Uluslararası İleri Doğa Bilimleri ve Mühendislik Araştırmaları Dergisi
Sayı 7, S. 55-61, 4, 2023

Araştırma Makalesi

IJANSER

https://as-proceeding.com/index.php/ijanser
ISSN: 2980-0811

International Journal of Advanced Natural Sciences and Engineering Researches
Volume 7, pp. 55-61, 4, 2023

Research Article

Wastewater Treatment Using Active Microorganisms and Evaluation of Results

Zehra Gülten Yalçın[1*], Mustafa Dağ[1], and Ercan Aydoğmuş[2]

[1]*Department of Chemical Engineering, Engineering Faculty, Çankırı Karatekin University, Çankırı, Türkiye*
[2]*Department of Chemical Engineering, Engineering Faculty, Fırat University, Elazığ, Türkiye*

[*]*Email of corresponding author: zaltin@karatekin.edu.tr*

(Received: 10 April 2023, Accepted: 25 April 2023)

(DOI: 10.59287/ijanser.2023.7.4.550)

(1st International Conference on Scientific and Innovative Studies ICSIS 2023, April 18-20, 2023)

ATIF/REFERENCE: Yalçın, Z. G., Dağ, M., & Aydoğmuş, E. (2023). Wastewater Treatment Using Active Microorganisms and Evaluation of Results. *International Journal of Advanced Natural Sciences and Engineering Researches,* 7(4), 55- 61.

Abstract – In this study, samples are taken from the facility where the wastewater is located, and tests and analyzes are made with an active microorganism (EM). EM Technology means technology using Active Microorganisms. EM is not composed of a single microorganism, but a mixture of various groups of microorganisms. It has a positive and healthy effect on people, animals, and nature. EM is effective in both aerobic and anaerobic conditions. For this reason, it would be beneficial to apply it at all stages of treatment in conventional wastewater treatment systems, except for the biological reactor. When used in EM-activated wastewater, various compounds are formed that may be beneficial for wastewater (enzymes with high hydrolytic activity and some antioxidant substances). These compounds together with EM microorganisms provide high-capacity purification of wastewater. As a result of analyses using EM, it is seen that the desired values are achieved. Heavy metal determination is made in Çankırı wastewater and water treated with EM using an ICP-OES device at a lower detection limit (LOD) value of the device at ppm level. As a result of treatment with EM, it has been determined that a high concentration of strontium fell to the lower detection limit. This result shows that EM has an effective role in removing heavy metals. It has been seen that the use of EM in wastewater is extremely beneficial in terms of eliminating bad odors, increasing the sedimentation rate of organic matter, and reducing chemical oxygen demand (COD), biochemical oxygen demand (BOD), and suspended solids amount (SSM). Besides, ionization is suppressed by the anti-oxidation effect. When EM is used, the operating cost will be lower as O_2 consumption can be reduced. Since the water will still contain EM microorganisms after being treated, it is thought that wherever it is discharged from the wastewater plant to nature, a great improvement will be observed in terms of vegetation and the environment.

Keywords – Wastewater Treatment, Active Microorganism, Lower Detection Limit, Chemical Oxygen Demand

I. INTRODUCTION

The wastewater sample used in the study was taken from Şabanözü district of Çankırı. The district was established on the slopes of Agglomerated Basalt andesite, one of the volcanic rocks, and on the Sanı Stream. While the general population of the district had an economic structure based on agriculture and animal husbandry and small-scale workshops and workplaces, industrialization started in the district in 1985. Şabanözü Organized Industrial Zone, whose legal personality was registered in 2005 and whose expropriation and zoning works were completed, and the roads existing in the zoning plan within the scope of the infrastructure (Electricity-Water-Sewerage-Road) [1].

Rehabilitation of stream and treatment of wastewater in Şabanözü District, which divides the district into two, was supported by the European Union Central Finance and Contracts Unit within the scope of the "Sanı Stream Rehabilitation and Wastewater Treatment Plant" project [2].

It is thought that the use of water in the world will cause many problems in the supply of resources in the future. For this reason, wastewater treatment is important. With wastewater treatment and its subsequent use in appropriate places, the increasing water needs are met, and savings are achieved in terms of water resources [3].

Wastewaters are water-based solids and liquids that are discharged into the sewer, representing the wastes present in the communal living area. Wastewater contains dissolved and suspended organic solids that decompose or biodegrade over time. Two general categories of wastewater cannot be separated, mainly domestic and industrial wastewater [4].

Domestic qualified wastewater is polluted sewage water generated as a result of use in residential units such as houses, sites, residences, motels, and hotels. Detergents, organic substances, and oils constitute the biggest pollution loads in these waters. Detergents, organic substances, and oils make up a large part of the pollutants found in these waters, and pathogenic microorganisms and micro-pollutants must be completely removed from the aquatic environment during their recovery and reuse [5].

Industrial wastewater is an important environmental problem. Numerous organic pollutants, heavy metals, and non-degradable materials are present in extreme concentrations. Currently, the effective removal of these pollutants from industrial wastewater has become a very important issue. Efficient treatment efforts are needed to remove these contaminants before disposal [6].

Pollution caused by industrial waste can be divided into organic pollutants, solid pollutants, toxic pollutants, petroleum pollutants, acid-based pollutants, biological pollutants, nutritional pollutants, aerobic pollutants, thermal pollutants, and sensory pollutants [7].

Physical Properties of Waste Water

Total solids: On average, domestic wastewater contains 720 mg/L of total solids. About 500 mg/L of the total solid matter is in the dissolved state, and the rest is in the suspended solid state. Dissolved and suspended solids can be either fixed or volatile.

Smell: It is caused by gases formed by the deterioration of organic substances in wastewater. Oils, petroleum, and organic solvents also cause wastewater to smell.

Color: Water is a colorless and odorless substance. Drinkable water should be colorless. It varies depending on industrial wastes, organic, and inorganic melts [8].

Chemical Properties of Waste Water

Biochemical oxygen demand (BOD): It is the amount of dissolved oxygen used by microorganisms during the biochemical oxidation of organic substances in wastewater.

Chemical oxygen demand (COD): COD test is performed to measure the organic matter content of wastewater. COD of wastewater is higher than BOD.

pH value: It is the parameter of hydrogen ion condensation in wastewater. This value of wastewater is important in determining biological and chemical treatment processes. The pH value of drinking water is between 6-8, seawater 8, natural water 7, and domestic wastewater 7-8.

Chloride: The major source of chlorides in domestic wastewater is human urine. In regions with high water hardness, large amounts of chloride are mixed into the wastewater with the use of water softeners.

Alkalinity: It consists of the presence of hydroxide, carbonate, and bicarbonates of elements such as calcium, magnesium, sodium, potassium, or ammonia. Wastewater is generally alkaline.

Nitrogen: It is a nutrient for microorganisms in wastewater. Nitrogen addition may be required to treat wastewater when nitrogen is not sufficient. Nitrogen in domestic wastewater is present in the required amount for biological treatment.

Phosphorus: It is a nutrient for microorganisms in wastewater. If there is phosphorus in the treated wastewater discharged to the receiving environment, it may cause eutrophication (abnormal growth of plants in the water) in the receiving environment.

Sulfur: The sulfate ion is naturally present in wastewater. Sulfates are chemically reduced to sulfides and hydrogen sulfide (H_2S) by bacteria under anaerobic (oxygen-free) conditions. It is then biologically oxidized to hydrogen sulfide to sulfuric acid.

Heavy metals and toxic compounds: Heavy metals such as nickel, bird, chromium, cadmium, zinc, copper, and mercury and the compounds they form are toxic to microorganisms. Therefore, it creates a problem in the biological treatment of wastewater. Heavy metals and toxic elements are not found in domestic wastewater. Gases in domestic wastewater can be listed as nitrogen, oxygen, carbon dioxide, ammonia, and methane. The amount of oxygen in wastewater is very low due to the oxygen consumption of microorganisms. One of the by-products of the anaerobic decomposition of organic substances in wastewater is methane gas. This gas is highly flammable and explosive. The toxic effect of H_2S gas is very high [9,10].

Biological Characteristics of Waste Water

Significant groups of organisms are found in domestic wastewater; microorganisms such as plants, animals, fungi, protozoa, viruses, bacteria, and algae. Many of the microorganisms in domestic wastewater are disease-causing for humans and animals. Coliform bacteria are an indicator of contamination from human waste. Algae also cause taste and odor problems. During the treatment of wastewater, organic substances are broken down by bacteria [11-12].

Treatment Methods of Domestic Wastewater

Physical Treatment Methods

Grids: These are the treatment units used to prevent large volumes of substances from damaging the pump and other equipment by separating from the wastewater and to alleviate the burden on other treatment units. There are varieties depending on the amount of spacing, including fine and coarse grids, and can be designed as manual or automatic cleaning.

Sand Traps: They are the treatment system units used to separate substances such as sand and gravel from the wastewater, to prevent the wear of pumps and similar equipment in treatment plants, and to prevent the danger of clogging that may occur in sedimentation pools.

Sand Traps: They are the treatment system units used to separate substances such as sand and gravel from the wastewater, to prevent the wear of pumps and similar equipment in treatment plants, and to prevent the danger of clogging that may occur in sedimentation pools.

Filtration Pools: These are pools used for homogenization of the composition in wastewater, preventing damage to the system during shock loads, and regulating the wastewater flow rate. The filtration process is applied to eliminate the remaining turbidity.

Chemical Treatment Methods

Coagulation: It is the process of adding coagulant substances to wastewater at the appropriate pH and combining them with colloidal and suspended solids in the wastewater to become ready to form a flock.

Flocculation: It is the process of combining small grains formed by the coagulation process with each other as a result of mixing wastewater at the appropriate speed and forming flocs that can collapse easily.

Ion exchangers: Ion exchange is the ion exchange process between the ion exchange resin and water. The most well-known problem caused by water-soluble substances is hardness. Calcium (Ca) and magnesium (Mg) dissolved in water cause hardness.

Hardness: It causes the excessive use of cleaning materials, clogging in pipes, inefficiency in heater and steam generating devices, energy losses, tastelessness in water, and many problems.

Chlorination: Disinfection is carried out to destroy pathogenic microorganisms in the water. Chlorine is the most commonly used disinfection process. The chlorination unit is the unit where the chlorine added to the water is stored and made ready for dosing. Chlorine, which is stored as a liquid in pressurized tanks, is mixed with water after it turns into steam.

Biological Treatment Methods

Biological Filter: Biological treatment is the process of removing dissolved organic substances in wastewater by decomposing them with bacteriological activities. For bacteria to carry out the purification process, parameters such as pH, temperature, dissolved oxygen, and toxic substances must be kept under control.

Applications: activated sludge systems, biofilm systems, stabilization ponds, aerated lagoons, and trickling filters.

Activated Sludge and Modifications: The most used system among biological treatment systems is the activated sludge system. In Figure 1, the activated sludge process is an aerobic biological treatment method since the microorganisms that are treated can grow in suspension [14].

Stabilization modifications: Stabilization of sludge is especially effective in reducing the volume of sludge. The main purpose of the stabilization process is to remove the organic substances in the sludge by physical, biological, or chemical methods. Stabilization methods such as aerobic or anaerobic digestion significantly reduce sludge volume [13].

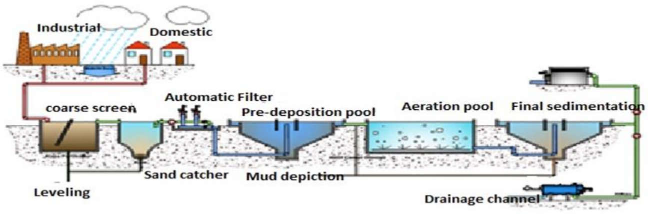

Figure 1. Wastewater treatment plant flow chart

Anaerobic System: Anaerobic wastewater treatment is a process in which organic substances are converted into inorganic substances such as methane (CH_4), CO_2, and ammonia in an oxygen-free environment. Anaerobic decomposition of biodegradable organic substances is a purification method performed by different groups of bacteria. Anaerobic wastewater treatment has gained importance in recent years due to some of its advantages and numerous studies have been conducted on it. A large number of anaerobic treatment plants have been established especially for the treatment of concentrated industrial wastewater. In our country, there are a limited number of anaerobic facilities built by obtaining licenses from foreign companies in recent years [15].

The demand for clean and safe water is increasing with the rapid population growth, widespread industrialization, urbanization, and widespread agricultural practices throughout the world Jul. Today, various methods are used for water pollution and purification. However, these methods usually involve chemicals. Today, there is a need to reduce the use of chemicals and develop new wastewater treatment methodologies [16].

Active Microorganism (EM)

EM is called an active microorganism. It consists of various types of microorganisms and is collected from nature and produced under its unique conditions. It is a cocktail of microorganisms available on the market in the form of brownish liquid. It is preferred as a field of use in the fields of agriculture, animal husbandry, and the environment. Water treatment using EM technology is quite economical in terms of cost. In addition, it has the potential to improve the chemical and physical properties of water. EM is an environmentally friendly product and its use in agriculture and industrial areas is quite common. There are applications on a municipal basis, especially in wastewater treatment, and cleaning of water resources [17].

In the literature review, it is observed that the studies on microorganisms related to nitrogen removal in wastewater treatment plants focus on ecological distribution using the 16S rRNA gene or functional gene sequencing. With the development of high-efficiency sequencing techniques and subsequent data analysis methods, it is seen in the studies carried out that it is possible to reveal more of the potential molecular and metabolic mechanisms of the main microorganisms in depth with the development of high-efficiency sequencing techniques and subsequent data analysis methods [18].

Another study shows that drug residues in wastewater are often used as environmentally friendly for the decontamination of pharmaceutical pollutants in wastewater, among new water purification techniques, microbial electrochemical technologies (METS), instead of traditional water purification processes, are used environmentally friendly for the treatment of pharmaceutical pollutants in wastewater [19].

In another study, it is seen that wastewater treatment systems aim to maintain high activity and density of microorganisms that meet different treatment requirements. It is stated that the waste produced by the pharmaceutical industry is an environmental problem. Bioremediation technology has been preferred for the removal of heavy metals as an innovative and optimistic technology. It is stated that it will be an important study when evaluated in terms of both cost and environmental compatibility. It has been emphasized that various microorganisms, including algae, fungi, yeasts, and bacteria, can function as biologically active methylators that can replace toxic species. Microorganisms play a crucial role in heavy metal bioremediation [20].

In this study, treatment studies were carried out with effective microorganisms, which are a conventional and alternative method, of the existing wastewater in Şabanözü district of Çankırı. Physical, chemical, and biological treatment, which is one of the classical methods used in the treatment process, may be insufficient. It was determined that strontium heavy metal was 7.5 ppm above the limit value in the wastewater before treatment with EM. It was determined that the strontium value in high concentration decreased to the limit value of 5 ppm after using EM. This result showed that EM has an effective role in removing heavy metals.

II. MATERIAL AND METHOD

Materials

HQ11D Portable pH meter is in the operating range of temperature -10±110 °C.

HQ14D Digital conductivity meter

Hach 2100Q Portable turbidimeter (EPA)

ICP-OES device was used for heavy metal determination.

Method

In this study, the standards used in the analysis are as follows: Temperature, pH, conductivity, dissolved oxygen, turbidity, color, iron, manganese TSE 266, phosphonate ISO 6878-1-1986, DIN 38405 D11-4, total nitrogen, nitrate, nitrite, ammonia Worked with EN ISO11905-1 standard. In addition, heavy metal determinations in wastewater were determined in ICP-OES Plasma Quant 9100 Series brand and model device.

III. RESULTS AND DISCUSSION

Analysis results of wastewater before and after treatment with EM are given in Table 1 and Table 2. Here, it was determined that the temperature in the raw wastewater was 15.5 °C and increased to 19.9 °C after treatment with EM. The pH was found to be basic with 9.58 in both cases. It is seen that the alkalinity is high in both cases. The reason for the increase in conductivity is thought to be an indicator of dissolved matter. It was determined that the amount of dissolved oxygen increased to 6.16 mg/L, the turbidity in the color was removed, iron decreased to 0.11 mg/L, and the amount of manganese, which was 0.555 at first, decreased to 0.043 mg/L as a result of the process. It was determined that the recovery was 7.74 %.

Since turbidity is an indicator of AKM (suspended solids), it is not desired to be in the wastewater. When looking at the raw water, it is determined that while the turbidity is 18.5, it is reduced to 2.27 as a result of the process, resulting in improvement. If we look at the iron analysis result, it was 0.66 in raw water and 0.11 in EM water, and an improvement of 16.6 % was detected. Phosphonate is a factor limiting the phosphorus deficiency algae population. Phosphonate was measured as 4.12 mg/L in raw water, and 0.994 mg/L in EM water, a decrease of 24 % is observed. Nitrogen in raw water is an indicator of organic pollutants. While the total nitrogen was 80.7, the result of the treatment decreased to 61 by 75.6 %. While TOC was 84.75 in raw water, 79.5 results were reached in EM, showing a decrease of 93.80 %. As a result, EM has proven that it can be used as an auxiliary element in the fight against the dissolved organic matter.

In addition, when EM is evaluated in terms of cost and features; since the oxygen consumption can be reduced, the operating cost will decrease, and since the water will still contain EM microorganisms after purification, wherever it is discharged from the facility to the nature, a great improvement will be observed in terms of vegetation and the environment. This improvement is a result of the increased biological quality of the water. The use of EM in water treatment is an inexpensive technology that gives good and effective results.

Table 1. Heavy metals in Çankırı wastewater

Heavy Metals	Low detection limit (LOD) value of the device (ppm)	Values (ppm)
Arsenic	3	<3
Silver	1	<1
Strontium	**5**	**7.5**
Manganese	5	<5
Molybdenum	5	<5
Cobalt	5	<5
Antimony	5	<5
Zinc	5	<5
Chromium	5	<5
Boron	20	<20
Nickel	5	<5

Selenium	10	<10
Lithium	5	<5
Titanium	5	<5
Vanadium	5	<5

As a result of the values obtained by using the ICP-OES device in Table 2, heavy metals other than strontium were found below the low detection limit (Limit of Detection, LOD). Strontium, one of the heavy metals, was found to be 7.5 ppm. In line with this result, a very high concentration of strontium heavy metal was detected in Çankırı wastewater.

Table 2. Heavy metals in wastewater after EM

Heavy Metals	**Low detection limit (LOD) value of the device (ppm)**	**Values (ppm)**
Arsenic	3	<3
Silver	1	<1
Strontium	**5**	**<5**
Manganese	5	<5
Molybdenum	5	<5
Cobalt	5	<5
Antimony	5	<5
Zinc	5	<5
Chromium	5	<5
Boron	20	<20
Nickel	5	<5
Selenium	10	<10
Lithium	5	<5
Titanium	5	<5
Vanadium	5	<5

In Çankırı waste and EM-treated waters, heavy metals were determined at the low detection limit (LOD) value of the device at the ppm level by using the ICP-OES device. As a result of treatment with EM, it was determined that the low detection limit of strontium in high concentration decreased. This result showed that EM has an effective role in removing heavy metals.

REFERENCES

[1] Apaydın, A., Aktaş, E.D., Kaya, S., *The Role of Environmental Isotopes (^{18}O, ^{2}H, ^{3}H) on the Assessment of Recharge State and Groundwater dynamics of Şabanözü/Çankırı Confined Aquifer*. 4th National Symposium on Isotope Techniques in Hydrology, 2019.

[2] *Atıksu Arıtımı Eylem Planı*. T.C. Çevre ve Şehircilik Bakanlığı, Çevre Yönetimi Genel Müdürlüğü, 2017-2023: 1-314.

[3] Bingül, Z., Altıkat, A., *Usability of domestic wastewater treatment plant effluent in agricultural irrigation*. Journal of the Institute of Science and Technology, 2012: 7(4), 69-75.

[4] Sonune, A., Ghate, R., *Developments in wastewater treatment methods*. Desalination, 2004: 167, 55-63.

[5] Ben-David, E.A., Habibi, M., Haddad, E., Hasanin, M., Angel, D.L., Booth, A.M., Sabbah, I., *Microplastic distributions in a domestic wastewater treatment plant: Removal efficiency, seasonal variation and influence of sampling technique*. Science of the Total Environment, 2021: 752, 141880.

[6] Abdelbasir, S.M., Shalan, A.E., *An overview of nanomaterials for industrial wastewater treatment*. Korean Journal of Chemical Engineering, 2019: 36, 1209-1225.

[7] Shahedi, A., Darban, A.K., Taghipour, F. et al., *A review on industrial wastewater treatment via electrocoagulation processes*. Current opinion in electrochemistry, 2020: 22, 154-169.

[8] Novikov, A., Poddubskiy, A., Dugin, E., Poddybskaya, O., Filimonov, M., Gurina, *Wastewater treatment and disposal of individual residential buildings in agriculture*. 18th International Scientific Conference" Engineering for Rural Development, 2019: 18, 397).

[9] Rashid, R., Shafiq, I., Akhter, P., Iqbal, M.J., Hussain, M., *A state-of-the-art review on wastewater treatment techniques: the effectiveness of adsorption method*. Environmental Science and Pollution Research, 2021: 8, 9050-9066.

[10] Shewa, W.A., Dagnew, M., *Revisiting chemically enhanced primary treatment of wastewater: A review*. Sustainability, 2020: 12(15), 5928.

[11] Jasim, N.A., *The design for wastewater treatment plant (WWTP) with GPS X modelling*. Cogent Engineering, 2020: 7(1), 1723782.

[12] Ahmed, S.F., Mofijur, M., Parisa, T.A., Islam, N., Kusumo, F., Inayat, A., Ong, H.C., *Progress and challenges of contaminate removal from wastewater using microalgae biomass*. Chemosphere, 2022: 286, 131656.

[13] Crini, G., Lichtfouse, E., *Advantages and disadvantages of techniques used for wastewater treatment*. Environmental Chemistry Letters, 2019: 17, 145-155.

[14] Oden, M.K., Ozen, K., Midik, E., *Contaminant Removal from Drilling Wastewater by Electrocoagulation Method*. Aksaray University Journal of Science and Engineering, 2022: 6(2), 152-161.

[15] Van Lier, J.B., Mahmoud, N. Zeeman, G., *Anaerobic wastewater treatment*. Biological wastewater treatment: principles, modeling and design, 2008: 415-456.

[16] Jain, K., Patel, A.S., Pardhi, V.P. et al., *Nanotechnology in wastewater management: a new paradigm towards wastewater treatment*. Molecules, 2021: 26(6), 1797.

[17] Yalçın, Z.G., Dağ, M., Aydoğmuş, E., *Removal of Dissolved Organic Matter in Drinking Water Using Active Microorganisms (EM)*. European Journal of Science and Technology, 2022: 34, 10-13.

[18] Yang, Y., Pan, J., Zhou, Z., Wu, J., Liu, Y., Lin, J.G., Gu,

J.D., *Complex microbial nitrogen-cycling networks in three distinct anammox-inoculated wastewater treatment systems*. Water Research, 2020: 168, 115142.

[19] Xu, W., Zou, R., Jin, B., Zhang, G., Su, Y., Zhang, Y., *The ins and outs of pharmaceutical wastewater treatment by microbial electrochemical technologies*. Sustainable Horizons, 2022: 1, 100003.

[20] Saeed, M. U., Hussain, N., Sumrin, A., Shahbaz, A., Noor, S. et al., *Microbial bioremediation strategies with wastewater treatment potentialities–A review*. Science of the total environment, 2022: 818, 151754.