Environmental management implementation in wastewater treatment at a machine-building enterprise: from theory to practice

Alona Bosiuk*, *Olesya* Filenko, *Andrii* Shkop, *Serhii* Kulinicn, *Tetiana* Tykhomyrova, and *Oleksii* Shestopalov

National Technical University "Kharkiv Polytechnic Institute", 61002 Kharkiv, Ukraine

Abstract. This study examines environmental management implementation in the context of wastewater treatment at machine-building enterprises. The article aims to assess how effectively environmental management is used in the wastewater treatment system to ensure rational resource use. It is noted that wastewater contains a significant amount of various pollutants that must be removed before disposal. A wastewater samples analysis was carried out to assess the environmental management implementation's effectiveness. The changes in the concentration of the pollutants during three months were found: the hydrogen indicator decreased from 7.83 mg/dm^3 to 7.58 mg/dm^3. The oil product concentration increased from 22.2 mg/dm^3 to 3.4 mg/dm^3, while the fat concentration remained stable. The received results provide important information for improving the wastewater treatment system and environmental management implementation. To ensure environmental safety and compliance with environmental standards, it is necessary to implement environmental management in wastewater treatment at machine-building enterprises. The optimal wastewater treatment technology choice and monitoring program development are described. The article contains practical recommendations for the implementation of environmental management at a machine-building enterprise and a perspective on this direction of development. The research is relevant and useful for machine-building complexes that have problems with wastewater treatment and aim to implement environmental management.

1 Introduction

With the development of engineering technology and scale, the shortcomings of pollution prevention technology as well as environmental pollution problems become increasingly prominent, and the demonstration role of environmental protection is weak [1].

Previous studies were mostly conducted on environmental consciousness from the consumer perspective based on correlations with concepts, attitudes, and behaviours, whereas there are insufficient studies on environmental consciousness and environmental management performance at the organizational level [2].

* Corresponding author: Alona.Bosiuk@mit.khpi.edu.ua

And therefore, environmental management at enterprises began to emerge as a result of growing awareness the need to preserve natural resources and environmental protection. As a result, environmental management and resource rational use are important aspects for enterprises that have wastewater. In order to ensure sustainable development and environmental protection, it is necessary to control resources use and wastewater treatment efficiency. To achieve this aim, it is necessary to implement an environmental management system at enterprises, which will include: an environmental situation analysis on the enterprise's territory; an action plan development to ensure resource-rational use; monitoring system establishment.

Environmental consciousness is a conceptualized attitude to reduce environmental concerns and problems [2]. Environmental responsibility awareness, green attitude, and green knowledge positively influence green purchase intention [3]. Moreover, in [4] argued that environmental consciousness is a key factor that affects consumer purchase intention (product). Joshi and Rahman [5] argued that the key motive for pro-environmental purchase behaviour begins with the high level of consumer interest in environmental issues [6]. This also applies to industry.

The endangerment of economic growth caused by environmental pollution highlights the importance of environmental governance as a potential solution to mitigate such pollution. Therefore, it is essential to examine the correlation between environmental governance and environmental pollution [7].

To provide reuse water, which is fit for purpose, several requirements have to be considered to achieve sustainability [8]. Therefore, the aim of the article is to analyze the environmental management implementing process for wastewater treatment at machine-building enterprises and to investigate the transition from theory to practice. Also it is important to assess implementation impact on the environment, enterprise development and wastewater reuse possibility.

The need for wastewater reuse has been identified by several global and internationally recognized organizations (World Health Organization 2006; ACWUA 2010; National Research Council 2012; US Environmental Protection Agency 2012). The reuse of water and especially the reuse of municipal wastewater will become a significant part of future water management and become an important part of the water supply for various water sectors [9].

The results of the research can become the basis for recommendations development and environmental management implementation practices improvement at machine-building enterprises and other industries.

2 Materials and methods

The proper state of the technical infrastructure, both in cities and in the countryside, is a factor that stimulates the economic development and contributes to the improvement of the quality of the population's life [10].

Environmental management refers to the strategies and actions implemented by companies to oversee and regulate the environmental impact of their business operations. These measures encompass various activities, such as gathering environmental data, devising eco-friendly solutions, addressing environmental concerns within legal frameworks, and conducting training and communication initiatives. Environmental management is a multifaceted managerial endeavour that involves not only implementing targeted pollution prevention and control measures but also fostering collaboration and synergy between the environmental department and other departments within the organization. It necessitates striking a balance between environmental objectives and broader corporate goals.

Moreover, the specific resources required and the influence on environmental performance may vary across different environmental management practices [11]. The strategic aims of environmental management are key guidelines that are established to achieve sustainable development and efficient resources use at enterprises. They are aimed at ensuring a balanced interaction between the company's activities and the environment. Strategic aims include (Fig.1).

Fig. 1. Strategic aims of environmental management: key directions for enterprises sustainable development.

Using this environmental management strategic aims in enterprises helps to ensure a balance between economic and environmental goals, contributes to the natural resources conservation, ensures compliance with legislation and regulations, improves enterprise status in society and promotes positive perception by consumers.

Quality management is a way of managing an organization, and includes a set of principles that are applied to all aspects of the organization and are integrated with the key business processes and activities to satisfy different stakeholders, especially customers. Quality management emphasizes a balance between technical, managerial, and people issues [12].

In order to determine the environmental management implementation effectiveness, a comprehensive study was conducted at a machine-building enterprise located in Kharkiv, Ukraine. Data collection included wastewater analysis, existing wastewater treatment system assessment and literature review. Such methods as quantitative analysis of wastewater parameters, environmental audits, treatment processes modelling were used. All methods were chosen in view of their relevance to the investigated aspects and ensuring received results reliability and accuracy. Table 1 comparing the theoretical and practical aspects of environmental management implementing for wastewater treatment at a machine-building enterprise. This table helps to reveal the connection between the concepts studied in theoretical works and their practical implementation in the enterprise. It shows how theoretical approaches influence practice and provides insight into how the environmental management implementation can change approaches to wastewater treatment.

Table 1. Theoretical and practical aspects of implementing environmental management comparison for wastewater treatment at a machine-building enterprise.

Theoretical aspects	Practical aspects
Environmental situation analysis on the enterprise's territory	Wastewater parameters measurement, including chemical and physicochemical parameters
Possible pollution sources indication	Wastewater treatment system installation that meets the environmental legislation requirements
environmental management implementation plan development	Monitoring system installation to control the wastewater treatment quality
Effective methods of wastewater treatment determination	Technological processes and methods of wastewater treatment development that ensure efficiency and economy
Development of measures plan to reduce the environmental impact	Implementation of energy efficiency and resource saving measures to reduce waste water treatment costs

This table offers a comparative overview between the theoretical concepts under investigation and their practical implementation in machine-building enterprises. It helps to identify similarities and differences between implementing environmental management the theory and practice, as well as to understand how the implementation of these concepts affects the wastewater treatment efficiency. The transition from theory to practice makes it possible to evaluate the implemented measures and strategies effectiveness. In practice, you can collect data, compare them with previous indicators and draw conclusions about the effectiveness of using environmental management in wastewater treatment.

3 Discussion

One of the priority directions of scientific and technological and innovative development at the present stage is the creation of systems of resource conservation on the basis of the formation of the industry of recycling and waste management [13]. This article analyses the received results of wastewater concentrations change of various pollutants, in particular the hydrogen index, oil products and fats. Discussion of these results will allow understanding changes in the wastewater quality during the specified period and identifying possible impacts on the environment.

The industrial environment is a vital contingent variable influencing the relationship between market orientation and environmental management. Enterprises in an industry with the more intense competition are induced to consider the market, and those market-oriented enterprises emphasizing customer demand would be more likely to implement an environmental management strategy and related activities [14].

Natural environment hasn't enough recourse for regeneration and is constantly impoverished, but the increasing anthropogenic impacts and globalisation may lead to catastrophic results [15].

Environmental management is a human resource-intensive process, so how to motivate employees to engage in this process is essential to achieve firms' environmental performance. Thus, human factors are quite necessary for the implementation of strategies and plans within a firm [16].

Conducted research and environmental management implementation in wastewater treatment at the machine-building enterprise has shown that using flocculants is important.

At the same time, it must be taken into account that using flocculants in the water purification, methods of separating solid and liquid phase's methods are also important. Usually, after aggregation in various mixers or flocculators, the sediment is supplied to lighting units for clarification [17]. This approach is important and helps ensure the wastewater treatment process efficiency at industrial engineering enterprises.

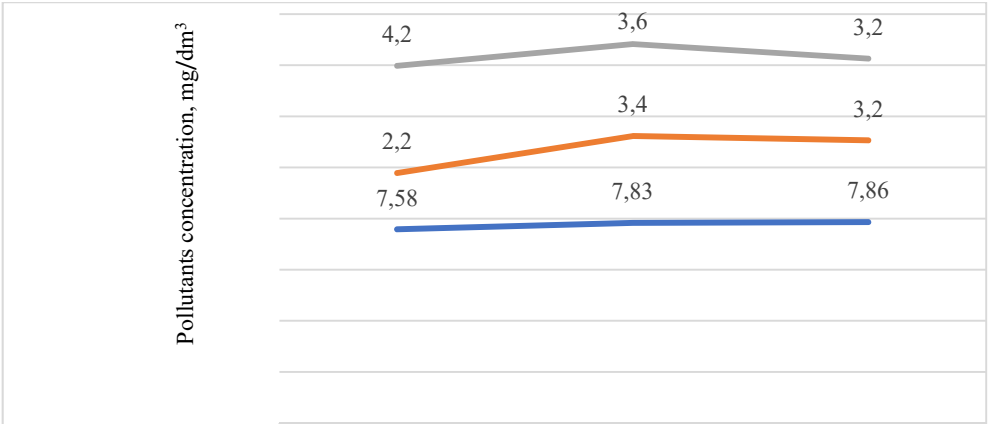
Liquid phase clarification processes intensification due to the polymer flocculants use is carried out at all stages of sediment thickening and dehydration. As a result of formed flocs destruction during the sediment transportation from the thickener to the dewatering devices in modern water supply and drainage schemes, reflocculation is carried out in front of each device [18], which helps to maintain the optimal treatment system efficiency and ensures the treated wastewater quality at an industrial enterprise.

For a specific production, some wastewater parameters affecting flocculation efficiency remain constant on average, and some may change over time. Most often, the solid phase concentration in wastewater changes during the day, which has the greatest impact on the flocculation efficiency [19]. This requires flocculant dosing system constant monitoring and adjustment to ensure optimal conditions for the stable flocs formation and to achieve treated wastewater highest quality.

Environmental management implementation in wastewater treatment at a machine-building enterprise requires attention to solid and liquid phase separation methods. Flocculants use and liquid phase clarification processes intensification are of great importance. Reflocculation is also an important stage in modern water supply and drainage schemes. In addition, wastewater parameters, in particular solid phase concentration, can change over time, which affects flocculation efficiency. Therefore, the successful use of the flocculation process in wastewater treatment requires flocculant dosing system constant control and adjustment in order to achieve optimal results and ensure treated wastewater high quality.

4 Results

A sample laboratory analysis was carried out in order to assess the wastewater quality and identify the contamination level of three substances. This analysis allows you to receive objective information about the various pollutants in wastewater, such as hydrogen index, oil products, and fats. It allows you to determine how efficiently the wastewater treatment system works at the enterprise and whether it meets the established standards and requirements for wastewater quality. Laboratory analysis is an important component for monitoring wastewater quality, identifying the enterprise's impact on the environment, and improving treatment processes to achieve more efficient and environmentally safe wastewater management. Below is a graph that shows the change in concentrations of three sample substances (hydrogen index, oil products, and fats) from three samplings (Fig. 2). The graph shows the dynamics of water pollution by these substances during a certain period. The X-axis shows sampling dates, and the Y-axis shows pollutant concentrations. Each substance is represented by a separate line colour, which allows you to easily track their change. With the help of this graph, we can see how their concentration changes over time. Analysing this information, we will be able to draw conclusions about the effectiveness of the implemented measures for wastewater treatment and some factors impact on pollution levels. The graph is built on wastewater laboratory analysis results, which allows monitoring the change in pollutants concentrations in the samples during the specified period.



	February 2022	December 2021	November 2021
Fat	4,2	3,6	3,2
Oil products	2,2	3,4	3,2
Hydrogen index	7,58	7,83	7,86

Fig. 2. Pollutants concentration dynamics in water during three months.

Analyzing the graph and given indicators, the following conclusions can be made:

1. The recorded hydrogen indicator values in February (7.58 mg/dm^3), December (7.83 mg/dm^3) and November (7.86 mg/dm^3) are at almost the same level, which indicates the stability of this indicator during the specified period.

2. The oil products concentration in water has a tendency to increase during three months. In February, it was 2.2 mg/dm^3, in December it rose to 3.4 mg/dm^3, and in November it decreased to 3.2 mg/dm^3. Such dynamics may indicate an increase in water pollution by oil products not only during the considered period, but also throughout the year.

3. Fat contain in February (4.4 mg/dm^3), December (3.6 mg/dm^3) and November (3.2 mg/dm^3) show a concentration decreasing these substances in water over time. This may indicate the success of the wastewater treatment applied methods and the fat pollution level reduction.

In general, the graph and given indicators mention the pollutant concentration dynamics. The hydrogen indicator remains stable while the oil product concentration increases and the fat concentration decreases. This may indicate the need for further improvement of the water purification system to remove oil products and ensure effective fat removal. The received results may indicate problems with environmental management at the enterprise or the inefficiency of existing cleaning systems. Such conclusions require attention and the adoption of urgent measures to reduce the negative impact on the environment and ensure compliance with environmental regulations. In this case, it is possible to propose the complex wastewater treatment technology used, which includes physical-chemical and biological processes. First, mechanical cleaning is used to remove solid particles and large impurities. Next, the process of physical and chemical precipitation is used to remove fats and oil products. After that, a biological process is applied. This complex technology provides effective fat and oil product removal and raises the hydrogen indicator level in wastewater, ensuring the high quality of purified water before its discharge.

5 Conclusions

Having analysed the environmental management implementation in wastewater treatment at a machine-building enterprise, we can conclude that the transition from theory to practice is an important stage in achieving sustainable development and ensuring environmental efficiency. The environmental management implementation allows the enterprise to effectively purify wastewater, reduce the negative environmental impact, and use resources more rationally. Wastewater analysis helps to establish the pollution level and identify the main pollutants, which enables effective decisions to be made to improve the treatment system. A monitoring program is being developed to effectively control wastewater quality and monitor its environmental impact. This program includes the systematic collection and analysis of data on pollutant concentrations, ecosystem impact assessment, and environmental compliance. This will allow the company to respond to any deviations in a timely manner.

The implementation of environmental management contributes not only to the environmental sustainability of the enterprise but also creates favourable conditions for society's development and improves the quality of people's lives. Implementing practical ecological principles in wastewater treatment requires constant improvement of technologies and monitoring systems to ensure long-term ecological efficiency and sustainable development. The strategic goals of the adoption of environmental management at enterprises determine the direction of their activities in the environmental protection area and put the enterprise on a sustainable development path. Based on the study results, it is recommended that the enterprise implement the proposed wastewater treatment technology. This may require investment in buying necessary equipment, employee training, and process adjustment, but it is an investment in the sustainability of the enterprise's environmentally responsible operation in the long term. The proposed comprehensive approach to wastewater management will allow the enterprise to ensure optimal water treatment, reduce the negative environmental impact, and comply with environmental legislation requirements. The optimal wastewater treatment technology application has the potential to reduce the risk of water pollution and improve water quality in nearby ecosystems.

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