

STABILIZING THE ENVIRONMENTAL SITUATION IN TASHKENT CITY: WATER RESOURCE POLLUTION AND ECOLOGICAL MECHANISMS FOR ITS REDUCTION

A. Kayumov

Associate Professor, Head of the Department of the Branch Center for Retraining and
Advanced In-Service Training of Academic Staff Under Uzbekistan State World
Languages University

Abstract

This article provides a scientific analysis of water pollution as one of the key factors affecting the environmental sustainability of Tashkent, with particular attention to major anthropogenic pollution sources and environmental risks to aquatic ecosystems. The study aims to identify the principal factors contributing to the pollution of water resources in Tashkent and hydrologically connected areas, assess their environmental implications, and develop scientifically grounded recommendations for reducing anthropogenic pressure on water bodies. The methodological framework combines systems analysis, comparative analysis, content analysis of scientific and official sources, cause-and-effect analysis, and the synthesis of environmental monitoring data. The findings indicate that the ecological condition of Tashkent's water resources is shaped by the combined effects of industrial and municipal wastewater discharges, urbanisation, urban surface runoff, increasing pressure on sewerage infrastructure, and intensive water use. The study substantiates the need to modernise local wastewater treatment facilities at industrial enterprises, improve wastewater treatment efficiency, introduce automated environmental monitoring systems, expand the safe reuse of treated wastewater, and strengthen the implementation of integrated water resources management principles. The findings have practical relevance for improving environmental policy and water governance mechanisms aimed at enhancing the long-term environmental sustainability of Tashkent.

Keywords: Tashkent, environmental conditions, water resources, water pollution, wastewater, anthropogenic impact, water quality, environmental monitoring, urbanisation, sustainable development.

Аннотация:

Мазкур мақолада Тошкент шаҳрида экологик вазиятни барқарорлаштириш нуқтаи назаридан сув ресурсларининг ифлосланиши, унинг асосий антропоген манбалари ҳамда сув экотизимларига таъсир этувчи экологик хавф омиллари илмий жиҳатдан таҳлил қилинган. Тадқиқотнинг мақсади Тошкент шаҳри ва унга гидрологик жиҳатдан боғлиқ ҳудудларда сув ресурсларининг ифлосланишига таъсир этувчи асосий омилларни аниқлаш, уларнинг экологик оқибатларини баҳолаш ҳамда сув объектларига антропоген босимни камайтиришга қаратилган илмий-амалий таклифларни ишлаб чиқишдан иборат. Тадқиқот жараёнида

тизимли таҳлил, қиёсий таҳлил, контент-таҳлил, сабаб-оқибат таҳлили, экологик мониторинг маълумотларини умумлаштириш ҳамда замонавий илмий адабиётларни таҳлил қилиш усулларида фойдаланилди. Натижалар Тошкент шаҳрида сув ресурсларининг экологик ҳолатига саноат ва коммунал-маиший оқова сувлар, урбанизация жараёнлари, шаҳар ер усти оқимлари, канализация инфратузилмасига тушадиган юкларнинг ортиши ҳамда сув ресурсларидан интенсив фойдаланиш каби омиллар комплекс таъсир кўрсатишини кўрсатди. Сув ресурсларининг ифлосланишини камайтириш мақсадида саноат корхоналарида локал тозалаш тизимларини модернизация қилиш, оқова сувларни тозалаш самарадорлигини ошириш, автоматлаштирилган экологик мониторинг тизимларини жорий этиш, тозаланган оқова сувлардан қайта фойдаланиш механизмларини ривожлантириш ҳамда сув ресурсларини интеграциялашган бошқариш тамойилларини кенг татбиқ этиш зарурлиги асосланган. Тадқиқот натижалари Тошкент шаҳрининг экологик барқарорлигини таъминлашга қаратилган комплекс сув сиёсати ва экологик бошқарув механизмларини такомиллаштиришда амалий аҳамиятга эга.

Калит сўзлар: Тошкент шаҳри, экологик вазият, сув ресурслари, сув ифлосланиши, оқова сувлар, антропоген таъсир, сув сифати, экологик мониторинг, урбанизация, барқарор ривожланиш.

Аннотация:

В статье проведён научный анализ загрязнения водных ресурсов как одного из ключевых факторов экологической устойчивости города Ташкента, рассмотрены основные антропогенные источники загрязнения и экологические риски, оказывающие воздействие на водные экосистемы. Цель исследования заключается в выявлении основных факторов загрязнения водных ресурсов Ташкента и гидрологически связанных с ним территорий, оценке их экологических последствий и разработке научно обоснованных предложений по снижению антропогенной нагрузки на водные объекты. Методологическую основу исследования составили системный и сравнительный анализ, контент-анализ научной литературы и официальных материалов, причинно-следственный анализ, а также обобщение данных экологического мониторинга. Результаты исследования показывают, что экологическое состояние водных ресурсов Ташкента формируется под комплексным воздействием промышленных и коммунально-бытовых сточных вод, процессов урбанизации, поверхностного городского стока, возрастающей нагрузки на канализационную инфраструктуру и интенсивного использования водных ресурсов. Обоснована необходимость модернизации локальных очистных сооружений промышленных предприятий, повышения эффективности очистки сточных вод, внедрения автоматизированного экологического мониторинга, расширения безопасного

повторного использования очищенных сточных вод и применения принципов интегрированного управления водными ресурсами. Полученные результаты могут быть использованы при совершенствовании экологической политики и механизмов управления водными ресурсами, направленных на повышение экологической устойчивости города Ташкента.

Ключевые слова: Ташкент, экологическая ситуация, водные ресурсы, загрязнение воды, сточные воды, антропогенное воздействие, качество воды, экологический мониторинг, урбанизация, устойчивое развитие.

INTRODUCTION

In the 21st century, the acceleration of urbanisation processes in large cities is leading to an increase in anthropogenic pressure on natural resources, especially water resources. Population growth, the expansion of industry and service sectors, high construction rates, the development of transport and engineering and communication infrastructure directly affect the stability of urban ecological systems. In such conditions, the issue of the quality of water resources and their rational use becomes an important component of the city's ecological safety.

Tashkent is the largest administrative, economic and industrial centre of Uzbekistan. The socio-economic development of the city, along with the increase in demand for water resources, also increases the anthropogenic load on water bodies. Domestic and industrial wastewater, surface runoff from the city, and pollutants resulting from the activities of various economic entities can affect the ecological state of the water environment.

Pollution of water resources is not only a hydrological or sanitary problem. It is a complex problem that is inextricably linked with other components of the urban ecological system. The decline in water quality can affect the natural functions of water ecosystems, soil condition, biodiversity, and the ecological quality of the population's living environment. Therefore, the protection of water resources should be considered one of the priority areas of the strategy for stabilizing the ecological situation in Tashkent.

A study on the water quality of the Chirchik and Ahangaran basins, published in the journal Environmental Monitoring and Assessment in 2024, noted the presence of anthropogenic pressure on water resources in this basin associated with industrial and agricultural activities. The study showed that the change in the chemical composition of water from upstream to downstream and the increase in the concentration of some components may be associated with anthropogenic impact.

The relevance of the topic is determined by the need to organize the protection of water resources in the Tashkent agglomeration not only from the point of view of eliminating the consequences, but also on the basis of identifying sources of pollution, assessing their impact in advance, and forming preventive environmental management mechanisms.

The purpose of the study is to analyze the main anthropogenic factors affecting the pollution of water resources from the point of view of stabilizing the ecological situation in Tashkent and to substantiate scientific and practical measures aimed at reducing their negative impact.

Based on this goal, the study set the following tasks: to identify the main sources of pollution affecting the water resources of Tashkent, to assess the ecological significance of industrial and municipal wastewater, to analyze existing mechanisms for monitoring water quality, to consider opportunities for increasing the effectiveness of environmental monitoring, and to develop scientifically based proposals for reducing water pollution.

MATERIALS AND METHODS

The study was organized on the basis of the IMRAD methodological model. The objects of the study were selected as water bodies functionally connected with the city of Tashkent and its ecological system, wastewater discharge and treatment systems, and the main sources of anthropogenic impact on water resources.

The subject of the study is the processes of pollution of urban water resources, the anthropogenic factors that cause them, and mechanisms for reducing the negative impact on the water environment.

The systematic approach was used as the main methodological principle in the scientific analysis. This approach allows us to study the ecological state of water resources not at the level of individual pollutants, but within the framework of the interrelationship "anthropogenic source - wastewater - water body - ecological impact - management mechanism".

The information base of the study was formed by official data on the protection of water resources in Uzbekistan, the results of environmental monitoring, analytical materials of international organizations, and modern scientific research on water quality. In particular, the Fourth Environmental Performance Review of Uzbekistan, published in 2026 by the United Nations Economic Commission for Europe, assessed the impact of economic sectors on water, air, soil, and biodiversity, pollution control, and adaptation to water scarcity as an integral part of a comprehensive environmental policy.

Official environmental monitoring data on the wastewater activities of industrial enterprises in Tashkent were also analyzed. In 2024, within the framework of environmental control, 140 industrial enterprises discharging industrial wastewater into sewerage networks connected to the "Salar", "Bektemir" and "Bozsuv" wastewater treatment plants were monitored. The inspections included the state of disinfection and treatment of wastewater before discharge into the sewage system, the presence of local treatment facilities and their efficiency.

Also, official environmental monitoring data on the activities of industrial enterprises in Tashkent city related to wastewater were analyzed. In 2024, 140 industrial enterprises discharging industrial wastewater into sewage networks connected to the "Salar", "Bektemir" and "Bozsuv" wastewater treatment plants were monitored within

the framework of environmental control. The inspections examined the state of disinfection and treatment of wastewater before discharge into the sewage system, the presence of local treatment facilities and their effectiveness.

The study used comparative analysis, cause-and-effect analysis, content analysis and generalization methods to process the data. Sources of water pollution were divided into industrial, municipal and household and diffuse anthropogenic sources formed in the urban area by their origin.

RESULTS

The analysis showed that the ecological state of water resources in Tashkent city is formed under the influence of several interrelated anthropogenic factors. Among them, industrial wastewater, municipal wastewater, changes in surface runoff as a result of urbanization, an increase in the load on the sewage infrastructure, and intensive use of water resources are of particular importance.

The first important factor is related to industrial wastewater. Depending on the nature of the production process at industrial enterprises, various mineral and organic compounds, suspended solids, and other polluting components may appear in the composition of wastewater. If such water is discharged into the centralized sewage system without sufficient preliminary treatment, an additional technological load will be created on the city's treatment facilities.

The fact that 140 industrial enterprises in Tashkent are covered by special environmental monitoring indicates the importance of this factor from the point of view of environmental management. The official monitoring separately studied the condition of local treatment facilities and compliance with environmental standards established by enterprises.

The second factor is related to municipal wastewater. In large cities, the increase in population and the volume of public utilities leads to an increase in the volume of wastewater. As a result, the hydraulic and organic load on sewer collectors, pumping stations and treatment facilities increases. Therefore, the demographic and territorial development of the city must be coordinated with the pace of modernization of water and sewage infrastructure.

The third factor is urban surface runoff. Water flows formed as a result of precipitation and snowmelt move along roads, construction sites, industrial zones and other urbanized areas, carrying various pollutants to water bodies. In urban areas, the replacement of the natural soil layer with asphalt, concrete and other impermeable coatings limits the infiltration process and increases the volume of surface runoff.

The fourth important direction is related to the differences in the chemical composition of the upstream and downstream parts of watersheds. A modern geochemical study of the Chirchik and Ahangaran basins showed that the water composition in the upper reaches is formed more under the influence of natural geological processes, while in the lower reaches a significant increase in the amount of sodium, potassium, sulfate,

chloride and nitrate was observed. The authors attribute some of the changes to anthropogenic loads, including agricultural activities.

At the same time, it is methodologically incorrect to generalize the results of this study directly to all water bodies of Tashkent city. Since the study covered the Chirchik-Ahangaran basin. However, these results are important scientific evidence indicating the sensitivity of water quality to anthropogenic pressure in areas hydrologically connected with the Tashkent agglomeration.

As a result of the study, it was found that pollution of water resources directly and indirectly affects the ecological situation of the city. The direct impact is expressed in changes in the physicochemical properties of water, increased anthropogenic load on water ecosystems and limited opportunities for further economic use of water. The indirect impact is manifested in increased costs for water resource treatment, additional load on urban infrastructure and the need for additional resources to manage environmental hazards.

DISCUSSION

The results obtained show that water resource pollution in Tashkent should be assessed not as a separate environmental problem, but as a complex process related to the general socio-ecological system of the city.

The effectiveness of environmental management in modern cities should be based on the principle of preventing the release of pollutants into the water environment, rather than eliminating it after it has occurred. In this case, the main object of environmental policy should be not only the water body, but also the source of pollution.

From this point of view, the availability and technological efficiency of local treatment facilities at industrial enterprises are of great importance. Treatment of industrial wastewater from the enterprise to a certain level before sending it to the centralized sewage system allows reducing the chemical load on city treatment facilities.

Special monitoring of industrial enterprises discharging wastewater into the sewage networks connected to the "Salar", "Bektemir" and "Bozsuv" treatment facilities in Tashkent indicates that the practice of establishing control at the source of pollution is being formed. However, in order to achieve environmental efficiency, such monitoring should not be limited to periodic inspections, but should be supplemented with continuous or high-frequency instrumental monitoring at high-risk facilities.

The development of a digital environmental monitoring system is of great importance in the protection of water resources. Regular monitoring of water quality indicators, compilation of data into a single digital database and analysis of their dynamics make it possible to identify pollution trends at an early stage.

In this case, the monitoring system may include monitoring of water temperature, pH, electrical conductivity, dissolved oxygen, mineralization, nitrogen and phosphorus compounds, organic pollution indicators, as well as individual metals and other components depending on the level of environmental risk.

Another promising direction for the city of Tashkent is the expansion of mechanisms for the reuse of treated wastewater. Reuse of water that has undergone deep treatment for technical needs, certain industrial processes and other purposes that comply with environmental standards can serve to reduce pressure on clean water resources. This approach is consistent with the principles of a circular economy.

Another important element of water resources management is the effective application of the “polluter pays” principle. Under this approach, an economic entity that violates environmental requirements must not only pay a fine, but also bear economic responsibility for reducing the environmental damage caused, modernizing treatment technologies, and eliminating the risk of re-pollution.

The fact that an interdepartmental working group meeting on water pollution prevention and waste storage facility safety was held in Tashkent in 2026 indicates the high institutional importance of water protection issues. The participation of representatives of the water resources management, sanitation, industrial safety, and environmental protection sectors in the meeting confirms that combating water pollution requires a comprehensive institutional approach.

To stabilize the ecological situation in Tashkent, it is necessary to strengthen an integrated approach to water resources management. In this regard, information exchange and coordinated decision-making mechanisms between environmental control bodies, water supply and sanitation organizations, local authorities, sanitation authorities, industrial enterprises, scientific institutions and civil society institutions are of great importance.

The 2026 Environmental Performance Review of the United Nations Economic Commission for Europe for Uzbekistan also assesses environmental pollution, water resources, climate change and sustainable management of natural resources as interrelated policy areas. This indicates the need to integrate the issue of water protection in Tashkent with general “green city” and climate adaptation strategies.

Based on the results of the study, the following priority areas can be identified for reducing water resource pollution and stabilizing the environmental situation in Tashkent:

- technological audit of local wastewater treatment facilities at industrial enterprises and their phased modernization;
- systematic assessment of the technical and environmental efficiency of the main wastewater treatment systems such as “Salar”, “Bektemir” and “Bozsuv”;
- control of the content of industrial wastewater at the source of pollution and introduction of automated monitoring tools at high environmental risk facilities;
- formation of a single geo-information ecological monitoring base for urban water bodies;
- development of digital ecological maps reflecting territorial and temporal dynamics of water quality indicators;
- to expand the mechanisms of repeated use of treated wastewater for technical purposes based on ecological and sanitary requirements;

- promoting the use of stormwater management, permeable surfaces and green infrastructure elements in urban construction;
- strengthening the exchange of information between government bodies, scientific organizations and economic entities in the field of water resources protection;
- ensuring the openness and publication of environmental monitoring results in a form understandable to the public;
- increasing the environmental culture of the population on water conservation and prevention of household waste discharge into water bodies.

The implementation of these measures is not limited to improving water quality. They also serve to increase the city's environmental sustainability, efficient use of resources, sanitary safety and adaptability to climate change.

CONCLUSION

The results of the study showed that the protection of water resources is of strategic importance in stabilizing the environmental situation in Tashkent. Water quality in the city and adjacent hydrological zones can be affected by industrial and municipal wastewater, urbanization processes, surface runoff, and anthropogenic loads on water and sewage infrastructure.

The analysis shows that relying solely on the final treatment stage is not enough to effectively reduce water pollution. Pollution prevention should be based on a comprehensive management system that includes identifying the source of pollution, ensuring primary treatment at the enterprise level, regular monitoring of wastewater, modernization of urban treatment facilities, and digitalization of water quality monitoring.

Integration of water resources protection policy with environmental monitoring, urban planning, industrial policy, sanitary safety, and climate change adaptation measures is an important condition for ensuring the long-term environmental sustainability of Tashkent.

From this point of view, it is advisable to form a modern model of water resources protection in Tashkent based on the principles of “monitoring - prevention - treatment - reuse - control - ensuring public participation”.

The scientific significance of the study is that it systematizes water resource pollution as a complex anthropogenic process that affects the ecological sustainability of Tashkent. Its practical significance is determined by the development of proposals to reduce the anthropogenic load on water bodies, improve environmental monitoring, and increase the efficiency of wastewater management.

In future studies, it is advisable to take seasonal samples from individual water bodies in Tashkent, analyze the physicochemical and microbiological parameters of water in laboratory conditions, model the spatial distribution of pollution indicators based on GIS technologies, and conduct a comparative analysis of indicators in different years. Such empirical data will allow identifying specific sources of water pollution and developing a scientifically based water quality management model for Tashkent.

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