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Application of Artificial Intelligence for Monitoring and Forecasting the State of the Environment in Cities: The Case of Small Rivers

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Abstract : This article is devoted to the study of modern experience in the application of artificial intelligence in monitoring and assessing the state of the environment in cities using the example of small rivers . reasons occurrence Environmental issues in megacities, the potential of neural networks for processing large volumes of data, and practical examples of their use are discussed. The importance of environmental monitoring for environmental protection and public health is explored. An overview of existing approaches is provided, prospects for further development within the framework of national projects and strategic initiatives are proposed, and a practical example of using the systemic approach developed by the authors to forecast the state of a small river based on proposed development scenarios is presented.

1 INTRODUCTION

The modern world is characterized by accelerated urbanization, increasing population density, and the development of infrastructure systems. These trends are leading to complex environmental problems, including deteriorating air quality, water pollution, and climate change. Traditional methods of environmental monitoring and assessment often prove ineffective when processing large volumes of heterogeneous data. Consequently, there is a need to implement innovative technologies, such as artificial intelligence and deep learning, to improve the accuracy and speed of analysis.

The aim of this study is to improve the methodological approach for using artificial intelligence to monitor and assess the state of the urban environment, where traditional approaches are ineffective due to insufficient automation and the processing speed of large volumes of heterogeneous data. The practical results of this study will enable faster, more optimal management decisions based on an understanding of the mechanisms of environmental risk propagation and transformation.

2 MATERIALS AND METHODS

An analysis of a number of scientific papers shows that artificial intelligence is actively used in environmental analytical research. Studies have been published describing the successful implementation of artificial intelligence to assess the health status of residents of large industrial cities, revealing a correlation between pollutant emissions and population diseases (Potylicyna , Lipinskij , Sugak , 2013). Another study emphasizes the importance of artificial intelligence in environmental monitoring and natural resource management, demonstrating its ability to predict changes in ecosystems and optimize resource use (Olawade , Wada , Ige , Egbewole , Olojo , Oladapo , 2024). The analysis of the existing research base is presented in Table 1.

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Table 1: Analysis of the existing research base.

No.	Name	Date of publication	Summary	Conclusions based on the results of sources
1	Using artificial neural networks to solve environmental problems (Potylicyna , Lipinskij , Sugak , 2013)	2013	This article explores the use of artificial neural networks to solve applied environmental problems, such as assessing and predicting the health status of residents of large industrial cities. The authors propose a methodology based on the analysis of statistical data on pollutant emissions and population health, which allows for the identification of cause-and-effect relationships between these factors.	It enables the automation of large-scale data processing and the generation of accurate public health risk forecasts. The proposed methodology is an effective tool for identifying high-risk areas and developing measures to reduce the negative impact of industrial facilities on the environment and human health.
2	Artificial Intelligence in Environmental Monitoring: Achievements, Challenges, and Future Directions (Olawade , Wada , Ige , Egbewole , Olojo , Oladapo , 2024)	2024	The article examines the role of artificial intelligence (AI) technologies in ecology and natural resource management.	Significantly improves the efficiency of natural resource management. Modern methods allow for the prediction of ecosystem changes, environmental monitoring, and optimization of resource use.
3	Neural network-based urban change monitoring using deep temporal multispectral and SAR remote sensing data (Zitzlsberger , Podhoranyi , Svaton , Lazecky , Martinovic , 2021)	2021	The development of a fully automated method for continuously monitoring urban development changes by combining optical and radar data. This approach overcomes the challenges of manual sampling and the limited scope of studies, offering a scalable and effective tool for continuous monitoring of urban change.	The proposed method demonstrates high sensitivity to changes in urban infrastructure and the ability to combine the advantages of both types of remote sensing data. The results show that combining optical and SAR data improves the overall performance of the neural network in change detection.
4	Deep learning solutions for smart city challenges in urban development (Psaropa , Kontogiannis , Lolis , Hatzianastassiou , Pikridas , 2025)	2024	This article explores the role of artificial intelligence and Bayesian regularization in the process of intelligentizing urban spaces. The authors examine the integration of advanced smart city technologies aimed at solving complex problems in modern urban planning .	The integration of deep neural networks and Bayesian approaches represents a powerful tool for transforming the urban planning process.

Modern approaches include integrated methodologies that combine different types of data, such as satellite imagery and remote sensing (Zitzlsberger , Podhoranyi , Svaton , Lazecky , Martinovic , 2021). Such integrated models can detect even minor changes in urban space, providing early warning and effective responses to environmental threats.

Currently, artificial intelligence is already being applied in such areas of environmental monitoring and assessment as:

- monitoring of air pollution levels, which is carried out through the collection of data on the concentration of substances, as well as the analysis and forecasting of pollution (Psaropa , Kontogiannis , Lolis , Hatzianastassiou , Pikridas , 2025);
- water quality control, including monitoring of water resources with processing of data on chemical composition, bacterial content, pollution diagnostics, predictive risks, etc. (Yuan , Li , Zhang , Zhao , Zhang , Li , 2025);
- management of traffic flows through optimization of the movement of various types of

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transport, traffic analysis in real time and traffic light regulation (Shepelev , Glushkov , Slobodin , Cherkassov , 2023);

- energy monitoring and management of energy resources, which consists of assessing energy consumption and selecting energy-saving solutions (Kok , Heng , Koh , Teo , 2025);

- assessment of the state of green areas and vegetation cover to obtain up-to-date classification, planning restoration programs and analyzing satellite images (Chen , Chen , Xie , Shi , Chen , Chen , 2025);

- interactive maps and information panels as a format of interactive services capable of providing residents with information about the state of the environment in real time (see Fig. 1).

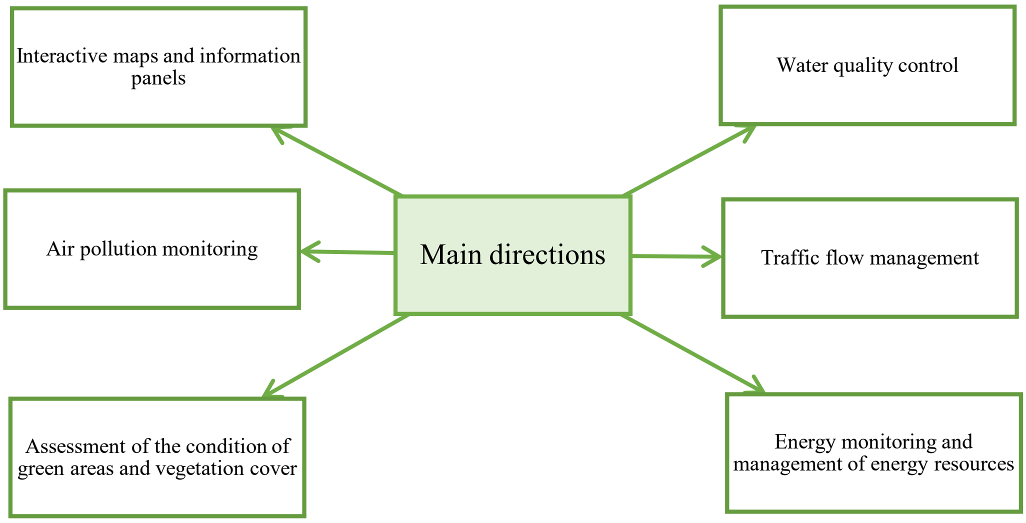

Figure 1: Using artificial intelligence for environmental monitoring and assessment (drawing by the author) .

Table 2 provides a more detailed description of each of the areas in terms of content and conclusions in areas of practical application.

Table 2: Main areas of use of artificial intelligence for environmental monitoring and assessment.

No.	Name	Summary	Conclusions from the study of sources
1	**Air pollution monitoring**	Data collection. Sensors record concentrations of PM2.5, NO_2, SO_2, CO, and other air pollutants.	Obtaining an accurate picture of the current state and long-term forecast to inform the public and make management decisions.
		Analysis and forecasting. Deep neural networks are used to analyze time series and identify patterns, generating pollution forecasts. (Kachba , Chiroli DMdG , Belotti Alves de Souza Tadano Siqueira , 2020)	
2	**Water quality control**	Water resource monitoring. Neural networks process data on water chemistry, pH levels , bacterial counts, and other indicators.	The possibility of organically incorporating water resources into the ecological framework of the city for its harmonious development.
		Pollution diagnostics. Using historical data, networks identify anomalies and warn of potential health risks.	

		Infection risk forecasting. Early identification of disease outbreak threats and timely implementation of preventive measures.	
3	**Traffic flow management**	Traffic optimization. Real-time traffic analysis reduces emissions by minimizing congestion and rerouting routes.	Real-time traffic analysis and traffic light control reduce emissions, providing the basis for designing comfortable residential areas and developing sustainable urban transport infrastructure.
		Traffic light control. Artificial intelligence controls traffic lights, reducing harmful emissions and speeding up traffic flow.	
4	**Energy monitoring and management of energy resources**	Energy consumption assessment. Artificial intelligence tracks energy consumption in buildings and neighborhoods, helping to identify inefficient areas.	Real-time traffic analysis and traffic light control reduce emissions, providing the basis for designing comfortable residential areas and developing sustainable urban transport infrastructure.
		Energy-saving solutions. Optimizing electricity and heat consumption, reducing resource loss, and reducing environmental impact.	
5	**Assessment of the condition of green areas and vegetation cover**	Status classification. Determining the state of vegetation and assessing its dynamics for the timely detection of signs of disease and stress.	The ability to objectively assess the dynamics of change and plan restoration measures. Implementation of a scientific basis for integrating environmentally sustainable green spaces into urban development and comprehensive landscaping projects.
		Action planning. Based on the analysis, programs for the restoration and modernization of green spaces are developed.	
		Satellite images and photographs. The images provide data on greenery area, tree condition, and grass cover.	
6	**Interactive maps and information panels**	Interactive services. Maps and applications based on neural networks provide residents with up-to-date information on environmental conditions, pollution levels, and weather.	Transforming environmental data into accessible formats, creating a transparent environment that enables citizens to make informed decisions and a basis for sustainable urban development planning.
		Solving everyday problems. Users receive helpful tips and behavioral recommendations based on current conditions.	

However, important questions remain unresolved regarding the reliability of the results and the transparency of the algorithms (Arar , Halicioglu , 2025). overcoming these To address these limitations , systematic research and standardization of methods are needed.

3 RESULTS

The object of our research is the process of monitoring and assessing the state of the environment in urban conditions. We let's focus on The applicability of artificial intelligence and deep neural models for the automatic analysis and prediction of environmental factors based on manually collected data. Key objectives include: rapid identification of pollution hotspots, public health risk assessment, and minimizing the costs of preventing environmental damage.

To test our solution, we selected the results of water monitoring for the small Temernik River in Rostov-on-Don, which included approximately forty data logs from various points along the riverbed (see Fig. 2). We compiled and applied a systemic approach to analyze the existing logs, which revealed key issues such as high water turbidity, exceeding the maximum concentration of certain substances, and low level biodiversity .

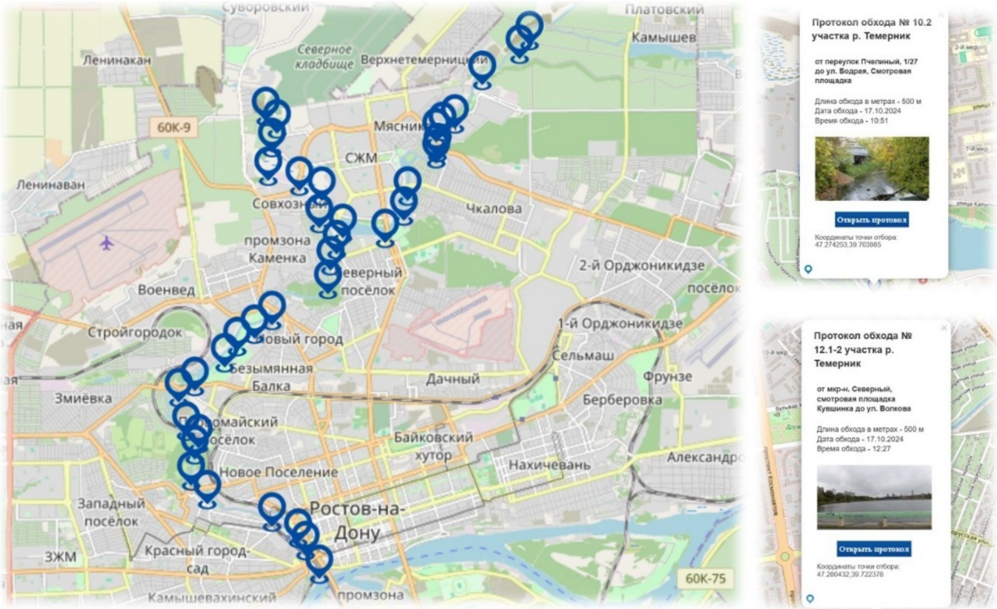

Figure 2: Survey protocols for areas along the small Temernik River as a basis for a design experiment (source - https :// park - temernik . ru / karta - reki /).

Next, using artificial intelligence, we obtained the predicted state of the river under three scenarios and presented it in Tables 3, 4 and 5: no intervention in the state of the water body under study, local intervention and the use of an integrated approach to solving the problem. According to received According to the forecast , the absence of intervention will lead to further deterioration of water quality, the spread of pollution and disease, economic losses, social risks, and environmental and economic damages. Localized intervention can selectively positively impact water quality, biological activity, aesthetics, and public health. A comprehensive approach to problem-solving can lead not only to the rehabilitation of the water body but also to sustainable economic growth and social benefits for the population (Bahadori - Jahromi , Room , Paknahad , Altekreeti , Tariq , Tahayori , 2025).

Table 3: Predicted state of a small river without intervention.

1. Water deterioration	Increasing levels of toxic substances in water will lead to further reduction of biodiversity and death of sensitive fish and plant species. The risk of disease will increase among local residents who use water for drinking and domestic purposes. The risk of waterborne infectious diseases will increase.
2. Spread of pollution	Pollution will spread further downstream, affecting the ecosystems of downstream settlements and natural areas. The increase in the amount of solid waste and organic residues will create favorable conditions for the proliferation of pathogenic microorganisms.
3. Economic losses	The need for expensive measures to restore water balance and clean up areas. Loss of income from tourism and fisheries due to the decline in the attractiveness of the region.

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	Costs of treating diseases caused by drinking contaminated water.
4. Social risks	Tensions among the local population due to problems with the quality of drinking water and health. Negative impact on the quality of life and reduction in the well-being of families living near the river.
5. Ecological and economic losses	Lost profits from underutilization of the tourism industry's potential.

Table 4: Predicted state of a small river with local intervention.

1. Water quality	Turbidity: After removal of contaminants and cleaning of bottom sediments, a noticeable reduction in turbidity to standard values (<10 NTU) is expected.
	Odor: Removing sources of unpleasant odors by removing litter and clearing stagnation will improve the overall perception of the river.
	Colour: Without changes to the production process and effluent discharge, significant improvements in water colour are unlikely, but accidental discharges will be eliminated.
	Maximum Permissible Concentration (MPC): Reduction of concentrations of heavy metals and organic compounds by removing accumulated sediments and pollutants.
	Salt content: remains unchanged, since salt content is mainly related to the geological features of the area.
2. Biological activity	Cleaning the river stimulates the growth of phytoplankton and zooplankton, contributing to the creation of a healthy aquatic ecosystem. There is an opportunity to restore populations of fish and other aquatic organisms.
3. Aesthetics and tourism	The beauty and attractiveness of coastal areas will increase the interest of tourists and vacationers, creating additional opportunities for regional development. The revitalization of the tourism sector will have a positive impact on the region's economy.
4. Population health	Drinking purified river water reduces the risk of infections and diseases associated with poor water quality.
	Residents will be able to freely use water for household needs and recreation. The main benefits of river cleaning: Improving the sanitary and epidemiological situation. Improving the aesthetics of the landscape and increasing tourist interest. Stimulating economic growth and infrastructure development around the river. Improving the health of the population living near the river.

Table 5: Predicted state of a small river with an integrated approach to problem solving.

1. Water quality	Significant reduction in turbidity and color. Complete disappearance of unpleasant odor. Compliance with the requirements of maximum permissible concentrations (MPC). Revival of flora and fauna: The return of native fauna, including fish and waterfowl. Formation of a healthy community of algae and bacteria that maintain the balance of the ecosystem.
2. Economic growth	The number of tourists and holidaymakers is growing, attracted by beautiful landscapes and opportunities for active recreation. Opening new businesses and creating jobs that stimulate the economic development of the region.
3. Social benefits	Improving public health by improving the quality of drinking water and promoting active lifestyles. Strengthening a sense of pride in the city and citizen participation in environmental conservation activities.

Our next step is to develop a model capable of processing large amounts of data from sensors and laboratories to form a comprehensive picture of environmental conditions. This includes assessing water chemistry, vegetation status, and so on (see Figs. 3-4).

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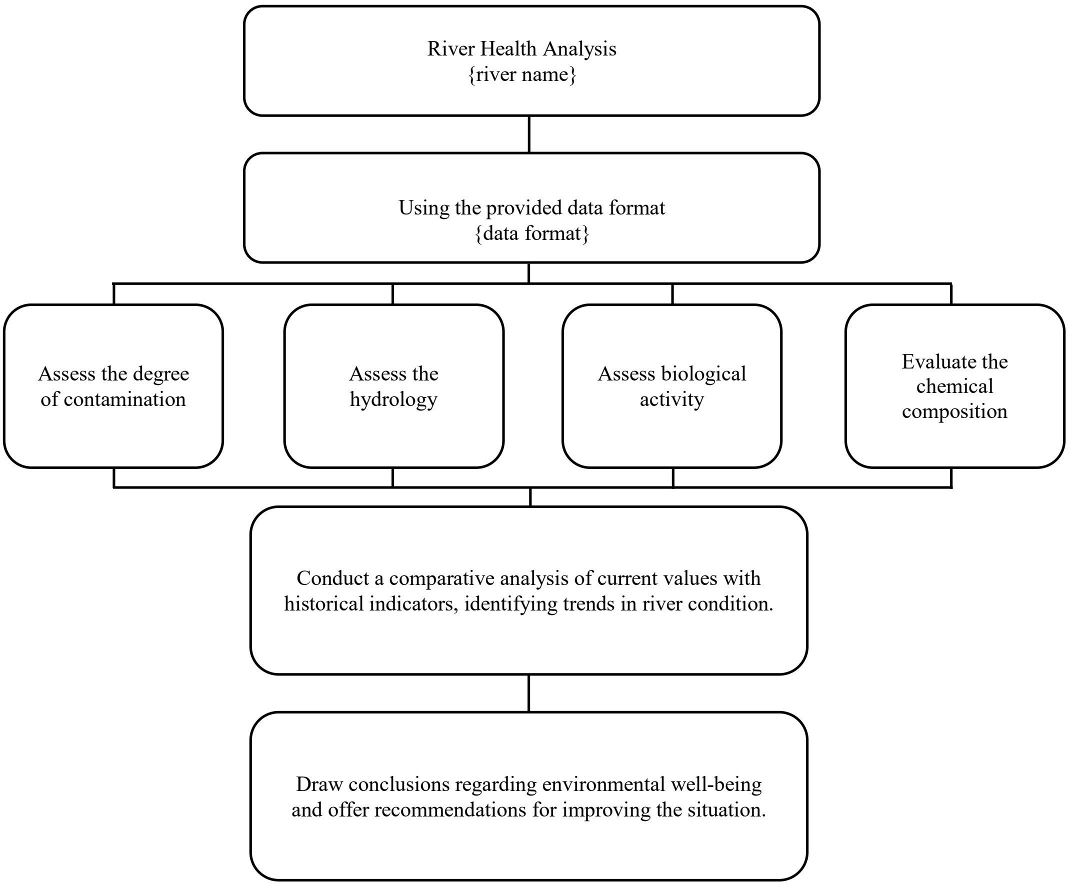

Figure 3: Structure of the system prompt .

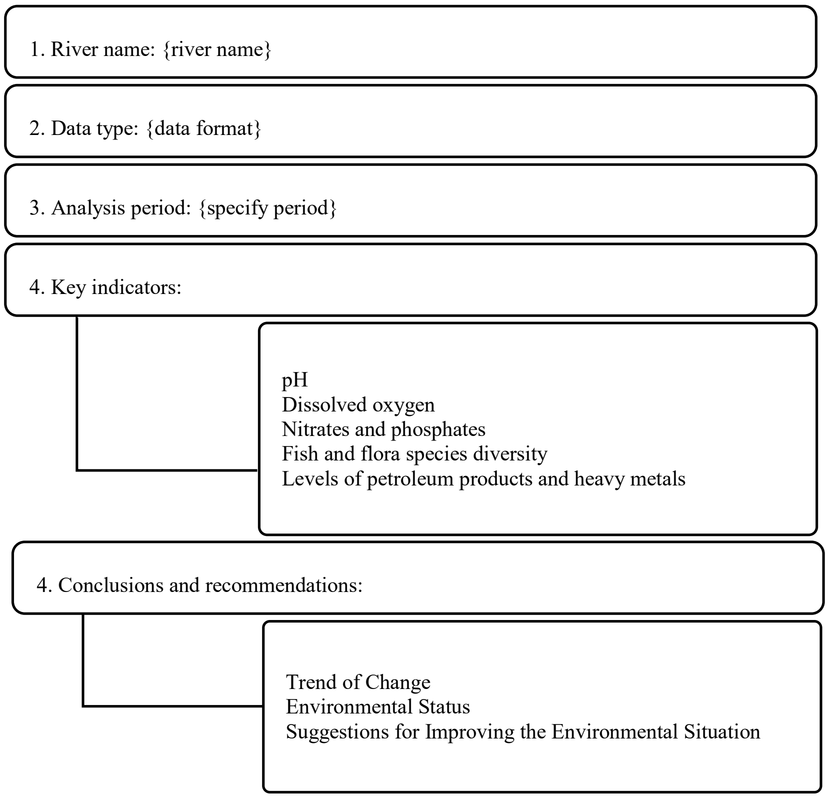

Figure 4: Report format.

The assessment method is modeling using multilayer neural networks (Wu , Zhang , Peng , Wang , 2024), which are trained on collected data and are capable of generating future forecasts. This method offers significant advantages over traditional methods, reducing time costs and improving the quality of decisions.

4 DISCUSSION

The results of this study, using small rivers as an example, confirm that artificial intelligence is a powerful tool for optimizing urban environmental monitoring and assessment. Specifically, it enables the accurate processing of large volumes of data, predicting development scenarios, and identifying correlations between various environmental parameters. However, to fully realize the potential of artificial intelligence, a number of issues related to standardizing the methods used, increasing data accessibility, and integrating the results into existing urban management systems must be addressed . Our team will focus on these areas of research in the future.

5 CONCLUSIONS

Thus, we achieved the stated objective of this study, which was to improve the methodological approach for using artificial intelligence to monitor and assess the state of the urban environment using small rivers as an example. We developed and applied our own proprietary method . Using this method and available water quality monitoring data for the Temernik River, we obtained forecasting results for three scenarios, which enable optimal management decisions regarding this element of the city's aquatic and green framework. We believe that implementing this improved approach in scientific and practical activities will reduce the negative human impact on the environment, create comfortable living conditions, and ensure sustainable urban development. We believe that the introduction of artificial intelligence into environmental monitoring and assessment processes is a promising approach that can contribute to improving the environmental situation in cities and enhancing the quality of life.

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