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### Economic impact of restructuring the municipal wastewater treatment system in San Francisco: Possibilities for application in ukrainian realities

**Elti Shahini\***

*Master of Public Administration, Lecturer  
Aleksander Moisu University  
2001, Lagjja 1, Rruga e Currilove, Durres, Albania  
<https://orcid.org/0009-0004-8299-4236>*

**Fabiola Bali**

*Doctor of Medicine  
University of Medicine  
1004, 8RRM+W7X, Rruga e Dibrës, Tirana, Albania  
<https://orcid.org/0009-0005-0846-2466>*

**Abstract.** The relevance of the subject matter is conditioned by the existing difficulties of operating the wastewater treatment system of large modern cities and the need to make qualitative changes in the structure of their functioning. The main purpose of the study is to investigate the economic effect of restructuring the municipal wastewater treatment system in the city of San Francisco in the context of analysing the promising possibilities of applying this experience in Ukrainian realities. The basis of the methodological approach is a combination of methods of systematic analysis of the experience gained in San Francisco during the restructuring of the wastewater treatment system, with an analytical investigation of the factors influencing the assessment of the economic effect of the implementation of this event. The study revealed the need for comprehensive investment into the restructuring of the wastewater treatment system existing in a large modern city to obtain a sustainable economic effect from the implementation of such programmes and improve the quality of water use services provided to residents of modern Ukrainian cities. The results obtained and the conclusions formulated on their basis are of significant practical importance from the standpoint of prospects for improving the functioning of wastewater treatment facilities in large modern Ukrainian cities and stabilising the overall environmental situation in these cities, as well as obtaining a tangible economic effect from the modernisation of wastewater treatment systems to improve the quality of services provided to city residents

**Keywords:** modernisation of the wastewater system; wastewater treatment; economic effect; treatment system restructuring; municipal level; environmental situation

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\*Corresponding author

## Introduction

To date, an urgent problem of modern cities is the systematic improvement of the quality of wastewater treatment with the complete exclusion of their discharge into the natural water bodies of the city. In real conditions, with an increase in the load on urban wastewater treatment plants over time, the only possible way out of this situation is the modernisation of wastewater treatment plants and their restructuring, which significantly improves the quality of functioning and efficiency of wastewater treatment (Shcherbakova, 2013).

The relevance of the issues of assessing the economic effect of the restructuring of the wastewater treatment system in modern Ukrainian cities is largely based on the problems of operating sewage treatment plants in these cities. This is conditioned by the obsolescence of the equipment of purification systems, the high degree of contamination of reservoirs, and the lack of investment funds for the implementation of such projects (Nazyuta *et al.*, 2004). It is the prospect of reducing operating costs for the maintenance of sewage treatment plants, combined with an increase in the degree of purity of natural reservoirs of cities, that are key factors in assessing the degree of expediency of such measures. The ecological factor is also a crucial one, since it is the degree of purity of natural urban reservoirs that largely determines the features of their further use and affects the environmental situation and the standard of living in cities as a whole.

Ensuring the quality of available water resources depends on monitoring and controlling sources of pollution and discharges of all possible types. Polluted water bodies pose a significant danger to human health and the functioning of ecosystems of large modern cities. Uncontrolled discharges into reservoirs can lead to contamination of drinking water sources, overload of water bodies with organic substances (causing eutrophication), and accumulation of heavy metals and other harmful pollutants (Alabaster *et al.*, 2021). The way out of this situation may be the restructuring of the wastewater treatment system in large modern cities to achieve the optimal economic effect of its subsequent use and improve the quality of services provided to residents of large modern cities.

Wastewater from industrial facilities of a large modern city contains a large number of various impurities which have an extremely negative impact on the sanitary condition of reservoirs located in the city and beyond. In addition, the organoleptic indicators of the water quality of these reservoirs are undergoing changes, including possible toxic effects on people and animals living in the locality. A significant amount of organic impurities is in the solid phase of the runoff, and meltwater should be considered the most saturated in terms of the concentration of mineral and organic impurities (Shah *et al.*, 2021). For this reason, a large variety of impurities in wastewater causes the variability of their composition, which causes significant difficulties in their purification.

Industrial wastewater contains a large variety of compounds, such as hazardous organic pollutants, heavy metals, salts and nutrients, which makes it difficult to clean them.

On the other hand, wastewater treatment using existing technologies is unprofitable due to high energy consumption and contributes to the emission of greenhouse gases. Thus, the use of conventional methods of water purification is not sustainable and not always effective. In this sense, the restructuring of the existing wastewater treatment system opens up broad prospects for improving the treatment system of complex industrial wastewater and their subsequent sustainable functioning (Shah *et al.*, 2022).

The purpose of the study is to investigate the prospects for achieving a sustainable economic effect by restructuring the wastewater treatment system at the municipal level in the city of San Francisco in the context of the possibility of applying this experience in Ukrainian realities.

## Materials and Methods

The methodology of this study was based on a combination of system analysis of the experience of San Francisco, which was obtained during the restructuring of the wastewater treatment system, with an analytical investigation of a complex of factors that influenced the assessment of the resulting economic effect. The research was preceded by the creation of a qualitative theoretical base designed to ensure an objective perception of the information provided, as well as the definition of key concepts of the presentation of theoretical and practical material within the framework of the stated subject of research. The theoretical basis included the findings of a number of Ukrainian and, mainly, foreign researchers involved in the modernisation and restructuring of wastewater treatment systems of large modern cities, and an assessment of the economic effect that can be achieved as a result of the successful implementation of such measures.

A systematic analysis of the experience of the city of San Francisco, which was obtained during the restructuring of the wastewater treatment system, allowed assessing the real state of the city's wastewater treatment system, since its establishment in 1952. The use of the principles of system analysis systematised the sequence of restructuring the wastewater treatment system of the city of San Francisco in the context of the relationship with the possible economic effect of the implementation of this set of measures.

The conducted study provided detailed information on the factors determining the economic effect of the restructuring of the San Francisco municipal wastewater treatment plant, including the availability of real prospects for the implementation of this experience in Ukraine.

This combination of scientific research methods predetermined the existence of its specific stages.

The annual economic effect of the restructuring of the municipal wastewater treatment system in San Francisco can be determined using the equation:

$$EE_y = (E_y - E_{nc} \times C) \times 100\%,$$

where,  $E_y$  – annual savings, the results that are achieved due to the restructuring of the wastewater treatment system in the city of San Francisco;  $E_{nc}$  – standard efficiency ratio, the

final value of which depends on the specific field of activity (for the restructuring of the city's wastewater treatment system,  $E_{nc} = 0.85$ );  $C$  – costs of restructuring, including upgrading the wastewater treatment system and setting up a pumping and treatment facility.

With regard to the assessment of the annual effect of the restructuring of the wastewater treatment system in San Francisco, the calculation of the annual economic effect of the restructuring of the wastewater treatment system of the city will have the form:

$$EE_y = (945,000,000 - 1,125,000,000 \times 0.85) \times 100 = 22.5\%$$

## Results

The San Francisco wastewater treatment system was established in 1952. The project of restructuring the sewage treatment plant system was developed by a consortium consisting of the largest construction company MHWConstructors, specialising in the creation of projects for the reconstruction of water treatment and sanitation systems, and WebcorBuilder. According to approximate expert estimates, the total cost of the San Francisco wastewater treatment plant restructuring project amounted to USD 945 million. The annual savings from the restructuring of the treatment plant system have amounted to USD 1,125 million. The sewage treatment plant is scheduled to become operational in the summer of 2025 after the completion of its restructuring (New treatment facilities will be built in San Francisco, 2018).

To date, San Francisco uses a combined wastewater treatment system. There are two sewage treatment plants in the city – 1952 and 1993, which allows for the treatment of up to 80% of all wastewater in the city (62 million gallons of water per day) (4., 06/14/2022) The main objectives of the San Francisco wastewater treatment system restructuring project include the restoration of four main combined sewage discharge (CSD) facilities and the installation of monitoring sensors and equipment that prevents backflow. These measures are aimed at preventing the ingress of salty seawater into the combined urban sewage system at high tide, and optimising the existing wastewater treatment system.

Modernisation of the treatment plant system included the following mandatory steps:

1. Improvement of deep mechanical cleaning of clogged water drains, which is carried out in order to eliminate debris, sand and sediment removal. During the works, up to 10 tonnes of the above-mentioned contaminants were removed, preventing the normal operation of the wastewater treatment facilities.

2. Improving the quality of biological wastewater treatment with separation of activated sludge and subsequent clarification of treated wastewater. In particular, the pH level increased from 4.5 to 7.1, while the hardness index decreased from 8.6 to 6.4.

3. Conducting laboratory studies aimed at determining the level of compliance with the maximum permissible concentrations of pollutants in treated wastewater. In particular, the concentration of iron was noted at the level of 0.2-0.25 mg/l, nickel – at the level of 0.02-0.03 mg/l, copper – at the level of 0.001 mg/l. All indicators correspond to the minimum permissible limits.

4. Improvement of the process of channelling treated wastewater into the natural reservoirs of the city, in particular, into the San Francisco Bay, as well as Merced and Stow lakes.

With regard to the San Francisco sewage treatment plant system, it should be noted that the combined sewage discharge system of this city allows collecting and treating wastewater along with storm water directly in one sewage system.

The potential economic effect of the restructuring of the municipal wastewater treatment system in San Francisco is conditioned by the following factors:

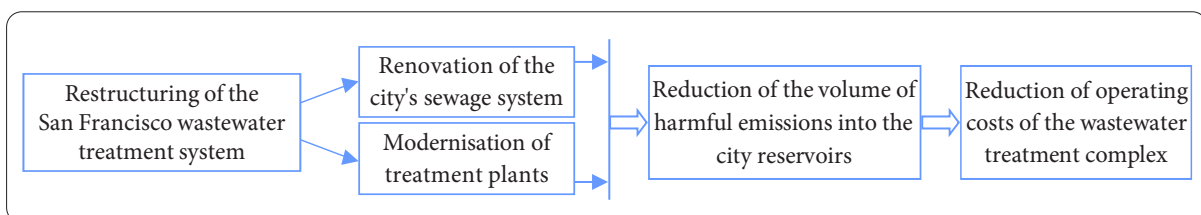
1. Reduction of harmful emissions into natural reservoirs and the absence of the need for their subsequent cleaning. In particular, there was a significant decrease in emissions of iron, nickel, and copper, the content of which after all the measures corresponds to the maximum permissible regulatory values.

2. Reducing the cost of cleaning the sewage system up to 20% of the previous volume by preventing salt seawater from entering it.

3. Improving the quality of wastewater treatment by restructuring the treatment system.

When assessing the expected economic effect, 22.5% of the savings spent annually on the repair of sewage treatment plants, it is worth considering the improvement of the water quality of natural reservoirs of the city due to the reduction of harmful discharges and a decrease in the of disease among residents due to the overall improvement of the environmental situation.

Figure 1 shows a flowchart of the relationship of factors determining the overall economic effect of the restructuring of the municipal wastewater treatment system in San Francisco. Implementation of the measures is planned for the period 2018-2022.



**Figure 1.** Factors determining the overall economic effect of the restructuring of the municipal wastewater treatment system in the city of San Francisco

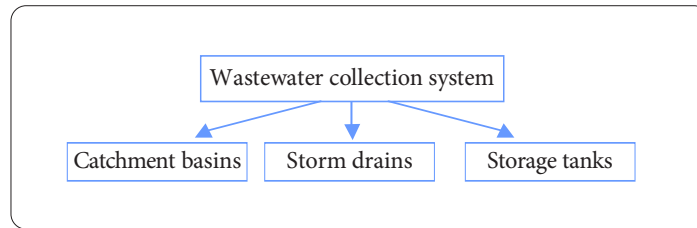
The reduction of costs for the operation of the San Francisco sewage treatment system in the amount of up to 20% after their technical modernisation and restructuring of the entire system as a whole is conditioned by the following factors:

1. There is no need to carry out planned and unscheduled repairs of worn-out equipment of treatment facilities after its modernisation.

2. Improvement of the quality of wastewater treatment in general.

3. A significant reduction in the volume of emissions of pollutants into the natural reservoirs of the city, which subsequently eliminates the need for cleaning of reservoirs.

Figure 2 shows the scheme of the wastewater collection system in San Francisco.



**Figure 2.** Wastewater collection system in the city of San Francisco

Qualitative restructuring of the wastewater treatment system involves the modernisation and increase of the total number of catchment basins in order to increase the volume of wastewater received. To date, there are over 25,000 such reservoirs in San Francisco, an increase in their number will significantly simplify the flow of storm water.

Storm drains provide redirection of water flows into sewer pipes that direct water into the bay without cleaning it. Modernisation of treatment facilities provides for redirection of water flows to them, in order to carry out cleaning before discharge into natural reservoirs.

Storage tanks are designed to collect wastewater for the purpose of their subsequent transportation to treatment facilities. Wastewater treatment is carried out in the tanks, which includes the deposition and separation of floating materials. The total capacity of the storage tanks located around the perimeter of the city today is over 200 million gallons. Currently, 95% of all discharges in San Francisco are storm water (Wastewater Collection System., 2018).

The process of restructuring San Francisco's municipal sewage treatment plants includes the following key aspects:

1. Reorientation of the city's wastewater collection system to drain water masses into the units of treatment plants.

2. Strengthening control over the functioning of the combined sewage system in order to prevent the ingress of salty seawater.

3. Launch of a Sewer System Improvement Programme (SSIP), which involves the creation of a seismically safe and robust system for monitoring the condition of the sewer system.

4. Commissioning of treatment plants that have passed the stage of modernisation in the process of restructuring the city's treatment facilities system.

The possibility of practical application in Ukrainian realities of the experience of assessing the economic effect of restructuring the wastewater treatment system of large modern cities is determined by the following factors:

- current state of the wastewater treatment system;
- actual level of pollution of urban reservoirs;
- volume of investment funds required for the qualitative

implementation of the programme of the wastewater treatment system restructuring;

- prospects for improving the complex of hydraulic treatment facilities in the future.

In this context, the organisation of surface runoff from the territories of cities and industrial enterprises is essential.

Surface runoff from the territory of cities and industrial enterprises should be considered as an intensive factor of anthropogenic load on natural water bodies. For this reason, the key purpose of sewage treatment plants for industrial wastewater at various industrial enterprises is to prepare and clean wastewater for reuse or to ensure their discharge into sewer networks. Sewage treatment reduces the content of petroleum products, fats, oils, insoluble salts and suspended solids to a minimum. A specific option for wastewater treatment in industrial enterprises should be chosen based on the available types of wastewater and the requirements that the resulting water must meet (Yamaliev & Barieva, 2014).

To date, the possibilities of applying programmes for restructuring wastewater treatment systems in Ukrainian cities are significantly limited due to the lack of funds in the city budget. In many Ukrainian large cities and small settlements, hydraulic treatment facilities are in a dilapidated state, which is conditioned by the lack of funds for scheduled and unscheduled repairs. The ecological situation in the regions also leaves much to be desired, due to the impossibility of performing a quality wastewater treatment and its large-scale pollution by industrial wastes and the daily life of the inhabitants of modern Ukrainian cities.

## Discussion

O. Gorb *et al.* (2022) considered a number of problematic aspects of wastewater treatment methods, using the example of the Dikanevskiy wastewater treatment plant (Kharkiv). The researcher notes that the restructuring of the Dikanevskiy wastewater treatment plant provided comprehensive sewage treatment, with significant improvements in complete biological and chemical treatment. Wastewater

coming from industrial and municipal enterprises, as well as from the population, is being treated. The throughput capacity of the city's treatment facilities is 450 m<sup>3</sup> per day. Mechanical water purification involves the flow of wastewater into the screen chamber, where the first stage of the process takes place. Screen and rake installations purify water from large waste. Sand and other solid waste in the wastewater is deposited in a special channel. Then the water enters the primary settling tank, which is a reservoir with a volume of 50 thousand cubic metres, where it remains for 7-8 hours. The remaining solid waste is deposited here and the light waste floats up. At the next stage, biological wastewater treatment is carried out in 7 tanks with a volume of 25,000 m<sup>3</sup> each. Special beneficial bacteria are used for this. In general, the author's conclusions completely coincide with the results obtained in the course of this study.

E. Margolina investigated the problematic aspects of the construction of economic mechanisms to stimulate the reduction of discharges of polluted wastewater. According to the researcher, there are currently no well-established mechanisms to stimulate industrial enterprises to limit the volume of wastewater discharges into natural urban reservoirs, which complicates the work of urban wastewater treatment plants. The researcher came to the conclusion that economic methods in most cases do not work, because often the financial condition of enterprises is very complex and the ecological problem of the city is of little importance to their managers (Margolina, 2016). To date, payments for discharges of pollutants are calculated based on information contained in approved reporting forms, which are filled out by the balance sheet method by the payer enterprises themselves, based on information about the volume of output, the volume of raw materials used, data on standards for emissions of pollutants. At the same time, the exact volumes of discharges can only be determined at large enterprises that have their own chemical laboratories. This significantly complicates the possibilities of calculating payments for discharges of pollutants by modern industrial enterprises.

M. Sillanpaa addressed the issues of improving water purification systems, while considering a number of problematic aspects of restructuring the treatment plant system in the city of Boston. The researcher came to the conclusion that the qualitative restructuring of the city's sewage treatment plant system allows improving its water supply and enhancing the quality of water in urban reservoirs. The researcher notes that during the restructuring of the treatment plant system of Boston in 1948-1949, it was possible to reduce the volume of harmful impurities in the water several times, while the cost of operating treatment facilities in the city decreased by 30-35%. This saved the city budget by directing them to the implementation of a number of public and social programmes (Sillanpaa., 2020). The author's conclusions regarding the reduction of costs for the maintenance of treatment facilities through their modernisation completely coincide with the results obtained during the implementation of this study, which confirms the existence of economic

prospects for the modernisation and restructuring of the treatment facilities system.

S. Ameta and R. Ameta, in a joint scientific study, considered a number of problematic aspects of improving oxidation processes during the restructuring of the wastewater treatment system. It was revealed that the use of new, environmentally friendly chemical technologies in wastewater treatment systems of large modern cities ensures the achievement of high results in the search for an environmentally friendly method of wastewater treatment. As an example, during the restructuring of the wastewater treatment system in the city of Plovdiv (Bulgaria), results were obtained indicating a significant improvement in the state of wastewater with the introduction of technology based on the use of a series of settling tanks and filters in which water suspensions of varying severity settle. The technology is completely environmentally friendly and does not require additional use of chemically active substances. In addition, the economic effect of using such technology, according to the presented calculated data, is up to 15%, which is expressed in a reduction in the cost of operating treatment facilities (Ameta & Ameta, 2018). Thus, the experience of restructuring the sewage treatment plant system in Bulgaria clearly shows that the use of innovative solutions during the restructuring of the wastewater treatment system of a modern city can reduce the cost of operating wastewater treatment facilities and improve the quality of wastewater in a modern city.

The team of authors represented by A.N. Khan, M. Naushad and A.H. Hamidi, conducted a joint study of a number of problematic aspects of improving the functioning of the wastewater treatment system of a large modern city. The researchers found that during the restructuring of the wastewater treatment system of Patna (India), as a result of mistakes made during the work, a significant release of harmful substances into the waters of the Ganges River was produced, which caused large-scale pollution and significantly worsened the environmental situation in the region. It was possible to rectify the situation through the introduction of a set of measures for biological wastewater treatment, which stabilised the environmental situation and led to its gradual levelling. In turn, this helped to reduce the costs of developing new measures to improve the quality of wastewater treatment, and also reduced the operating costs of maintaining treatment facilities that have undergone restructuring (Khan *et al*, 2022). In general, the conclusions of the researchers correspond to the results obtained in the course of this study, complementing them in the context of assessing the role of biological methods of wastewater treatment in the overall complex of work on the restructuring of treatment facilities in a large modern city.

A. Stefanakis and I. Nikolaou conducted a joint study of a set of measures to organise a circular economy and assess its sustainability in the realities of the modern market system. In the course of the study, the researchers evaluated the effectiveness of the restructuring of the treatment plant system of the city of Lodz (Poland) and the impact of this

process on the allocation of city budget funds. Researchers have come to the conclusion that a uniform reduction in wastewater treatment costs, due to the modernisation and restructuring of the city's sewage treatment plant system, is completely realistic considering the prospects for obtaining a significant economic effect (Stefanakis & Nikolaou, 2021). According to the authors, the restructuring of the city's sewage treatment plant system improves the quality of wastewater treatment and reduces the cost of its maintenance up to 25% of the funds allocated from the city budget. In general, the conclusions completely coincide with the results obtained in this study in the context of assessing the economic efficiency of restructuring the treatment facilities system of a large modern city.

The high contamination of natural reservoirs in large modern cities creates great problems for the operation of sewage treatment plants. The issues of urban water resources management are directly related to the problems of restructuring existing wastewater treatment facilities in cities. In particular, various aspects of the recycling and reuse of wastewater from modern cities are of particular relevance (Srivastava *et al.*, 2022). A qualitative solution to such issues will contribute to a more rational use of urban wastewater treatment facilities and the improvement of methods for cleaning natural urban reservoirs. One of the most optimal solutions to this problem is the gradual reorientation of the wastewater discharge of urban enterprises from natural reservoirs into the system of urban wastewater treatment plants.

In the conditions of large modern cities, the optimal solution to the problem of wastewater treatment can be the modernisation of treatment facilities, in parallel with the introduction of modern complexes of biological treatment methods. One of these is floating biological reactors. They contain strains of microorganisms capable of processing water pollution, which ensures the high quality of natural water purification in urban reservoirs (Bhattacharyaj *et al.*, 2017). The subsequent release of biologically treated water into the city's wastewater treatment plant system, with its passage through the filtration system, leads to a significant improvement in the quality of municipal wastewater treatment and the environmental situation in the city.

Reconstruction and restructuring of treatment facilities do not allow the use of standard solutions. Therefore, the key principles of the reconstruction of urban treatment facilities should be the maximum reduction of material investments in capital construction, with the achievement of the maximum possible economic effect from the commissioning of treatment facilities that have undergone modernisation (Shah, Rodriguez-Couto & Biswas, 2021). The economic effect of the restructuring of the wastewater treatment system in this context should be decisive, since it is its achievement that makes it expedient to modernise the treatment system.

Microbial wastewater treatment focuses on the use of microorganisms as decontamination agents for the treatment of contaminated wastewater, which is a worldwide problem. Microbial-based processes are seen as promising technologies for solving the ever-growing problem of

polluted wastewater and natural reservoirs in modern cities. In this context, the developed technological processes are of fundamental importance to address the five main trends in wastewater treatment, including nutrient removal and recovery, trace amounts of organic compounds, energy conservation and production, sustainability and community participation (Shah, Rodriguez-Couto, 2019). Microbial wastewater treatment technologies are of fundamental importance from the standpoint of developing modern methods of restructuring the wastewater treatment system of modern large cities, and also have significant prospects from the standpoint of the practical application of the latest technologies to address issues of improving the environmental situation in a large modern city.

Reconstruction of the sewage treatment plant system, as a rule, involves equipping them with new, more modern equipment, which in the future can ensure the achievement of higher wastewater treatment rates (Ranade & Bhandari, 2014). High-quality and uninterrupted operation of this equipment for a considerable period of time guarantees a sustainable economic effect in the long term. This is conditioned by the fact that in this case, the volume of harmful emissions into natural urban reservoirs is significantly reduced, which causes the absence of the need for their regular cleaning. In addition, for a certain period of time, there will be no need to incur costs for carrying out planned repairs of treatment facilities after their modernisation.

Improvement of the functioning of sewage treatment plants can be achieved by introducing a large volume of algae and microorganisms into the purification system for water purification in natural urban reservoirs (Bandh & Malla, 2022). In combination with improving the operation of urban drains, this measure can become very effective.

Biological treatment facilities are now beginning to be actively used in cities. Their appearance is caused by the fact that very often operating sewage treatment plants are not able to fully meet the needs of the city in the quality of wastewater treatment and environmental safety of natural urban reservoirs. At the same time, the introduction of biological wastewater treatment methods into urban wastewater treatment systems often justifies itself purely from an economic standpoint (Mohammad & Ang, 2021). In particular, the modernisation of urban sewers today may include the installation of additional biological treatment units, disinfection and elimination of sediment. These are significant additions to the mechanical cleaning units, which are usually installed in the system of urban sewage treatment plants. Biological purification units perform the function of extracting organic elements from water, as well as phosphoric and nitrogenous compounds. The choice of an effective combination of water purification methods during the modernisation of urban sewage treatment plants largely determines the overall efficiency of the urban wastewater treatment plant system.

The restructuring of the wastewater treatment process of a large modern city should affect all its stages, from mechanical treatment to disinfection of wastewater. In this context,

it is mandatory to improve the hydraulic structures included in the wastewater treatment system, and to replace outdated equipment with new, more advanced ones if such a need arises. In this case, it is possible to achieve a gradual reduction in the costs of implementing the wastewater treatment process and increase the economic efficiency of the entire treatment system as a whole. The final quality of wastewater treatment is of fundamental importance from the standpoint of ensuring a high level of environmental safety for the residents of a large modern city and maintaining the proper level of environmental protection for the overall population.

### Conclusions

The restructuring of the wastewater treatment system of a modern large city, which was considered on the example of San Francisco, necessarily includes the modernisation of functioning wastewater treatment facilities to improve the overall quality of wastewater treatment and, as a result, improve the overall quality of water supply and water use services provided to residents of a large city. At the same time, the expected economic effect of the restructuring of the San Francisco wastewater treatment plant system includes the difference between the results of the system's activities before and after the restructuring process, and the costs incurred to obtain similar results for changes in the operating conditions of the entire system. In the modern conditions of the city of San Francisco, this means that in order to calculate the mentioned economic effect, it is necessary to account for the costs of creating a complex for pumping and treating wastewater and upgrading the city's sewage treatment plant system.

The application of the experience of the city of San Francisco in Ukrainian realities implies careful control of the funds allocated for the work. At the same time, it is advisable to adopt the experience of successive modernisation of the city's sewage treatment plants in parallel with the modernisation of the wastewater collection system. Also particularly effective in this context will be the improvement of the sewage systems of Ukrainian cities, which would allow reorienting the city's wastewater collection systems to drain water masses into the units of treatment facilities. This will contribute to enhancing the overall efficiency of treatment facilities and improving the overall environmental situation in Ukrainian cities. In addition, the consistent modernisation of urban wastewater treatment plants with the reconstruction of urban sewers will lead to a reduction in the cost of maintenance of wastewater treatment plants, due to the reduction of harmful emissions into urban reservoirs. In general, there are real opportunities to apply the experience of San Francisco in the realities of modern Ukrainian cities. This opens up additional opportunities to improve the quality of treating of natural reservoirs in Ukrainian cities and will also allow saving the funds of the city budget allocated for their cleaning in the long term.

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### Conflict of Interest

None.

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## **Економічний ефект реструктуризації системи очищення стокових вод на муніципальному рівні в місті Сан-Франциско: можливості в українських реаліях застосування**

**Елті Шахіні**

Магістр державного управління, викладач  
Університет Олександра Мойсу  
2001, Lagjja 1, Rruga e Currilove, Дуррес, Албанія  
<https://orcid.org/0009-0004-8299-4236>

**Фабіола Балі**

Доктор медичних наук  
1004, 8RRM+W7X, Rruga e Dibrës, Тирана, Албанія  
<https://orcid.org/0009-0005-0846-2466>

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**Анотація.** Актуальність тематики експлуатації статті обумовлюється наявністю складних систем очищення стокових вод великих сучасних міст і необхідністю внесення якісних змін у структуру їх функціонування. Основною метою роботи є дослідження посиленого ефекту реструктуризації системи очищення стокових вод на муніципальному рівні в місті Сан-Франциско, в контексті вивчення перспективних можливостей застосування отриманого досвіду в українських реаліях. Основу методологічного підходу в цьому науковому дослідженні становить поєднання методів системного аналізу досвіду, отриманого в Сан-Франциско в ході проведення реструктуризації системи очищення стокових вод, з аналітичним дослідженням факторів, що впливають на оцінку ефекту від виконання цього заходу. У ході проведення наукового дослідження були отримані результати, що свідчать про необхідність здійснення комплексних інвестиційних впливань у реструктуризацію системи очищення стокових вод, існуючих у великому сучасному місті, з метою отримання стійкого ефекту від реалізації такого роду програм і підвищення якості послуг водокористування, що надаються сучасним жителям українських городів. Результати, отримані в науково-дослідній роботі, а також сформульовані на їх підставі висновки, мають суттєве практичне значення з точки зору перспективи поліпшення функціонування системи очищення великих сучасних українських міст і стабілізації загальної екологічної ситуації в цих містах, а також отримання досліджуваного ефекту посилення. від проведення робіт по модернізації системи очищення стокових вод з метою підвищення якості послуг, що надаються жителям міст

**Ключові слова:** модернізація системи сточної води; очищення стокової води; економічний ефект; реструктуризація системи очистки; муніципальний рівень; екологічна ситуація