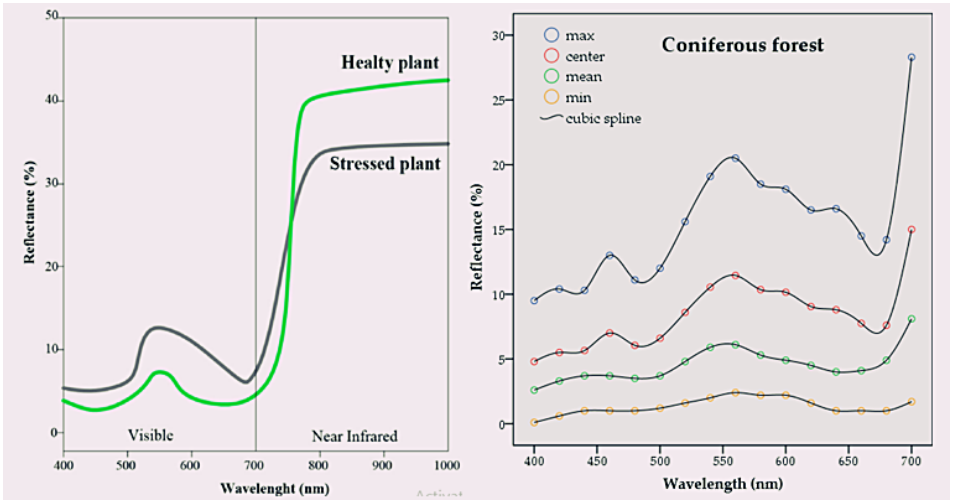

Figure 3. Approximation wave range of healty and stressed plant reflectance (left) and coniferous forest (right)

The correlations between beech, oak, birch and acacia reflections is presented in Table 3.

Table 3. Correlation matrix.

	Beech	Oak	Birch	Acacia
Beech	1.000	0.596	0.917	0.747
Oak	0.596	1.000	0.673	0.872
Birch	0.917	0.673	1.000	0.732
Acacia	0.747	0.872	0.732	1.000

CONCLUSION

Continuous smooth curves can be used to present reflectance and classify different types of forests in digital processing. This proposed model has applications in agriculture, urban planning, and ecology. The proposed numerical simulation gives the comparative mean and central reflectance values. Instead of observing the surrounding environment, the approach enables measurement of reflection to track the health of forests. The research done shows that if the measured reflection between the central and the mean value, the health condition of the forest is satisfactory. According to that, forest monitoring is made possible by taking measurements of the natural environment's reflectance at various times of the year and building a database for areas of interest.

Acknowledgments:

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USEFULNESS OF SPSS SUPPORT IN HIGHER EDUCATION TEACHING

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ABSTRACT

This paper shows the importance of using Information Technology (IT) in higher education, example on lessons from Statistics courses. University Union "Nikola Tesla" (Belgrade, Serbia) and its faculties, offers complex and useful knowledge in the field of statistics, among other things SPSS (Statistical Package for the Social Sciences) is a part of the curriculum. SPSS is the most widely used statistical package and is applied by professionals as well as in higher education institutions, and it represents the important IT support. That is why we chose SPSS program for our Statistics course and tested it in order to see the impact on teaching process. The research group consisted of 100 students, at three faculties (*Faculty for Entrepreneurial Business and Real Estate Management, Faculty of Economics and Finance and Faculty of Informatics and Computer Science*). During the research, it was concluded that using *SPSS* made students work easier and more motivated. A significant number of them insisted that using IT (software, internet, etc.) enabled easier understanding, learning and implementation of knowledge. Students' remark, and consequently one of the conclusions of the research, was that IT is an important aspect of teaching and learning process especially when using SPSS.

Keywords: IT, higher education, lecturing, SPSS

INTRODUCTION

Studies showed that many students did not obtain an adequate understanding of basic statistics concepts in class and were unable to solve applied problems (Garfield, 1995; Garfield & Ahlgren, 1988). Educators have employed multiple technological solutions in teaching, such as visual aids, simulations or animations, with hope of enhancing college student statistics learning (Chance et al., 2007).

Nowadays, the usage of different kinds of Information Technology (IT) is largely included in higher education because it allows the wider spectrum of possibilities in teaching and learning. Using IT is very useful in the process of explaining statistical ideas, abstract terms, theorems, problems, etc.

The aim of this article is to recognize the importance of using Information Technology in the teaching process.

Different kinds of statistical software programs have been developed exclusively for helping students learn statistics.

IBM SPSS software

The IBM SPSS software platform offers advanced statistical analysis, a vast library of machine learning algorithms, text analysis, open source extensibility, integration with big data and seamless deployment into applications.

Its ease of use, flexibility and scalability make SPSS accessible to users of all skill levels. Moreover, it is suitable for projects of all sizes and levels of complexity and can help users find new opportunities, improve efficiency and minimize risk.

That is why we chose SPSS program for our Statistics course and tested it in order to see the impact on teaching process.

COURSE OF STATISTICS WITH *SPSS* PROGRAM

Correlation and Simple Linear Regression with SPSS

Example 1 – case study:

Suppose we are interested in whether there is a quantitative connection between student success in the exam in statistics and mathematics (by the number of points from 0 to 100) at the Union „Nikola Tesla" University. The first stage in such an analysis consists of taking a random sample of n elements. The data were entered into SPSS program as given in the following Figure 1.

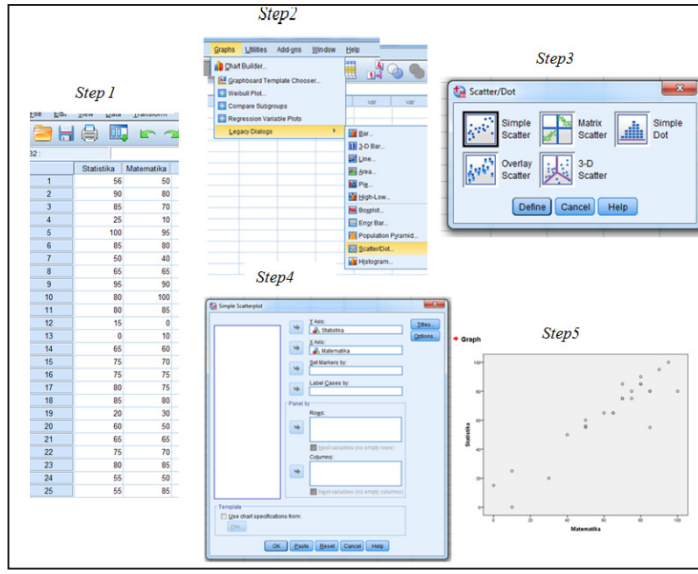

Figure 1 Scatter plot of chest girth versus length (step 1 (database in SPSS), step 2, step 3, step 4, step 5)

RESEARCH METHODOLOGY

Questions of the research

Do students solve tasks more easily and are they more motivated for lectures and independent work when using SPSS program?

Participants of the Research

The research group consisted of 100 students, at three faculties (*Faculty for Entrepreneurial Business and Real Estate Management* (40 students)*, Faculty of Economics and Finance* (40 students) *and Faculty of Informatics and Computer Science* (20 students)) of the UNION Nikola Tesla University, Belgrade, Serbia.

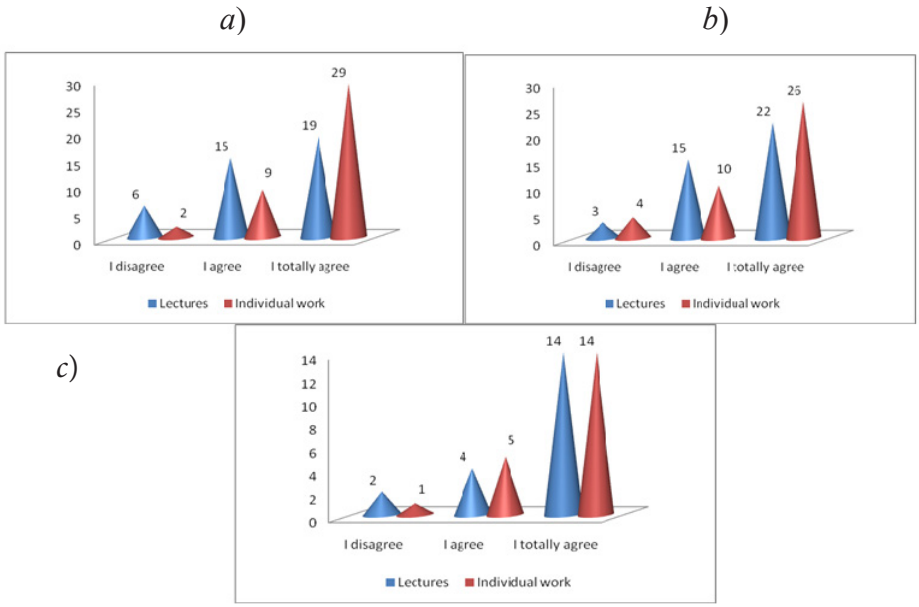

Figure 2 Students' answers to the question: Should SPSS be used in teaching and learning statistics (a) Faculty for Entrepreneurial Business and Real Estate Management, b) Faculty of Economics and Finance and c) Faculty of Informatics and Computer Science)?

METHODS, TECHNIQUES AND APPARATUS

Students had a course in Statistics with SPSS program. The material includeed examples that we had dealt with the mentioned software tool. Students could solve problems in a much faster and more efficient way. Students were enabled to make conclusions about dependent variables by changing independent variables (their relationship, correlations, etc.). Students could modify these parameters and initial conditions to explore and make their own conclusions.

Assessment can focus on giving students data sets and having them complete a full analysis on their own, which may include "cleaning" the data first (e.g., Holcomb 2004). Such exercises empower students as users of statistics and allow them to better understand and experience the practice of statistics (Ben-Zvi 2004).

RESULTS

When asked whether it was easier for them to learn, understand and solve problems after having lectures and individual work with SPSS approach, students answered the question as shown in Figure 2.

DISCUSSION AND CONCLUSIONS

Many research works in different scientific fields, including statistics, have proven that IT makes learning process much easier.

It is very important to try to find ways to access and utilize appropriate technology to help students learn statistics. The GAISE College Report (Franklin et al., 2000; Franklin & Garfield, 2006) lists some issues to consider when selecting technological tools to use in helping students learn statistics: ease of data entry, ability to import data in multiple formats, interactive capabilities, dynamic linking between data, graphical, and numerical analyses, ease of use for particular audiences, availability to students, portability.

From all the above, we can conclude that the analysis of data in SPSS program is of great importance for obtaining adequate research results, as well as for presenting the results in a precise way.

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BIOCOMPATIBLE ANTIBACTERIAL HYDROGELS FOR MEDICAL APPLICATIONS

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Abstract

Hydrogel-based materials are especially interesting for wound dressing applications, considering their favorable biocompatibility, sorption and mechanical properties, as well as the potential for immobilization and incorporation of antibacterial agents, such as silver nanoparticles (AgNPs). The synthesis of silver nanoparticles (AgNPs) became very interesting for potential applications in biomedicine, since nanocrystalline silver is proved to be the most efficient antimicrobial agent with a wide inhibiting spectrum towards different types of microorganisms. AgNPs embedded in hydrogel matrices are attractive for biomedical applications due to possibility for their controlled release resulting in antimicrobial activity. Thus, combination of AgNPs with biocompatible hydrogels, poly(vinyl alcohol) (PVA) and chitosan (CHI), provides potential for design of improved medical treatments and devices (antimicrobial wound dressings, soft tissue implants). In this work, we attempt to synthesize new wound dressing materials with electrochemically synthesized silver nanoparticles inside the PVA/CHI hydrogel matrix. Synthesized hydrogels were characterized by UV-Vis, FE-SEM, AAS, MTT cytotoxicity test and test of antibacterial activity against pathogenic bacteria strain *Staphylococcus aureus* and *Escherichia coli.* The results indicated that investigated Ag/PVA/CHI hydrogels are excellent candidates for wound dressings.

Keywords: hydrogel, poly(vinyl alcohol), chitosan, silver nanoparticle, antibacterial, cytotoxicity.

1. INTRODUCTION

In-hospital wound infections and overwhelming emergence of antibiotic-resistant bacterial strains are an ever-looming threat in medicine and patient care. Infected wounds can be very difficult to treat and are a major cause of patient mortality [1]. Traditional wound dressings, e.g., gauzes, bandages etc. are ill equipped for this purpose, especially for more severe wounds, due to many shortcomings such as low absorption ability, the need for frequent replacing, high adhesiveness and sticking to the wound tissue which could cause damage to the newly-formed epidermis [2]. The biomaterials science is quickly evolving in this regard, with increasing focus on developing novel wound dressing formulations to combat persistent infections by multidrug-resistant bacteria [3]. Wound healing is a complex process occurring over several phases, including hemostasis, inflammation, epithelial cells migration, proliferation, followed by remodeling of epithelial tissue and wound healing [4]. During this initial period, it is critically important to prevent bacterial migration and adhesion to the wound, so it is desirable for a wound dressing to contain an active antibacterial component which should impede biofilm formation in the first 24-48 h [5]. An ideal wound dressing should provide protection and support to the wound during the entire remodeling and healing process, and in this regard needs to fulfill many strict prerequisites such as biocompatibility and nontoxicity, oxygen and water vapour permeability, ability to maintain local moisture to prevent drying of the wound, the ability to absorb wound exudates and low adhesiveness to alleviate the danger of wound trauma during dressing replacement [2,6,7]. Hydrogels, highly porous cross linked polymer matrices containing up to 90 % liquid phase, are potentially excellent wound dressing materials as they could be tailored to successfully meet all aforementioned requirements. High water content in the hydrogel enables effective moisture regulation; the swelling ability of polymer hydrogels is advantageous for exudate absorption and removal of necrotic tissue from the wound surface, whereas the porosity of the matrix assures good O_2 and CO_2 permeability. In this paper the electrochemical synthesis of Ag/PVA/CHI hydrogels and their biological properties, swelling characteristics and silver release have been investigated [8].

2. MATERIALS AND METHODS

2.1. Materials

The following p.a. grade chemicals were used, as received from the supplier: fully hydrolyzed poly(vinyl alcohol) powder, 70-100 kDa molecular weight (MW) (Sigma Aldrich); medium MW (190-310 kDa) chitosan powder with deacetylation degree of 75-85 % (Sigma Aldrich); potassium nitrate (Centrohem); silver nitrate (Sigma Aldrich); glacial acetic acid (Beta Hem). For antibacterial properties evaluation, monobasic (Centrohem) and dibasic (Sigma Aldrich) potassium phosphates were used. Cell culture suspensions for cytotoxicity tests were prepared using MTT tetrazolium salt, EDTA, fetal calf serum and antibiotic-antimycotic (Sigma Aldrich). All solutions were prepared using 18 MΩ ultra-pure distilled water (Millipore).

2.2. Synthesis of silver/poly(vinyl alcohol)/chitosan hydrogels

For the poly(vinyl alcohol), PVA, colloid dispersions, PVA powder was dissolved in distilled water at elevated temperature (90 °C) on a magnetic heater-stirrer. Chitosan (CHI) was dissolved in 2 vol% CH_3COOH under constant stirring at room temperature. After cooling of PVA, the CHI dispersion was added dropwise and the final dispersions (containing 10 wt% PVA and 0.1 wt% or 0.5 wt% CHI) were homogenized by mixing at room temperature for 2-3 h. The hydrogels were prepared by physical cross linking method in 5 cycles. One cycle consisted of 16 h freezing at -18 °C followed by 8 h thawing at 4 °C. Before electrochemical synthesis of silver nanoparticles (AgNPs), swelling of the hydrogel discs was performed 48 h in 0.25 mM $AgNO_3$ solution. The silver nanoparticles synthesis was carried out at constant voltage of 90 V, 4 min, to pre-swollen hydrogels. The electrochemical cell consisted of a glass container with Pt working and counter electrodes, electrically connected to a MA8903 Electrophoresis power supply [8].

2.3. Characterization

The incorporation of AgNPs was confirmed by UV-visible (UV-vis) spectroscopy using LLG-uni*SPEC* 2 Spectrophotometer (LLG Labware), in the wavelength range 1000-250 nm. Field-emission scanning electron microscopy (FE-SEM) was carried out on LEO SUPRA 55 microscope (Carl Zeiss) operated at 10 kV. The swelling of the prepared hydrogels was investigated using gravimetric method, in a phosphate buffer (37°C, pH ~ 7.4). Cytotoxicity was

determined on MRC-5 cell line by MTT test, while antibacterial activity against pathogenic bacteria strain *Staphylococcus aureus* and *Escherichia coli* was determined using test in suspension. Silver release was determined by atomic absorption spectroscopy (AAS) [8].

3. RESULTS AND DISCUSSION

3.1. UV-Vis spectroscopy

AgNPs incorporation was confirmed using UV-visible spectroscopy (Fig. 1), by appearance of surface plasmon resonant (SPR) peaks at ~400 nm. Increase in chitosan concentration in starting dispersions increases the hydrogels peak absorbance, denoting increased content of silver nanoparticles incorporated in Ag/PVA/CHI hydrogel.

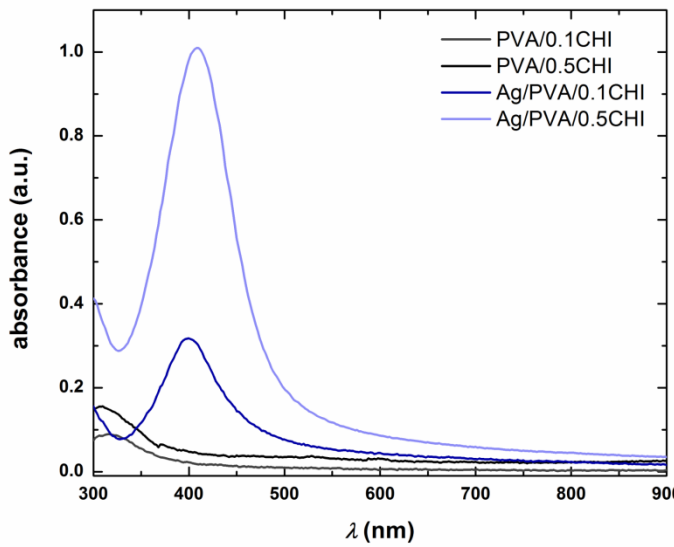

Figure 1. UV-vis spectra of PVA/0.1CHI, 0.25Ag/PVA/0.1CHI, PVA/0.5CHI and 0.25AgPVA/0.5CHI hydrogels

3.2. Swelling properties and silver release kinetics

Swelling ability is one of the most important properties of hydrogel materials aimed for wound dressings. Hydrogels would optimally have a high swelling ratio in order to allow efficient absorbing of wound exudates, and to ensure that

the wound environment is kept moist in order to prevent drying of the wound and sticking of the dressing [8]. Increase in chitosan concentration in the starting dispersion, as well as silver nanoparticles embedded in hydrogels, increase the hydrogel swelling degree (Fig. 2).

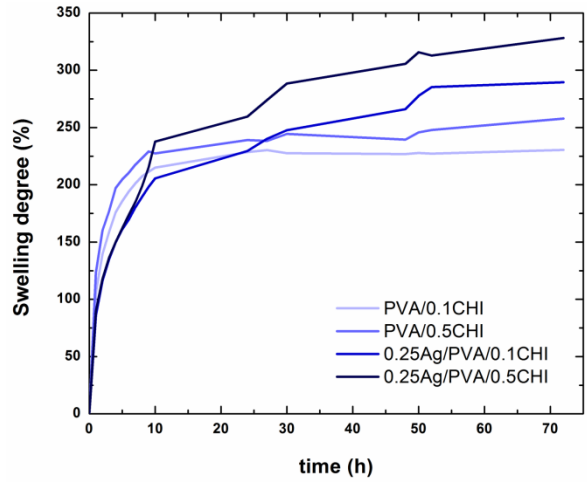

Figure 2. Swelling degree of PVA/0.1CHI, 0.25Ag/PVA/0.1CHI, PVA/0.5CHI and 0.25AgPVA/0.5CHI hydrogels in phosphate buffer at 37 °C

The silver release profiles for 0.25Ag/PVA/0.1CHI and 0.25Ag/PVA/0.5CHI hydrogels [8] proved the silver burst release during initial time period, which is favorable in preventing the biofilm growth.

3.3. Cytotoxicity and antibacterial activity

The results of the MTT test for MRC-5 (human fibroblasts) cell line are presented in Figure 3, proving strong evidence of non-cytotoxic effect for 0.25Ag/PVA/0.1CHI and 0.25AgPVA/0.5CHI hydrogels [8]. Furthermore, strong antibacterial activity against both *S.aureus* and *E. coli* was confirmed for both 0.25Ag/PVA/0.1CHI and 0.25AgPVA/0.5CHI hydrogels [8].

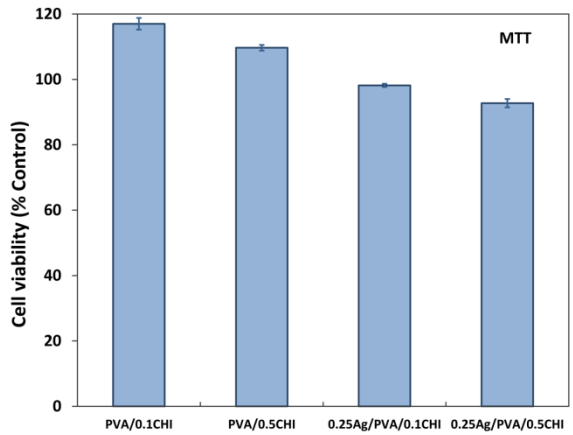

Figure 3. Cell viability of MRC-5 in PVA/0.1CHI, 0.25Ag/PVA/0.1CHI, PVA/0.5CHI and 0.25AgPVA/0.5CHI hydrogels

4. CONCLUSION

The exceptional antibacterial activity of both synthesized 0.25Ag/PVA/0.1CHI and 0.25AgPVA/0.5CHI hydrogels was validated against bacterial strains *S. aureus* and *E. coli*, whereas the MTT test confirmed non-toxicity, proving their potential for wound dressing applications. Silver burst release indicated their possibility to prevent the formation of biofilm.

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ANN MODEL OF AIR QUALITY ON THE CONSTRUCTION SITE

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Abstract

The construction industry is one of the main producers of dust, greenhouse gases and air pollutants. Effective operation and management of construction site operations can significantly reduce the project's carbon footprint and other environmental impacts. Through the cooperation of scientific and research institution and construction company, real-time monitoring of air quality at the construction site was implemented using IoT technologies. An IoT-based system framework that integrates a distributed sensor network to collect real-time data and demonstrate air quality at a construction site was implemented. Different types of sensors were used to collect data related to NO2 and PM2.5, PM10 particles, as well as meteorological parameters – wind speed and direction, humidity, pressure and temperature. The results of real-time measurements provide a picture of the state of air pollution at the construction site and the connection with construction activities that can be managed in order to reduce the concentration of polluting gases and suspended particles. Through on-site monitoring of construction site in Belgrade City, this study found that the dust level of construction activities is relatively high. Comparing the wind direction and PM concentrations, it can be concluded that the construction activity had a significant impact on the air quality around the construction surrounding areas. Regarding the main factors affecting the building construction dust emission, the correlations show that building construction dust emission was not significantly correlated with meteorological factors.

Key words: construction; PM concentrations; correlation; meteorology

INTRODUCTION

With the looming consequences of climate changes, sustainability measures, including quantifying the amount of air pollution during various types of activities, have become an important goal in all branches of the economy, including the construction industry. All construction sites generate high levels of pollution over a long period of time. The construction industry is one of the main producers of greenhouse gases (GHG) with a share of about 12% of the total world emissions. According to official figures from the Delhi Pollution Control Committee (DPCC), 30% of air pollution by dust is caused by emissions from construction sites. Various construction activities such as excavation, diesel engine operation, demolition, burning and working with toxic materials contribute to air pollution. The main factor that contributes to air pollution with nitrogen and sulfur oxides during construction projects is the use of heavy equipment, ie. machines (excavators, loaders, bulldozers, etc.) as a result of burning the fuel used by these machines. PM pollution is mainly attributed to excavation work. A significant source of PM 2.5 particles on construction sites are exhaust gases from diesel engines and diesel generator sets, vehicles and heavy equipment. Harmful substances from oils, glues, solvents, paints, treated woods, plastics, cleaning agents and other hazardous chemicals widely used on construction sites also contribute to air pollution.

In the Balkans, Serbia is the leader in the construction industry, which is growing year by year. In August 2022, 2,562 building permits were issued. This construction trend promises a further significant increase in the concentration of greenhouse gases and other pollutants. For these reasons, it is primarily necessary to introduce monitoring of polluting gases and PM particles in real time in order to propose measures to reduce the concentration of polluting gases and PM particles through insight into the amount of pollution present and depending on the atmospheric conditions.

Although emissions of harmful substances in construction industry are becoming more and more significant due to the accelerated trend of construction in Serbia, a real-time emission monitoring tool, which is essential to help construction teams avoid excessive emissions of harmful substances, has not yet been introduced to construction sites in the Republic of Serbia. The great importance of the application of this system and the implementation of this type of research is for the health of the employees at the construction site who often have health problems due to the working conditions, i.e. the poor air quality at the construction sites, which sometimes reaches such a bad quality that it endangers the lives of the workers.

Particulate matter (PM) is one of the most common air pollutants globally as well as nitrogen oxides (NOx), photochemical oxidants including ozone (O3), carbon monoxide (CO), lead (Pb), and sulfur dioxides (SO2) (EPA, 2021).

In the last few years, research has been done on the effects on dust concentration at construction sites, with a focus on PM10 and PM2.5 (Moraes et al , 2016; Hassan et al., 2016; Yan et al., 2019). It was found that there are a number of factors that influence the concentration of PM particles at the construction site. Certainly, the surroundings of the construction site itself represent a source of certain emissions that are transported and registered on the construction site itself, independently of the activities on the construction site. These are so-called background emissions. When it comes to meteorological factors, several studies have been done on the connection between meteorological parameters and the concentration of polluting substances (including PM particles), and there are conflicting views on that topic. Some authors (Araújo et al., 2014) believe that meteorology has an extremely important influence on the concentration of PM particles at the construction site, although due to the lack of concentration data, they failed to develop a model for the dependence of PM particle concentrations on meteorological parameters. According to some other authors (Zhang et al., 2009), dust emissions from construction sites have significant seasonal changes, which was also confirmed by other researchers in their research (Zhao et al., 2010). This again indicates a strong relationship between the concentration of PM particles and meteorological parameters. In some research (Luo, 2017; Guo, 2010) that also studied the relationship between construction works and meteorological parameters, it was concluded that PM particles are highly positively correlated with wind speed and relative air humidity, and weakly with temperature. In addition to excavation work, internal works on buildings also have a certain contribution to emissions. Kinsey et al. (2004) found that vehicles leaving a construction site can carry a large amount of dust and sediment to nearby roads, leading to the rise of secondary dust. Azarmi et al. (2014) carried out a detailed monitoring of certain phases of work on the construction site, such as mixing concrete, drilling and cutting. PM10, PM2.5 and PM0.1 Concentrations of PM particles during drilling and cutting activities were up to 14 times higher than background concentrations. Moraes et al. (2016) focused on monitoring the concentration of particulate matter (PM10) generated from concrete and masonry in construction activities. These and similar studies have shown that certain phases and activities during work on construction sites are an important factor that affects the concentration of PM particles (Fan et al., 2011).

The goal of this research is a deeper and more detailed analysis of the relationship between the concentrations of PM particles on the construction site that are emitted due to excavation work and meteorological parameters. The data analysis was done to check the possibility of applying artificial intelligence to predictions of the concentration of PM particles depending on the weather conditions.

MATERIALS AND METHODS

The experiment, which consisted of measuring the concentrations of suspended particles PM2.5 and PM10, then NO2, as well as meteorological parameters (pressure, temperature, humidity, speed and wind direction) was carried out at one construction site in Belgrade (Figure 1) during 15 days in July 2022, from the first to the fifteenth of July. The excavation zone is located west and southwest of the location of the measuring station, while additional sources of emissions on the construction site, such as carpentry and reinforcement works, are placed on the north and northwest side from monitoring device on the constructin site. The Figure 2 shows the distances of individual emission sources from the measuring station. Emissions from other sources come from the south and east direction and can be treated as background emissions. During the whole fifteen days, two electric powered machines were working in the excavation area. All days except Sunday, work was done from 13:00 to 17:00. The waste was taken away by truck every day.

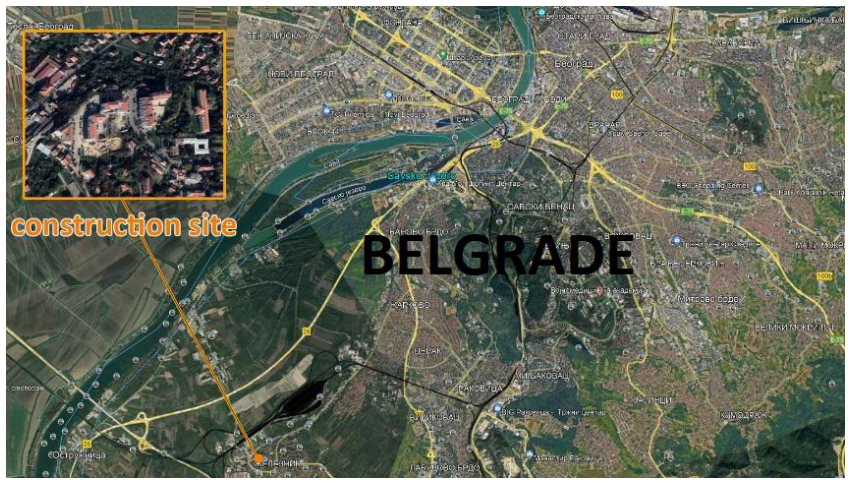


Figure 1

Location of the construction site on the map of Belgrade

The devices that were used were sensor type and the results were recorded every 5 minutes.

RS-MG111-WIFI-1 is an air environment multi-element transmitter. It is used to detect NO2, PM2.5 and PM10. The transmitter adopts the original imported sensor and control chip, which has the characteristics of high precision, high resolution and good stability. Using WIFI network transmission, it is directly connected to the on-site WIFI network, and the connection is convenient. With the free monitoring platform software or the free IoT cloud platform , it directly formed

Online Integrated air environment monitoring system. Widely used in building HVAC, building energy saving, smart home, schools, hospitals, airport stations and other places.

Another device is CC-M12 weather station: an anemometer (WD, WS), temperature, pressure and humidity with RH&T and 4G communication.

The devices are portable (with the possibility of installation outdoors and indoors). Such a system allows the manager of the construction site and the company to have a detailed insight into the quality of the environment in real time. In doing so, sources of harmful gas emissions are identified from three main activities in construction: earthworks, transport and interior works. Different types of sensors were used to collect data related to NO2, PM2.5, PM10 particles, as well as meteorological parameters – wind speed and direction, humidity, pressure and temperature. Web and mobile application provide data visualization (map, list, chart), notifications/alarms when values are outside the defined range, algorithms for data processing, export to csv file. SPSS 23.0 statistical software was used for data analysis in this study.

RESULTS AND DISCUSSION

The measurement results are shown in Figures 3-8 and Table 1. The results are given as Full Day results (FD), where the graphs show the measurement results during the total time, 24 hours a day, for all 15 days, as well as Working hours results (WH) that show the separated working hours from 7 a.m. to 5 p.m. on weekdays (Monday to Saturday).

Table 1 Basic statistical analysis of measured parameters

	PM2.5 (μg/m^3)	PM10 (μg/m3)	NO2 (μg/m^3)	p (kapa)	T (°C)	hum (%)	v (m/s)
FD av	15.301	16.811	94.243	1004.78	25.192	51.030	0.354
FD SD	9.5752	11.155	131.989	2.618	6.401	18.534	0.698
FD min	1	1	0	999	12.4	18.1	0
FD max	133	143	510	1010	46.2	98.3	17.8
WH av	14.660	16.0597	167.741	1004.977	28.600	20.2	0.467
WH SD	9.147	10.577	144.859	2.835	5.556	13.749	0.574
WH min	1	2	0	999	15.2	91.1	0
WH max	71	82	510	1010	41.1	40.696	3.2

By monitoring the concentration of polluting substances, 3 sets of data were obtained, including PM2.5, PM10 and NO2.

Apart from the basic statistical analysis, Table 1, a correlation analysis was done between PM concentration and meteorological data. Table 2 shows that the concentrations of PM10 and PM2.5 were not significantly correlated with any meteorological factor.

Table 2 Values of the linear correlation coefficient among the measured parameters

	PM2.5	p	hum	T	v
PM10	0.987	-0.092	0.299	0.201	0.003
PM2.5	1	-0.103	0.297	0.236	0.008
p		1	0.053	-0.416	-0.989
hum			1	-0.660	-0.030
T				1	0.326

ANN

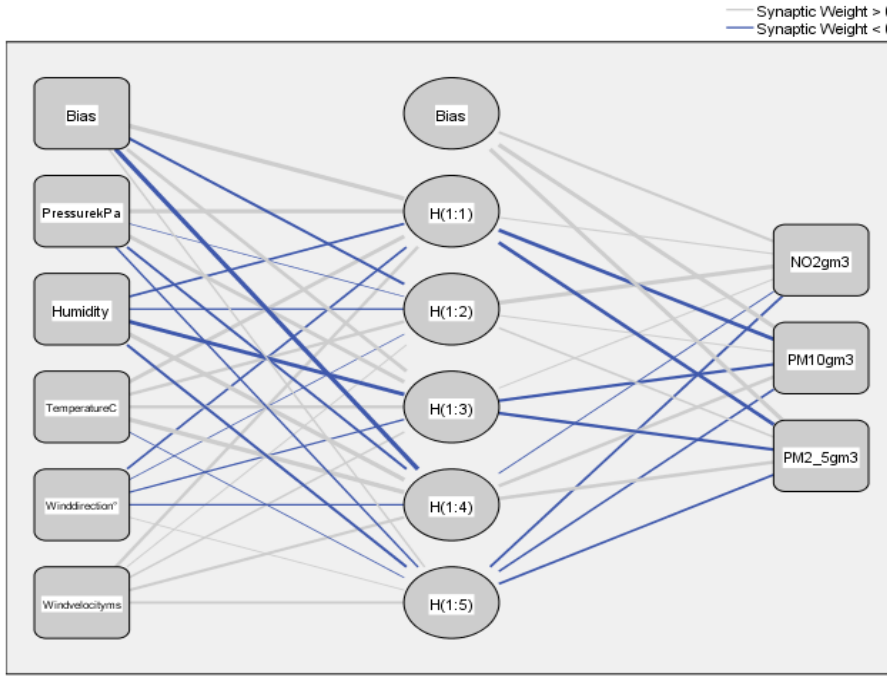
Case Processing Summary

		N	Percent
Sample	Training	1040	69.7%
	Testing	452	30.3%
Valid		1492	100.0%
Excluded		0	
Total		1492	

Network Information

Input Layer	Covariates	1	Pressure [kPa]
		2	Humidity [%]
		3	Temperature [C]
		4	Wind direction [°]
		5	Wind velocity [m/s]
	Number of Units[a]		5
	Rescaling Method for Covariates		Standardized
Hidden Layer(s)	Number of Hidden Layers		1
	Number of Units in Hidden Layer 1[a]		5
	Activation Function		Hyperbolic tangent
Output Layer	Dependent Variables	1	NO2 [?g/m3]
		2	PM10 [?g/m3]
		3	PM2_5 [?g/m3]
	Number of Units		3
	Rescaling Method for Scale Dependents		Standardized
	Activation Function		Identity
	Error Function		Sum of Squares

a. Excluding the bias unit



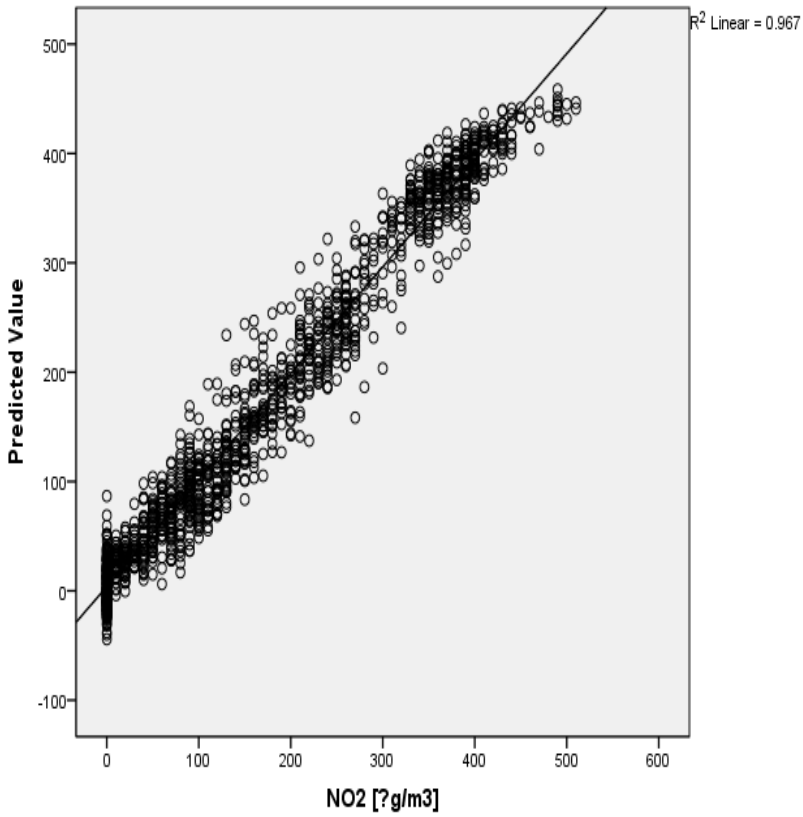
Hidden layer activation function: Hyperbolic tangent

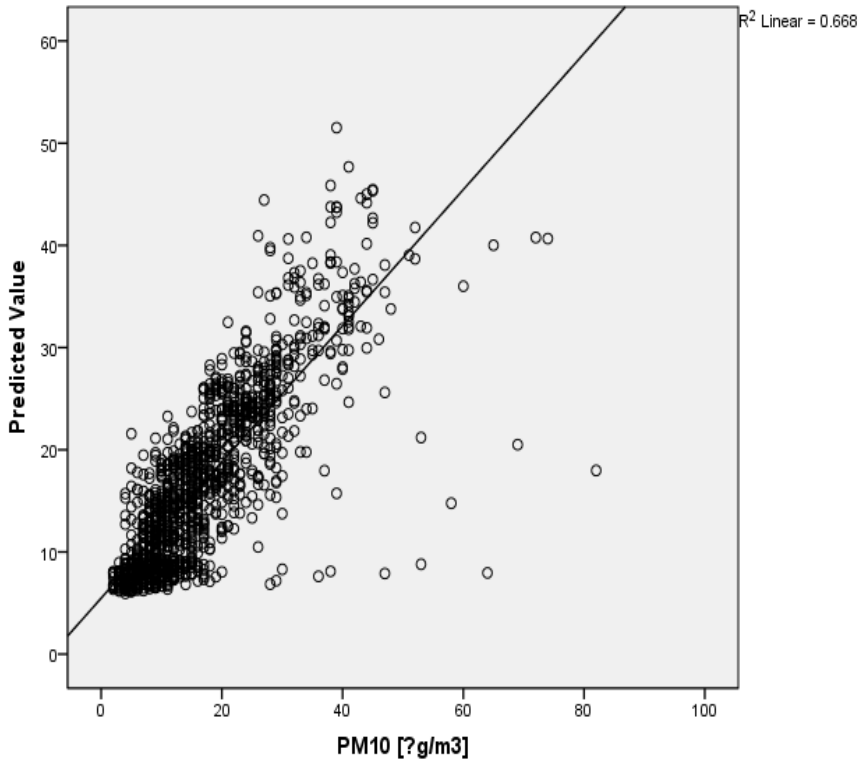
Output layer activation function: Identity

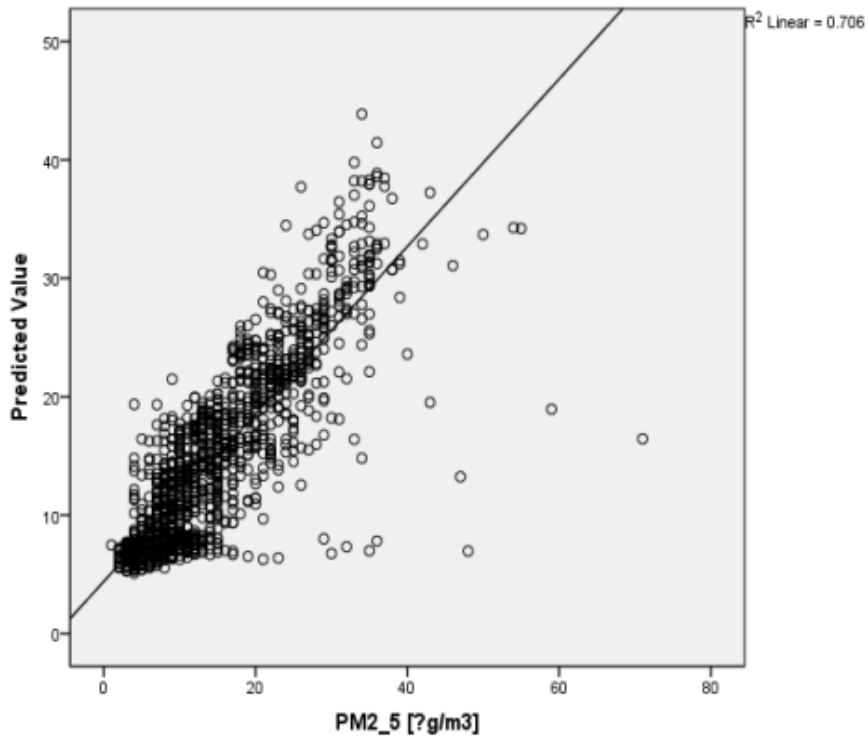
Model Summary

Training	Sum of Squares Error		351.995
	Average Overall Relative Error		.226
	Relative Error for Scale Dependents	NO2 [?g/m3]	.033
		PM10 [?g/m3]	.342
		PM2_5 [?g/m3]	.303
	Stopping Rule Used		1 consecutive step(s) with no decrease in error
	Training Time		00:00:00.318
Testing	Sum of Squares Error		106.071
	Average Overall Relative Error		.186
	Relative Error for Scale Dependents	NO2 [?g/m3]	.034
		PM10 [?g/m3]	.302
		PM2_5 [?g/m3]	.268

a. Error computations are based on the testing sample.


R2 Linear = 0.967
Predicted Value
NO2 [?g/m3]
500
400
300
200
100
0
-100
0
100
200
300
400
500
600


R² Linear = 0.668
Predicted Value
PM10 [?g/m3]
0
10
20
30
40
50
60
0
20
40
60
80
100


R² Linear = 0.706
Predicted Value
PM2_5 [?g/m3]
0
10
20
30
40
50
0
20
40
60
80

CONCLUSION

The data of meteorological and construction intensity were collected to determine the main factors affecting the construction dust emission, which can provide a basis for reducing the impact of dust generated by construction activities on the surrounding area. The main conclusions of the article are as follows:

Through on-site monitoring of construction site in Belgrade City, this study found that the dust emission level of construction activities is relatively high. The average PM10 concentration was 16.42 μg/m3 and the PM2.5 concentration was 8.37 μg/m3. Analyzing the average 24-hour values for PM2.5 and PM10, it can be concluded that PM2.5 represents a far greater health hazard due to far higher values compared to the prescribed daily limits. In addition, compared with the upwind direction concentration, the construction site makes downwind direction , PM10 and PM2.5 concentration increased by around 70% and 35%, respectively, which indicates that the construction activity had a significant impact on the air quality around the construction surrounding areas.

Regarding the main factors affecting the building construction dust emission, the results show that building construction dust emission was not significantly correlated with any single meteorological factor when it did not change too much.

Considering the very low correlation between the concentration of PM particles and meteorological parameters, the possibility of applying ANN for the purpose of creating a prediction model is excluded. A further subject of research will be the application of machine learning in the development of a predictive model that would aim at smart management of the construction site while taking into account the quality of the working and living environment.

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IMPROVED PROPERTIES OF ALTERNATIVE BINDERS AND THEIR POTENTIAL APPLICATION FOR SOIL STABILIZATION

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Abstract

This paper investigates the influence of mechanical activation of different types of fly ash on the properties of alternative binders – geopolymers based on alkali activated fly ash. Fly ash was firstly mechanically and then alkali-activated. Mechanical activation of fly ash was conducted in a planetary ball mill. Alkali activation of fly ash was carried out at room temperature by use of sodium silicate solution as an activator. Structural changes of geopolymers were assessed by SEM and EDS analysis. Mechanical activation of fly ash led to a significant increase in strength of these alternative binders, thereby expanding their potential application, such as soil stabilization.

Keywords: mechanical activation, alkali activation, fly ash.

INTRODUCTION

Fly ash (FA) is generated as an industrial waste material in the process of coal combustion in thermal power plants. There is an ongoing demand worldwide for the use of large quantities of FA. Geopolymers based on alkali activated fly ash (FA) represent quite attractive binding material, known for high compressive strength, good durability in aggressive environments, low shrinkage and good thermal resistivity (Provis and van Deventer, 2009). On the other hand, the lack of a good foundation ground layer that could be used for construction proposes is a common problem all over the world. Geopolymers also emerged as a good alternative to traditional binders (lime and cement) for soil stabilization (Chen, et al. 2020). Portland cement is energy-intensive with high-carbon footprint. Today, more and more researches are focused on finding new solutions to improve the properties of binders in order to obtain a stabilized foundation layer.

The advantage of low carbon emission and energy consumption — which are synonymous with the use of geopolymers — are undoubtedly desirable. Thereby put them ahead of cement and lime stabilization in the face of the current heightened demand for greener methods (Jeremiah, et al. 2021). The limiting factor for wider use of FA in the synthesis of geopolymers is its low reactivity and consequent low strength gain when cured at room temperature. The reactivity of initial FA in the reaction of alkali activation can be improved by the appropriate choice of the alkali reaction conditions or by mechanical activation of FA (Marjanović et al., 2014).

In this work the reactivity of FA was enhanced by mechanical activation. The effects of mechanical activation of FA on the strength and microstructure of the resulting alkali-activated binders – geopolymers were investigated.

MATERIALS AND METHODS

Materials

In the experimental work, four samples of fly ash from thermal power plants (TPP) in Serbia were used as starting material:

1. FA TENT A, TPP "Nikola Tesla", Unit A, Obrenovac, Serbia
2. FA TENT B, TPP "Nikola Tesla", Unit B, Obrenovac, Serbia
3. FA Kolubara, TPP "Kolubara", Veliki Crljani
4. FA Kostolac, TPP "Kostolac" B_1, Kostolac, Serbia

The following materials were used to prepare the alkaline activator solution:

- Sodium silicate solution ("Galenika–Magmasil", Zemun, Serbia, 13.60% Na_2O, 26.25% SiO_2, 60.15% H_2O, with starting modulus n (SiO_2/Na_2O mass ratio) 1.93).
- Sodium hydroxide pellets (NaOH (p.a. min. 99%, "Lach-Ner")

Mechanical activation of FA

Mechanical activation of FA (TENT A, TENT B, Kolubara and Kostolac) was carried out in a planetary ball mill (Fritch Pulverisette type 05 102, Germany). FA to ball mass ratio was 1:20 (Marjanović et al., 2014). FA samples were mechanically activated in an air atmosphere for 15 minutes, while the speed of rotation was 380 rpm.

Preparation of geopolymer samples

Starting sodium silicate modulus was adjusted to the value 1.5 by adding NaOH pellets. The concentration of the activator was 10% Na_2O with respect to the FA mass. Geopolymer mortar prisms (40 mm × 40 mm × 160 mm) were prepared by mixing the initial FA (FA) or mechanically activated FA (MFA) with alkali activator and water, and then with sand.

Table 1. Conditions of mechanical and alkaline activation of FA and curing conditions

Sample	Duration of mechanical activation (min)	Water/binder ratio	Curing condition	
			Temperature (ºC)	Time (days)
FA TENT A	0	0.85	20±2 °C	1, 3, 7, 28
FA TENT B		0.80		
FA Kolubara		0.65		
FA Kostolac		0.69		
MFA TENT A	15	0.40		
MFA TENT B		0.40		
MFA Kolubara		0.40		
MFA Kostolac		0.40		

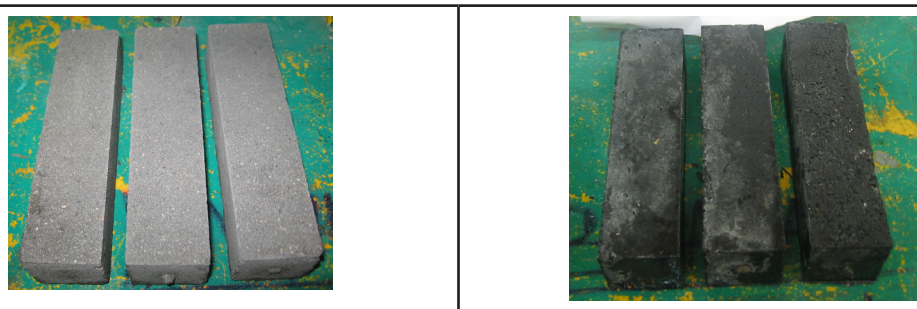
In the case of geopolymer mortars based on the initial FA (G-FA) water was added in the amount to obtain equal consistency (mortar flow measured on a flow table was 120±5 mm). On the other hand, geopolymer mortars based on mechanically activated FA (G-MFA) were all prepared with the same water/binder ratio. Water in water/binder ratio represents the total amount of water in the system, including water from the activator, while binder represents total fly ash mass and solid part of activator. FA/MFA : sand mass ratio was 1 : 3. Mortar prisms were cured at room temperature in a humid chamber (90±5% rel. humidity) for 1, 3, 7 and 28 days (Table 1). Preparation of the geopolymer pastes was performed in the same manner as the preparation of mortars, only without the sand. After the period of curing, paste samples were crushed and soak in isopropyl alcohol in order to stop further reaction.

Methods

The determination of strength of geopolymer mortars was performed using the CONTROLS ADVANTEST 9 device. Morphological characterization of the geopolymer pastes was done by SEM (VEGA TS 5130 MM, Tescan), while energy dispersive X-ray spectroscopy (EDS) was performed by INCAP-entaFET-x3 (OXFORD Instruments).

RESULTS AND DISCUSSION

Visual appearance of geopolymer mortar prisms based on FA/MFA TENT B is given in Figure 1. There are no visible cracks or deformations on geopolymer mortar prisms. The color of the geopolymer mortar is strikingly transformed by mechanical activation, from light gray (Figure 1a) to dark gray, almost black (Figure 1b). This is most likely the result of a greater dispersion of unburned carbon particles, which are known to be possible supplement for carbon black pigment (Marjanović et al., 2014).



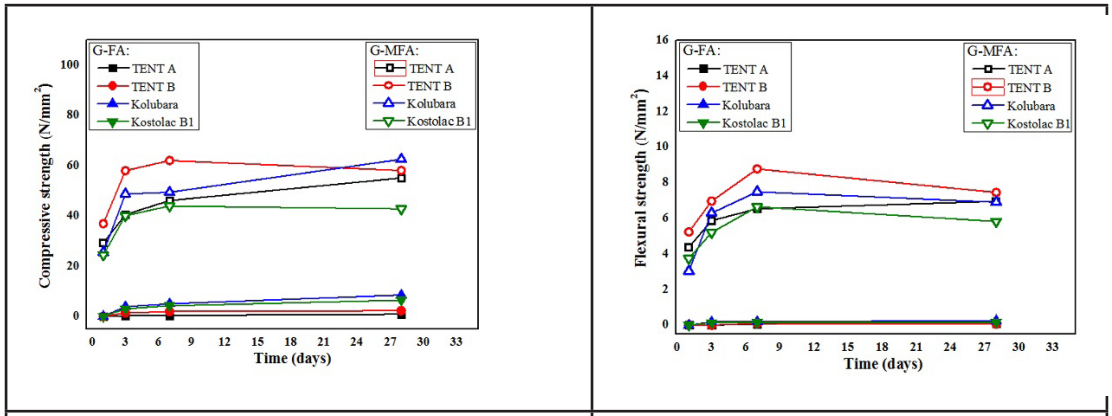
a) G-FA TENT B | b) G-MFA TENT B

Figure 1. Geopolymer mortars based on initial FA and mechanically activated MFA

The water demand for G-MFA was considerably lower than in the case of G-FA. This can be explained by the destruction of unburned carbon particles in FA samples by mechanical activation. It is known that, when FA is used as a substitution for cement, the presence of porous unburned carbon particles influence the higher water demand for standard consistency of mortars (Marjanović et al., 2014).

The mechanical strength of geopolymers based on FA and MFA after curing at room temperature are given at Figure 2. Geopolymers with very low flexural and compressive strength were obtained by alkaline activation of the initial FA

after curing at room temperature. Geopolymer mortars based on the initial FA were fragile and could easily broke under the hand. In contrast to that, the mechanical strength of geopolymers based on MFA, exceeded the values of 50 N/mm^2. Based on the presented results, it can be unambiguously concluded that mechanical activation affects the drastic enhancement of FA reactivity in the process of alkali activation.



a) Compressive strength of geopolymers

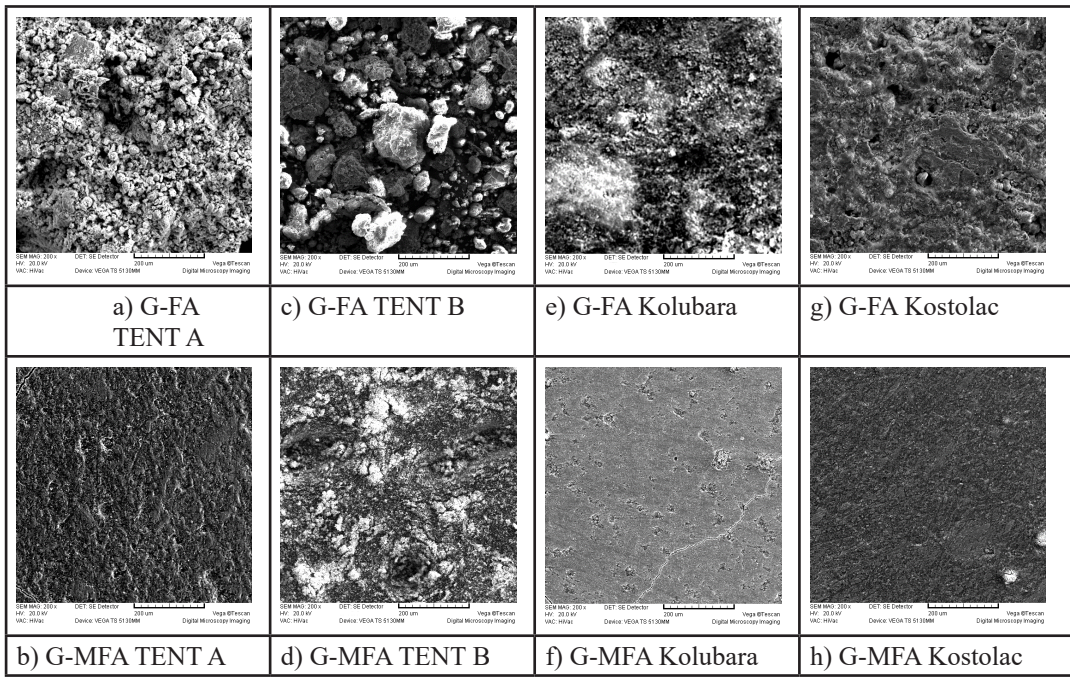
b) Flexural strength of geopolymers

Figure 2. Compressive and flexural strength of geopolymers based on alkali activated FA/MFA

The curing time does not significantly affect the development of the strength of the mortar based on the initial FA, because even after 28 days there is no increase in strength. From this, it can be clearly concluded that the alkali activation of the initial FA at room temperature is extremely slow, i.e. the reactivity of FA at room temperature is very low. In contrast, alkali activation of mechanically activated (MFA) resulted in geopolymers which compressive strength after 1 day of curing was in all cases higher than 20 N/mm^2, and after 3 days of curing higher than 40 N/mm^2. According to the quality requirements defined by the SRPS EN 197-1:2013 standard, the compressive strength of Portland cement-based mortar after 28 days of curing must be in the range of 30-50 N/mm^2, depending on the cement class. Therefore, geopolymer mortars based on mechanically activated MFA after 3 days of curing show strengths comparable to the strengths that Portland cement-based mortars develop after 28 days. With the extension of the curing time up to 7 and 28 days, the compressive strength values slightly increase for geopolymers based on MFA. The geopolymer based on MFA TENT B achieved the highest flexural and compressive strengths in relation to all tested

samples. The compressive strength of this mortar after 7 days (62.08 N/mm^2) is more than 30 times higher than the initial FA TENT B mortar (1.99 N/mm^2) cured under the same conditions. The presented results clearly show the influence of the mechanical activation of FA on the achieved geopolymer strengths and improved properties.

The differences in the microstructure of geopolymers derived from FA/MFA can be clearly distinguished (Figure 3). The geopolymers based on FA appear highly heterogeneous, with loosely structured precipitates and cavities in the structure (Figure 3 a,c,e,g), originating most probably from the evaporation of water. In contrast to this, the geopolymers derived from MFA showed very dense and compact microstructure, implying the formation of aluminosilicate gel, as the main reaction product, to a greater extent (Figure 3 b,d,f,h).



a) G-FA TENT A	c) G-FA TENT B	e) G-FA Kolubara	g) G-FA Kostolac
b) G-MFA TENT A	d) G-MFA TENT B	f) G-MFA Kolubara	h) G-MFA Kostolac

Figure 3. SEM of geopolymers based on initial FA and mechanically activated MFA

The results of EDS analysis (Figure 4) showed that in the geopolymers based on MFA there was a somewhat higher Al/Si ratio, indicating the higher proportion of incorporated aluminum in the aluminosilicate gel phase. Greater extent of aluminum incorporation can be related to the greater availability of this component during the alkali activation. It is known that the amount of available aluminum and the rate of its release during the reaction is very important factor,

since it highly affects the geopolymer gel properties (Provis and van Deventer, 2009). Greater availability (the faster release) of aluminum during the reaction influences the gel homogeneity, contributing to the formation of a more homogeneous gel and better strength development. With greater aluminum availability, faster alkali activation, i.e. formation of aluminosilicate gel occurs and the gel network eventually consists of more aluminum component (Provis and van Deventer, 2009).

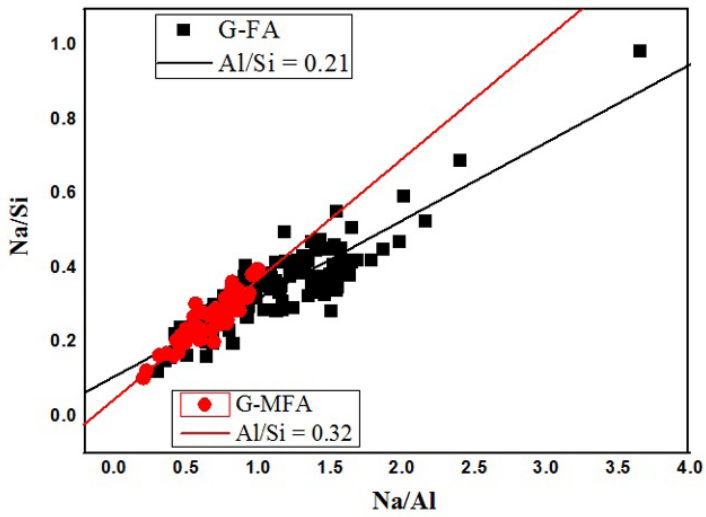


Figure 4. EDS results - ratios of major elements in the geopolimers based on FA/MFA

CONCLUSION

In this paper, the influence of mechanical activation of FA on mechanical properties and structure of geopolymer mortars was investigated. Based on the results presented the following conclusions can be drown:

- Mechanical activation influences lower water demand in the synthesis of geopolymers
- Mechanical activation seems to affect the greater availability of the aluminum, contributing to the formation of more homogeneous aluminosilicate gel.
- Mechanical activation in a duration of 15 min drastically enhances the FA reactivity in the process of alkaline activation at room temperature, which is confirmed by exceptional increase of mechanical strength of geopolymers based on MFA.

The main advantage of binding materials synthesized by alkaline activation of FA is primarily the significantly reduced emission of carbon dioxide into the atmosphere during their synthesis. Of great importance is the possibility of synthesis at room temperature, which represents a contribution to significant energy savings compared to the synthesis process of Portland cement clinker, which takes place at temperatures of approximately 1500 °C. The use of industrial waste (FA) as a starting material for the synthesis of binders also has positive effects from an environmental point of view, such as the saving of natural mineral raw materials, reduced environmental pollution and the valorization of industrial waste material. An additional advantage and importance of the mechanical activation of FA is the possibility of using the entire amount of this material in the alkali activation.

ACKNOWLEDGEMENTS

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IMPLEMENTATION OF SEMANTIC MAPPING OF RELATIONAL DATABASES

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ABSTRACT

The Semantic Web presents an extension of the existing web architecture that improves quality by enriching content with formal semantics. Semantic data models encompass the implicit meaning of data on the Web by specifying their concepts and connections. The term semantic Web was introduced with the aim of establishing a web that not only provides the interconnection of documents, but also reveals the meaning of information in documents. In this way, the Web is transformed from a series of interconnected, but semantically isolated data sets, into a database for data storage, manipulation and search. The Semantic Web can be used as a suitable platform for the implementation of electronic education systems because it provides the development of ontologies, semantic annotation (tagging) of learning materials, integration of semantic technologies into electronic education systems, as well as learning materials delivery in accordance with semantic standards. The paper presents an example of semantic mapping of the Moodle LMS platform with D2R server. D2R server enables the transformation of relational databases into a semantic database.

Keywords: Semantic web, mapping data, relational databases, D2R server.

INTRODUCTION

Semantic web

The Semantic Web term is an extension of the existing web architecture that enhances the quality by enriching content with formal semantics. Semantic data models include the implicit meaning of data on the web by specifying their terms

and relationships, Taheriyan et al.(2016)spreadsheets, XML, JSON, and Web APIs contain a tremendous amount of structured data that can be leveraged to build and augment knowledge graphs. However, they rarely provide a semantic model to describe their contents. Semantic models of data sources represent the implicit meaning of the data by specifying the concepts and the relationships within the data. Such models are the key ingredients to automatically publish the data into knowledge graphs. Manually modeling the semantics of data sources requires significant effort and expertise, and although desirable, building these models automatically is a challenging problem. Most of the related work focuses on semantic annotation of the data fields (source attributes. The concept of semantic web was introduced in 2001 by Berners-Lee et al.(2001) with the goal of establishing a web that not only provides interconnection of documents, but also reveals the importance of information in documents. In this way, the web is transformed from a series of interconnected, but semantically isolated datasets into a database for storing, manipulating and searching data. The application of semantic web in the field of education is based on three possibilities (Anderson & Whitelock 2004): possibilities for efficient storage and information retrieval, intelligent software options for interpreting the meaning of information and the ability of the web to increase the communication skills of web users in a variety of formats, without limitations, in terms of space and time.

Semantic web architecture

The main feature of the semantic web architecture is a layered hierarchical structure. He proposed the layered structure of Berners-Lee's layer cake (Berners-Lee, 2003). The complexity of architecture is reflected in the fact that higher level languages can use syntax and semantics of languages at lower levels. The initial architecture was enhanced by the development of two new layers due to the development of semantic web (Berners-Lee, 2005). This is an emphasis on the structure of ontologies. Figure 1 shows the semantic web structure.

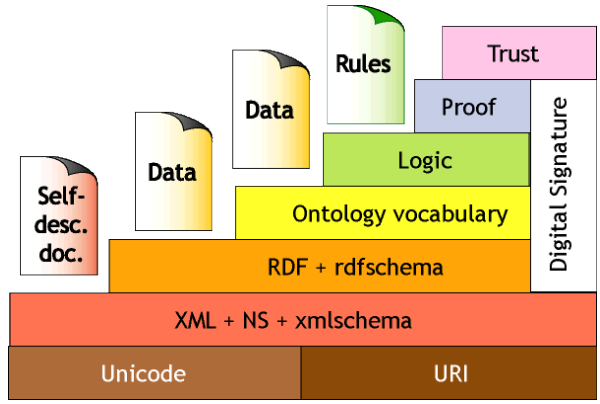


Figure 1 Semantic Web Architecture

On the first (lowest) hierarchical layer of semantic web architecture there are standards for presentation of text - Unicode and URI (Uniform Resource Identifier). Unicode provides standardized character representation, while URI provides identification of web resources that are not directly accessible through a computer network and abstract concepts that do not physically exist. Semantic Web is based on the sharing of terminology (description of terms), which is achieved using the URI of the standard, Oren et al. (2006). The URI uniquely names the web resource by pointing to the address where its description is located. On the second layer of the semantic web architecture, there is XML (Extensible Markup Language), which plays a role in presenting the content and structure of data on the web. It is essential for the interoperability of the system and web applications. XML defines a set of rules for encoding documents in a format that is human and machine readable. XML allows content to be composed of smaller datasets in larger groups that meet the needs of individuals or groups (Pahl & Holohan, 2004). XML is said to represent a meta-language, since it allows the definition of other languages at a higher level. XML syntax is used on advanced architectural levels (RDF, RDFS and OWL), thus providing the possibility of semantic search and marking, i.e. mapping data on the web. XML is characterized by optimization, simplicity, interoperability, learning speed and text formats. At the higher level of architecture there is RDF (Resource Description Framework) that represents the language for data exchange on semantic web. RDF is based on XML syntax and is used to enrich content on web semantics. It is designed to standardize the definition and use of metadata, but it is also suitable for the purpose of displaying data. RDF provides the implementation, distribution, and reuse of structured metadata (Gašević, 2004). The basic building block RDF language is a triplet object-attribute-value, which

is suitable for defining and displaying concepts in ontologies. RDF provides a standardized and flexible framework for publishing structured data on the web in the following way: (1) data can be linked, embedded, expanded and reused by other RDF data; (2) heterogeneous data from independent sources can be automatically integrated with the help of software agents, and (3) the meaning of the data can be defined using the simple ontologies described in the RDF language using the RDF scheme and the OWL language, Hogan et al (2011). The RDF Scheme (RDFS) plays a role in defining a dictionary for RDF data. It can replace RDF language restrictions in explaining the meaning of web content. OWL (Ontology Web Language) is a standard language for describing ontologies that allows for greater expressiveness when describing objects and their connections. OWL represents the extension of the RDF scheme and is derived from the DAML + OIL ontological language (Jovanović, 2007). The OWL ontology can be viewed as an RDF graph that can be represented in the form of an RDF triplet. The OWL ontology can be described using a similar syntax form, as well as an RDF scheme. The advantage of the OWL language in relation to the RDF scheme is a more accurate description of classes and properties. SPARQL (Eng. SPARQL Protocol and RDF Query Language) is the standard language for creating semantic queries over RDF dictionaries. SPARQL searches the information described and contained in semantic models (Raju & Ahmed, 2012). A semantic query is a patern by which the triplets that are defined in the paternity are chosen. Semantic query is placed above triplets. Its result is a triplet in the form of a RDF graph Huang et al (2011). SWRL (Semantic Web Rule Language) allows writing semantic rules. SWRL can be used to define the OWL mapping, O'Connor et al (2007). Semantically speaking, the SWRL is built on the basis of the same descriptive logic as OWL, but it expands the set of OWL axioms by defining them more precisely. SWRL rules consist of two parts: body and head. The last two levels in the layered semantic web architecture, Proof and Trust, are underdeveloped. The Proof layer is used to check the results obtained from intelligent agents and to verify the behavior of intelligent agents. The Trust provides a mechanism for trust and balance between information sources and users (Sivakumar & Ravichandran, 2013).

Semantic annotation web resources

Semantic annotation encompasses the conceptual mapping of elements and sets of data values into elements and sets of values of standardized semantic schemes, Najjar et al (2004). The basic approaches to semantically mapped databases are: application of D2R server, application development environment *Jena* and *R2RML*, *KAON2* and *OWL API* (Horridge & Bechhofer, 2011). The D2RQ

data model contains an instance class along with features created in ontology. Ontology is a file with the extension .OWL. In the case that an ontology uses elements of another ontology or elements of other ontologies, it is necessary to save it as an RDF file with the .RDF extension. Data obtained from both files (.OWL and .RDF) represent data ontology. The data ontology associated with the Pellet locking mechanism becomes a locking model. By joining the D2RQ data on the ontological model, the SPARQL query is performed over the ontology. When semantic mapping of data, there are three basic components of this process, Yunianta et al (2014). The first component is the D2RQ module, which is the basic part of the process of mapping semantically described data. The D2RQ module is responsible for communicating with internal (local) and external data sources and creating a D2RQ mapped file that can be used to communicate with local applications using the Jena library and the RDF dump file. Another key component of the system is the D2R server, which plays a role in communication and integration with other systems from external environments using HTTP protocols. This component enables the implementation of the following concepts: SPARQL languages that can be accessed through SPARQL clients, an RDF file that can be accessed through linked data clients and an HTML language that can be accessed via the HTML browser. The third key component of the semantic system data mapping process is the D2RQ mapped text file with a „turtle" extension (.ttl). The mapped file contains semantic data descriptions from local databases and is based on ontological languages. The D2RQ mapping language is a declarative language for describing links between the relational databases and RDFS vocabulary or OWL ontologies. The result of D2RQ mapping is the RDF file in turtle syntax. Mapping in a file is expressed by defining terms in the D2RQ namespace domain. The terms defined within the Namespace domain are formally defined in the D2RQ RDF schema.

Semantic mapping of relational database

The mapped data that the D2R server provides is HTML and RDF, and for manipulating the mapped database, the SPARQL access point of the D2R server is used. D2R server allows translating relational database in the semantic database. In addition to MySQL database, it supports translation into the semantic form of the following databases: Oracle, PostgreSQL, SQL Server, HSQLDB, Interbase / Firebird. The syntax used to work with the mapped file is Turtle with .ttl extension. At the beginning of the mapped file, a set of prefixes is displayed ontologies and dictionaries used in the semantic mapping process. After defining ontological prefixes and dictionaries, the initialization of the Moodle database in semantic form is followed in Figure 2:

dev3.ttl dev.ttl

```
@prefix map: <#> .
#@prefix db: <> .
@prefix vocab: <vocab/> . #definicija iz baze
@prefix owl: <http://www.w3.org/2002/07/owl#>  .
@prefix dc: <http://purl.org/dc/terms/#> .
@prefix mau: <http://www.mau.rs/mau.owl#> .
@prefix rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#> .
@prefix rdfs: <http://www.w3.org/2000/01/rdf-schema#> .
@prefix foaf: <http://xmlns.com/foaf/0.1/#> .
@prefix xsd: <http://www.w3.org/2001/XMLSchema#> .
@prefix lom: <http://www.mau.rs/LOM.owl#> .
@prefix d2rq: <http://www.wiwiss.fu-berlin.de/suhl/bizer/D2RQ/0.1#> .
@prefix jdbc: <http://d2rq.org/terms/jdbc/> .
@prefix d2r: <http://sites.wiwiss.fu-berlin.de/suhl/bizer/d2r-server/config.rdf#> .
@prefix meta: <http://www4.wiwiss.fu-berlin.de/bizer/d2r-server/metadata#> .

<> a d2r:Server;
  rdfs:label "My D2R Server";
  d2r:baseURI <http://www.mau.rs:2020/>;
  d2r:port 2020;
  d2r:vocabularyIncludeInstances true;

  d2r:sparqlTimeout 300;
  d2r:pageTimeout 10;

  meta:datasetTitle "Mau dataset" ;
  meta:datasetDescription "My dataset contains many nice resources." ;
  meta:datasetSource "This other dataset" ;

  meta:operatorName "Jasmina Perisic" ;
  meta:operatorHomepage "www.mau.rs" ;
  .
map:database a d2rq:Database;
    d2rq:jdbcDriver "com.mysql.jdbc.Driver";
    d2rq:jdbcDSN "jdbc:mysql:///moodle";
    d2rq:username "root";
    d2rq:password "jasmina semantika";
    jdbc:autoReconnect "true";
    jdbc:zeroDateTimeBehavior "convertToNull";
    .
map:User a d2rq:ClassMap;
    d2rq:dataStorage map:database;
    d2rq:uriPattern "user/@@mdl_user.id@@";
    #d2rq:class mau:Student;
    d2rq:class mau:User;
    d2rq:classDefinitionLabel "User";
    d2rq:condition "mdl_user.id > 2 && mdl_user.confirmed = 1 && mdl_user.deleted = 0 ";
    # prva dva korisnika su admin
    .
map:owlType a d2rq:PropertyBridge;
    d2rq:belongsToClassMap map:User;
    d2rq:property rdf:type;
    d2rq:constantValue owl:NamedIndividual;
```

Figure 2 View of semantically mapped data from the Moodle MySQL relational database

For mapping classes and properties from existing standards, in this paper we used FOAF standard for user mapping, and Dublin Core and LOM standards for semantic annotation and mapping of learning objects. The basis of the complete mapped file is the MAU ontology. Figure 3 shows examples of semantic mapping of FOAF, DC, LOM standard elements in the mapped Moodle MySQL relational database.

Figure 3 Examples of semantic mapping of FOAF, DC, LOM standard elements in the mapped Moodle MySQL relational database

An example of multiple semantic mapping between several tables is presented in Figure 4a) between the Course, Enrol and User tables and Figure 4b) between the Logs and Workshop tables.

```
map:participate_course_inverse a d2rq:PropertyBridge;
    d2rq:belongsToClassMap map:User;
    d2rq:property mau:isParticipating;
    d2rq:refersToClassMap map:Course;
    d2rq:join " mdl_course.id => mdl_enrol.courseid ";
    d2rq:join " mdl_enrol.id => mdl_user_enrolments.enrolid ";
    d2rq:join "mdl_user_enrolments.userid => mdl_user.id  ";
    .
```

a)

```
map:mdl_logstore_standard_log_workshop_submission a d2rq:PropertyBridge;
    d2rq:belongsToClassMap map:Logs;
    d2rq:property mau:relatedToWorkshop;
    d2rq:property mau:relatedTo;
    d2rq:refersToClassMap map:Workshop;
    d2rq:join "mdl_logstore_standard_log.contextinstanceid => neki_view.c_cid  ";
    d2rq:join "  mdl_logstore_standard_log.contextid => neki_view.c_id  ";
    d2rq:join "   neki_view.instance <=  mdl_workshop_submissions.id";
    d2rq:join "   mdl_workshop_submissions.workshopid <=  mdl_workshop.id";
    d2rq:condition "mdl_logstore_standard_log.objecttable = 'workshop_submissions' ";
```

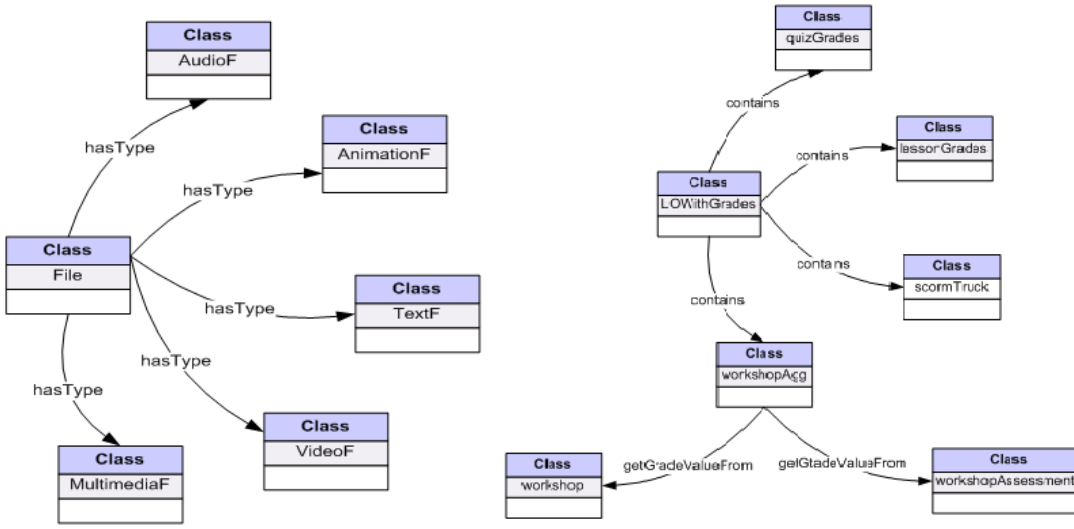
b)

Figure 4 Multiple mapping of semantic data

The purpose of a class as a semantic concept is to define objects which is shown in Figure 5. The resource is a common name for attributes and objects. The code from the Moodle relational database, mapped using the D2RQ server in the semantic database, is shown in the text below, where the standard prefix vocab is replaced by semantic i.e. ontological prefix mau. In this way, data mapping is not performed from a Moodle relational database, but a semantic database is called. In the same way, the semantically mapped record has changed the standard class name (for example, the map: mdl_assign has been changed to the folders: Assign), thus generalizing the concept of semantic class marking. As for semantic attribute marking, the procedure is the same (instead of vocab: mdl_assign_id, d2rq property mau: hasId is used).

Figure 5 A set of mapped classes

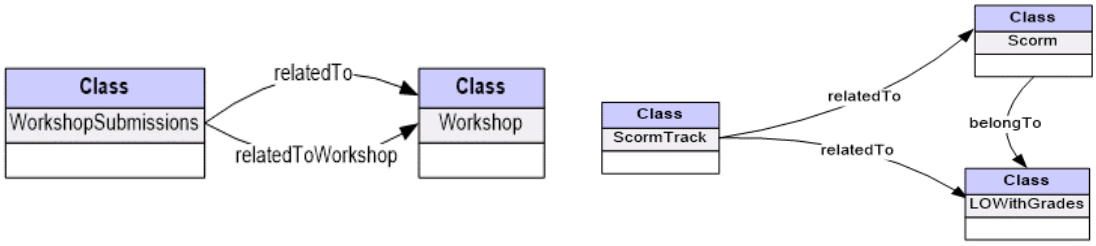
Each semantically mapped table is represented by a class. Table columns are semantically mapped into properties to objects and properties to other objects. Data in classes obtained by the process of semantic mapping represent instances or individuals. Figure 6 shows classes related to file types and classes such as WorkshopAgg that takes the average grade from 2 tables: WorkshopSubmissions and WorkshopAssessments. The LOWithGrades class represents a grouping of graded resources (quiz, lesson, scorm, and workshop).



a) b)

Figure 6 Display of graphs of subsequently created classes

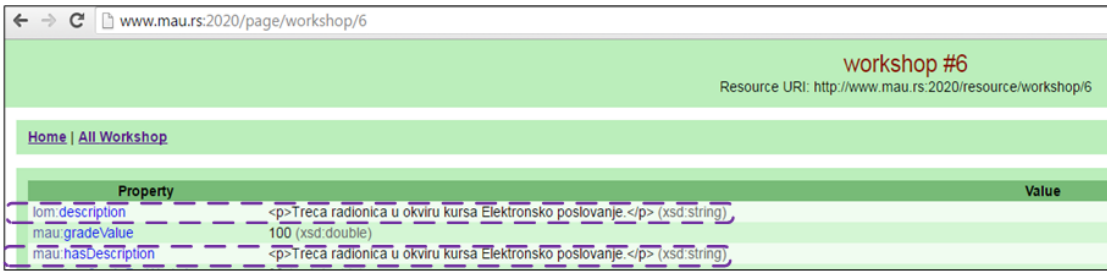
During semantic mapping, synonymous links between classes can often be created, as well as synonymous classes grouped by some criteria. The creation of generalized (group) or specialized classes and connections between classes depends on the goals of the ontology itself and the possibility of creating semantic queries. In some cases, it is impossible to obtain an adequate instance if such concepts are not made. In Figure 7a there are synonymous links relatedTo and RelatedToWorkshop between classes WorkshopSubmissions and Workshop. The relatedTo link is generalized and can be applied between any 2 classes that describe a resource, while the RelatedToWorkshop link specifically refers to the Workshop resource. Figure 7b shows an example of mapping between the synonymous classes ScormTrack to Scom and ScormTrack to LOWithGrades. Which connection will be applied depends on whether the semantic query needs to be generalized or specialized, i.e. whether it refers to all graded resources or a testable Scorm lesson.



a) b)

Figure 7 Examples of graphs of synonymous connections between classes

In the same way, semantic mappings are repeated for those properties in classes that are inherited from external ontologies, and are necessary for the MAU ontology. The semantic mapping results are identical, as can be seen in Figure 8.



a) Semantic resource mapping

b) Semantic mapping of files

Figure 8 Mapping of MAU ontology properties and inherited properties from external ontologies

DISCUSSION AND CONCLUSION

Semantic annotation can be defined as a procedure for linking words or parts of text with appropriate concepts of domain ontologies or their parts, Kiryakov et al (2004). In this way, semantically described web resources are provided that are legible and understandable to computers. Most structured data on the web is stored in relational databases. In the work of the author (Bizer & Cyganiak, 2006) the semantic approach to relational databases for which specialized software tools must be used are explained, Michel et al (2014). DR2Q allows an easy integration of the mapping in web applications by enabling accessing non-RDF relational databases as read-only RDF graphs. D2R server enables the manipulation of the mapped file as well as the mechanisms for creating and testing semantic queries over open repositories and other vocabularies, ontologies and semantic datasets. Each table in Moodle is mapped to the corresponding class, and each attribute is mapped to a property. D2R server has built-in APIs that enable working with semantic datasets and mapped input files.

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RESIDENTAL CONSTRUCTION OF ENERGOPROJEKT FROM THE POINT OF SUSTAINABILITY AND ENERGY EFFICIENCY

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ABSTRACT

The Electric Company of Serbia was established in Belgrade in 1945, with a view to helping the rehabilitation of the power stations destroyed in World War II. In 1951, this company turned into *Energoprojekt*, the greatest Serbian construction enterprise, which has been ranked among the top 250 design and engineering companies worldwide to this day. Residential buildings are one of the multifarious types of facilities built by *Energoprojekt*. Using case studies focusing on three buildings dating from different periods and the comparative analysis method, this paper aims to determine the extent to which *Energoprojekt*'s residential buildings are able to meet today's energy efficiency standards. The analysis covers three buildings – the YUBC, Blue Centre and Park 11 – with emphasis on the thickness of thermal insulation. The main hypothesis is that a facility with high quality joinery and possessing minimal thickness of thermal insulation according to the modern energy efficiency guidelines certainly meets the basic energy efficiency requirements.

Keywords: *Energoprojekt*, **residential buildings, sustainability, energy efficiency**

INTRODUCTION

Energoprojekt's beginnings are related to the period just before the end of WWII and the revival of the country, which needed a business organisation that would reconstruct the destroyed power stations and build new plants. In 1945, *The Electric Company of Serbia* (the so-called EPS) was founded, boasting its own Hydropower Department for the design of facilities using the power of water flow, the Thermal Energy Department for the design of power-generating

facilities using coal and steam, and the Architectural Department for the design of civil and building construction facilities.[13] The demands in the field of design and engineering followed the country's economic growth, and the form of business entities to execute these tasks was changing hand in hand with the developing socio-economic system. With time, the organisational division into sectors was established; this structure has been preserved to this day, albeit under different names, with the closing of certain sectors and the launching of new ones. A point was reached when any idea could be easily turned into reality. In 1963, *Energoprojekt* bought its first electronic computer intended for solving scientific and technical problems, Eliott 803B, and started using it in early 1964 already.[14]

In July 1963, *Energoprojekt* was officially registered with the specialised organizations of the United Nations. This represented yet another recognition of *Energoprojekt*'s success and opened the door to gaining even more renown in the field of its expertise.[15]

RESIDENTIAL BUILDINGS CONSTRUCTED BY ENERGOPROJEKT AND ENERGY EFFICIENCY

Although *Energoprojekt* was initially founded for the purpose of designing and erecting new power stations, soon an Architectural and Civil Department joined the original Hydropower Department and Thermal Energy Department; as it soon turned out, this sector played a key role in the implementation of all projects, leading to *Energoprojekt*'s expansion and ranking among the best design and engineering companies worldwide.

Energy efficiency first became a topic in this region in the 1970s, when the price of fuels surged due to the oil crisis; meanwhile, *Energoprojekt* had already paid attention to the quality and standards of all facilities it executed, particularly in the case of residential buildings.

One such example is the „economical flat" design created by *Energoprojekt*, the design of a one-bedroom or two-bedroom flat, which was popular for its modest price and practicality, and became a widely implemented standard-type

13 Jokšić, V.; Petković, D. (1961) *Energoprojekt,* Београд : Енергопројект штампарија, p.3

14 Ивана Јовић, Горан Динић, (2016) *Energoprojekt,* монографија поводом 65 година постојања, Београд: Енергопројект Енергодата а.д.

15 Душан Кљакић (1963), Енергопројект прво Југословенско предузеће регистровано код специјалних организација Уједињених Нација, часопис *ENERGOPROJEKT,* БРОЈ септембар 1963 - Beograd, p.1

flat design. By 1961, a total of 926 flats of this type were executed in the Republic of Serbia and the Republic of Croatia. [16]

Figure 1 Economical flats – a physical model (Source: Energoprojekt archive)

To gain better insight into the quality of *Energoprojekt*'s residential buildings in terms of energy efficiency, it should be borne in mind that the Law on Energy Efficiency started to be actively implemented in the Republic of Serbia only in 2011, while the energy efficiency of all buildings erected before depended solely on the client's willingness to install a thermal envelope of adequate thickness and high quality joinery. In many residential buildings constructed before 2011, with the exception of those built by *Energoprojekt*, the thermal insulation of outer façade walls, which is the most important aspect of a building's energy efficiency, contributing to the most significant savings of energy needed for the heating and cooling of buildings, was not planned at all. As this was not the case with *Energoprojekt*, today there are residential buildings designed by *Energoprojekt* twenty or more years ago that meet even the modern energy efficiency standards in terms of thermal insulation thickness.

AIM OF PAPER AND CASE STUDY

The aim of this paper is to compare and analyse *Energoprojekt*'s residential buildings designed and constructed in different periods using specific examples and to determine their ability to meet the contemporary energy efficiency requirements and standards in terms of thermal envelope thickness. First of all, it should be pointed out that thermal insulation (the thermal envelope of a building) in this geographical area usually refers to the implementation of mineral

16 Jokšić, V.; Petković, D. (1961) *Energoprojekt,* Београд : Енергопројект штампарија, p.58

wool or so-called „rock wool". The term derives from the mineral used as the main raw material for producing this insulation, a type of volcanic rock of excellent acoustic and thermal characteristics. In the Republic of Serbia, mineral wool insulation has been manufactured since 1974 in a factory in the town of Surdulica, at the time sold under the Vunizol brand name. In 2005, Knauf Insulations took over the factory, significantly improving its capacities. This analysis is based on the fact that the conductivity characteristics of Vunizol mineral wool manufactured in 1980, for example, are not largely different from those of modern mineral wool produced today.

Case study 1

The first building to be analysed is the residential-cum-office building known as the Yugoslav Business Centre (YUBC), designed and built by *Energoprojekt* in the Block 12 neighbourhood of New Belgrade. The author of this design is the renowned Serbian architect Mario Jobst.[17]

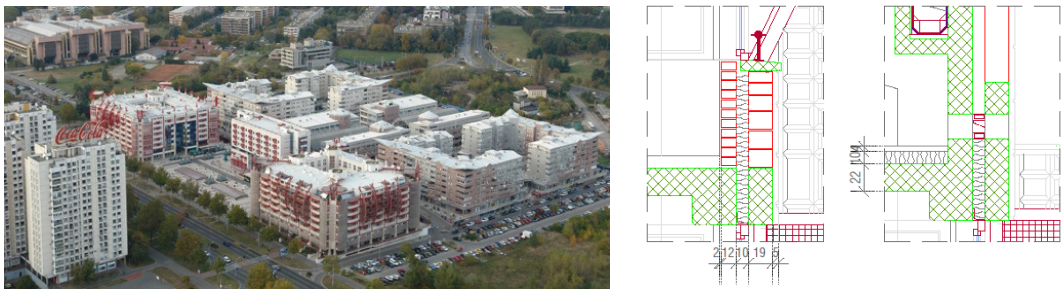

Figure 2 – The YUBC in Block 12, New Belgrade (source: Energoprojekt archive)

The detail drawings (the façade-wall cross-section and the roof-cross section) were created according to the excerpt from the original design titled *Block 12 – Phase 2 – New Belgrade – Building E from March 2003.*

The residential-cum-office buildings within the YUBC complex in Block 12 represent the benchmark of New Belgrade architecture. The urban design of the complex solves the issue of the city square, a break, while the exclusive location and the attractive position along one of the main city corridors connecting the old city centre and New Belgrade account for its representative character.

17 Маневић, З. (2016). Јобст, Београд: АСА Музеј асоцијације српских архитеката, p.39

The building's architecture comes with a message. It represents a marker on the road – the colour red is an accent, a stop-and-look element, recognised as such in traditional Eastern Serbian architecture and icon painting. What constitutes the promenade of Block 12 is the interplay of the full and the empty, the effect of colour, the prominent structure and the carefully modelled ground floor surfaces, gradually dividing the space into semi-public and public. The project's investor was *Energoprojekt Visokogradnja*, while *Energoprojekt Urbanizam i Arhitektura* was in charge of the technical documentation development. The building's façade walls were executed using the so-called cogged system, where thermal insulation is found between two rows of brick. Figure 2 features the detail drawings representing the cross-sections through the façade wall and the ceiling of the last floor towards the unheated attic space, clearly showing the thickness of the thermal envelope. It can be seen from the detail drawings that the total thickness of the façade wall is 48 cm, including the following layers: 1 cm of mortar, 12 cm of full brick, 10 cm of mineral wool, 19 cm of hollow brick and another 5 cm of mortar. The total thickness of the last floor's ceiling towards the unheated attic space is 36 cm, including the following layers: 22 cm of reinforced concrete slab, 10 cm of mineral wool and 4 cm of mortar.

Considering the year of construction of this building and the fact that the façade walls are very thick and thermally insulated, with high quality joinery installed and without a thermal break, while the last floor towards the unheated attic space is also thermally insulated, it can be easily concluded that this building meets the basic energy efficiency requirements of today.

Case study 2

The second building which is the subject of this paper is the Blue Centre, built in 2010, located in the Block 26 neighbourhood of New Belgrade. The building itself cannot be classified as a residential building; however, due to its properties, it is extremely important to mention it in the context of *Energoprojekt*'s energy efficiency awareness. Designed and executed in compliance with the international standards of building, this business facility represents the first facility in Belgrade to have met the strict criteria for class A+ office buildings, in terms of both the implemented technical solutions and the applied materials and equipment.

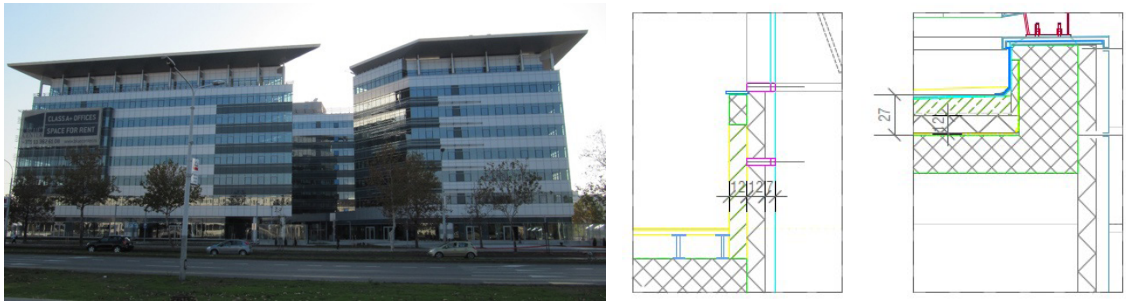

Figure 3 – The Blue Centre office building in New Belgrade, Block 26 (source: Energoprojekt archive)

The detailed drawings (the façade-wall cross-section and the roof-cross section) were created according to the excerpt from the original design titled *Office Building Unit 1 Block 26 New Belgrade* dated December 2008.

This building is situated in the central New Belgrade zone, which occupies the area from the Palace of the Federation, across Belgrade Arena and all the way to the New Belgrade railway station. The building's design was a part of several open calls aiming to examine and select the best engineering solution to mark the future New Belgrade landscape. The client (*Energoprojekt Holding*) requested that the building be executed in full compliance with the Class A+ Office Buildings standards. The design was developed by *Energoprojekt Urbanizam and Arhitektura*, and the responsible designer was Svetlana Šojić.

With a total of 32,750 m², the building was conceived as two independent wholes – Buildings A and B – separated by an inner courtyard used for the circulation of passengers between these two facilities. On the ground floor, representative halls occupy the central place. The façades are fully glazed, which emphasises the fusion of outdoor and indoor space. Floors from 1 to 6 are of standard type, featuring open office space which can subsequently be merged or divided in accordance with the users' needs. The roof terraces were created by the recession of the façades in relation to the main façade plain, with canopies above. There are two-storey underground garages with 392 parking lots. The complex also includes two self-standing facilities – double-purpose shelters.

In order to meet the strict Class A+ office building standards, among other requirements, this facility needed to have double floors in the offices, ceilings at least 2.80 m high, a flexible layout design, a stand-by power source, a façade system with windows that can be opened, state-of-the-art telecommunication systems and special computer management control and regulating and measuring systems.

When the crucial elements of a building's energy efficiency are considered, namely, thermal insulation and quality joinery, which bear the greatest losses of energy necessary for heating and cooling, it can be seen that when designing this building, *Energoprojekt* again complied with all applicable regulations and standards. Figure 3 includes detail drawings showing that the façade walls were planned as a structural façade with a 12-cm mineral wool filling. The reinforced concrete slab of the last floor (roof) is also insulated with a 12-cm layer of thermal insulation, which in combination with the other layers and the slope for the drainage of stormwater ensures waterproofness.

A class A+ facility, the Blue Centre is a prime example of *Energoprojekt*'s construction focused on energy efficiency. The initial idea behind the whole project was to execute a building of the highest energy efficiency properties, in compliance with international regulations and standards for office buildings. Owing to its architecture and location on one of the busiest streets of New Belgrade, even today, more than a decade after its construction, the Blue Centre building leaves the most varied impressions both on those who pass it by on a daily basis and those who see it for the first time.

Case study 3

The third facility analysed in this paper is the Park 11 residential-cum-office building in New Belgrade, located between Bulevar Mihajla Pupina and Bulevar Nikole Tesle streets, in the immediate vicinity of *Energoprojekt*'s premises and Block 12.

The design was developed by a team of engineers and technicians at the time employed by *Energoprojekt Urbanizam and Arhitektura*, led by responsible designer Žarko Čajić.

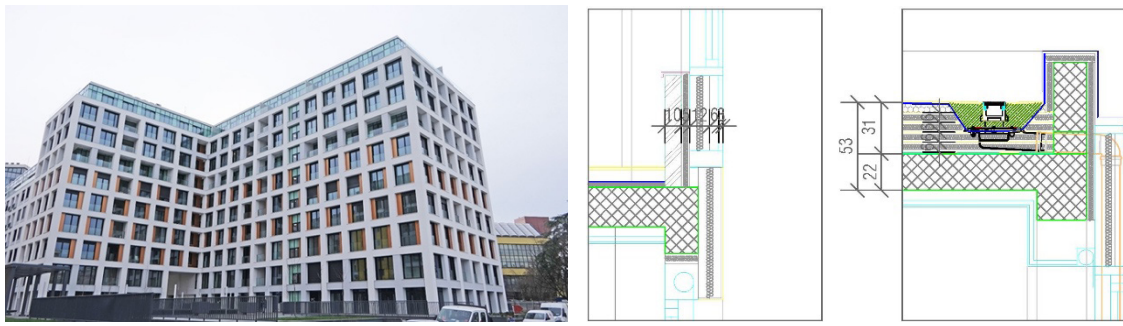

Figure 4 – The Park 11 residential-cum-office building, New Belgrade (downloaded from https://artinvesthome.com/wp-content/uploads/2021/02/Energoprojekt-Park-11-20.jpg)

The detailed drawings (the façade-wall cross-section and the roof-cross section) were created according to the excerpt from the original design titled *Park 11 Residential-cum-office Building CM 1005/28 – New Belgrade, Block 11a* dated May 2018.

With 20,055.44 m² gross building area and an irregular ground floor layout, the building's design envisaged a commerical area (shops and offices) on the ground floor and a residential area on the upper floors. The building is comprised of two building units (cluster blocks) – the northern and the southern unit. A picturesque plateau bordered by shops and services is enriched with lush landscape architecture, a green garden, a water feature and lines of trees. This building houses 134 flats of different organisational structures, 16 commercial properties, 4 entrances into the residential area and a two-storey garage with a total of 208 parking lots, and as such is an excellent example of *Energoprojekt*'s luxury building.[18]

The flats in the Park 11 building meet the high functionality and design standards in line with the global tendencies. Only first-rate construction materials were used and high quality joinery was installed. The detail drawings given in Figure 4 show that the façade walls were made of 10 cm gas-concrete blocks and glass panes, with two layers of thermal insulation in between (a 5-cm layer and a 12-cm layer, 17 cm in total). Between the thermal insulation and the glass pane, there is a 6-cm air gap, constituting a ventilated façade system together with the other layers. The last floor of the building towards the unheated space is insulated with a 24-cm layer of thermal insulation (four 6-cm layers), covered by a sloped layer for the discharge of stormwater made of Simporlit lightweight concrete. The total thickness of the roof with the remaining layers is 53 cm in the lowest part (see detail drawing F). Bearing in mind that this is a recently erected building, the development of an Energy Efficiency Report was mandatory according to the Serbian Law on Planning and Construction, and *Duma d.o.o.* was entrusted with this task.

According to **the Rulebook on the conditions, content and method of issuing certificates on the energy performance of buildings** („The Official Gazette of the RoS", no 61/2011), the energy class of a building is determined based on the yearly maximum allowed final energy required for heating [kwh/(m2a)], defined by a regulation directing the energy properties of buildings, particularly in the case of new and existing buildings. For this building, the yearly maximum allowed final energy for heating QH,nd,max [kwh/(m2a)] corre-

18 https://energovg.rs/projekti/poslovni-objekat-blue-center/

sponds to energy class C. All data on the annual consumption were taken from the Energy Efficiency Report for the Park 11 Building No 14/2018, signed by responsible designer Olgica Jovanović.

$Q_{H,nd}$=	754866.00	kWh/a
qH,nd=	55.35	kWh/m²a
$Q_{H,nd,rel}$=	92.25	%
Class	C	

Figure 5 A graphic representation of the building's energy class - (from the Energy Efficiency Report for the Park 11 Building, New Belgrade)

When all the aforementioned facts are analysed – namely, that *Energoprojekt*'s Park 11 is a recent building, constructed using modern and high quality materials in full compliance with the applicable standards and regulations, and for which an Energy Efficiency Report was developed and a class C energy certificate was obtained, it can be undoubtedly concluded that this building fully meets today's energy efficiency standards.

CONCLUDING REMARKS

Every well-planned design, whether that of a residential building, an office space or another type of facility, must comply with the applicable energy efficiency recommendations and standards. For over seventy years of its existence, *Energoprojekt* has repeatedly proven itself as a consistent competitor in the field of design and engineering of the most varied types of facilities, including residential buildings, always acting in full compliance with the measures contributing to the reduced consumption of energy required for heating and cooling. The analysis and comparison presented in this paper prove that all three observed facilities have appropriate insulation, in line with today's energy efficiency guidelines and standards. Even though the Blue Centre building is not a residential one, it was covered by this analysis as evidence of the high energy efficiency standards fostered by *Energoprojekt*. It can be concluded that all three facilities are energy efficient to a lesser or greater degree, which confirms that *Energoprojekt* has always paid full attention to the quality of applied materials and the energy efficiency of its buildings; what is more, it had done so even before a law governing this area was introcuded in Serbia.

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Park 11 Energoprojekt Bul. Mihaila Pupina 12, Novi Beograd - Београд: Енергопројект штампарија

https://energovg.rs/projekti/poslovni-objekat-blue-center/

BIOPHILIA – NATURAL LEYERS IN INTERIOR DESIGN

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ABSTRACT

Over time, our connections to the natural world diverged in parallel with technological developments. Today, most people spend almost 80-90% of their time indoors, moving between their homes and workplaces. Biophilia is the idea that humans possess an innate tendency to seek connections with nature. Contemporary interiors are increasingly inspired by biophilia as a holistic approach to design. Biophilia's core principle is to connect humans with nature and, as a result, improve well-being. The term translates to 'the love of living things' in ancient Greek (philia = the love of / inclination towards). Centering on experience, *biophilia* influences the moment-to-moment physical and sensory elements found within interiors. It impacts our emotions, health, and overall feelings. Biophilia consists of different natural layers that echo interior design. These layers address universal issues of human health and well-being. Case studies in this paper include nature in space, natural analogs, and, more broadly, the nature of space itself. The patterns range from visual connections, non-rhythmic sensory stimuli, temperature, and airflow to dynamic lighting and the presence of water. They can be understood in terms of direct experience (light, air, weather), indirect experience (natural materials, evoking nature), and the experience of space and place (prospect and refuge, mystery and risk).

Keywords: biophilia, nature, space, interior, design

INTRODUCTION

As the world population continues to urbanize, attributes oriented towards nature are becoming more crucial than ever. Importance of biophilic approach in interior design has many benefits, it may lower stress, enhance creativity and cognitive function, increase our well-being, and speed recovery (Browning et al., 2014). To understand this term that becomes more and more important in the recent times, it is important to understand the meaning of the term that is used to describe this way of designing personal or other space (Pranjale-Bokankar,

2019). Biophilia is the inborn biological affinity that humans have for the natural world. It explains why sounds like crackling flames and breaking waves fascinate people, how a view of a garden can inspire people, how heights and shadows arouse both intrigue and anxiety in people, and how spending time with animals and taking a stroll in a park can have restorative and healing effects (Dias, 2015). It may also be possible to use biophilia to explain why some urban parks and structures are preferred over others. Researchers, designers, and other design professionals have spent decades identifying the natural features that have the biggest influence on how satisfied we are with our constructed surroundings (Beatley, 2016; Browning et al., 2014).

The goal of biophilic design is to provide suitable living spaces for people in the built environment. Like all species, humans developed in reaction to environmental rather than artificial influences, and these adaptations over time were incorporated into the biology of our species (Browning et al., 2014). In the contemporary built environment, biophilic design aims to meet these innate adaptations to nature and improve people's physical, mental, and emotional well-being. The technique put forth in this framework is undoubtedly meant to be a useful tool for more effective built environment design (Browning et al., 2014).

However, in order to be successfully used, a new attitude toward nature as well as a new design method must be used. Recognizing how much human physical and mental welfare still depends on the caliber of our ties to the world outside of ourselves, of which we remain a part, is necessary for understanding biophilia and biophilic design.

MATERIAL AND METHODS

Origin of the biophilic design

It is important to state that this concept is not new, although the name and the attention put on it is. The earth and their culture were very important to all ancient builders and architects, who imitated natural shapes to build monuments that still astound us today. The Egyptian sphinx, Japanese interest with the bonsai tree, and fishponds are just a few examples of stylized creatures and plants that have been utilized as aesthetic and symbolic decoration (Ramzy, 2015). Prior to the development of biophilic design, it is crucial to revisit and reassess the ways in which „nature" was (intentionally) incorporated into several attractive designs. The quality of „biophilia" can also be found in older buildings. Even though these buildings may not have been created with the idea of biophilia in mind, they nonetheless reflect the worries and attempts of the architects to

connect with nature. The Humble Administrator's Garden in China imitates the wealth of information found in nature through various combinations of stones, plants, architecture, and water; the Japanese Zen Garden serves as a good example of traditional architecture that coexists with nature through metaphorical natural landscapes; the Saint Basil's Cathedral in Moscow recalls natural shapes and forms; and the Milan Cathedral serves as an example of the incorporation of natural patterns and geometries (Ramzy, 2015).

Benefits of biophilic design

The topic of „Nature in the Space" which is a core or understanding biophilic design focuses on the immediate, tangible, and transient presence of nature in a place or space. Included in this are the various forms of life—plant, animal, and aquatic—as well as the noises, smells, and other natural aspects. Potted plants, flowerbeds, bird feeders, butterfly gardens, water features, fountains, aquariums, courtyard gardens, green walls, and vegetated roofs are a few typical examples. By establishing deep, personal relationships with these natural elements, especially through diversity, mobility, and multi-sensory interactions, the strongest Nature in the Space experiences can be attained. A wide range of behavioral, emotional, and physical benefits should follow from the effective use of biophilic design. Improved physical fitness, reduced blood pressure, greater comfort and contentment, a reduction in the symptoms of sickness, and better health are examples of physical outcomes. benefits of the mind include increased (Gray & Birrell, 2014).

Less stress and anxiety, more motivation, and better problem-solving and creativity. Better coping and mastery abilities, more focus and attention, greater social interaction, and less animosity and aggression are all examples of positive behavioral change.

Professor of social ecology Kellert offered a set of standards for the biophilic design. Stephen R. Kellert (2008) listed six components for biophilic design in his writings. They are as follows:

→ Environmental characteristics

→ Organic forms and shapes

→ Light and space

→ Place-based interactions

→ Evolved human-nature partnerships

→ Natural patterns and processes.

It is also important to list and to acknowledge multiple benefits of this design. With developing awareness about importance of nature and variety of ways how connecting to the nature can be beneficial to people, more benefits are researched, and the list expends. But so far, most important aspects are the following.

First, it reduces emotions of stress and worry; improves physical health as seen by a drop in blood pressure and muscle tension; restores mental and emotional energy; and fosters a sense of interpersonal connection. It keeps the environment clean and eliminates pollutants which is not only beneficial for the people who spend the time in that space but has more general beneficial impact (Zhong et al., 2021). To add, the biophilia design contributes to productivity, increased creativity, and improved human wellbeing. Even though they are seated inside a building, people, students, and employees feel a connection to nature. The reduction of energy use and preservation of natural resources are the main reasons why these solutions are needed. It is one of the environmentally friendly methods for obtaining green environment. In addition, in should be mentioned that contact with nature has also been linked to healthy childhood maturation and development.

The one of the most important questions is how biophilic designed can be applied. Biophilic design contributes to maintaining the effectiveness, functionality, and durability of natural processes over time. Certainly, big development and building construction result in adaptation of natural techniques. In the short term, the use of Biophilic Design can change a structure's or a landscape's environmental requirements, but in the long run, it should support a natural civilization that is environmentally sound and sustainable. Using Biophilic Design effectively has a variety of positive effects on the body, mind, and behavior.

Forms of the biophilic design

The core concepts of biophilic design are represented by three different forms of nature experiences (Fig. 1-3). These include the perceptions of space and place, indirect perceptions of nature, and direct perceptions of nature. Perception of space and place refers to the organized complexity, integration of parts as wholes, mobility, cultural and ecological attachment to a place. Situations where several components come together to form a cohesive whole are desired. The sequential and successional connection of areas, as well as the presence of distinct and definite borders, are frequently used to create the impression of an emergent whole. A central focal point, which can be either thematically or functionally oriented, can increase this gratifying integration of space (Kellert

et al., 2008). To further explain this form, it is important to also include more detail explanation of cultural and ecological attachment to a place. Because it encouraged the management of resources, improved safety and security, and eased movement and mobility, humans evolved as a territorial creature. This territorial drive is shown in a preference for familiar surroundings, which can be strengthened through both cultural and ecological means. Culturally appropriate designs encourage a sense of location and a setting's unique human identity (Kellert & Calabrese, 2015). Ecological ties to a location, notably an appreciation of native landscapes, indigenous fora and fauna, and distinctive meteorological conditions, can similarly build an emotional commitment to a place. People are frequently motivated to preserve and protect both natural and constructed surroundings because of their cultural and ecological ties to a particular location (Kellert & Calabrese, 2015).

While indirect perception of nature obtains following aspects, images of nature are part of the indirect perception of nature, same as the natural materials and colors. Also, important is to add the naturalistic shapes and forms. Natural geometries are also important element of the indirect perception of nature that is one of the three main forms of biophilic design. As a part of this form, it is important to stimulate natural light and air. Third form, defined by Kellert and Calabrese (2015) is direct perception of nature. Direct experience of nature contains following elements. These elements are air, light, water, plants, natural landscapes and ecosystem and fire.

Some of the problems that might be addressed by usage of the elements of direct perception of nature. Airflow, temperature, humidity, and atmospheric pressure fluctuations can all promote natural ventilation in constructed environments. The prerequisites for that can be met by providing access to the outside through devices like movable windows, the stack effect, or more sophisticated technological and engineering methods. The desired element in developed environments is natural light. Natural light is preferable to artificial light because it is more comfortable, healthy, and productive. By using techniques like glass walls and clerestories, reflecting colors and materials, and other design tactics, natural light may be introduced deeply into interior spaces (Wijesooriya & Brambilla, 2020). The urge for a connection to water can be satisfied in several ways, including views of notable water bodies, constructed wetlands, fountains, aquariums, etc. Buildings should have abundant, biologically integrated landscapes that tend to highlight local species. The plants can increase comfort, physical health, performance, and productivity while reducing stress.

Another example refers to the natural materials that are used in the creation of vernacular structures. Important natural materials utilized in furnishings, fabrics, and other interior and exterior designs include wood, stone, wool, cotton, and leather. The transformation of natural materials often yields pleasing visual and tactile effects, but also uses less energy during construction, making it sustainable and affordable (Wijesooriya & Brambilla, 2020).

The naturalistic forms can take many different forms, such as leaf-like patterns on columns, animal and plant shapes on building facades, and animal impersonations woven into fabrics and coverings. A static place can acquire the dynamic and ambient behavior of a living system when naturalistic shapes and forms are present.

Figure 1-3. Case studies of biophilia in interior - different forms of nature experiences

(https://www.archdaily.com/945220/revitalized-public-spaces-fostering-human-connections-in-cities?ad_medium=widget&ad_name=related-article&ad_content=935258) *Retrived July 20, 2023.*

DISCUSSION AND CONCLUSION

Today, metropolitan regions are home to more than half of the world's population. UN research claims that by 2050, urbanization and general growth might add another 2.5 billion people to the world's metropolitan population. The objective of biophilic urbanism is to reverse the current urban disconnect from nature by incorporating the natural world's experience more fully into daily urban living (Xue et al., 2019). With a combined focus on the physical environment, urban design, lifestyle, attitudes, and experiences, biophilic urbanism is emerging as a planning and design strategy for the holistic enhancement of urban areas (Russo, 2017).

The idea of a „biophilic smart city" describes how to plan for and remodel cities to include the natural environment. Biophilic urbanism, which incorporates nature into urban settings, can address a wide range of ecosystem services,

including food production, CO2 reduction, microclimate benefits, flood control, and water quality. One such small city that is a good example of a biophilic city is Singapore, where the growth of green spaces and green buildings is regenerating the natural processes of the city and producing an urban environment resembling its original design (Kellert, 2018). That is a future expectation from biophilic design.

Still, it is important to reconsider some challenges as well. Architecture that incorporates nature must be carefully planned and maintained (Sadick et al., 2023). For instance, plants may die or cause structural concerns, excessive humidity, pest problems, or odor problems, and extremely artificial „green" designs need significant energy consumption and care (Sadick et al., 2023).

This brief discussion about biophilic design can be concluded with the words of Rick Fedrizzi, President, CEO and Founding Chairman, U.S. Green Building Council who said:

"„When nature inspires our architecture-not just how it looks but how buildings and communities' function-we will have made great strides as a society. Biophilic Design provides us with tremendous insight into the 'why', then builds us a road map for what is sure to be the next great design journey of our times."

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EUROPEAN CENTRAL BANK IN THE POST COVID GREEN TRANSITION

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ABSTRACT

Governments, central banks, federal executive bodies and regulators during Covid-19 have been trying to enhance liquidity in the market, introducing new monetary and financial policy measures, tax breaks, and other appropriate measures in order to mitigate consequences of Covid-19, which caused a sharp contraction in economic development, reducing liquidity and demanding access to capital. Therefore the aim of the paper is to analyze the measures of post covid green transition related to climate change risks and adaptation policies in financial institutions, as they can be a strong and significant instrument of raising economic sector competitiveness contributing to overall economic development. The paper shall analyze the newest European Central Bank climate related measures that include the development of new macroeconomic projections, conducting theoretical and empirical macroeconomic modelling and scenario analyses to monitor the implications of climate change. By new statistical framework, new experimental indicators on statistical data for climate change risk analyses covering relevant green financial instruments and the carbon footprint of financial institutions, as well as their exposures to climate-related physical risks, European Central Bank shall try to achieve its transition towards a more sustainable economy in order to fulfil its primary objective of maintaining price stability.

Key words: *climate change, green transition, European System of Central Banks, European Central Bank*

INTRODUCTION

In response to the Covid-19 pandemic in order to mitigate the economic consequences of Covid-19, strong public support and macro prudential policies

have tried to maintain stability. Central banks have been at crossroads having turned to newer, more unconventional strategies to control the money supply and boost economic growth (Song and Zhou, 2020). The crisis caused by the Covid-19 pandemic has also led to disruptions in global production chains and the spread of the virus has been difficult to contain. Other risks in the Eurozone have included the outcome of negotiations on Brexit, the risk of increased trade protectionism, and the risk of long-term adverse effects on global supply chains (Welfens, 2020). The European System of Central Banks provided substantial monetary policy support in 2021 to mitigate the impact of the pandemic. Several methods have been used to trace the effects of monetary policy innovations on macroeconomic variables employing suitable instruments to measure the effect of monetary shocks. The main goal of the European System of Central Banks is to maintain price stability which has been challenged in the Covid-19 crisis. The aim of the paper is to analyze the measures of climate change risks and adaptation policies in financial institutions, as they can be a strong and significant instrument of raising economic sector competitiveness contributing to overall economic development.

EUROPEAN SYSTEM OF CENTRAL BANKS

The Treaty establishing the European Community obliges the European System of Central Banks (ESCB) to perform its central banking function ensuring effective independence (functional, institutional, personal and financial) and incorporating principles of sustainable growth. The existence of an economic and monetary union requires the following elements (Jovanović, 2004):

- centralization of monetary policy,
- a single central bank or a system of central banks that control the implementation of stabilization policies,
- the convertibility (at least internal) of the currencies of the countries participating in the Union,
- unique performance on international financial markets,
- capital market integration,
- identical inflation rates,
- harmonization of fiscal systems,

- continuous agreement on economic policies and their harmonization among the participating countries, as well as salary corrections at the Union level.

The European System of Central Banks is not in itself a legal entity, and due to the differentiated level of integration in the European Monetary Community, the real actors are the European Central Bank (ECB) and the national banks of the member states. National banks of member states are in the function of the real ESCB and operating under the name Eurosystem (Hochreiter, 2000). The European System of Central Banks comprises the ECB and the 27 national banks of the EU member states. The ESCB operates following the principles of an open market economy with free competition and works to achieve the objectives of the European Union, such as a high level of employment and sustainable and non-inflationary growth, by its primary goal, although challenged by its accountability for a broader set of issues. The primary tasks performed by the ESCB (Vapa Tankosić, 2022):

- Formulation and implementation of single monetary policy in the EC supervising all euro area banks;
- Conducting foreign exchange operations as absolute independence of monetary policy does not exist from foreign exchange rate policy;
- Holding and managing official foreign exchange reserves held by national central banks;
- Improvement and smooth functioning of payment systems;
- The exclusive right to authorize the issuance of euro banknotes in the EC and the approval of the issuance of banknotes;
- Keeping statistics;
- Contribution to financial stability and supervision;
- Developing international cooperation.

Table 1 Euro area NCBs' contributions to the ECB's capital

National central bank	Capital key (%)	Paid-up capital (€)
Nationale Bank van België / Banque Nationale de Belgique (Belgium)	2.9630	320,744,959.47
Deutsche Bundesbank (Germany)	21.4394	2,320,816,565.68
Eesti Pank (Estonia)	0.2291	24,800,091.20
Central Bank of Ireland	1.3772	149,081,997.36
Bank of Greece (Greece)	2.0117	217,766,667.22
Banco de España (Spain)	9.6981	1,049,820,010.62
Banque de France (France)	16.6108	1,798,120,274.32
Croatian National Bank (Croatia)	0.6595	71,390,921.62
Banca d'Italia (Italy)	13.8165	1,495,637,101.77
Central Bank of Cyprus (Cyprus)	0.1750	18,943,762.37
Latvijas Banka (Latvia)	0.3169	34,304,447.40
Lietuvos bankas (Lithuania)	0.4707	50,953,308.28
Banque centrale du Luxembourg (Luxembourg)	0,2679	29,000,193.94
Central Bank of Malta (Malta)	0.0853	9,233,731.03
De Nederlandsche Bank (Netherlands)	4.7662	515,941,486.95
Oesterreichische Nationalbank (Austria)	2.3804	257,678,468.28
Banco de Portugal (Portugal)	1.9035	206,054,009.57
Bank of Slovenia (Slovenia)	0.3916	42,390,727.68
Národná banka Slovenska (Slovakia)	0.9314	100,824,115.85
Suomen Pankki – Finlands Bank (Finland)	1.4939	161,714,780.61
Total	81.9881	8,875,217,621.22

Note. Taken from https://www.ecb.europa.eu/ecb/orga/capital/html/index.en.html

The term European System of Central Banks refers to the institutional framework representing the "organic link" between the ECB and the central banks of the Member States. The European System of Central Banks ensures centralized decision-making and ensures that the identified tasks are performed jointly and following the system's allocation of functions and objectives. The European System of Central Banks includes all national banks of EU member states, even those that have not adopted the euro due to special status or derogation. In the Table 1 the national banks contributions to the ECB's capital are shown.

Central banks credibility is crucial for controlling inflation and the European Central Bank and the central banks of the member states are legal entities and actual executors, while the ECB is the central hub of EU economic policy. There are three fundamental political and economic reasons why the whole system was created for the euro as the Central Bank and not just one single central Bank (Scheller, 2004):

1. The establishment of a single central bank for the entire euro area would not be acceptable for political reasons;
2. The Eurosystem's approach is based on the experience of Member States' central banks and calls for the preservation of their institutional framework, infrastructure, operational capabilities, and expertise; the central banks of the member states continue to perform activities that are not exclusively linked to the euro;
3. Due to the large geographical area of the euro, it was appropriate to provide an opportunity for all institutions to be the "entry point of central banking" in each of the individual countries. Due to a large number of nations and cultures in the Eurozone, domestic institutions are taken as the best entry points for access to the Eurosystem.

The main goal of the European System of Central Banks is to maintain price stability which has been challenged in the Covid-19 crisis. The growing awareness of the impacts of climate change on prices and financial stability among central banks has been shown by the integration of climate change into the strategy of central banks in China, Brazil, Sweden, France, Netherlands, Japan or the United Kingdom and this new strategy is indispensable to allow the ECB to achieve its monetary policy objectives in the future.

THE ECB'S CLIMATE CHANGE ACTION PLAN

Since 2007 The European Central Bank (ECB) has decided to take measures to systematically dealt with the issue of environmental sustainability. The ECB attaches great importance to climate change in January 2021 it has founded the Center for Climate Change with the aim of unifying the work on climate change (Martin, 2022). ECB supports a transition to a carbon-neutral economy with adequate measures promoting the development of sustainable finance and creating incentives for a greener financial system. The Eurosystem has to take into account the impact of climate change and the transition towards a more sustainable economy in order to fulfil its primary objective of maintaining price stability. The main reason for incorporating climate considerations into its mon-

etary policy framework is that the macroeconomic and financial market disruptions are linked to climate change and transition policies to carbon neutrality could affect the conduct of monetary policy and thus the ability of the ECB to deliver on its price stability mandate, as climate related risks not only have crucial implications for price stability but also affect the transmission of monetary policy through other areas of central bank competence, such as financial stability and banking supervision as stated by the Governor of the Banco de España (De Cos, 2022).

The ECB measures include the development of new macroeconomic projections and conducting theoretical and empirical macroeconomic modelling and scenario analyses to monitor the implications of climate change and related policies for the economy, the financial system and the transmission of monetary policy through financial markets and the banking system to households and firms. ECB shall develop the statistical framework, new experimental indicators on statistical data for climate change risk analyses covering relevant green financial instruments and the carbon footprint of financial institutions, as well as their exposures to climate-related physical risks. ECB shall adapt its operational framework in relation to the market neutrality and efficiency concepts in monetary policy operations and the introduction of disclosure requirements in line with EU policies as an eligibility requirement in collateral framework and asset purchases. The adoption of other climate change criteria in other areas include the assessment of the climate-related risks in the Eurosystem's balance sheet, climate change risks in credit ratings for collateral and asset purchases, climate change risks in the collateral framework and climate change risks in the Corporate Sector Purchase Programme. ECB has therefore published a comprehensive action plan on climate change together with a detailed roadmap to incorporate climate change considerations into its monetary policy framework extending to 2024.

Table 2 ECB roadmap to incorporate climate change considerations

Areas of activity	Measures
Eurosystem/ECB staff macroeconomic projections	Introduce technical assumptions on carbon pricing for forecasting and regularly evaluate the impact of climate-related fiscal policies on the Eurosystem/ECB staff macroeconomic projections baseline

Areas of activity	Measures
Macroeconomic modelling and scenario analyses	Integrate climate risks into the ECB's workhorse models and assess their impact on potential growth. Conduct scenario analyses regarding transition policies. Model implications of climate change for the transmission of monetary policy
Statistical data for climate change risk analyses	Develop indicators on green financial instruments Construct indicators on exposures of financial institutions to climate-related physical risks through their portfolios Derive indicators on the carbon footprint of portfolios of financial institutions
Market neutrality and efficiency concepts in monetary policy operations	Assess potential biases in the market allocation amid market inefficiencies and the pros/cons of alternative allocations.Make concrete proposals for alternative benchmarks, in particular for the Corporate Sector Purchase Programme (CSPP).
Disclosures in line with EU policies as an eligibility requirement in collateral framework and asset purchases	Proposal and adoption of EU disclosure regulation. Design adequate policies and conduct legal and operational preparations
Climate stress-testing of the Eurosystem balance sheet	Conduct pilot stress test based on the 2021 ECB economy-wide climate stress test and 2022 supervisory climate stress test of individual banks
Climate change risks in credit ratings for collateral and asset purchases	Assess rating agencies' disclosures and understand how they incorporate climate change risk in ratings Develop minimum standards for internal credit ratings
Climate change risks in the collateral framework	Review collateral valuation and risk control framework to ensure that climate change risks are reflected. Assess financial innovation related to environmental sustainability
Climate change risks in the Corporate Sector Purchase Programme (CSPP)	Conduct enhanced due diligence to incorporate climate change risks Prepare climate-related disclosures of the CSPP Develop proposals to adapt the CSPP framework to include climate change considerations.

Note. Taken from ECB Annual Report 2021, Annex: Detailed roadmap of climate change-related actions
https://www.ecb.europa.eu/pub/pdf/annrep/ecb.ar2021~14d7439b2d.en.pdf

CONCLUSION

The impact of crisis caused by the COVID-19 pandemic on financial markets and institutions has shown us that it is necessary to analyze the reactions of central banks, which usually act as the first line of defense. The crisis caused by the COVID-19 pandemic has led to disruptions in the global market as well as in the Eurozone. Monetary measures are aimed at controlling the money supply, supporting liquidity by lowering required reserves for banks, easing collateral requirements, increasing repo operations to obtain liquidity, and extending the term of such operations. Financial measures for commercial banks, as well as financial measures for borrowers, aim to enable businesses to access additional capital through government credit guarantees to ease the pressing liquidity problem and boost economic recovery (Vapa Tankosić, et al., 2020). The European Central Bank (ECB) has been under increased pressure to take action on climate and therefore its new action plan to include climate change considerations in its monetary policy strategy. ECB has therefore published a comprehensive action plan on climate change. The new ECB measures include the development of new macroeconomic projections, the statistical framework, new experimental indicators on statistical data for climate change risk analyses covering relevant green financial instruments and the carbon footprint of financial institutions, market neutrality and efficiency concepts in monetary policy operations, the introduction of disclosure requirements and other climate change criteria in other areas include the assessment of the climate-related risks in the Eurosystem's balance sheet, climate change risks in credit ratings for collateral and asset purchases, climate change risks in the collateral framework and climate change risks in the Corporate Sector Purchase Programme.

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RETHINKING ARCHITECTURAL OBJECT: THOUGHTS ON ADAPTIVE REUSE IN THE ANTHROPOCENE

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ABSTRACT

This paper aims to propose new perspectives on architectural object in the Anthropocene era through the concept of adaptive reuse. It examines several principles derived from the architectural and philosophical inquiry that can contribute to redefining the status of the contemporary architectural object. The Anthropocene presents a unique challenge. It signifies not only a geological shift but also demands a reevaluation of the complex relationship between nature and culture. Moreover, it raises the question of whether progress for humanity may necessitate a moment of self-erasure or even the monumental dismantling of the modernist ego. In addition, history shows us that the modernist linear concept of time where the world is a unidirectional set of causes and effects, although more convenient for human comprehension, is potentially disastrous as it does not take into consideration a multitude of feedback loops in our reality. In the context of the complexities of the Anthropocene, we propose that adaptive reuse can serve as a catalyst for a paradigm shift in redefining the architectural object, offering valuable insights into its potential positive impact on both human and non-human environments. As the process of adapting always assumes sets of previous behaviors, i.e. existing buildings, adaptive reuse first requires the right question to be posed within the existing system and, secondly, it ideally requires a relational attitude in which an architectural object is always a thing of a special status in the world, one that has the potential of speaking of elusiveness in Graham Harman's words. With insights from thinkers like Harman, Bruno Latour, and Beau Lotto, we can now explore the novel status of the architectural object within an extended ecological context. We find that adaptive reuse is one of those practices where the modernist legacy of relationalism is already dismantled which provides us with a

compelling experiment to think architecture not only in terms of interconnectivity and interdependence but also in terms of objects of surprise and estrangement.

Keywords: Adaptive Reuse, Anthropocene, architectural object, Object Oriented Ontology

INTRODUCTION

Architecture has long narrated the stories of objects, humans, and occasionally non-humans—capturing their lives, relationships, contexts, actions, and temporalities. Recent decades have witnessed a significant transformation in the architectural landscape. The focus has shifted towards understanding the relational dynamics within the architectural realm, exploring the interiorities and exteriorities of architectural objects. Simultaneously, there has been a deliberate shift away from placing the designer at the center of the creative process, with randomness intentionally introduced into the equation. Architects' anxieties to keep up with the challenges of the complex network systems came along with efforts to present non Euclidean space. (Ruy, 2013) This strive to "belong to reality" following contemporary philosophical and scientific discussions, brought architecture to an uneasy position of often being a victim of the circumstances and invisible relationships, beyond usually understandable theorem that it is a discipline directly tied to political and cultural processes. In this paper, we propose a scenario in which architecture is not merely a passive byproduct of processes of which we often do not have even full grasp, but an intentional and responsible practice in the age of a planetary shift.[19] This leads to a fundamental question: what is the nature of architectural object in the face of Anthropocene we all are immersed in? In our argument for the ecological, we propose that ecological means to create joyful environments where sentient beings can thrive. From this foundation, numerous benefits can follow with reduced carbon footprint being only one of the benefits that go under the set of principles called sustainability.[20]

19 ¨Surely the most striking feature of the Anthropocene is that it is the first geological epoch in which a defining geological force is actively conscious of its geological role." Palsson G, Szerszynski B, Sörlin S, et al. (2013) Reconceptualizing the 'anthropos' in the Anthropocene: Integrating the social sciences and humanities in global environmental change research. Environmental Science & Policy 28: 3-13.

20 It seems obvious that joyful is an unstable category as it can be interpreted in a myriad of ways. We intend to support this statement with examples from practice in the research to come. In addition, one can claim with a certain level of certainty that certain environments are universally accepted as beautiful. Elisabet Grosz: "The question of an ethics of affect in the field of architecture is a complex one, one that at least some architects are attempting

NEW STATUS OF ARCHITECTURAL OBJECT

An architectural object is a unique entity, something located somewhere that encapsulates a set of activities related to the unveiling of life. It is, by its very nature, a historically constituted entity, even when we strive for absolute novelty. Often it is formed through centuries of practice that followed human development in all its virtuous and less honorable behaviors. Therefore, in the world of objects, architectural object is traditionally of special status in the mind of the architect. We agree here with Avşar Gürpınar's statement that "although the definition of an object is elementary, objects themselves are very complicated things. Thus, every object could also be considered a hyperobject." (Gürpınar, 2022) It is an entity that is connected to urban and other conglomerates and seems to be radically different from the natural world, despite the organicist rhetoric in certain cases.[21] In this text we propose a new understanding of the architectural object. It is both independent and interdependent, autonomous and relational, contingent on the circumstances at hand and the level of 'withholding' in Graham Harman's words: "The object is like a black hole withdrawn from view, yet still leaking radiant energy or releasing its fumes and powers into the world." (Harman, 2005, p. 95)[22] Our hypothesis is not a fixed statement; it needs constant reinvention and scrutiny. The intentional contradiction we embrace aligns with the concept of dialetheism, where true contradictions are considered possible, as seen in certain spiritual (such as Buddhism) and philosophical practices. We do not deny the systemic and relational nature of the world; rather, we argue that architecture facilitates relationships through the virtues of its objects. For architects, maintaining a certain degree of autonomy of the architectural „thing"

to address, in whatever inventive ways they can—see, for example the adventurous architecture of Arawaka and Gins, which challenges the body out of its habitual modes while bringing about a new, almost counter-intuitive body—the way architecture impacts on and transforms the body to bring out joyous affects and to diminish sad affects, to extend life or inhibit it. This is not, however, typical of most architecture, which aims at a functionality that is as inexpensive and open to ready transformation (including its own redundancy) as possible." In "Time Matters: On Temporality in the Anthropocene" in Turpin E. (ed.) Architecture of the Anthropocene, Open Humanities Press, p. 133

21 Even when we turn our buildings into nature-friendly systems that respond promptly to the environment, as biophilic architecture strives to do, it remains valuable to think of architecture as the provider of temporary objects, but in a new and different way.

22 In "From Things to Relationships: Architecture of the Ecological Mind " I explore the concept of interdependence in reality and the relational universe. At this point in history, for various reasons, it does seem more productive and more reasonable to discuss architectural object as an object, understood in a new way.

is essential so that in its "elusiveness", more or less predictable, it can radiate desirable outcomes in the environment.

MODERN LEGACY: DRAG AND DROP ON THE MARGIN

Modern legacy has been revised over and over again in the last half a century. From the point of view of ecology, its ideology is highly problematic, despite the enormous energy invested in the betterment of architecture, its health benefits, and the beauty of some of its objects. Sometimes the road to hell is paved with good intentions. What a dream it was to think that it is possible to "replace the "subjective" space and time by a really rational view of a space belonging to no space and a time made of timeless instants." (Latour, 2014, p. 13) Nevertheless, even as a well-founded critique of philosophical modernism is presented, no one can deny the power of thinking lying behind architecture's modernity. However, now when its legacy has been reconsidered many times, we might start thinking of dropping the whole issue while keeping in check lurking of its biases. History reveals that the prevailing modernist view of time, which depicts the way of the world as a one-way progression of causes and effects, although easier for human comprehension, is potentially disastrous due to its oversight of numerous feedback loops within our reality. To put it simply, without invoking any religious connotations, we often fail to realize that inadequately managed situations, if not treated thoughtfully and with care, can eventually return to haunt us. If we disregard the intricate nature of time, celebrate constant novelty, and allow new possessions to repeatedly encroach upon pristine land, thinking that we are going ahead at full speed with no consequences, we are in deep denial of our reality.

ART IS TO BE FOLLOWED

As an ecologist would say, for us to be able to move towards the more fulfilling mode of living, we need to understand our own position within the ecological system. Or, as one of our architecture professors used to say: to be able to design a horse barn you need to be able to imagine yourself as a horse. Or, as one spiritual teacher says: when you walk into the woods, be the woods. However, as Beau Lotto beautifully discusses in his book *Deviate*: our senses are seriously limited and made to suit only our evolution. It is difficult for us to live any other reality than the one we perceive. The paradox of the human condition is that we think that our perspective is the central one.

Throughout history, diverse artistic avenues have pioneered novel expressions, shaping our understanding of the world. Today as we propose to integrate artistic practices into architecture (once again) through the lens of Object-Oriented Ontology, we are poised to reimagine space, inspire awe, and conjure a sense of enchantment. (Harman, 2014) This aligns seamlessly with the notion that sustainability should not be mere lip service to greening the environment but radical and political approach towards betterment of life in all its forms. Art has an entire repertoire of tools that can offer especially since it is not preoccupied with functional concerns, which taken literally in architecture can be a stumbling point and source of all kinds of literalisms. Making the invisible visible is one of those tools, such as presenting slow-paced natural processes or melting glaciers by Olafur Eliasson. The insinuation, the unusual rhetoric, engagement with the body, atmosphere, and affect are others. What the best contemporary art, or art historically, does, generally speaking, is throw the viewer of the usual, habitual perception of things. In object-oriented philosophy, according to Harman, "there are a number of ways in which we can know the real without knowing it directly. This happens in cases where the real falls out of joint with its surface qualities, as in Heidegger's case of the broken hammer, or in metaphor where the object is ascribed strange properties and therefore becomes unknowable yet vaguely compelling. Language is often used to hint or insinuate rather than to state directly, though the modern era hates rhetoric so much that it forgets how crucial insinuation and innuendo are to everyday speech. The arts, too, are well aware that many things must be hinted at subtly rather than stated in literal terms." (Weir and Harman, 2022, p. 55) Secondly, art is not afraid to speak about beauty of the existence. It is not afraid to speak about the ugliness of existence either. This is not to say that architecture's job is to perpetually throw the human off the track; it is to say that a certain level of surprise, of estrangement is required, as Harman already noted. In today's world marked by familiarity art has traditionally had good results in invigorating the human mind, not allowing things to be taken for granted, which is a challenge that seems to be necessary today.

DESIGN IS THE KEY

Design as a multifaceted practice has builtin insecurity about the (life) processes and its results. Architectural object is ideally always a project involving all kinds of others and design depends on how interactions between humans, non-humans, things, and ideas are played together. As Bruno Latour notes "Design is the antidote to founding, colonizing, establishing, or breaking with the

past. It is an antidote to hubris and to the search for absolute certainty, absolute beginnings, and radical departures." (Latour, 2021, p. 155) In our mind, the significance of the design has to do with critical thinking and responsibility, negotiating, and repurposing. It requires basic psychological, physical and if you will, spiritual hygiene that fosters the health of the environment. Concerning architectural objects, we advocate for designs that harmonize creativity with efficiency. In Deviate, Beau Lotto illuminates how his home's architecture is meticulously crafted to foster thrive: "We all must engineer our own ecology of innovation, at home and at work, both in spaces we create and through the people with whom we populate them. Because your brain is defined by your ecology, the "personality" of the space you inhabit will necessarily shape itself accordingly." (Lotto, 2017, p. 279) If, as Lotto claims, we understand that "we are our context," design might arise to a whole new level. What things are made of and how to energize the object is the key task of the design: "How odd it has been for the Moderns to imagine that their materiality could be made of atomic points without spatial extension and of instants without duration." (Latour, 2014, p. 154)

OBJECT OF ADAPTIVE REUSE: CONCLUDING REMARKS

In the realm of architecture, the practice of adaptive reuse emerges as an active reevaluation of the intricate relationship between function and form. As we assert here, the present juncture necessitates a fresh perspective on the architectural object's place in the world. With the Anthropocene looming at our doorstep and within the very spaces we inhabit, the urgency of comprehending objects through an ecological lens becomes inescapable. Amidst pragmatic considerations and the quest for apt forms, architecture's true creative essence beckons exploration.

Aside from the obvious benefits of adaptive reuse which is working with invested energy of the existing buildings, lowering carbon footprint, mitigating urban sprawl, allowing for positive city intensification, healing brownfield, and so on, adaptive reuse enables derelationalization (Harman's term) of an architectural object from its form. Its request to engage the building's history with a new use opens up a space for "estrangement", a bit of surprise for the viewer here and there, thus pulling the observer away from the automatic response and absent-minded perception. Aesthetics (of non usual, non simplistic) lies between visible and hidden qualities of objects. (Harman, 2022) Adaptive reuse enables relaxing and even collapsing habitual responses to architectural design. In this process, the "function taken for granted" of the modernist agenda is naturally

melted away and the space for new types of encounters and relationships arises. This, of course, with the understanding that the old building is not a passive host for a new use, otherwise the potential of "estrangement" is gone, and literalism, to use Harman's term, is in place.

Several critical considerations demand immediate attention in the design process. Foremost is the reevaluation of context. If, as Lotto posits, we are the embodiment of our context, what implications does this hold for the architectural object? Perhaps, the first thing that comes to mind: we would want the function of breathing, of vitalizing ourselves emotionally, physically, and psychologically. And this is not to say that we need to immerse ourselves in a new phenomenological project; on the contrary. Next, the architectural program requires a fresh focus. This question has been around for a while, Anthony Vidler being most articulate about it, but now, life processes and beneficial feedback loops of all sentient beings need to be at the core of the design, depending on the task at hand. The question of design in the process of adaptive reuse is the question of proper framing of the issue at hand. And there lies the inherent complexity. When we, architects, get an assignment to do adaptive reuse we need to understand: "The world is a continuum. Where to draw a boundary around a system depends on the purpose of the discussion – the question we want to ask." (Meadows, 2009. p. 97) Therefore, design problem in adaptive reuse becomes a problem of posing the right questions.

In the spectrum spanning micro and macrocosm, the architectural object emerges as an agent of homeostatic regulation, gracefully oscillating between equilibrium and unexpected twists. Many circumstances of remembering and forgetting that inherited building carries within itself have to find an appropriate framework: one has to draw the right level of complexity that can be addressed in a project. Often, it is the right level of simplicity that needs to be addressed. Just because many aspects of our well-being have non-visual dimensions or are beyond our senses does not mean that we do not need to address them, over and over again. Let us learn from other non-human creatures who have vision better than ours, run faster than us, fly higher than us, and include as many life perspectives on this planet as we can; then we might be closer to understanding what this planet is about.

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GROSS ALPHA AND GROSS BETA ACTIVITY IN LEAVES (FIG, APRICOT AND VINE)

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ABSTRACT

This paper presents the results for gross alpha and gross beta activity in leaves samples: Fig (*Ficus carica),* Vine (*Vitis vinifera* L.), and Apricot (*Prunus armeniaca*). Samples were collected in Iraq (Sulaymaniyah, Kurdistan region), and in the Serbia (Belgrade), in the summer 2018. The analysis was done in dried and milled samples as well as in the annealed samples, using gas flow proportional counter. Determination of gross alpha and gross beta activity presents rapid method, essential for the analysis of radioactivity in environmental samples. The gross alpha activity is defines as the total activity of alpha emitters, and originates from the decay chains of ^{238}U and ^{232}Th, which quantity depends on the geological and geographical formation of natural radionuclides. The main contributor to the gross beta activity is natural long-lived isotope ^{40}K, as well as ^{210}Pb, ^{228}Ra. The gross beta measurements also include a contribution from anthropogenic radionuclides ^{137}Cs and ^{90}Sr. Radionuclides that emitting low-energy beta radiation (^{3}H and gaseous or volatile radionuclide such as iodine) cannot be detected by gross beta activity measurements.

Keywords: radioactivity, gross alpha and gross beta activity, fruit leaves

INTRODUCTION

Natural radioactivity in environment originates mainly from the primordial radionuclides, such as ^{40}K, and the radionuclides from the ^{238}U and ^{232}Th and their decay products. Radionuclides from the ^{232}Th and ^{238}U series are responsible for the largest contribution to the gross alpha activity while activity of ^{40}K comprises about 89 % of the gross beta activity, while the remainder arises from ^{90}Sr, ^{137}Cs ^{210}Pb, and ^{228}Ra [1-3]. During the nuclear weapons testing in the 1960s and after nuclear accidents in Chernobyl and Fukushima, artificial radionuclides ^{137}Cs and ^{90}Sr were released in the atmosphere from where they were deposited on the soil surface by fallout. Based on their long half-life these radionuclides can still be found in the environment [3,4]. From that reason monitoring of radioactivity in environment is of great importance. In order to assess concentration of radionuclides in plants it is necessary to know that the accumulation of radionuclides by plants may occur by two ways: absorption by the leaves and shoot of the plant from the air and precipitation (direct method), or by root uptake from the soil (indirect method). The first way is dominant at the moment and immediately after nuclear and other accidents that lead to an increase of concentration of anthropogenic radionuclides in the atmosphere, while the second way is dominant when the concentration of radionuclides decreases [5].

Soil-root uptake is conditioned primarily by soil chemical and physical factors which may selectively retain a radionuclide, such as ^{137}Cs. The uptake of radionuclides by plants is a process based on five main factors: the amount of organic matter or clays; the pH of the soil; the chemical composition of the soil; the chemical species of the radionuclides; the presence of fungi and bacteria. UO_2^{2+} is a chemical form that is taken up by plants in the pH range 5.0–5.5. In the case that U forms hydroxide, phosphate, or carbonate complexes, its bioavailability is reduced. Ra and Pb are mainly associated with organic matter, and their transfer to plants is therefore via this pathway. The presence of organic matter, inorganic colloids (clay), and competing elements will strongly affect the uptake of ^{90}Sr and ^{137}Cs by plants from the soil. [5,6]

The transport of radionuclides across the epidermis of plant leaves is determined in part by the anatomy of the leaf, and by physiological factors. Artifiical radionuclides ^{90}Sr and ^{137}Cs, which enter to the gross beta activity, are readily taken up by the leaf. ^{137}Cs undergoes more translocation into fruit and seeds than ^{90}Sr which tends to remain in the plant part in which it was initially absorbed [5].

The plants (vegetables and fruits) may cause accumulation of radionuclides in their organs, and that may be multiplied risk to human population via food chain.

The aim of this work was to measure gross alpha and gross beta activity in leaves samples: Fig (*Ficus carica),* Vine (*Vitis vinifera* L.), and Apricot (*Prunus armeniaca*) collected in Iraq (Sulaymaniyah, Kurdistan region), and in the Serbia (Belgrade).

MATERIAL AND METHODS

Fruit plants are divided into three classes: woody trees, bushes and herbaceous plants, according to their gross morphology and physiology [7]. Leaves samples investigated in this work belong to woody trees. Sampling of leaves: Fig (*Ficus carica),* Vine (*Vitis vinifera* L.), and Apricot (*Prunus armeniaca*) were carried out in Iraq (Sulaymaniyah, Kurdistan region), and in the Serbia (Belgrade), in the summer 2018. Samples were dried at room temperature and in the oven at the temperature of 105°C. After drying samples were ashed at 450 °C [8]. Analysis was done in ashed samples using the gas low-level proportional counter Thermo-Eberline FHT 770T. The counting gas is a mixture of 90 % Ar and 10 % methane. Efficiencies of detectors were determined using the certified radioactive calibration standards ^{241}Am and ^{90}Sr (9031−OL−334/11 and 9031−OL−335/11, respectively, Czech Metrology Institute), traceable to the Bureau International des Poids et Mesures (BIPM). The counting efficiency was 26 % for alpha and 35% for beta radiation. Measurement time was 14400 s, by 4 independent detectors simultaneously. Measurement uncertainty was expressed as an expanded measurement uncertainty at the confidence level of 95% (k=2).

RESULTS AND DISCUSSION

The obtained results for gross alpha and gross beta activity in investigated leaves samples are presented in Table 1. It can be observed that for all investigated samples activity is higher for samples collected in Iraq. In Apricot leaves and Vine leaves samples the difference between the values, for both gross alpha/beta activities, for samples from Iraq are almost twice as large. For Fig leaves samples the obtained results are similar.

Table 1 Gross alpha and gross beta activity (Bq/kg) in investigated samples

Sample	Gross alpha activity	Gross beta activity
Apricot leaves (*Prunus armeniaca*) Serbia	61 ± 11	518 ± 29
Apricot leaves (*Prunus armeniaca*) Iraq	108 ± 12	949 ± 39
Vine leaves (*Vitis vinifera* L.) Serbia	33 ± 7	220 ± 16
Vine leaves (*Vitis vinifera* L.) Iraq	56 ± 8	448 ± 23
Fig leaves (*Ficus carica)* Serbia	56 ± 12	400 ± 27
Fig leaves (*Ficus carica)* Iraq	69 ± 11	413 ± 27

In the literature there are no data about gross alpha and gross beta activity in similar samples. In order to determine specific activity of individual radionuclide, gamma spectrometric analysis and ^{90}Sr determination, by radiochemical procedure, must be performed.

The study [9] shows a comprehensive analysis of radionuclide concentration in soil, water and plants in Iraq using gamma spectrometry. Analyzes of radionuclide content are mostly done in the fruit sample (apricot) [10,11].

In Serbia, the monitoring of radioactivity is carried out in accordance with the Rulebook on the establishment of programs for systematic testing of radioactivity in the environment [12]. According to the environmental monitoring program continuous testing and measurements of radioactivity in different types of samples are performed, among other things it is also done in plants. The obtained concentrations of radionuclides in fruit samples (apricot, fig) can be seen in [13,14,15], but these results were obtained using gamma spectrometry.

The existence of the difference in the obtained values in this paper for Apricot leaves and Vine leaves can be explained by the fact that concentrations of naturally occurring radionuclides in fruit vary widely because of the differing background levels, climate, and agricultural conditions that prevail.

CONCLUSION

Gross alpha and gross beta activity in fruit leaves samples (Apricot, Vine and Fig) were analyzed. Investigation was performed for samples taken in Iraq and Serbia. The obtained results show higher values for gross alpha and gross beta activity in Apricot leaves and Vine leaves for samples from Iraq. For Fig leaves the results are similar. In the absence of recent atmospheric releases of radionuclides, the use of plants as monitors of soil deposits or reservoirs of ra-

dionuclides should be used primarily when some information on the characteristics of the soil reservoir is known. In order to estimate which way is dominant for radionuclide absorption by the plant, further analysis is necessary, including gamma spectrometry analysis of radionuclides as well as ^{90}Sr determination. It is also necessary to performed analysis of soil samples and estimate transfer factor of radionuclides.

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