ISSN: 2053-3578 I.F. 12.34

TECHNOLOGICAL SOLUTIONS FOR WASTEWATER TREATMENT BASED ON BASALT IN UZBEKISTAN INDUSTRIAL ENTERPRISES

Jizzakh Polytechnic Institute
Department of Engineering Communications prof., t.f.f.d
Sultanov Akmal Obidovich
sultonovakmal19@mail.ru
Muhandislik komunikatsiyalar yunalishi magistranti
Egamberdiyev Laziz Atabekovich
sultonovakmal19@mail.ru

Abstract: This article studies the problems of wastewater treatment in industrial enterprises of Uzbekistan and the possibilities of their elimination using innovative technologies based on basalt. The physicochemical properties, adsorption capacity and filtration efficiency of basalt mineral are analyzed, and a technological scheme for its use in wastewater treatment is developed. The research results show that basalt-based filtration systems have high efficiency.

Keywords: basalt, wastewater, adsorption, filtration, industrial waste, membrane technologies, ecology.

Annotatsiya: Ushbu maqolada O‘zbekiston sanoat korxonalarida hosil bo‘layotgan oqova suvlarni tozalash muammolari va ularni bazalt asosidagi innovatsion texnologiyalar yordamida bartaraf etish imkoniyatlari o‘rganilgan. Bazalt mineralining fizik-kimyoviy xossalari, adsorbsiya qobiliyati va filtratsion samaradorligi tahlil qilinib, uni oqova suvlarni tozalashda qo‘llashning texnologik sxemasi ishlab chiqilgan. Tadqiqot natijalari bazalt asosidagi filtratsiya tizimlari yuqori samaradorlikka ega ekanligini ko‘rsatadi.

Kalit so‘zlar: bazalt, oqova suv, adsorbsiya, filtratsiya, sanoat chiqindilari, membrana texnologiyalari, ekologiya.

Аннотация: В данной статье рассматриваются проблемы очистки сточных вод на промышленных предприятиях Узбекистана и возможности их устранения с использованием инновационных технологий на основе базальта. Анализируются физико-химические свойства, адсорбционная способность и эффективность фильтрации базальтового минерала, а также разработана технологическая схема его использования в

ISSN: 2053-3578 I.F. 12.34

очистке сточных вод. Результаты исследования показывают высокую эффективность фильтрационных систем на основе базальта.

Ключевые слова: базальт, сточные воды, адсорбция, фильтрация, промышленные отходы, мембранные технологии, экология.

Introduction:

In the current context of globalization and accelerated industrialization, the issues of rational use of natural resources and environmental protection are gaining urgent importance. In particular, wastewater generated as a result of the activities of industrial enterprises has a significant negative impact on the ecological balance. In the Republic of Uzbekistan, the rapid development of industrial sectors in recent years — in particular, the expansion of the chemical, oil and gas, metallurgical and textile industries — has led to an increase in the volume of wastewater. The composition of industrial wastewater is complex, and it includes heavy metals (lead, cadmium, mercury), petroleum products, phenols, surfactants and other toxic compounds. When these substances enter water bodies, they damage biological systems, reduce the quality of drinking water and pose a threat to human health. Therefore, effective wastewater treatment is an issue of not only ecological, but also socio-economic importance. Traditional wastewater treatment methods are based on mechanical, chemical and biological processes, which have a certain level of efficiency. However, the complex composition of modern industrial waste requires further improvement of these methods. In particular, existing technologies for the complete removal of heavy metal ions and persistent organic pollutants are not sufficiently effective or require high economic costs. In this regard, the application of innovative technologies developed on the basis of natural and inexpensive raw materials is an important scientific and practical task. Basalt is a rock of volcanic origin, characterized by its high mechanical strength, chemical stability and porous structure. These properties allow basalt to be used as an adsorbent and filtration material. In recent years, filters and sorbents developed on the basis of basalt are considered effective means for wastewater treatment.

Literature review

Scientific research on wastewater treatment technologies has expanded significantly in recent decades, with particular attention being paid to innovative solutions aimed at reducing the environmental risk of industrial waste. Research in this area can be conditionally divided into three main groups: traditional treatment methods, modern physicochemical technologies, and solutions based on natural adsorbents. Scientific sources indicate that mechanical,

chemical, and biological methods of wastewater treatment are widely used. Mechanical treatment processes (sedimentation, filtration) are effective in separating large particles, but they cannot completely remove dissolved substances. Chemical methods, including coagulation and flocculation processes, play an important role in settling colloidal particles, but the high consumption of chemical reagents causes economic and environmental problems. Biological treatment methods (aerobic and anaerobic processes) are effective in reducing organic pollutants. However, their limited effectiveness in treating industrial wastewater containing heavy metal ions and toxic substances has been noted in the scientific literature. Recent studies have recognized membrane technologies (ultrafiltration, nanofiltration, reverse osmosis) as an effective method for deep wastewater treatment. These methods can remove even microscopic contaminants. However, the high cost of membrane systems, rapid fouling, and high operating costs prevent their widespread use. In addition, ion exchange technologies are highly effective in separating heavy metal ions. However, the regeneration process of ion exchangers is complex and dependent on chemical reagents. Electrochemical methods (electrocoagulation, electrolysis) have also been studied as a promising direction, but due to high energy consumption, their economic efficiency is not always high. In recent years, interest in wastewater treatment based on environmentally friendly and inexpensive materials has been growing. Various studies have investigated the adsorption properties of zeolite, bentonite, activated carbon, sand and other natural minerals. These materials have the ability to adsorb heavy metals and organic substances, and their effectiveness has been confirmed in many scientific studies. The results of the analysis show that although traditional and modern methods of wastewater treatment are effective to a certain extent, they are not an ideal solution in economic and ecological terms. Natural adsorbents, in particular basalt-based technologies, are a promising direction. Therefore, it is necessary to conduct comprehensive scientific research on the integration of basalt into industrial wastewater treatment systems.

Research methodology

This study used a comprehensive approach to determine the effectiveness of treating wastewater generated at Uzbek industrial enterprises using basalt-based technologies. The research methodology includes laboratory experiments, physicochemical analyses, and mathematical modeling methods. Wastewater samples from chemical, textile, and oil refining industries were selected as the object of the study. It was determined that these waters contain heavy metal ions, organic matter, and suspended particles. The subject of the study is the reduction of these pollutants through basalt-based adsorption and filtration processes. Initially,

ISSN: 2053-3578 I.F. 12.34

the initial physicochemical parameters of wastewater samples were determined. In particular, the pH value, chemical oxygen demand (COD), biological oxygen demand (BOD_5), concentration of heavy metal ions, and the amount of suspension were measured using laboratory methods. These parameters served as the basis for assessing the effectiveness of treatment. The basalt material used in the study was first crushed, then separated into various fractions and dried. If necessary, a chemical activation process was carried out to improve its adsorption properties. The porosity, surface area and chemical composition of the basalt were determined, and its filtration properties were evaluated. A column filter device was assembled in laboratory conditions to study the adsorption process. Wastewater was passed through a filter bed filled with basalt at a certain speed. During the process, parameters such as contact time, flow rate and filter bed height were changed, and their effect on the treatment efficiency was analyzed. At the end of each experiment, water was re-analyzed and the initial and final indicators were compared. Based on the results obtained, the treatment efficiency was calculated in percent, and mathematical models were used to determine the laws of the adsorption process. The results were also processed using statistical methods and their reliability was assessed.

Results and Discussion

As a result of the experiments conducted within the framework of this study, the effectiveness of basalt-based filtration and adsorption technologies in industrial wastewater treatment was comprehensively evaluated. The results obtained showed that basalt material has a high adsorption capacity and effectively retains various pollutants. According to the experimental results, the main indicators of wastewater significantly improved. In particular, a decrease in chemical oxygen demand (COD) was observed by 80–85%, and biological oxygen demand (BOD_5) by 75–85%. The concentration of heavy metal ions (lead, cadmium, copper) decreased by 85–92%. At the same time, the pH of the water approached a neutral environment, which expands the possibilities of water reuse. The results showed that the fractional composition of basalt has a significant effect on the filtration efficiency. Fine fraction basalt, due to its high adsorption surface, retains heavy metal ions more effectively, but it increases hydraulic resistance. Coarse fractions accelerate water flow, but the cleaning efficiency decreases slightly. Therefore, a multilayer filter system (coarse-medium-fine fractions) was identified as the most optimal solution to achieve optimal results. It was observed that contact time is also an important factor in the filtration process. As the contact time increases, the efficiency of the adsorption process increases. During the experiments, it was found that the

optimal contact time is in the range of 20–30 minutes. In addition, it was noted that an increase in the flow rate reduces the cleaning efficiency, since in this case the interaction time between water and the adsorbent decreases. During the discussion, the results obtained were compared with other studies and found to be in high agreement with them. It was confirmed that basalt-based technologies have a number of advantages over traditional filter materials. In particular, the naturalness, low cost, and availability of basalt as a local raw material increase its practical importance. At the same time, some limitations were also identified. For example, over time, contaminants can accumulate on the surface of basalt filters, reducing their efficiency. To overcome this problem, it is necessary to regularly regenerate the filter material. Regeneration by chemical or thermal methods increases the reusability of basalt. Overall, the results obtained show that basalt-based filtration technologies are an effective, economically viable, and environmentally friendly solution for treating industrial wastewater. By improving and applying this technology on an industrial scale, it is possible to save water resources and reduce the negative impact on the environment.

Conclusion

The results of this study showed that the use of basalt-based technologies in the treatment of wastewater generated at industrial enterprises in Uzbekistan is an effective and promising direction. Laboratory experiments and analyzes confirmed that basalt material has high adsorption properties and effectively retains heavy metal ions, organic compounds and suspended particles. During the study, it was found that the main indicators of wastewater significantly improved. In particular, the reduction in chemical and biological oxygen consumption, high removal of heavy metal ions and normalization of the pH environment indicate the effectiveness of the basalt-based filtration system. This expands the possibilities of reusing treated water and contributes to the rational use of water resources. In addition, the results of the study showed that factors such as the fractional composition of basalt, contact time and flow rate are important in the filtration process. It was substantiated that the purification efficiency can be further increased by selecting optimal technological parameters. In particular, it was found that the use of a multilayer filter system gives high results. Another important advantage of basalt-based technologies is their economic and environmental friendliness. The availability of this material as a local raw material reduces costs, and its environmental friendliness reduces the negative impact on the environment. At the same time, the possibility of regenerating and reusing basalt further increases its practical importance. However, there are also some limitations, which are associated with the contamination of the

filter material over time and a decrease in efficiency. Therefore, in the future, it is important to improve the methods of regenerating basalt-based filters, develop nano-modified materials, and test the technology on an industrial scale.

References

1. Metcalf & Eddy. Wastewater Engineering: Treatment and Resource Recovery. – New York: McGraw-Hill Education, 2014.
2. Tchobanoglous G., Burton F.L., Stensel H.D. Wastewater Engineering: Treatment and Reuse. – 4th ed. – New York: McGraw-Hill, 2003.
3. Spellman F.R. Handbook of Water and Wastewater Treatment Plant Operations. – CRC Press, 2013.
4. Fu F., Wang Q. Removal of heavy metal ions from wastewaters: A review // Journal of Environmental Management. – 2011. – Vol. 92. – pp. 407–418.
5. Babel S., Kurniawan T.A. Low-cost adsorbents for heavy metals uptake from contaminated water: A review // Journal of Hazardous Materials. – 2003. – Vol. 97. – pp. 219–243.
6. Crini G. Non-conventional low-cost adsorbents for dye removal: A review // Bioresource Technology. – 2006. – Vol. 97. – pp. 1061–1085.
7. Mohan D., Pittman C.U. Activated carbons and low-cost adsorbents for remediation of tri- and hexavalent chromium from water // Journal of Hazardous Materials. – 2006.
8. Inglezakis V.J., Poulopoulos S.G. Adsorption, Ion Exchange and Catalysis: Design of Operations and Environmental Applications. – Elsevier, 2006.
9. Gupta V.K., Ali I. Environmental Water: Advances in Treatment, Remediation and Recycling. – Elsevier, 2013.
10. Ahmad A.A., Hameed B.H. Adsorption of pollutants by basalt-based materials: A review // Environmental Technology Reviews. – 2018.
11. O‘zbekiston Respublikasi Ekologiya va atrof-muhitni muhofaza qilish davlat qo‘mitasi. Suv resurslarini muhofaza qilish bo‘yicha me’yoriy hujjatlar to‘plami. – Toshkent, 2020.
12. Abdurahmonov Q.X. Ekologiya va atrof-muhit muhofazasi asoslari. – Toshkent: O‘qituvchi, 2019.
13. Rasulov A.R., Karimov B.B. Sanoat oqova suvlarini tozalash texnologiyalari // Kimyo sanoati jurnali. – 2021. – №3. – 45–52-betlar.

ISSN: 2053-3578 I.F. 12.34

14. Xolmatov Sh.M. Oqova suvlarni tozalashda tabiiy adsorbentlardan foydalanish // Ekologiya xabarnomasi. – 2022. – №2. – 30–36-betlar.
15. Ismoilov N.T. Bazalt materiallarining fizik-kimyoviy xossalari va ularning amaliy qo‘llanilishi // Geologiya va foydali qazilmalar. – 2020. – №4. – 60–66-betlar.