Environment Protection Engineering

Vol. 50 2024 No. 3

DOI: 10.37190/epe240301

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MODEL FOR RISK ASSESSMENT IN THE INSTALLATION OF WASTEWATER TREATMENT PLANTS

The goal of this research is an analysis of risk factors that occur with the installation of wastewater treatment plants. Another purpose of this paper is to demonstrate the clear identification of risk factors during the construction of wastewater treatment plants. Also, this study aims to develop models for risk factors assessment as a basis for the analysis of risks associated with the installation of wastewater treatment plants. The paper will point out the identification of risk factors during the installation of wastewater treatment plants in a project conducted in the Republic of Serbia. The analysis identified risk factors that brought the project being conducted in the city of Krusevac. The purpose of research and identification of risk factors is to relax managing high-risk situations and to ensure an approach for eliminating the negative effects that risks create. The expected result is a developed model with defined risk factors for the estimation of their negative impact on wastewater treatment plants.

1. INTRODUCTION

In the last few years, there has been more research on identifying risk factors during the installation of wastewater treatment plants. Significant growth of the human population, large industrialization, and industrial development contribute to the increase of wastewater. Therefore, they must be treated in a wastewater treatment plant (WWTP) [1]. The construction of wastewater treatment plants is a significant part of preserving social and natural communities. With the rapid development of urbanization, municipal wastewater treatment plants have been widely constructed in intensely urban areas with high population densities [2]. Because of environmental protection, there are many projects about wastewater treatment plants (WWTP). These projects carry lots of risk factors that are not yet examined. This study also reviews plenty of potential risk factors in the WWTP project that may occur and hurt environmental protection as a whole.

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The research aims to create a model consisting of risk factors related to the construction of WWTP. The model created in this way may serve to display the most significant risk factors that appear during the construction of WWTP. It is necessary to establish a more simple, accurate and interpretable prediction model to realize risk factor assessment in the WWTP field. Certainly, this model will contribute to further environment. In addition, some studies expanded the environmental analysis to include meaningful aspects [3]. The basis for the creation of this model represents the project that is being implemented in Krusevac. Size facility, climatic conditions, influent loads and over/underuse were factors affecting the WWTP efficiency [4]. The main step in creating a model is the identification of risk factors. For research purposes, two methods were used, one theoretical and the other practical, the unification of which resulted in a model with risk factors. First, the theoretical identification of risk factors, and then the practical one, which included experts in the field of environmental research were done. Wastewater treatment plants play a significant role in minimizing environmental pollution by treating wastewater and reducing the release of contaminants into the environment [5]. The theoretical part of the research included many studies in the field of risk assessment in WWTP. The result of the research showed that a lot of risk factors appeared in the construction of the WWTP. The model with risk factors is presented clearly and simply through tables.

This paper analyzes the project conducted in 2022 in Krusevac, in the Republic of Serbia, about installing wastewater treatment plants (WWTP). Hence, WWTPs could also represent a potential threat to the sustainability of ecosystems [6]. To realize the risk assessment of WWTP, this paper proposes a risk assessment model, which includes risk factors in four categories. The project brings analysis in the time frame of one year through several categories such as law-legal, technical-technological, environmental protection, and logistics. This research contains an analysis of many experts such as mechanical, electrical, and construction engineers, as experts in environmental protection. It is necessary to achieve proper control of risk factors during installations of WWTP in such projects, so can to reduce the negative impact on environmental protection. WWTP effluents carrying plenty of nutrients and micropollutants pose serious threats to receiving rivers, however, the response of microbial community structure and function WWTP effluents discharge is still poorly understood [7]. It is required to analyze all possible processes and activities during installations of WWTP. With the establishment of WWTP, it is necessary to determine originate state of the environment, so we can throughout the process, analyze risk factors to facilitate activities during the installation of WWTP. A basic practice for the systematic operation of urban water distribution networks is effective non-revenue water management [8]. This research can be useful for the development of potential strategies for risk control and management in the field of drinking water [9]. In continuation, we will analyze all steps in the project of installations of WWTP. Also, during this project, we will explore all possible risks that may appear.

2. MATERIALS AND METHODS

The research was based on two methods. The first one was used to create a systematic literature review (SLR) using digital platforms. It was created by searching digital databases of original scientific papers, Science Direct, Web of Science, Scopus, Emerald Insight, Wiley Online Library, Google Scholar, EBSCO, etc. We used the following keywords for searching the digital database:

- wastewater treatment plant (WWTP) AND risk factor AND impact,
- wastewater treatment plant (WWTP) AND risk assessment AND project,
- wastewater treatment plant (WWTP) AND environmental AND impact,
- risk AND identification OR selection OR grouping.

We have created a database of risk factors related to WWTP that appear most frequently in the literature (Table 1). All original research used has the Science Citation Index (SCI). SLR was used to create a database of risk factors that will be further helpful in examining the project of construction of a WWTP in Kruševac. It is the first part of the research that served to create a theoretical framework of risk factors.

Table 1

Results of the literature review

No.	Risk factor	Comments based on literature
1	Violation in management of environmental protection during the plant installation	one action point of the plan is to ensure the security of water for ecological and environmental purposes [22]
2	Violation in management of system quality during the installation of plants	the need for stricter adherence to ISO standards to ensure quality and transparency are made clear and emerging challenges for life cycle assessment applications in the WWTP are discussed, including a paradigm shift from pollutant removal to resource recovery [23]
3	Violation in management of system reliability during the installation of plants	specific standards on environmental impacts should be set up, while bonuses can even be provided when the environmental impacts of operation are low [24]
4	Violation in management of system security during the installation of plants	many technologies have been developed for wastewater treatment to cater to different requirements ranging from safe environmental disposal standards to recycling and reuse [25]
5	Violation in law and legal regulations	therefore, regional management should refine the classification of the standards to ensure the effective use of energy in pollution control plans [26]
6	Poor collaboration with the public and supervising authority	the advantage of the proposed decision support concept for selecting the location of WWTP is that this model enables the timely inclusion of all relevant stakeholders (experts, government/investors, citizens) required to ensure a high-quality planning process. The method allows the inclusion of the opinions of the city government throughout every stage of the planning process, whether directly or indirectly, and that is adaptable when conditions are altered and amenable to customizations required by all other stakeholders indirectly [27]

Table 1

Results of the literature review

7	Insufficient documentation for projects	the pollutant concentrations in influent were relatively unsteady after upgrading, however being in line with previous reports [28]
8	Violation of urban plans	the rapid development of the economy, industrialization, and urbanization without adequate investment in wastewater treatment has resulted in degraded water quality [29]
9	Lack of construction permit	the WWTP with sustainable performance while complying with the discharge regulation which fully satisfies different requirements from manufacturing companies [30]
10	Lack of control during the installation of plants	accurate forecasting of the amount of wastewater discharge is essential to making more effective policies relative to wastewater control and management to achieve more sustainable economic development [29]
11	Violation in contracts	accurate forecasting of the amount of wastewater discharge is essential to making more effective policies relative to wastewater control and management to achieve more sustainable economic development [29]
12	Demographical changes	rural wastewater plans have to be developed for the long term, taking not only the ecology into account but also the demographic change [31]
13	Insufficient equipment at the construction site	one should account for both civil works (production of materials, transports from factory to workplace and combustible consumed) and also equipment (i.e. thousands of devices, including diffusers, pumps and blowers), which has to be replaced several times during the life span of the WWTP [32]
14	Insufficient infrastructure at the construction site	improving the wastewater treatment infrastructure becomes an urgent need since the WWTPs capacities are not equally increasing with the rapid population growth [33]
15	Inadequate mechanization and resources for work	a systematic and comprehensive assessment in the project planning or management processes could be significant which is to investigate the trade-off among a variety of issues (e.g., ambient ecosystem, engineering feasibility, infrastructure cost, energy consumption, recycled water pricing policies, community attitudes, etc.) [34]
16	Problems in assembling equipment and devices	a systematic and comprehensive assessment in the project planning or management processes could be significant which is to investigate the trade-off among a variety of issues (e.g., ambient ecosystem, engineering feasibility, infrastructure cost, energy consumption, recycled water pricing policies, community attitudes, etc.) [34]
17	Insufficient equipment for deep aeration	additional blower capacity inevitably has to be installed to treat higher organic loads regardless the added biomass comes in a new basin or it is fixed on a biofilm carrier system [33]
18	Low capacity of a cesspit	one should account for both civil works (production of materials, transports from factory to workplace and combustible consumed) and also equipment (i.e. thousands of devices, including diffusers, pumps and blowers), which has to be replaced several times during the life span of the WWTP [32]

Table 1

Results of the literature review

19	Poorly constructed sewage network	one of the main recommendations is that urban water mains and wastewater treatment systems should be adapted and modernized to meet the corresponding anticipated challenges of weather extremes (floods and droughts) as well as the sea-level rise [35]
20	Rinsing, dehydration and disposal of sand	the wastewater line is composed of preliminary treatment, involving screening, grinding and grit removal to prevent damage to equipment [36]
21	Problems in sewage sludge	a large number of variations of the conventional activated sludge process have been designed to improve system performance by modifying the reactor layout, aeration system, influent pattern, and operational conditions [37]
22	The deficient direction of wastewater in the cesspit	from a perspective of health, safety and environmental protection, urban wastewater and generated byproducts, such as sewage sludge, must be appropriately treated before recycled or discharged/disposed of into natural systems concerning standards and regulations [38, 39]
23	Unrefined rough and inert materials	the diesel associated with transporting the waste to the final destination, the deposition of inert material at a landfill, and the particulate matter emitted into the atmosphere are also contributing inputs to the wasting process [40]
24	Unrefined water with oil and grease	strengthen urban pollution control, strengthen the construction of supporting pipe networks, promote sludge disposal and recycled water use, and strengthen urban water saving [22]
25	Air pollution in certain areas and emission of harmful gases in the atmosphere	challenges related to global warming and climate change are often associated with the reduction of car exhaust and power plant emissions [41]
26	Occurrence in atmospheric water in plants	to compare the life cycle assessment of energy consumption, global warming, and eutrophication of water and wastewater service [42]
27	Occurrence in large amounts of gasses	consideration of all kinds of emissions and many types of environmental impacts is one of the strengths of life cycle assessment [43]
28	Occurrence in underground waters	monitor and oversee the total quantity of water, improve water use<efficiency, protect water resources scientifically, strengthen the management of rivers and lakes, determine ecological flow limits, strict control on groundwater exploitation, pay special attention to industrial water-saving, develop water-saving agriculture [22]
29	Occurrence in erosion, landslide and subsidence of terrain	the characterisation of the quantity and quality of the wastewater entering the WWTP involves phenomena of very different nature: rain, soil type (permeable or impermeable), invert level, temperature, population activity, industrial discharges, type and length of the sewer system, retention tanks, etc. [44, 45]
30	Noise during the demolition of existing objects	noise presents one of the most common environmental problems, which is also affected by the development of industry and transport; noise presents unwanted, disturbing, or, in some cases, harmful sound transmitted through sound waves [46]

Table 1

Results of the literature review

31	Vibration during the demolition of existing objects	the impact of vibration and the related mechanical noise of industrial plants and joining mechanical systems may cause an impact on, e.g., the reliability, productivity, durability, and other significant parameters [47]
32	Large amount creation in the communal waste	the water industry is responsible for various carbon emissions that require a significant amount of energy; the treatment of carbon--containing waste from the water industry can release a variety of emissions strongly affecting the management of water systems [41]
33	Impurity and outflow of feces	the interception of the pollutants to water bodies should be subject to real removal rather than displacement [48]
34	Disease and infection of the local population	exposure to surface water contaminated with human pathogens, i.e., viruses, bacteria or parasites may lead to infection and subsequent illness, such as gastroenteritis or skin, ear and eye infections [49, 50]
35	Occurrence in electromagnetic radiation and heat emission	challenges related to global warming and climate change are very often associated with the reduction of car exhaust and power plant emissions [41]
36	Endanger in natural resources of location	the first step is pretreatment with a screening, desanding and degreasing, followed by primary settling treatment; thereafter, the wastewater undergoes a biological process (secondary treatment), a conventional activated sludge (medium daily organic load per aerated sludge mass) and finally a secondary settling; the WWTP effluent is discharged to coastal waters [51]
37	Unapproachable locations for building plants	optimising area footprint for the synthesis of WWTP is one of the key components towards a more sustainable development of the WWTP [30]
38	Problems with ground clearing	the construction and demolition phases are commonly ignored in many papers as their proportion is assumed to be negligible compared with the operation stage [52]
39	A large amount of construction waste	the resulting values of the pollutant concentrations at the domestic source are higher than those reported at the entrance of the WWTPs [53]
40	Problems during equipment in plants	recycling water in industrial processes can provide a sustainable water supply for industry without straining municipal water supplies; however, industrial sites can also release organic water pollutants and produce waste during the treatment of water for consumption [41]
41	Impossibility of ground and construction work	the construction and demolition phases are commonly ignored in many papers as their proportion is assumed to be negligible compared with the operation stage [52]
42	Problems in transport	one should account for both civil works (production of materials, transports from factory to workplace and combustible consumed) and also equipment (i.e. thousands of devices, including diffusers, pumps and blowers), which has to be replaced several times during the life span of the WWTP [32]

Table 1

Results of the literature review

43	Problems in distribution and supply	to overcome the delay in the construction of the wastewater treatment plant by examining the implementation of supply chain management and building information modelling in the construction of a wastewater treatment plant [54]
44	Problems with water reception from the river	besides the changes in influx, climate change is also expected to influence river flow rates; in winter time, precipitation will increase river flow rates [55]
45	Built roads at construction sites	some authors have demonstrated this approach in a study of road construction materials [56]
46	Archaeological and cultural uncovering at the construction site	eco-suitability evaluation method integrating economic, social and ecological factors is employed to optimize the locations of the sewage treatment plants [57]
47	Impossibility of building plants due to weather conditions	reducing the impacts of climate change on the WWTP processes can also be achieved through the use of risk assessment tools such as impact assessments, continuous and systematic monitoring of the WWTPs and the use of the vulnerability aspect [58]
48	Lack of storage for dangerous waste	Kikuchi and Hirao [59] demonstrated the trade-off relationship between global impacts (global warming potential) and local impacts (occupational and neighbour's health risks) by studying potential human health impacts due to metal degreasing processes

The other method that we used to assess the risk factors is the Delphi method. It is an interactive research method for gathering the opinions of a panel of experts concerning a specific topic to validate a forecast of upcoming trends and changes based on the thematic convergence of respondents [10–12]. The first step is the configuration of the questionnaire which represents a tool that was used for the assessment of the importance of risk factors in THE WWTP project. Through the Delphi method, the opinion of a panel of experts is surveyed regarding a specific topic. It is featured by merging individual research and practical knowledge from selected experts [13, 14]. A practical model framework for risk assessment is created. The questionnaire consists of 48 risks divided into 4 categories. Based on the analysis of the project, experts evaluated the questionnaire with risk factors. Risk assessment as a systematic process plays a fundamental and essential role in managing various aspects of human life and organizational goals through the deep evaluation of events and their consequences [15, 16]. The experts had to answer the question for each risk factor whether it appeared during the installation of the WWTP. In this way, we established a synergy between SLR and the Delphi method.

The identification of risk factors was confirmed by 54 experts engaged in the construction of the WWTP project. The experts represented knowledge in the fields of environmental protection, construction, transportation, chemistry, law, the economy, and management. The interview was used to question experts to confirm the identified risk factors. The interviews reveal further layers of knowledge and may underline or contrast findings from the Delphi survey [17, 18] The research team reviewed and analyzed all the factors extracted from the literature and their respective definitions. They categorized the factors into distinct groups and provided an initial title for each category [19]. Working together and with systematic literature, 48 risk factors were identified. They were classified into four categories: law-legal, technical-technological, environmental protection, and logistics. Each category contained twelve risk factors. Based on the research on the location characteristics and conditions of the city of Krusevac, an inspection of the environment, specifics in the technology selected by the WWTP, and identification of risk factors have been made. This implies during the realization of the project, in emergencies, in a normal working state, and potential termination or stagnation of the WWTP. The conclusion is that risk factors can be short-term, periodic, or continuous during all stages of the realization of the project. Upon identification of possible risk factors, all short-term, local, and reversible factors were analyzed and valued for regular project work. Also, we explored the synergy between risk factors, long-term risk factors, periodical risk factors, and the probability of their repetition during the installation of the WWTP.

Identification of risk factors was based on an analysis of natural resources, location, building space for the WWTP, other conditions in a close-range environment, and inspection of the terrain. A detailed analysis of the state of the environment of Krusevac was performed as their capacity for installations of the WWTP, with aspects in place, characteristics, and conditions. In that manner, we could identify risk factors and create models for risk assessment. The list of risk factors was expanded through interaction with stakeholders and gathering data from the field. The proposed framework is expected to help researchers and decision-makers rank the risk factors and focus only on the most critical ones for minimizing the risks and reducing delays in project completion [20]. Effective recognition of a lot of risk factors in the project life cycle and management of the most important of them is essential to assembling models for assessment and analysis of risk factors.

The purpose of the research was to get opinions from experts about the impact of the factors of risks on the WWTP, which was accomplished through interviews and questionnaires that were conducted. The result of the research brings a model for all risk factors in categories for easier data analysis. The study employed a modified Delphi method to develop, validate, and finalize the scale. The Delphi studies are recognized as essential tools for comprehending trends and establishing standards [21]. Using the Delphi method, consensus from the experts was obtained regarding the most important questions to the construction of the WWTP. All experts confirmed that the risk factors identified in the literature were also present in the project after data were obtained and it is necessary to summarize results which will show which risk factors have an influence on the WWTP and analyze the negative effects they can produce.

The Delphi techniques have received positive feedback from experts in independent opinion, which is significant for study and research in the environmental field.

3. DISCUSSION AND RESULTS

After reviewing more than 40 studies, we consolidated similar risk factors and identified the four technical risk categories. The result of the research is the classification of risk factors performed according to (Table 2). In the law-legal category are sorted out risk factors like management standards, compliance with certain procedures and regulations, obtaining the necessary documentation, and implementation of administrative obligation during the installation of the WWTP. In the technical-technological category are sorted out risk factors about equipment, mechanization, resources for work, and infrastructure. In the category of environmental protection are sorted out all risk factors that harm the environment during the installation of the WWTP. In the logistics category, we have risk factors from aspects of locations, transport, distribution and supply, storage of waste, and weather conditions. Classified like this, into categories, risk factors represent a model according to which we can analyze and make assessments of them. In the continuation of the work, analysis will identify risk factors by the category in which they belong.

After the identification of risk factors and their categorization, a model for risk assessment was created, after that we performed a detailed analysis of risk factors during the installation of the WWTP in the city of Krusevac. In this study, we will understand risk factors from all categories through analysis. Research has shown four areas to be classified: legal-legal, technical-technological, environmental protection, and logistics and they will be analyzed in the project of installing the WWTP in the city of Krusevac.

Table 2

Model of identified risk factors

No.	Risk factor	Category
1	Violation in management of environmental protection during installation of plants	law-legal
2	Violation in management of system quality during installation of plants	
3	Violation in management of system reliability during installation of plants	
4	Violation in management of system security during installation of plants	
5	Violation in law and legal regulations	
6	Poor collaboration with the public and supervising authority	
7	Insufficient documentation for projects	
8	Violation of urban plans	
9	Lack of construction permit	
10	Lack of control during the installation	
11	Violation in contracts	
12	Demographical changes	

Table 2

Model of identified risk factors

13	Insufficient equipment at the construction site	technical--technological
14	Insufficient infrastructure at the construction site	
15	Inadequate mechanization and resources for work	
16	Problems in assembling equipment and devices	
17	Insufficient equipment for deep aeration	
18	Low capacity of the cesspit	
19	Poorly constructed sewage network	
20	Problems with rinsing, dehydration and disposal of sand	
21	Problems in sewage sludge	
22	The deficient direction of wastewater in the cesspit	
23	Unrefined rough and inert materials	
24	Unrefined water with oil and grease	
25	Air pollution in certain areas and emission of harmful gases in the atmosphere	environmental protection
26	Occurrence in atmospheric water in plants	
27	Occurrence in large amounts of gasses	
28	Occurrence in underground waters	
29	Occurrence in erosion, landslide and subsidence of terrain	
30	Noise during the demolition of existing objects	
31	Vibration during the demolition of existing objects	
32	Large amount creation in the communal waste	
33	Impurity and outflow of faeces	
34	Disease and infection of the local population	
35	Occurrence in electromagnetic radiation and heat emission	
36	Endanger in natural resources of location	
37	Unapproachable location for building plants	logistics
38	Problems with ground clearing	
39	A large amount of construction waste	
40	Problems during equipment in plants	
41	Impossibility of ground and construction work	
42	Problems in transport	
43	Problems in distribution and supply	
44	Problems with water reception from the river	
45	Built roads at construction sites	
46	Archaeological and cultural uncovering at the construction site	
47	Impossibility of building plants due to weather conditions	
48	Lack of storage for dangerous waste	

3.1. LAW-LEGAL RISK FACTORS

Primarily, experts considered laws and legal categories during the installation of a WWTP. Complying with the law and legal demands is very important in risk assessment during the installation of the WWTP. More attention to a healthier environment forced governments to find methods and tools for regulation, law and legal categories.

Assessment of risk factors in law and legal questions are also concerned with quality standards applied to working plants. Laws about water processing need approval from several different public institutions. Some countries set up new laws to regulate risks with the utilization of processed water and some others still use old regulations. These regulations and guidelines were examined to compile a comprehensive database, including all of the water quality monitoring parameters, and necessary treatment processes [60]. The project of installing the WWTP in the city of Krusevac complied with all laws and legal regulations, public and supervising authorities, and prevention measures to decrease risk factors.

When we talk about law and legal aspects during the installation of the WWTP, the most important risk factors are violations in the management of environmental protection, violations in the management of system quality, violations in the management of system reliability, and violations in the management of system security. When we analyze the legal risk factors for the installation of the WWTP in the city of Krusevac, we can conclude that everything is done according to public regulations and permissions, in compliance with project documentation, and concerning norms and standards for given activities within the legal framework. The requested supervision was made with the realization of safety measures to reduce all risk factors at the local level, be reversible, and have a small impact on the environment. Risk factors such as violations in the management of environmental protection during installation plants, violations in the management of system quality during installation plants, violations in the management of system reliability during installation plants, violations in the management of system security during installation plants, violations in law and legal regulations, and insufficient documentation for projects are reduced to a minimum.

The WWTP must be comprehended with urban and project plans, documents about construction permits, and contracts with all participants. It is necessary to control the whole documentation during the installation of plants. Also, there is a need for collaboration with political and supervising authorities, so construction of plants can be unobstructed. In law and legal categories, we often have changes in politics and regulations, so as an alteration in the volume of work that is stated in contracts. Installations of the WWTP in the city of Krusevac correlate with urban plans, construction permits, technical documentation, contract compliance, and other control measures during installation, so these risk factors have a small impact on the project.

During installations of the WWTP, we must analyze the influence of demographical changes at location and environment. That means analyses of the residential building, immediate surroundings, and concentration of population at the location. Residential buildings and inhabitants must be at a safe distance from a given location and those risks should be eliminated during plant building. Population changes also require the frequent and thoughtful revision of disaster mitigation, preparedness and response policies and plans. As such, emergency managers, planners, and other policymakers, should they endeavour to develop effective policy, must keep their fingers on the demographic pulse of their communities. Usage of land and degree of exploitation have a strong impact on social and economic development but also directly affect soil, hydrology, atmosphere, and other geographical elements, as well as the regional ecology environment. Developments in land use futures analysis could focus on integrating explorative scenarios that reflect possible outcomes with normative visions that identify desired outcomes. Such an approach would benefit from the broad and in-depth involvement of stakeholders to link scientific findings to political and societal decision-making for the set of key choices and consequences. Right risk factors assessment is crucial for control activities during the installation of the WWTP from demographical and geographical aspects. When experts consider demographical changes in terms of the demolition of residential buildings and population displacement, there was nothing changed during the realization of the project installation of the WWTP in the city of Krusevac. We should mention that there were also no immigrations in the city of Krusevac, so the population almost remained similar without demographic changes, so the risk factor was small. The location surrounding the installation of the WWTP is agricultural land. During the realization of the project and throughout the time when the WWTP operated in the city of Krusevac, control was implemented in all phases of realization to reduce risk factors from the law-legal category.

3.2. TECHNICAL-TECHNOLOGICAL RISK FACTORS

Right risk factors assessment in the domain of the technical-technological category is an application of correct equipment, good mechanization, and resources for work. Infrastructure at the construction site should serve for prevention and to eliminate or minimize possible risk factors during installations of the WWTP. Different technologies or strategies can be used to treat urban wastewater, all with the inherent drawback of generating solid and gaseous wastes in the course of the applied treatments [61]. Variations in characteristics of waste, geographical conditions, used technologies, availability of land, and labor cost, so as costs of collecting, transporting, and delaying waste are subject to uncertainties which may lead to risk development. Satisfactory waste flow plans could be identified according to system conditions and policy inclination, supporting in-depth tradeoff analyses between system optimality and reliability as well as between economic and environmental objectives [62] Many risk factors may occur during the demolition of existent objects, clearing up terrain, groundworks, work at construction sites, building infrastructure, and assembling equipment and devices, regarding the process of space preparation for building plants. Therefore, the decisions could be adjusted within the interval solutions according to actual conditions and policy inclination, allowing waste managers, interest partners and facility managers to incorporate implicit knowledge within the decision process and thus obtain satisfactory decision schemes [62]. Throughout building plants, we should enable an approach to advanced technological resources and services. During installations of the WWTP in the city of Krusevac, we noticed a deficiency of technology and techniques, which included insufficient equipment and infrastructure at a construction site, inadequate mechanization, and resources for work, and problems in assembling equipment and devices.

Risk factors that occur during the collection and disposal of wastewater in objects like cesspits, reservoirs, and water pipes should be considered throughout technical-technological aspects of materials for environmental protection. Real loss relates to the physical losses in the distribution installations, which typically result from leakages from the pipes and fittings, pumps and valves along with overflows of the reservoirs [63]. When the characteristics of water supply and sanitary services are weak, one malfunction can produce a failure of the system and cause a natural disaster. The quality of these objects prevents the outflow of wastewater in soil, such as water with oil and grease. Managing wastewater and its deficient direction in cesspits with low capacity, in the city of Krusevac are not adequately resolved and represent significant risk factors. As a result, pollution in surface and underground water may lead to agricultural land contamination, disease, and infection of the local population. Real losses comprise leakage from system elements and overflows of storage tanks. These losses are also caused by poor operations and maintenance activities, lack of active leakage control, poor quality of underground assets etc. and mainly contain visible and invisible leakage. Groundwater (aquifers) are complex and heterogeneous systems indicating significant challenges in the system modelling, respectively, in the quantification of sustainable management of water resources [64]. There is a need to analyze many risk factors such as occurrence in underground waters, impurity and outflow of feces, disease, and infection of the local population, as well as animals and plants. It is necessary to manage these risk factors properly, by increasing the capacity of cesspits with the direction of wastewater entirely in them. Congestion of cesspits can cause contamination of rivers, lakes, and other sources of water used for drink, swimming, or some other activities.

Floods in urban districts can be contaminated with fecal materials from wastewater in sewage networks. The primary risk for human health and atmosphere water is pathogen contamination because of the low capacity of cesspits and poorly constructed sewage networks. This happens when we have a deficient direction of wastewater in cesspits and leakage in sewage networks that pollute atmosphere water. The risk of degrading the constructed wetland through drying is reduced by an automatic low-level trigger that stops pumping from the wetland. Turbidity, salinity and pH are monitored continuously during aquifer injection and injection can be shut down if threshold levels are exceeded. This controls the risks of clogging and reducing recovery efficiency. Water outside of set boundaries is recirculated through the in-stream and holding basins and through the wetland [65]. However, in the case of combined sewer systems, the capacity of the sewer systems and the WWTPs may be exceeded during periods of high rainfall, and, untreated wastewater will be discharged directly into the surface waters [66]. Pollution of surface water, underground water, and land with wastewater or contaminated organic waste is an important risk factor for the environment and affects the health of people in the city of Krusevac. Urban wastewater treatment aims at the removal of organic and/or inorganic compounds, suspended and floatable material, nutrients and pathogens. From a perspective of health, safety and environmental protection, urban wastewater and generated byproducts, such as sewage sludge, must be appropriately treated before being recycled or discharged/disposed of into natural systems concerning standards and regulations [38].

During the process in the WWTP appears unrefined rough and inert material, should be removed to the intended place. If this operation does not go well, originates risk situations, creating sands in water to endanger the treatment of wastewater. Thereafter we have rinsing, dehydration, and disposal of sand in special containers. Identical to rough and inert materials, for sand also this process must be according to the instructions. In addition, unrefined water with oil and grease should be separated in hermetically sealed water-resistant containers. During the process in the WWTP sewage sludge appears and has to be postponed in the proper repository. Sewage sludge is an unavoidable by-product of the sedimentation processes throughout primary and secondary wastewater treatment processes [67]. Reproduced sludge may contain organic matter, which can be used in land fertilization. Utilization of sewage sludge is a highly accepted sustainable method for disposal with economic effect. During the installation of the WWTP in the city of Krusevac at the construction site, large amounts of waste and other potential pollutants like unrefined rough and inert materials, sand, oil, and grease, different types of gases, and sewage sludge should be properly postponed in special technical-technological processes. There is a greater possibility that these technical-technological risk factors will have a significant impact on the environment, lakes, rivers, and land.

3.3. RISK FACTORS IN ENVIRONMENTAL PROTECTION

Environmental protection is very important for human society and probably the most significant category in classifications of risk factors. WWTPs provide a barrier against the discharge of contaminants of emerging concern into the environment [68]. the WWTPs are built and operated to reduce wastewater pollution and minimize emissions and harmful effects on the environment and human health [69,70]. If possible, equipment for deep aeration should be applied, to decrease the dispersion of water particles in air that can be harmful. Likewise, installations of biofilters improve risk management and minimize negative effects during the construction of plants. Throughout the analysis of risk factors that endanger natural resources at the location, we pay attention to risks that jeopardize flora, fauna, and biodiversity. Air pollution in certain areas and the emission of harmful gases in the atmosphere are reduced with the installation of the WWTP. There is demand for elaboration of CO_2 emissions, char, and other depository substances as potential risk factors. Normally, CO_2 is produced during wastewater treatment by the respiration of the microorganisms that degrade organic matter, which concerns shortcycle CO_2. As the CO_2 generated is predominantly biogenic and therefore climate neutral, it is not usually included in the CO_2-balance [71]. When we evaluate the influence of the WWTP on environmental protection it is important valuation about specific risk factors that pollute the air. In the direction of assessing the environmental impact of the WWTPs, the estimation of the emission factors for specific pollutants as well as for odour is important, as it gives the first information about the quantity of each of them that is being emitted during a treatment process [72]. Before the realization of the project installation of the WWTP in the city of Krusevac, the given location did not present any of the risk factors for air pollution, but during the realization of the project, a wide area discovered several individual private fireplaces and risk factors were identified. These independent small sources of pollution have seasonal character, especially in emissions of CO_2, char, and other depository substances, and should be considered. However, because of the small density of the population, emissions of dangerous materials are low. Considering that the prominent phenomena involved in Contaminants of emerging concern removal by biological processes are sorption and biodegradation, solutions based on biological treatment optimization pose greater challenges for their management, as process performance is influenced by many factors, leading to highly the WWTP-dependent removal [73].

Nevertheless, when we talk about risk factors for environmental protection, we should consider the occurrence in the number of gasses that develop during the construction of plants, regardless in small or large amounts, because over time they may increase the concentration of pollution in soil, water, and air. This information can be helpful in different scenarios such as to understand the potential nuisance on the surroundings of an actual WWTP, to predict the effect on the surroundings of an operating WWTP by any process modification or even to estimate the potential impact on the surroundings of a new the WWTP before its construction [74]. Potential pollution at the construction site also can be from inadequate mechanization and vehicles during building plants, and they are specific pollutants with short-term effects. A significant source of pollution in the city of Krusevac is traffic. Contamination develops during the process of fuel combustion and releases product particles in the air, especially with incomplete combustion from vehicles. Pollution is directly proportional to the intensity of traffic and roads, which hurts air quality and increases risk factors for the environment.

Noise and vibration during the demolition of existing objects in the course of ground and construction work come from employed mechanizations, which lead to erosion, landslides, subsidence of terrain, and large amounts of communal waste, all potential risk factors. Poor understanding of natural resources, location, and underground waters leads to insufficient and inadequate equipment at the construction site. Furthermore, as a consequence of the employed mechanizations and equipment, noise and vibration occur during the demolition of existing objects and communal waste, which exposes the environment to risk. Also, we have the application of instruments to reduce vibrations and noise, and risk factors are not significant, so we do not hurt environmental protection. the WWTP in the city of Krusevac has many water pumps with engines that get low vibration and noise during regular work, so these risk factors are small. We can conclude that aspects of the environment are ecologically acceptable, and there is no large amount of these pollutants. the WWTP in the city of Krusevac, during standard work, uses a great number of water pumps with small amounts of rotations and compressors with protective acoustic elements, whereby all equipment is installed in closed spaces, so risk factors for noise and vibration are greatly downsized.

During the installation of the WWTP, we must take into account weather conditions until work is done to avoid the risk of natural disasters. The experiences with recent disaster recovery efforts have highlighted the need for additional guidance, structure, and support to improve the response to disaster recovery challenges [75]. Heavy rain can cause many problems in the water network and the reception of water in rivers. Plants must have an outflow system for atmospheric water that may occur that can transfer water to green surfaces The atmosphere and surrounding water, with a network of closed channels, are brought to the beginning of the WWTP process and then returned to the West Morava River. Also, the occurrence of electromagnetic radiation and heat emission is not present during the installation of the WWTP. Occurrences in erosion, landslides, and subsidence of terrain, as well as electromagnetic radiation and heat emission, are risk factors that need to be evaluated during the construction of the plants. Significant natural disasters such as earthquakes, floods, and droughts result in economic loss and social disorder. At the location, there was no erosion, landslide, or subsidence of terrain; this risk factor is almost nonexistent. With the analysis of natural resources in the location of the city of Krusevac, we did not find significantly important living species for biodiversity. Flora and fauna from this aspect cannot be exposed to danger, so there is no risk factor in the realization of the WWTP project.

3.4. LOGISTICS RISK FACTORS

Development patterns of the past that ignored the risks of building on vulnerable sites such as floodplains and hillsides have exacerbated the problem. Risk factors assessment implies analysis of the location for building plants. If during ground clearing, we find archaeological and cultural uncovering at a construction site, there is a risk that the project cannot be implemented with existing documentation. In case of risk situations when we have large amounts of construction waste, that also can be dangerous it is required to stop work, carry out rehabilitation, and act according to regulations about storage. There are many problems concerning the water, quality, quantity, reception, guidance, direction, and outflow. Although some existing models have considered both water quality and quantity issues, these two aspects have usually been analyzed separately. In water allocation models, water quality problems often took available water as a constraint and waste load was determined by the results of the water allocation models [76].

The presence of the mechanization, a large amount of construction waste, and an unapproachable location, during the phase of the preparation construction site and placement infrastructure, represent high-risk factors and degradation in place for the installation of the WWTP in the city of Krusevac. The ecotoxicological risk assessment methodologies developed up to now mainly focus on local pollution and do not incorporate an evaluation and prioritization of the different risk situations present in the same territory [77]. It should be taken care of to dispose of construction waste into the internal sewage network to avoid contamination of the environment. At the construction site for installation of the WWTP in a specially marked area, were placed containers with sorbent (sand, zeolite) and a specific repository for construction waste to decrease potential risk factors. To reduce gas emissions and overall pollution, the administration of the city of Krusevac built a sewage network with collectors to improve environmental protection at a given location.

During the installation of the WWTP in the city of Krusevac, there were no problems with transport, distribution, or supply. The location for construction was approachable, and it was established that there were no ruined buildings or objects, as well as an archeological site or cultural monuments. When we observe the location for installations of the WWTP in the city of Krusevac as a whole, the planned volume, and the duration of the project, we conclude that logistics risk factors will not have a significant effect on installations of the WWTP.

4. CONCLUSIONS

Installations of the WWTP represent a subject with more recognition in the social community for environmental protection. During the construction of these facilities, many problems need to be identified and dealt with in time, which is also the reason for conducting this study. The purpose of this research is to reveal potential risk factors in all phases of the WWTP project. The examination lasted for a year and obtained significant data on the risk factors that occur during the installation of wastewater treatment plants, also using the SLR. A large number of experts took part in the research, which adds to the quality of this study.

We focused on empirical surveys involving environmental experts to collect diversified opinions. In addition to the questioning of experts who participated in this project, a very significant contribution to this research was made by scientific studies in this area. Throughout a given period, we identified risk factors that occurred during the installation of the WWTP. After identification, we performed a classification of risk factors and their categorization by the aspects they belonged to. The goal is to define the Delphi model that will be used for the assessment of risk factors during the installation of the WWTP. The essence was to establish a framework for risk factor assessment, which is classified into four categories. These four categories constitute the most relevant method for the management of risk factors during the WWTP installations. This research accomplished a full analysis of risk factors from their aspects in all categories. Another purpose of this study is to enable easier implementation for all similar projects in the future. Exploration should draw attention to risk factors that have a negative impact and should be downsized or eliminated. Research is presented so that it can be further expanded with risk factors and put to the function of conducting new case studies. Also, the exploration aims to effectively manage risk factors during the installation of the WWTP. Some of the advantages of risk studies in projects of installation of the WWTP are the possibility of preventing risk situations, reducing unnecessary losses on the project, increasing project quality control, increasing project flexibility, and successful project implementation.

Future research should investigate the risk factors that affect the WWTP and expand this research. In addition, by adding new risk factors from future investigations, not only can the model be more effective in getting accurate predictions, but it can also provide environmental experts with more valuable insights into the processes of the WWTP. Furthermore, this model makes it possible for environmental experts to understand how the risk assessment model arrived at its predictions, enabling them to better trust and utilize the model's results.

REFERENCES

[1] PIOTROWSKI R., MILEWSKI K., MACIA B., *Adaptive stochastic and hybrid nonlinear optimization algorithms for improving the effectiveness of the biological processes at the WWTP*, Biochem. Eng. J., 2023, 193, 108852. DOI: 10.1016/j.bej.2023.108852.

[2] DRURY B., ROSI-MARSHALL E., KELLY J.J., *Wastewater treatment effluent reduces the abundance and diversity of benthic bacterial communities in urban and suburban rivers*, Appl. Environ. Microbiol., 2013, 79 (6), 897–1905. DOI: 10.1128/AEM.03527-12.

[3] PASCIUCCO F., PECORINI I., IANNELLI R., *A comparative LCA of three the WWTPs in a tourist area: Effects of seasonal loading rate variations*, Sci. Total Environ., 2023, 863, 160841. DOI: 10.1016/j.scitotenv.2022.160841.

[4] LORENZO-TOJA Y., VÁZQUEZ-ROWE I., CHENEL S., MARÍN-NAVARRO D., MOREIRA M.T., FEIJOO G., *Eco-efficiency analysis of Spanish the WWTPs using the LCA + DEA method*, Water Res., 2015, 68. DOI: 10.1016/j.watres.2014.10.040.

[5] TSANGAS M., PAPAMICHAEL I., BANTI D., SAMARAS P., ZORPAS A.A., *LCA of municipal wastewater treatment*, Chem., 2023, 341, 139952. DOI: 10.1016/j.chemosphere.2023.139952.

[6] DIAZ-ELSAYED N., REZAEI N., NDIAYE A., ZHANG Q., *Trends in the environmental and economic sustainability of wastewater-based resource recovery. A review*, J. Clean. Prod., 2020, 265. DOI: 10.1016 /j.jclepro.2020.121598.

[7] WANG J., CHEN Y., CAI P., GAO Q., ZHONG H., SUN W., CHEN Q., *Impacts of municipal wastewater treatment plant discharge on microbial community structure and function of the receiving river in Northwest Tibetan Plateau*, J. Hazard. Mater., 2022, 423, e127170. DOI: 10.1016/j.jhazmat.2021.127170.

[8] TABESH M., ROOZBAHANI A., ROGHANI B., FAGHIHI N.R., HEYDARZADEH R., *Risk assessment of factors influencing non-revenue water using Bayesian networks and fuzzy logic*, Water Res. Manage., 2018, 32, 11, 1–24.
[9] DIPPONG T., HOAGHIA M.A., MIHALI C., CICAL E., CALUGARU M., *Human health risk assessment of some bottled waters from Romania*, Environ. Pollut., 2020, 267, 115409. DOI: 10.1016/j.envpol.2020.115409.
[10] HALLOWELL M.R., GAMBATESE J.A., *Qualitative research: Application of the Delphi method to CEM research*, J. Construct. Eng. Manage., 2010, 136 (1), 99–107. DOI: 10.1061/(ASCE)CO.1943-7862.0000137.
[11] SHARIFF N., *Utilizing the Delphi survey approach: A review*, J. Nurs. Care, 2015, 4 (3), 246. DOI: 10.4172/2167-1168.1000246.
[12] TUROFF M., LINSTONE H.A., *The Delphi method. Techniques and applications*, Addison-Wesley, 2002. DOI: 10.2307/3150755.
[13] GRIME M.M., WRIGHT G., *Delphi method*, [In:] *Wiley StatsRef. Statistics Reference Online*, Wiley, 2016, 1–6, DOI: 10.1002/9781118445112.stat07879.
[14] LOO R., *The Delphi method. A powerful tool for strategic management*, Pol. Int. J. Pol. Strat. Manage., 2002, 25 (4), 762–769. DOI: 10.1108/13639510210450677.
[15] MARHAVILAS P.K., KOULOURIOTIS D., GEMENI V., *Risk analysis and assessment methodologies in the work sites. On a review, classification and comparative study of the scientific literature of the period 2000–2009*, J. Loss Prev. Proc. Ind., 2011, 24 (5), 477–523.
[16] VILLA V., PALTRINIERI N., KHAN F., COZZANI V., *Towards dynamic risk analysis: A review of the risk assessment approach and its limitations in the chemical process industry*, Saf. Sci., 2016, 89, 77–93.
[17] BRYMAN A., *Integrating quantitative and qualitative research: how is it done?*, Qual. Res., 2006, 6 (1), 97–113. DOI: 10.1177/1468794106058877.
[18] CRESWELL J.W., CLARK V.L.P., *Designing and conducting mixed methods research*, Sage Publications, 2017.
[19] JAHANVAND B., MORTAZAVI S.B., MAHABADI H.A., AHMADI O., *Determining essential criteria for selection of risk assessment techniques in occupational health and safety. A hybrid framework of fuzzy the Delphi method*, Saf. Sci., 2023, 167, 106253. DOI: 10.1016/j.ssci.2023.106253.
[20] SHELAKE A.G., GOGATE N.G., RAJHANS N.R., *An integrated approach for identification and prioritization of risk factors in tunnel construction*, Mater. Today: Proc., 2022, 65 (2), 1805–1812.
[21] SALAMEH A.A., AKHTAR H., GUL R., OMAR A.B., HANIF S., *Personality traits and entrepreneurial intentions. Financial risk-taking as a mediator*, Front. Psych., 2022, 927718. DOI: 10.3389/fpsyg.2022.927718.
[22] HAN D., CURRELL M.J., CAO G., *Deep challenges for China's war on water pollution*, Environ. Poll., 2016, 218, 1222–1233. DOI: 10.1016/j.envpol.2016.08.078.
[23] COROMINAS L.L., FOLEY J., GUEST J.S., HOSPIDO A., LARSEN H.F., MORERA S., SHAW A., *Life cycle assessment applied to wastewater treatment. State of the art*, Water Res., 2013, 47, 15, 5480–5492. DOI: 10.1016/j.watres.2013.06.049.
[24] YANG Z., MA S., DU S., CHEN Y., LI X., WANG R., LUO J., PAN Z., TAN Z., *Assessment of upgrading the WWTP in southwest China: Towards a cleaner production*, J. Clean. Prod., 2021, 326, 129381. DOI: 10.1016/j.jclepro.2021.129381.
[25] XU J., LUO P., LU B., WANG H., WANG X., WU J., YAN J., *Energy-water nexus analysis of wastewater treatment plants (the WWTPs) in China based on statistical methodologies*, En. Proc., 2018, 152, 259–264. DOI: 10.1016/j.egypro.2018.09.116.
[26] YANG J., CHEN B., *Energy efficiency evaluation of wastewater treatment plants (WWTPs) based on data envelopment analysis*, Appl. En., 2021, 289, 116680. DOI: 10.1016/j.apenergy.2021.116680.
[27] MARTIN C., VANROLLEGHEM P.A., *Analysing, completing, and generating influent data for the WWTP modelling. A critical review*, Environ. Modell. Soft., 2014, 60, 188–201. DOI: 10.1016/j.envsoft.2014.05.008.

[28] GALLEGO-SCHMID A., TARPANI R.R.Z., *Life cycle assessment of wastewater treatment in developing countries. A review*, Water Res., 2019, 153, 63–79. DOI: 10.1016/j.watres.2019.01.010.
[29] DING L., LV Z., HAN M., ZHAO X., WANG W., *Forecasting China's wastewater discharge using dynamic factors and mixed-frequency data*, Environ. Poll., 2019, 255, 113148. DOI: 10.1016/j.envpol. 2019.113148.
[30] HO J.Y., OOI J., WAN Y.K., ANDIAPPAN V., *Synthesis of wastewater treatment process (WWTP) and supplier selection via fuzzy analytic hierarchy process (FAHP)*, J. Clean. Prod., 2021, 314, 128104. DOI: 10.1016/j.jclepro.2021.128104.
[31] OPP C., ZIEBOLZ B., *Water analyses, eco-balance and socio-demographic analyses as prerequisites for solutions of the sewage treatment problems in rural areas*, J. Geosci. Environ. Prot., 2015, 3, 10.
[32] MORERA S., COROMINAS L., RIGOLA M., POCH M., COMAS J., *Using a detailed inventory of a large wastewater treatment plant to estimate the relative importance of construction to the overall environmental impacts*, Water Res., 2017, 122, 614–623. DOI: 10.1016/j.watres.2017.05.069.
[33] RIECHELMANN C., HABASHY M.M., RENE E.R., MOUSSA M.S., HOSNEY H., *Assessment of hybrid fixed and moving bed biofilm applications for wastewater treatment capacity increase. In situ tests in El--Gouna the WWTP*, Chem., 2023, 139783. DOI: 10.1016/j.chemosphere.2023.139783.
[34] CHEN Z., NGO H.H., GUO W., *A critical review on sustainability assessment of recycled water schemes*, Sci. Total Environ., 2012, 426, 13–31, DOI: 10.1016/j.scitotenv.2012.03.055.
[35] ABDULLA F., FARAHAT S., *Impact of climate change on the performance of wastewater treatment plant. Case study Central Irbid the WWTP (Jordan)*, Proc. Manuf., 2020, 44, 205–212.
[36] MOUSSAOUI T.E., BELLOULID M.O., ELHARBILI R., ASS K.E., OUAZZANI N., *Simultaneous assessment of purification performances and wastewater byproducts management plans towards a circular economy. Case of Marrakesh the WWTP*, Case Stud. Chem. Environ. Eng., 2022, 6, 100228. DOI: 10.1016 /j.cscee. 2022.100228.
[37] JAFARINEJAD S., *Cost estimation and economical evaluation of three configurations of activated sludge process for a wastewater treatment plant (WWTP) using simulation*, Appl. Water Sci., 2017, 7, 2513–2521. DOI: 10.1007/s13201-016-0446-8.
[38] BLUMENTHAL U.J., MARA D.D., PEASEY A., RUIZ-PALACIOS G., Stott R., *Guidelines for the microbiological quality of treated wastewater used in agriculture: recommendations for revising WHO guidelines*, Bull. World Health Org., 2000, 78, 1104–1116.
[39] *W.H.O. Sanitation Safety Planning: Manual for Safe Use and Disposal of Wastewater, Greywater and Excreta 978-92-4-154924-0*, World Health Org., Geneva, Switzerland, 2015.
[40] MOUSSAVI S., THOMPSON M., LI S., DVORAK B., *Assessment of small mechanical wastewater treatment plants. Relative life cycle environmental impacts of construction and operations*, J. Environ. Manage., 2021, 292, 112802. DOI: 10.1016/j.jenvman.2021.112802.
[41] TRUBETSKAYA A., HORAN W., CONHEADY P., STOCKIL K., MOORE S., *A methodology for industrial water footprint assessment using energy-water-carbon nexus*, Processes, 2021, 9, 393. DOI: 10.3390/pr9020393.
[42] XUE X., HAWKINS T.R., SCHOEN M.E., GARLAN J., ASHBOLT N.J., *Comparing the life cycle energy consumption, global warming and eutrophication potentials of several water and waste service options*, Water, 2016, 8 (4), 154. DOI: 10. 3390/w8040154.
[43] KUCZENSKI B., GEYER R., BOUGHTON B., *Tracking toxicants. Toward a life cycle aware risk assessment*, Environ. Sci. Technol., 2011, 45 (1), 45–50.
[44] BUTLER D., FRIEDLER E., GATT K., *Characterising the quantity and quality of domestic wastewater inflows*, Water Sci. Technol., 1995, 31 (7), 13–24. DOI: 10.1016/0273-1223(95)00318-H.
[45] BOTT C., PARKER D.S., *WEF/WERF study quantifying nutrient removal technology performance*, Water Environ. Res. Found. (WERF), Alexandria, VA, USA, 2010.

[46] MORAVEC M., BADIDA M., MIKUŠOVÁ N., SOBOTOVÁ L., ŠVAJLENKA J., DZURO T., *Proposed options for noise reduction from a wastewater treatment plant. Case study*, Sust., 2021, 13 (4), 2409. DOI: 10.3390/su 13042409.
[47] VASILYEV A.V., *Russian experience of power plants noise and vibration estimation and reduction*, [In:] Proc. of the Conf. Noise Control For A Better Environment, inter.noise 2019, Madrid, Spain, 16–19 June 2019, available online: http://www.sea-acustica.es/fileadmin/INTERNOISE_2019/Fchrs /Proceedings /2099. pdf [accessed on 23 November 2020].
[48] RODRIGUEZ-GARCIA G., MOLINOS-SENANTE M., HOSPIDO A., HERNÁNDEZ-SANCHO F., MOREIRA M.T., FEIJOO G., *Environmental and economic profile of six typologies of wastewater treatment plants*, Water Res., 2011, 45 (18), 5997–6010. DOI: 10.1016/j.watres.2011.08.053.
[49] BRUNKARD J.M., AILES E., ROBERTS V.A., HILL V., HILBORN E.D., CRAUN G.F., RAJASINGHAM A., KAHLER A., GARRISON L., HICKS L., CARPENTER J., WADE T.J., BEACH M.J., YODER J.S., *Surveillance for waterborne disease outbreaks associated with drinking water – United States, 2007–2008*, MMWR, Surv. Summaries, 2011, 60 (12), 38–68.
[50] SCHETS F.M., RODA HUSMAN A.M., HAVELAAR A.H., *Disease outbreaks associated with untreated recreational water use*, Epidem. Inf., 2010, 1–12.
[51] DÍAZ-GARDUÑO B., RUEDA-MÁRQUEZ J.J., MANZANO M.A., GARRIDO-PÉREZ C., MARTÍN-DÍAZ M.L., *Are combined AOPs effective for toxicity reduction in receiving marine environment? Suitability of battery of bioassays for wastewater treatment plant (WWTP) effluent as an ecotoxicological assessment*, Marine Environ. Res., 2016, 114, 1–11. DOI: 10.1016/j.marenvres.2015.12.011.
[52] SABEEN A.H., NOOR Z.Z., NGADI N., ALMURAISY S., RAHEEM A.B., *Quantification of environmental impacts of domestic wastewater treatment using life cycle assessment: a review*, J. Clen. Prod., 2018, 190, 221–233, DOI: 10.1016/j.jclepro.2018.04.053.
[53] HENZE M., HARREMOËS P., JANSEN J.C., ARVIN E., *Wastewater Treatment. Biological and Chemical Processes*, Springer, 1995.
[54] FADILAH M.I.S., HUSIN A.E., FIRDAOS S., HUSIN M.K.E., *Time performance improvement by supply chain management and 4d building information modelling (BIM 4d). Integration implementation on wastewater treatment plant international*, J. Adv. Sci. Technol., 2020, 29, 4, 3700–3708.
[55] MIDDELKOOP H., DAAMEN K., GELLENS D., GRABS W., KWADIJK J.C., LANG H., PARMET B.W., SCHÄDLER B., SCHULLA J., WILKE K., *Impact of climate change on hydrological regimes and water resources management in the Rhine Basin*, Clim. Change, 2001, 49 (1–2), 105–128.
[56] CARPENTER A.C., GARDNER K.H., FOPIANO J., BENSON C.H., EDIL T.B., *Life cycle based risk assessment of recycled materials in roadway construction*, Waste Manage., 2007, 27 (10), 1458–1464.
[57] ZHAO Y.W., QIN Y., CHEN B., ZHAO X., LI Y., YIN X.A., CHEN G.Q., *GIS-based optimization for the locations of sewage treatment plants and sewage outfalls. A case study of Nansha District in Guangzhou City, China*, Comm. Nonl. Sci. Num. Sim., 2009, 14, 4, 1746–1757. DOI: 10.1016/j.cnsns.2007.12.016.
[58] ZOUBOULIS A., TOLKOU A., *Effect of climate change in wastewater treatment plants. Reviewing the problems and solutions*, [In:] S. Shrestha, A. Anal, P. Salam, M. van der Valk (Eds.), *Management of Water Resources under Climate Uncertainty*, Springer, Cham 2015. DOI: 10.1007/978-3-319-10467-6_10.
[59] KIKUCHI Y., HIRAO M., *Practical method of assessing local and global impacts for risk-based decision making. A case study of metal degreasing processes*, Environ. Sci. Technol., 2008, 42 (12), 4527–4533.
[60] SHOUSHTARIAN M.F., NEGAHBAN A., *Worldwide regulations and guidelines for agricultural water reuse. A critical review*, Water, 2020, 12 (4), 971. DOI: 10.3390/w12040971.
[61] GOSTELOW P., PARSONS S.A., STUETZ R.M., *Odour measurements for sewage treatment works*, Water Res., 2001, 35, 579–597.
[62] TAN Q., HUANG G.H., CAI Y.P., *Identification of optimal plans for municipal solid waste management in an environment of fuzziness and two-layer randomness*, Stoch. Environ. Res. Risk Assess., 2010, 24, 147–164.

[63] TABESH M., ROOZBAHANI A., ROGHANI B., SALEHI S., RASI FAGHIHI N., HEYDARZADEH R., *Prioritization of non-revenue water reduction scenarios using a risk-based group decision-making approach*, Stoch. Environ. Res. Risk Assess., 2020, 34, 1713–1724.

[64] CHANG F.J., HUANG C.W., CHENG S.T., CHANG L.C., *Conservation of groundwater from over-exploitation. Scientific analyses for groundwater resources management*, Sci. Total Environ., 2017, 598, 828–838.

[65] PAGE D., GONZALEZ D., NAUMANN B., DILLON P., VANDERZALM J., BARRY K., *Stormwater managed aquifer recharge risk based management plan: parafield stormwater harvesting system*, Goyder Institute for Water Resources, Adelaide, South Australia, 2013.

[66] STERK A., MAN H., SCHIJVEN J.F., NIJS T., RODA HUSMAN A.M., *Climate change impact on infection risks during bathing downstream of sewage emissions from CSOs or the WWTPs*, Water Res., 2016, 105, 11–21. DOI: 10.1016/j.watres.2016.08.053.

[67] LIU C., LI K., YU L., XU Y., HUANG B., WU J., WANG Z., *POPs and their ecological risk in sewage sludge of wastewater treatment plants in Beijing, China*, Stoch. Environ. Res. Risk Assess., 2013, 27, 1575–1584.

[68] GABRIELLI M., COMPAGNI R.D., GUSMAROLI L., MALPEI F., POLESEL F., BUTTIGLIERI G., ANTONELLI M., TUROLLA A., *Modelling and prediction of the effect of operational parameters on the fate of contaminants of emerging concern in the WWTPs*, Sci. Total Environ., 2023, 856 (2), 159200. DOI: 10.1016/j.scitotenv.2022.159200.

[69] AENAB A., SINGH S., *Critical assessment of river water quality and wastewater treatment plant (WWTP)*, Int. J. Adv. Res., 2015, 3, 405–411.

[70] WANG X., LIU J., REN N., DUAN Z., *Environmental profile of typical anaerobic/anoxic/oxic wastewater treatment systems meeting increasingly stringent treatment standards from a life cycle perspective*, Biores. Technol., 2012, 126, 31–40.

[71] PARRAVICINI V., SVARDAL K., KRAMPE J., *Greenhouse gas emissions from wastewater treatment plants*, En. Proc., 2016, 97, 246–253. DOI: 10.1016/j.egypro.2016.10.067.

[72] GONZÁLEZ D., COLÓN J., SÁNCHEZ A., GABRIEL D., *Multipoint characterization of the emission of odour, volatile organic compounds and greenhouse gases from a full-scale membrane-based municipal the WWTP*, J. Environ. Manage., 2022, 313, 115002. DOI: 10.1016/j.jenvman.2022.115002.

[73] TRAN N.H., REINHARD M., GIN K.Y.H., *Occurrence and fate of emerging contaminants in municipal wastewater treatment plants from different geographical regions. A review*, Water Res., 2018, 133, 182–207. DOI: 10.1016/j.watres.2017.12.029.

[74] CAPELLI L., SIRONI S., DEL ROSSO R., CÉNTOLA P., *Predicting odour emissions from wastewater treatment plants by means of odour emission factors*, Water Res., 2009, 43, 1977–1985. DOI: 10.1016/j.watres.2009.01.022.

[75] KIM J., DESHMUKH A., HASTAK M., *A framework for assessing the resilience of a disaster debris management system*, Int. J. Dis. Risk Red., 2018, 28, 674–687.

[76] LIU D., GUO S., SHAO Q., JIANG Y., CHEN X., *Optimal allocation of water quantity and waste load in the Northwest Pearl River Delta, China*, Stoch. Environ. Res. Risk Assess., 2014, 28, 1525–1542.

[77] BRUS A., PERRODIN Y., *Identification, assessment and prioritization of ecotoxicological risks on the scale of a territory. Application to the WWTP discharges in a geographical area located in northeast Lyon, France*, Chem., 2017, 189, 340–348. DOI: 10.1016/j.chemosphere.2017.09.054.