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Evaluation of the wastewater treatment in Al-Azizia WWTP, Wasit Governorate, Iraq

Sadik Hameed Ftaysa and Raheem Aziz Hussein Al-Uqaily *

Chemistry Department, College of Science, Wasit University, Iraq.

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Abstract

The purpose of the current study was to assess the efficacy of the Al-Azizia WWTP in the Wasit Governorate of Iraq's wastewater treatment facilities. Activated sludge (conventional activated sludge) is the process used for wastewater treatment. At the central laboratory of the province of Wasit, wastewater quality was assessed using samples of the plant's influent and effluent. Based on the treated wastewater quality data, an estimation of the plant's performance was made. It was determined to establish correlations between influent and effluent TSS, COD, and BOD5. The findings demonstrate that every sample taken from the Al Azizia WWTP exceeded the permissible levels for Iraq. The acquired results indicated that the plant's treated wastewater did not meet the local, national, and international regulations and recommendations for treating wastewater and reusing it for agricultural purposes. The plant's wastewater was improved through trials using MBBR media and available injection air to increase treatment efficiency. The results showed that the treated water produced met local and international guidelines and could be used for agriculture without having a negative impact on the health of nearby residents or the general public.

Keyword: Wastewater Treatment Activated Sludge; Al Azizia WWTP; Wasit Governorate; Iraq.

1. Introduction

Many nations are finding that wastewater offers a reliable, cost-effective substitute for traditional water, especially in dry and semi-arid regions., as a result of the growing competition between higher-value urban and industrial uses and agricultural applications for freshwater supplies brought on by the rising demand for water. Reusing wastewater in place of fresh water in agriculture could significantly lessen water stress and maintain agricultural productivity in several semi-arid and desert regions. The technique of reusing agricultural wastewater has gained significant traction and is now a crucial aspect of water resource management in regions such as the USA, Australia, parts of China, the northern Mediterranean nations, North and South Africa, and the Middle East. It can include between 30 and 70 % of the water supply utilized for irrigation and between 10 and 40 % of the total water supply [1,2].

Even though increasing water stress is thought to be the primary driver of agricultural wastewater reuse, there are other factors as well, in both developed and developing nations. These include the strict environmental regulations for the disposal of sludge and wastewater, as well as increased flows of wastewater from cities as a result of growing urbanization. In addition, The Millennium Development Goals, which aim to eradicate poverty and hunger while ensuring environmental sustainability, are raising awareness of wastewater's potential as a resource and its nutritional value [3,4].

Depending on its rate of economic growth, a nation's development can be seen as good globally. Depending on the goods they manufacture, the business sector may have a very varied reputation. Certain areas' carrying capacities are under pressure due to rapid economic growth and their concentration in metropolitan or nearby locations. Pollutants discharged into rivers, lakes, and coastal waters frequently contaminate the water in these locations. Wastewater is the

* Corresponding author: Raheem A. H. Al-Uqaily

waste produced by human activity involved in the manufacturing and processing of basic materials. The procedures of cleaning, cooking, chilling, heating, removing, chemical reactions from the products, separation, and quality control are the first steps that lead to the end of the product's life. Previous treatment systems were created with the idea that demand would rise, which eventually resulted in a rise in the production of wastewater. Old technologies' drawbacks vanish as new ones take their place. In order to meet safety standards for wastewater treatment, wastewater treatment plants are designed to improve water quality. In addition to eliminating suspended particulates that can contaminate the waterway and alter the flow of water via the water and plumbing after installation, various treatment methods can lower the quantity of bacteria in water. Additionally, it lowers the biological oxygen demand (BOD) of organic waste [4,5].

To offer drinking water, wastewater treatment must be properly eliminated. Certain factors of water use must be managed in order to optimise the performance of the treatment plant; for this reason, these parameters must be considered during the design process. The removal of pollutants and the application of treatment/purification techniques are necessary for environmental protection because of the uncontrolled release of waste water into the environment and the transfer of poisons to the human body. Water resources are preserved and wasteful water use is decreased via efficient wastewater treatment. This study's primary goal is to present an overview of efficient methods for treating wastewater generated by different industries, along with information on the wastewater's properties and the locations of the impacted businesses [3,6].

Activities in the plants that have a direct impact on the health and safety of employees are reflected in environmental health and safety. Tasks performed immediately in the plant to address possible hazards which might be chemical, physical, or psychological factors that can result in workplace errors and related accidents have an influence on the caliber of work and the organization's profitability. The procedure for determining and characterizing hazards by expressing their likelihood, frequency, and seriousness as well as evaluating unfavorable outcomes, such as possible loss and harm, is known as "hazard identification" (HIRA). Using standards and guidelines for risk assessment, the industry must continuously identify hazards and evaluate related risks for tolerance. The process of methodically locating, evaluating, and assigning a risk level to each danger connected to an activity is known as risk assessment. Since hazards cannot be completely removed, it is vital to ascertain and calculate the degree to which an unintentional risk can be reduced in terms of the hazard mechanism, either quantitatively or qualitatively. An essential piece of infrastructure for protecting the environment and public health is the wastewater treatment facility. The concerns of environmental safety and health must be taken into consideration during the treatment process. Accidents and diseases related to the job are frequently caused by high-risk environments [6,7]. Because water treatment workers are frequently exposed to dirty working environments and high elevations, the industry is seen as dangerous. Seldom are occupational safety and health given greater priority. Although many managers think that working in the WWP is no longer as risky as it once was, there are still risks to an employee's health and even mortality, particularly if they are exposed to the electrical sources and deodorizing chemicals found there. Modern wastewater plants have automated operations that run on a low error rate. However, human supervision is always in place to make sure that these automated processes are followed; employees need to be familiar with the operation to ensure machine problems are resolved and safety concerns are addressed Apart from the automated functions, the plant poses a greater risk than the odour treatment system because it constantly requires gases like CO_2, SO_2, NH_3, H_2S, CH_3-SH, and so on, which are not allowed to be discharged into the atmosphere. When airborne components combine with pollutants, additional toxic gases are created, which causes respiratory problems. including nausea, dizziness, fainting, and so forth. with employees that frequently work in odor-handling roles and have a lengthy intake. Because big capacity machines and equipment are operated continuously in the water treatment plant, there is a very significant danger of worker harm. Employee carelessness when using machinery or other equipment or unsafe working circumstances can also result in accidents. Potential risks included chemical exposure, operational flaws, and exhaustion at work [7,8].

1.1. Wastewater treatment processes

Primary sedimentation typically occurs after initial screening or grit chamber treatment. Removing a significant portion (between 50 and 70 percent) of the wastewater's total suspended particles is the primary goal of this treatment stage. One should anticipate that 25–40% of the total BOD will be eliminated during the procedure because suspended solids also add to the wastewater's BOD level. The main sedimentation phase improves conditions by reducing oxygen demand and energy consumption rate due to BOD removal when biological treatment is applied afterward. Eliminating dispersed particles also lessens the possibility of issues arising during subsequent treatment procedures [9,10].

The most important design factor for sedimentation basins is the retention period, which needs to be long enough for wastewater particles flocculation and settling. According to the average wastewater flow rate, sedimentation basins are usually designed for a retention hydraulic duration of 1.5 to 2.5 hours. Lower values will result in less effective particle removal, whereas an excessively lengthy retention period will accelerate the rate of disintegration rather than the creation of new aggregates, which will result in less effective particle removal. The product of the tank's depth and surface area yields the retention period. It is important to adopt a depth in the basin geometry that allows the particles to flocculate without being too deep to prevent them throughout the hydraulic retention period, from getting to the sediment layer at the tank's bottom. In order to allow for maintenance without halting the plant or reducing treatment efficacy, the primary sedimentation reservoir is usually structured like a rectangular or circle basins with two or more separate units [11,12].

The most important operational and maintenance practices for a sedimentation tank are periodic cleaning and washing of the basin walls and removing of solid waste at a rate high enough to avoid interrupting the basin's detention period. While a reduction of up to one log unit may be anticipated, significant elimination of pathogenic organisms is not anticipated during the main treatment [13,14].

The concept that bacteria metabolize particulates and dissolved biodegradable materials into straightforward end products that can be removed as sludge from the waste water supply is frequently the foundation of biological wastewater treatment. These processes can also, to some extent, remove suspended and unstable colloidal solids because they are encased in biofilm or biological flocs [15,16].

It is also possible for nutrients like phosphorus and nitrogen to be eliminated through biological breakdown or as part of the solids content. In summary, to removing BOD is the main objective of secondary biological therapy. That is easily biodegradable and has escaped from the first treatment. It also aims to further remove suspended particles. Anaerobic procedures (which do not require oxygen) or aerobic processes (which do) can both be used to achieve biological treatment. Wastewater treatment typically involves two primary biological treatment methods: attached growth biological treatment, also referred to as the bio filter process, also referred to as the activated sludge method, suspended growth biological therapy [17,18].

1.2. The biofilter technique works on the idea

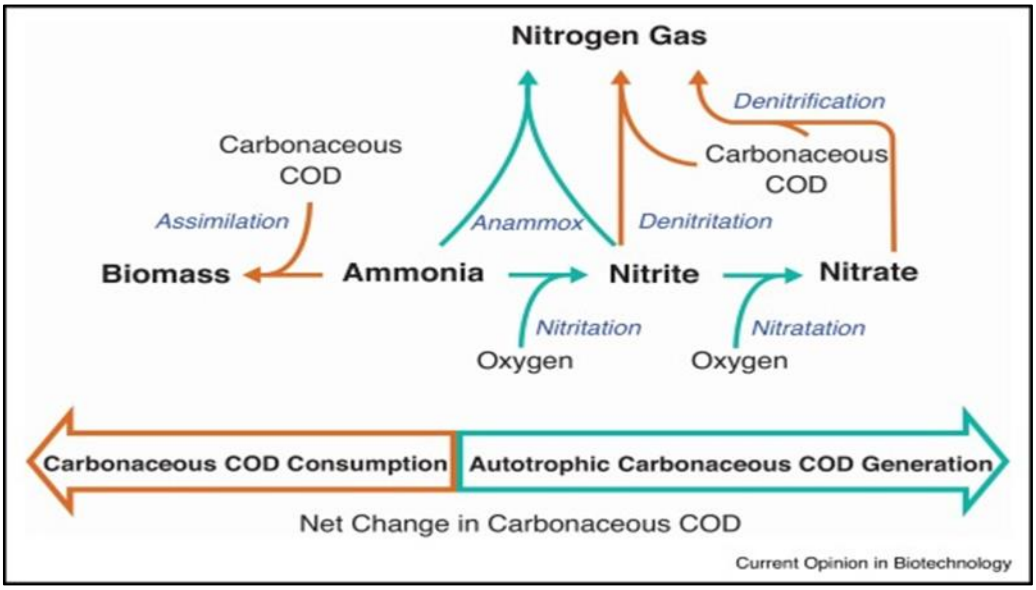

Figure 1 The biofilter technique works on the idea

that biofilm grows attached to a filter media, such rock or plastic, when air is present. Microbial activity occurs when untreated wastewater flows through the filter and is distributed throughout the surface of the filter media, where it soon forms a biofilm. The biofilm will continue to thicken until it includes suspended particulates and decomposed end products after it is forced free and distributed as particles with the effluent, making room for fresh biofilm to develop. One popular biofilter design is the trickling filter. According to the amount of weight of the media, a trickle filter is usually an annular bed of filter material which is 1–10 meters deep. Rotating arms powered by an electric motor or the dynamic response from wastewater distribution ensure that wastewater is dispersed uniformly throughout the filter's surface. The trickling filter's underdrain must be able to redirect wastewater and released particles without becoming blocked. In order to enable air to move through and serve as a ventilation channel when natural draft is used for aeration, the underdrain should be constructed such that the flow does not fill more than half of the channel. Fans that use forced draft provide a steady supply of oxygen and are a more expensive and energy-intensive option to natural draft ventilation [11,14].

Depending on the suspended solids concentration, secondary treatment systems may also be able to reduce harmful bacteria by up to 2 log units at optimal performance. Nitrification and subsequently de-nitrification are necessary processes for biological therapy to remove nitrogen. In the process of nitrification, When ammonia (NH4-N) is oxidized to nitrite (NO2-N) and subsequently nitrite to nitrate (NO3-N), oxygen is present.. Each phase also requires the presence of Nitrosomonas and Nitrobacteria, two distinct groups of autotrophic bacteria. Other bacterial groups may also contribute to the oxidation, but these are the most prevalent ones. The following are the general nitrification process formulas [12]:

De-nitrification of nitrate is required to accomplish total elimination of nitrogen molecules. This occurs when nitrate is broken down into naturally existing gases in the environment, such as nitric oxide, nitrous oxide, and nitrogen gas. Pseudomonas is the most prevalent form of bacterium that can de-nitrify, but other heterotrophic and autotrophic bacterial groups can also do so. When several organic substrates are biologically oxidized, nitrate or nitrite is used as electron acceptors rather than oxygen. This process is known as biological de-nitrification. The following are the reducing processes that take place during de-nitrification [9,12]:

$$NO_3 - \text{(nitrate)} \rightarrow NO_2 - \text{(nitrite)} \rightarrow NO \text{ (nitric oxide)} \rightarrow N_2O \text{ (nitrous oxide)} \rightarrow N_2 \text{ (nitrogen)}$$

At low organic loadings, nitrification can be accomplished in a bio filter process in addition to BOD removal. Due to their greater yield coefficients and quicker growth rates, the competitiveness of heterotrophic bacteria surpasses that of nitrifying bacteria. Therefore, substantial nitrification doesn't happen until the BOD concentration is lowered to a particular point. Nitrification is typically planned for in conjunction with BOD removal in secondary treatment units [12].

Because biological flocs make up a significant portion of the effluent from biological filters, a second clarifier is required before the wastewater may be further distributed. This is typically achieved by settling and removing solids as sludge from the wastewater stream in a secondary sedimentation tank. A secondary sedimentation tank's design specifications, upkeep procedures, and operational guidelines are comparable to those of a primary sedimentation tank [8,10].

The term "tertiary treatment" describes a variety of interventions that come after traditional secondary treatment. After secondary treatment, more treatment is often needed to remove enough nutrients to lower the danger of eutrophication in sensitive water bodies. Because these treatment processes generate sophisticated procedures, they are sometimes referred to as "advanced wastewater treatment." Different approaches can be used to build these steps in different ways [7,8].

After secondary treatment, filtering is a common method for tertiary nitrogen removal. Normally, the BOD concentration at this point would be very low (<10 mg/L), which would provide nitrification an excellent foundation. At this point, temperature, packing design, oxygen availability, and ammonia loading rate are all significant factors. Normally, nitrification is inhibited by the top biofilter's restricted oxygen supply [1,2].

Tertiary filtering is also helpful in removing pathogens from wastewater streams since they are removed as they travel through porous materials like sand. With tertiary filtering, bacteria can be reduced by up to three log units [1,2].

There could be serious concerns to the environment, food safety, and public health when using wastewater in agriculture. Farmers use untreated or poorly treated wastewater in many underdeveloped countries since wastewater treatment facilities are either nonexistent or operate insufficiently in these nations. High quantities of pathogens and disease agents connected to excreta, such as bacteria, viruses, protozoa, and nematode eggs, are found in wastewater that has been left untreated or inadequately treated. The most common cause of acute disease outbreaks, such as cholera in Dakar and Jerusalem and typhoid in Santiago, as well as chronic gastroenteritis, including diarrhea, has been linked to these pathogenic organisms. According to reports, farmers in Pakistan who utilize wastewater experience greater incidence rates of diarrheal illness than those who use groundwater [6,9].

Numerous infections, including helminth eggs and protozoa, exhibit notable resistance to standard biological treatment protocols. They therefore have a long existence in soils or on agriculture surfaces, are difficult to eliminate, and can transmit to humans or other animals. Intestinal parasite rates are higher in farmers who primarily use untreated wastewater than in those who use diluted wastewater, according to a study done in Dakar, Senegal. Another issue linked to direct contact to wastewater is skin disorders. Skin conditions including dermatitis have been linked to exposure with raw wastewater in Vietnam and Cambodia. Urban vegetable fields in Ghana and rice farmers in India have also reported experiencing issues like burning and itching in their hands and feet [7,9].

The health concerns linked to wastewater are not exclusive to agricultural laborers; they may also be seen in the families of workers and the surrounding populations when they are exposed to wastewater, eat product grown with wastewater, especially when it is consumed raw, and touch produce. For instance, it has been documented that irrigating urban vegetables in Sub-Saharan Africa using wastewater that is severely contaminated by microbes increases the associated health hazards for both farmers and consumers. Further data from suggests that helminth illnesses including Ascaris and hookworm are more common among consumers of wastewater-irrigated crops as well as the families of farmers. According to reports, farmers in Haroonabad, Pakistan, may have up to 80% of their population infected with hookworms as a result of using untreated wastewater [5,7].

Compared to fresh water, wastewater often has higher concentrations of main ions and total dissolved solids as well as higher electrical conductivity. This is especially true in hotter climates with longer dry seasons and higher evaporation rates. These ions and dissolved solids come from a variety of sources, including chemicals used in the treatment process, detergents, and laundry supplies. Wastewater has a variety of salinity levels, from water that is somewhat saline (EC 0.75 dS/m) to salty (EC >3 dS/m), with solidity (SAR) values ranging from 1.9 to 20.8[14].

There is often a greater danger of inorganic compounds, particularly heavy metals present in wastewater, when industrial wastewater is combined with municipal wastewater in developing countries where industrialization is advancing and mixed wastewater is utilized untreated or poorly treated. Heavy metal concentrations have been discovered to be higher than permitted limits in plant tissues when industrial effluent is utilized, even when wastewater and soil samples satisfy stated permissible values. Edible crops and fodder watered with wastewater may act as a pathway for the transmission of heavy metals within the human food chain. Evidence from an Indian survey study that watered the grass cattle was fed showed high levels of metal transfers from wastewater to cow's milk. The milk samples were severely contaminated by the elements cadmium (Cd) and lead (Pb) at concentrations that ranged from 1.2 to 40 times the permitted limit [13].

While the primary motivator for wastewater reuse in agriculture is thought to be the nutrient delivery capacity, wastewater can have too high nutrient concentrations. This might lead to unfavorable consequences from an excess of nutrients, particularly phosphorus and nitrogen. Reusing wastewater could result in an overabundance of nitrogen. It can result in reduced crop size and quality, excessive vegetative growth, and a delay in maturation, all of which would reduce economic production [1,2].

Another issue related to too much nitrogen in wastewater is nitrate leaching, which can contaminate groundwater and result in health issues, such as methemoglobinemia in newborns. Additionally, too much phosphorus and nitrogen in wastewater can affect the microbial communities in the soil, especially the ones involved in the cycling of these elements [3].

Numerous hazardous organic substances can be found in wastewater, including industrial compounds (phthalates, PCBs, non-ionic detergents), disinfection byproducts, pharmaceuticals, personal care products (PPCPs), synthetic and natural hormones, and priority organic pollutants (DDT, 2,4-D, Aldrin). There is a unique difficulty in identifying and assessing these substances. because many of them can be challenging to detect because there aren't enough appropriate analysis techniques that can directly detect them in low concentrations. In addition, the forms and mechanisms of action of these compounds vary greatly. Being Endocrine Disruptor Chemicals (EDCs), many of these dangerous pollutants have the potential to disrupt the hormone systems of both humans and animals. Additionally, they could be carcinogenic, teratogenic, and mutagenic. Endocrine disruptors have been associated with increased incidence of endocrine-related diseases, such as thyroid, testicular, breast, ovarian, and prostate cancer, yet there is currently no concrete evidence of detrimental effects on human health. Exposure to these contaminants has also been linked to abnormalities, immune system alterations, and population disruption in birds, reptiles, mammals, amphibians, and invertebrates [3,5].

The purpose of the study was to assess the effectiveness of wastewater treatment at El-Aziziya WWTP in Wasit Province, Iraq, as well as the dangers associated with reusing treated wastewater for agricultural applications both before and after treatment efficiency improvements.

2. Materials and methods

Influent and Effluent grab samples comprising of wastewater samples were collected from the Al-Aziziya plant during the study period.

Samples were collected in bottle containers previously cleaned by washing in non-ionic detergent, rinsed with tap water and later soaked in 5% HNO_3 for 24 hours and finally rinsed with deionized water prior to usage. Before sampling, the bottles were rinsed three times with sample water before being filled with the sample. Samples were accompanied with proper identification and labeling at point of sampling then transported to the laboratory for analysis. All physical, chemical and microbial analysis carried out according to standard methods for water and wastewater (APHA, 2017) [15].

3. Results and discussion

The study aimed to evaluate the efficiency of wastewater treatment in Al-Aziziya WWTP in Wasit Province, Iraq and also evaluate the risks of reuse the treated wastewater in agricultural purposes before and after improve the treatment efficiency.

Tables (1 and 2) illustrate the physical and chemical analysis for the influent and effluent of El Aziziya WWTP, during the period of study (Jan. to May. 2024), the data showed the min, max and average of the obtained data, and the removal percentage for each parameters, the data showed that, The obtained data show a weak efficiency for TSS (61.7%), chemical oxygen demand (COD) (73.5%), and biochemical oxygen demand (BOD) (68.0%), oil and grease (76.1 %) and ammonia (77.8%). The remaining parameters' efficiency is less than 60%. The treated water's parameter values exceed the local rules' discharge standards , as showed in Tables (1, 2) and Figures (1, 2 and 3). Also the values of microbial and biological parameters showed that the collected samples from the effluent of the plant didn`t comply with the regulation as indicated in Table (3, 4) and Figure (4). The treated wastewater cannot used for agricultural purposes in this case, so the study try to improve the wastewater treatment by uses the MBBR technology.

Table 1 Physical and chemical analysis of Inf. And Eff. of Al-Aziziya WWTP during the study (min-max, avg and sd) (Jan. to May. 2024).

No.	Parameter	Unit	Inf.				Eff.			
			Min	Max	Avg	Sd	Min	Max	Avg	Sd
1	Temperature	^0C	16.2	36.4	28.2	14.2	16.1	36.3	32.8	14.6
2	pH	-	8.02	8.24	8.1	8.4	7.31	7.71	7.54	8.8
3	DO	mg/l	0.2	0.2	0.2	0.1	2.4	3.8	3.4	11.1
4	TDS	mg/l	1410	1814	1654	39.2	1315	1711	1582	41.5
5	TSS	mg/l	174	268	208	19.6	54	93	79.6	23.4
6	COD	mg/l	321	548	423	33.8	94	169	112	29.4
7	BOD	mg/l	218	328	306	24.6	77	117	98	27.9
8	TN	mg/l	26.2	34.6	33.2	41.2	14.1	23.6	18.2	33.6
9	TP	mg/l	6.4	17.2	14.3	51.3	4.8	12.6	9.8	44.2
10	Ammonia	mg/l	14.6	28.2	21.6	31.8	3.2	7.1	4.8	46.1
11	OG	mg/l	11.2	17.6	15.5	19.6	1.8	4.4	3.7	22.4
12	Phenol	mg/l	0.1	0.17	0.12	9.4	0.05	0.09	0.07	11.1
13	H_2S	mg/l	6.4	10.8	9.1	33.3	2.1	4.5	3.8	18.4

No.	Parameter	Unit	Inf.				Eff.			
			Min	Max	Avg	Sd	Min	Max	Avg	Sd
14	Fe	mg/l	0.06	0.46	0.24	2.4	0.02	0.23	0.18	3.4
15	Mn	mg/l	0.04	0.42	0.31	3.1	0.02	0.25	0.19	4.2
16	Zn	mg/l	0.25	0.34	0.28	1.8	0.19	0.22	0.121	2.8
17	Cr	mg/l	0.01	0.03	0.02	1.3	0.001	0.001	0.001	0.1
18	Ni	mg/l	0.12	0.17	0.15	1.5	0.1	0.12	0.11	0.4
19	As	mg/l	0.001	0.001	0.001	0.1	0.001	0.001	0.001	0.1
20	Cd	mg/l	0.001	0.001	0.001	0.1	0.001	0.001	0.001	0.1
21	Pb	mg/l	0.01	0.02	0.016	2.1	0.001	0.001	0.001	0.1
22	Se	mg/l	0.001	0.001	0.001	0.1	0.001	0.001	0.001	0.1
23	Cu	mg/l	0.13	0.23	0.17	3.8	0.1	0.12	0.11	2.8

Table 2 Removal percentages of physical and chemical analysis of Eff. of Al-Aziziya WWTP during the study.

No.	Parameter	Unit	Eff.		
			Min	Max	Avg
1	Temperature	%	0.3	0.6	16.3
2	pH		8.9	6.4	6.9
3	DO		-1100.0	-1800.0	-1600.0
4	TDS		6.7	5.7	4.4
5	TSS		69.0	65.3	61.7
6	COD		70.7	69.2	73.5
7	BOD		64.7	64.3	68.0
8	TN		46.2	31.8	45.2
9	TP		25.0	26.7	31.5
10	Ammonia		78.1	74.8	77.8
11	OG		83.9	75.0	76.1
12	Phenol		50.0	47.1	41.7
13	H_2S		67.2	58.3	58.2
14	Fe		66.7	50.0	25.0
15	Mn		50.0	40.5	38.7
16	Zn		24.0	35.3	56.8
17	Cr		90.0	96.7	95.0
18	Ni		16.7	29.4	26.7
19	As		0.0	0.0	0.0
20	Cd		0.0	0.0	0.0
21	Pb		90.0	95.0	93.8

22	Se		0.0	0.0	0.0
23	Cu		23.1	47.8	35.3

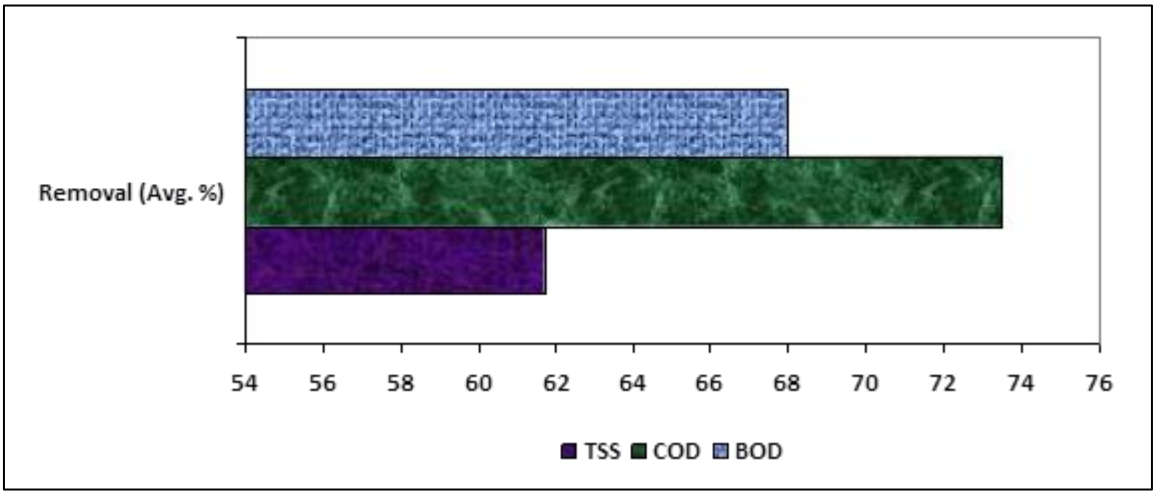

Figure 2 TSS, COD and BOD average removal percentage (%) during the study

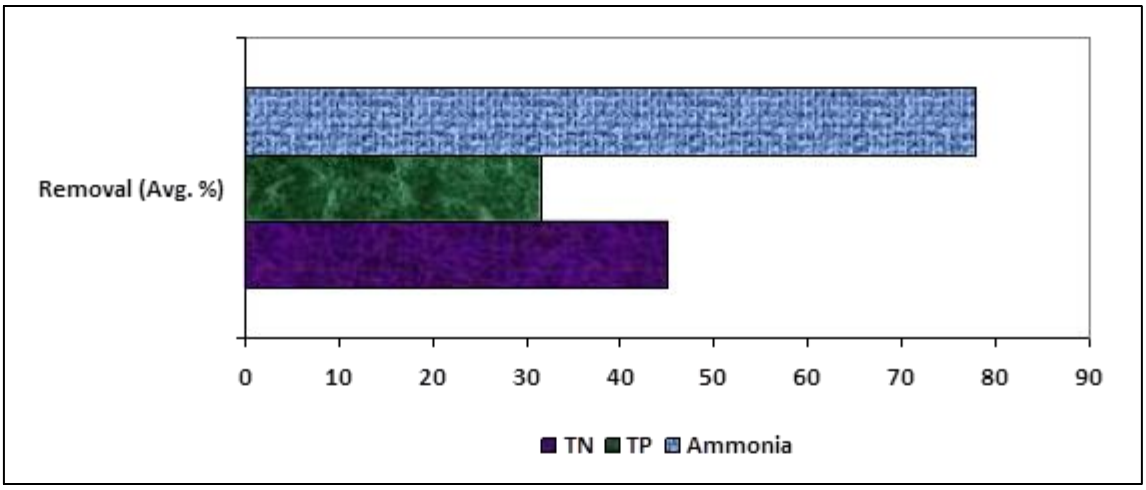

Figure 3 TN, TP and ammonia average removal percentage (%) during the study

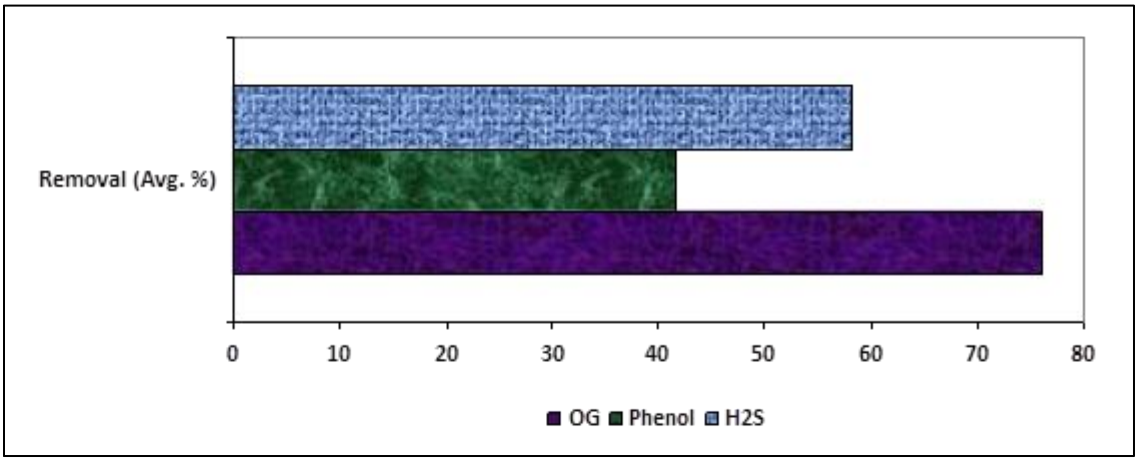

Figure 4 OG, phenol and sulphide average removal percentage (%) during the study

Table 3 Microbial and protozoa investigation of Inf. And Eff. of Al-Aziziya WWTP during the study (min-max, avg and sd) (Jan. to May. 2024).

No.	Parameter	Unit	Inf.				Eff.			
			Min	Max	Avg	Sd	Min	Max	Avg	Sd
1	TPC	CFU/100 ml	1.7 x 10^8	2.6 x 10^8	2.2 x 10^8	102	0.45 x 10^8	0.92 x 10^8	0.78 x 10^8	98
2	Helminthes egg	U/l	114	146	126	33.6	6	18	11	43.2

Table 4 Removal percentages of Microbial and protozoa analysis of Eff. of Al-Aziziya WWTP during the study.

No.	Parameter	Unit	Eff.		
			Min	Max	Avg
1	TPC	%	73.5	64.6	64.5
2	Helminthes egg		94.7	87.7	91.3

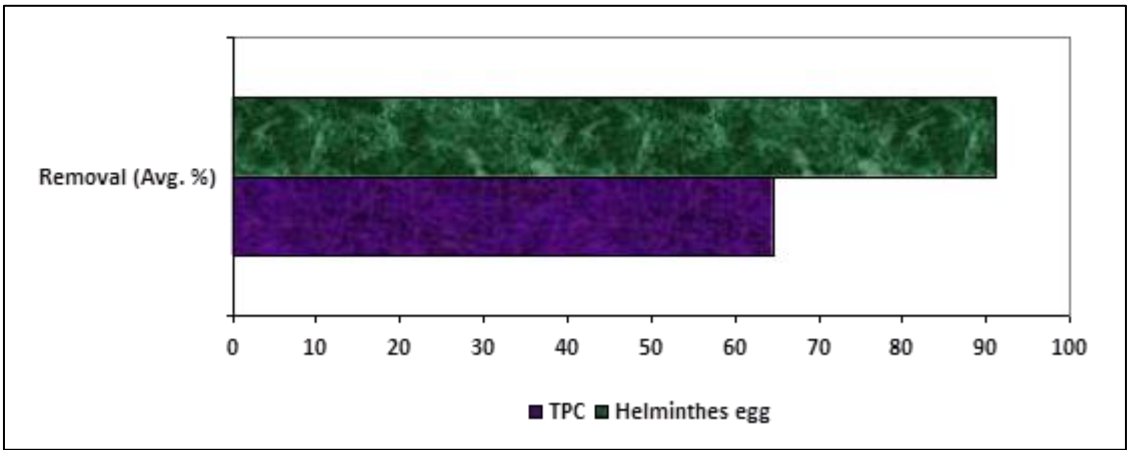

Figure 5 TPC and helminthes egg average removal percentage (%) during the study

3.1. Laboratory trials to improve the wastewater treatment in the plant by MBBR techniques:

The trials show highest efficiency for TSS (88.5%), chemical oxygen demand (COD) (89.6%), and biochemical oxygen demand (BOD) (89.8%), oil and grease (95.5 %) and ammonia (98.6%). The remaining parameters' efficiency is less than 50%. Since the treated water's parameter values are under the local rules' discharge standards, the MBBR media is operating effectively, as showed in Tables (5, 6) and Figures (5, 6 and 7). Also the obtained results of microbial and biological parameters of treated wastewater using MBBR technology showed that a high quality and less risks when using the treated wastewater for agricultural purposes as indicated in Tables (7, 8) and Figure (8).

Table 5 Physical and chemical analysis.

No.	Parameter	Unit	Inf.				Eff.			
			Min	Max	Avg	Sd	Min	Max	Avg	Sd
1	Temperature	^{0}C	16.2	36.4	28.2	3.1	16.1	36.2	32.8	3.3
2	pH	-	8.02	8.24	8.1	6.6	7.28	7.68	7.48	5.8
3	DO	mg/l	0.2	0.2	0.2	0.1	6.1	6.6	6.3	8.3

No.	Parameter	Unit	Inf.				Eff.			
			Min	Max	Avg	Sd	Min	Max	Avg	Sd
4	TDS	mg/l	1410	1814	1654	48.2	1312	1714	1588	43.1
5	TSS	mg/l	174	268	208	19.6	16	34	24	19.2
6	COD	mg/l	321	548	423	33.8	34.6	52.5	44.2	33.6
7	BOD	mg/l	218	328	306	24.6	23.4	36.5	31.1	22.6
8	TN	mg/l	26.2	34.6	33.2	41.2	9.6	13.6	12.1	19.2
9	TP	mg/l	6.4	17.2	14.3	51.3	1.3	3.6	2.8	9.9
10	Ammonia	mg/l	14.6	28.2	21.6	31.8	0.2	0.4	0.31	16.2
11	OG	mg/l	11.2	17.6	15.5	19.6	0.6	0.9	0.7	9.1
12	Phenol	mg/l	0.1	0.17	0.12	9.4	0.02	0.04	0.03	2.6
13	H_2S	mg/l	6.4	10.8	9.1	17.2	0.1	0.2	0.3	6.4
14	Fe	mg/l	0.06	0.46	0.24	9.1	0.01	0.02	0.01	3.9
15	Mn	mg/l	0.04	0.42	0.31	2.3	0.02	0.1	0.08	2.4
16	Zn	mg/l	0.25	0.34	0.28	3.1	0.14	0.18	0.16	3.6
17	Cr	mg/l	0.01	0.03	0.02	3.3	0.001	0.001	0.001	0.01
18	Ni	mg/l	0.12	0.17	0.15	2.3	0.01	0.018	0.014	2.4
19	As	mg/l	0.001	0.001	0.001	0.1	0.001	0.001	0.001	0.1
20	Cd	mg/l	0.001	0.001	0.001	0.1	0.001	0.001	0.001	0.1
21	Pb	mg/l	0.01	0.02	0.016	0.1	0.001	0.001	0.001	0.1
22	Se	mg/l	0.001	0.001	0.001	0.1	0.001	0.001	0.001	0.1
23	Cu	mg/l	0.13	0.23	0.17	2.8	0.054	0.09	0.062	2.3

Table 6 Removal percentages of physical and chemical analysis.

No.	Parameter	Unit	Eff.		
			Min	Max	Avg
1	Temperature	%	0.5	0.6	16.3
2	pH		9.2	6.8	7.7
3	DO		-2950.0	-3200.0	-3050.0
4	TDS		7.0	5.5	4.0
5	TSS		90.8	87.3	88.5
6	COD		89.2	90.4	89.6
7	BOD		89.3	88.9	89.8
8	TN		63.4	60.7	63.6
9	TP		79.7	79.1	80.4
10	Ammonia		98.6	98.6	98.6
11	OG		94.6	94.9	95.5

No.	Parameter	Unit	Eff.		
			Min	Max	Avg
12	Phenol		80.0	76.5	75.0
13	H_2S		98.4	98.1	96.7
14	Fe		83.3	95.7	95.8
15	Mn		50.0	76.2	74.2
16	Zn		44.0	47.1	42.9
17	Cr		90.0	96.7	95.0
18	Ni		91.7	89.4	90.7
19	As		0.0	0.0	0.0
20	Cd		0.0	0.0	0.0
21	Pb		90.0	95.0	93.8
22	Se		0.0	0.0	0.0
23	Cu		58.5	60.9	63.5

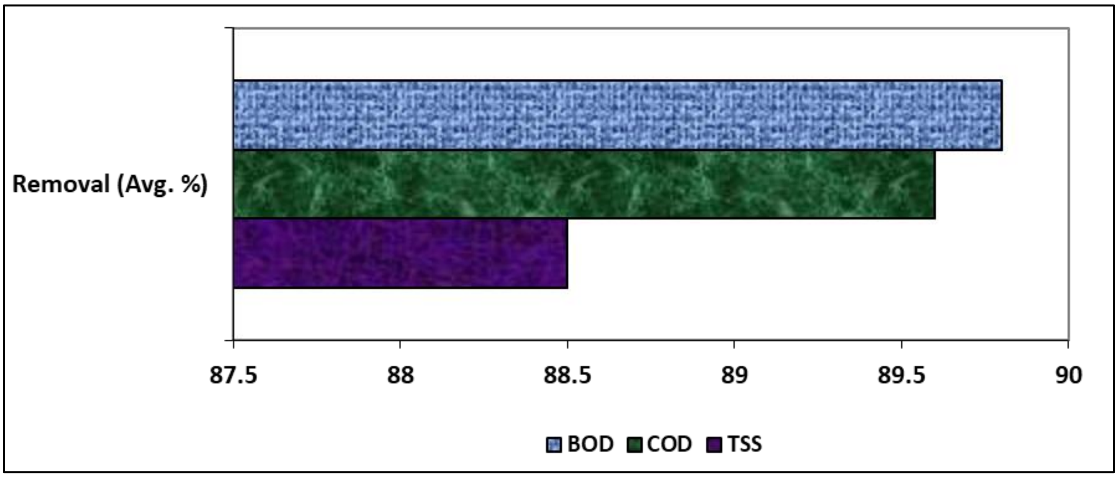

Figure 6 TSS, COD and BOD average removal percentage (%)

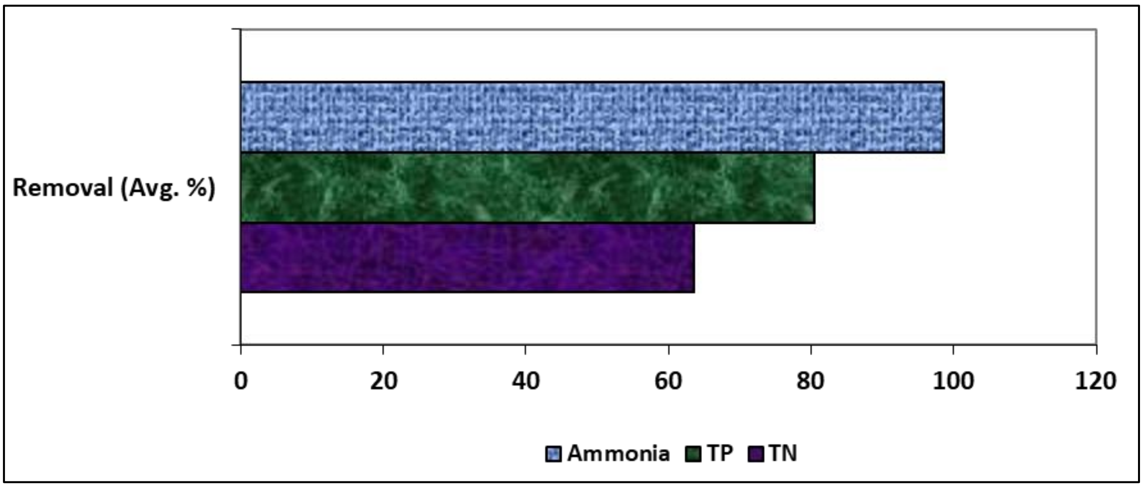

Figure 7 TN, TP and ammonia average removal percentage (%)

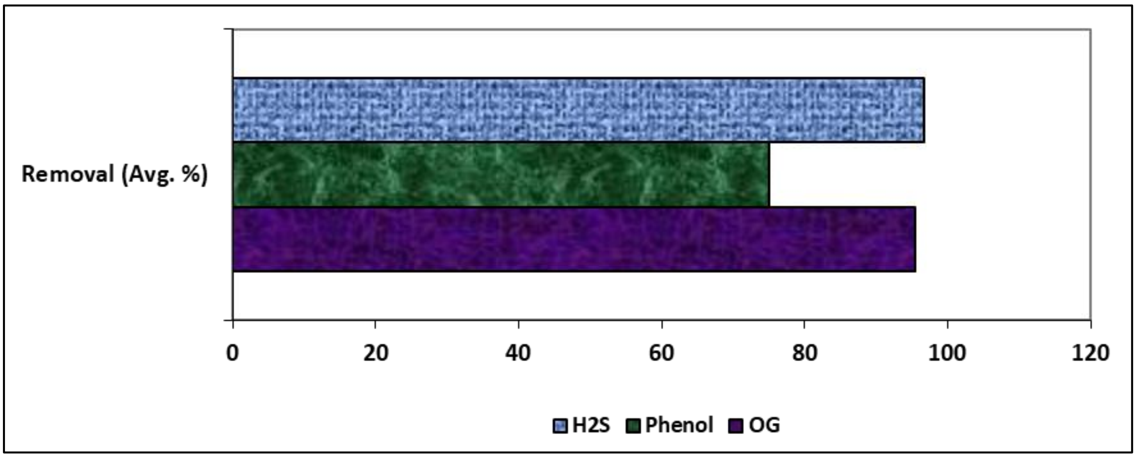

Figure 8 OG, phenol and sulphide average removal percentage (%)

Table 7 Microbial and protozoa investigation

No.	Parameter	Unit	Inf.				Eff.			
			Min	Max	Avg	Sd	Min	Max	Avg	Sd
1	TPC	CFU/100 ml	1.7 x 10^8	2.6 x 10^8	2.2 x 10^8	102	3200	48000	3920	47.2
2	Helminthes egg	U/l	114	146	126	33.6	Nil	4	2	11.5

Table 8 Removal percentages of Microbial and protozoa analysis

No.	Parameter	Unit	Eff.		
			Min	Max	Avg
1	TPC	%	100	100	100
2	Helminthes egg		100	98.1	98.7

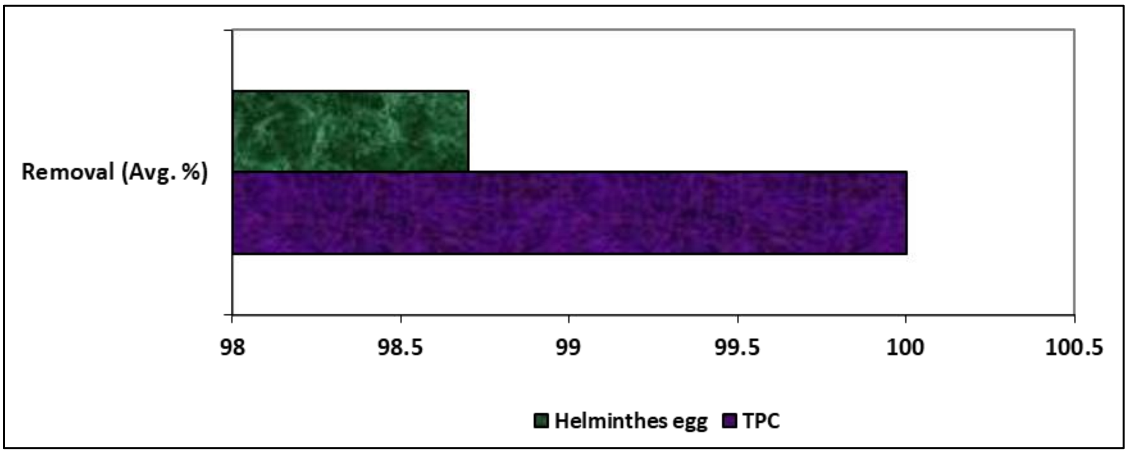

Figure 9 TPC and helminthes egg average removal percentage (%)

3.2. Quality Index

The procedure of estimated the wastewater quality index was illustrated in the following Tables (9, 10 and 11) based on the local regulation (permissible limits).

Traditional techniques of evaluating water quality involve measuring chemical characteristics in comparison to predetermined standards. The index of water quality (WQI) is used all over the world to manage vast and complex volumes in water quality data and to assess the water's quality. Furthermore, the WQI approach is most frequently employed since its primary goal is to translate complex data on water quality into information that is both comprehensible and useful. The most popular DWTP is known as the conventional DWTP since it can treat any kind of water with a specific quality independent of the water source. The chemical and microbial characteristics of water can be sufficiently handled with these plants. As a result, treatment plant methods ought to be created with the enhancement of water quality following DWTP purification and the mitigation of threats to human health in mind. Determining and evaluating the factors influencing water quality is also crucial.

In order to help with the optimization of specific treatment processes that are dependent on the raw wastewater quality and, ultimately, for the plant's sustainability, the WQI approach was employed in this study to assess the performance of the Al-Aziziya WWTP in Iraq. Numerous physical, chemical, and bacteriological factors are used to calculate WQI.

The WQI calculation based on the guideline values (max permissible limits), was 519 as showed in Table (9), the WQI for raw wastewater was 4247 as showed in Table (10), and the Al-Aziziya WWTP effluent was 1506 as showed in Table (11). The WQI for the trials using MBBR technology was 78, as showed in Table (12).

The study concluded that the MBBR technology when applied in the Al-Aziziya WWTP, can be reach to enough efficiency and quality to allowed the using the produced treated wastewater for agricultural purposes with a very low human risks.

Table 9 WQI calculation based on the max permissible limits and the weight for each parameter

Std				**WQI**
No.	Weight	Parameter	Max permissible limit	
1	0.1	COD (mg/l)	80	8
2	0.1	BOD (mg/l)	60	6
3	0.1	FC (CFU/100 ml)	5000	500
4	0.1	Ammonia (mg/l)	0.5	0.05
5	0.05	TN (mg/l)	10	0.5
6	0.05	TP (mg/l)	1	0.05
7	0.1	O and G (mg/l)	1	0.1
8	0.1	Phenol (mg/l)	0.05	0.005
9	0.1	TSS (mg/l)	40	4
10	0.05	H_2S (mg/l)	0.1	0.005
11	0.03	Cd (mg/l)	0.001	0.00003
12	0.03	Pb (mg/l)	0.001	0.00003
13	0.03	As (mg/l)	0.001	0.00003
14	0.03	Cr (mg/l)	0.05	0.0015
15	0.03	Ni (mg/l)	0.05	0.0015
Total	1.00			**519**

Table 10 WQI of Inf. calculation based on the weight for each parameter

Inf				**WQI**
No.	Weight	Parameter	Results (AVG)	
1	0.1	COD (mg/l)	423	42.3
2	0.1	BOD (mg/l)	306	30.6
3	0.1	FC (CFU/100 ml)	22000000	2200000
4	0.1	Ammonia (mg/l)	21.6	2.16
5	0.05	TN (mg/l)	33.2	1.66
6	0.05	TP (mg/l)	14.3	0.715
7	0.1	O and G (mg/l)	15.5	1.55
8	0.1	Phenol (mg/l)	0.12	0.012
9	0.1	TSS (mg/l)	208	20.8
10	0.05	H_2S (mg/l)	9.1	0.455
11	0.03	Cd (mg/l)	0.001	0.00003
12	0.03	Pb (mg/l)	0.016	0.00048
13	0.03	As (mg/l)	0.001	0.00003
14	0.03	Cr (mg/l)	0.02	0.0006
15	0.03	Ni (mg/l)	0.15	0.0045
Total	1.00			**4247**

Table 11 WQI of Eff. calculation based on the weight for each parameter

Eff				**WQI**
0	Weight	Parameter	Results (AVG)	
1	0.1	COD (mg/l)	112	11.2
2	0.1	BOD (mg/l)	98	9.8
3	0.1	FC (CFU/100 ml)	7800000	780000
4	0.1	Ammonia (mg/l)	4.8	0.48
5	0.05	TN (mg/l)	18.2	0.91
6	0.05	TP (mg/l)	9.8	0.49
7	0.1	O and G (mg/l)	3.7	0.37
8	0.1	Phenol (mg/l)	0.07	0.007
9	0.1	TSS (mg/l)	79.6	7.96
10	0.05	H_2S (mg/l)	3.8	0.19
11	0.03	Cd (mg/l)	0.001	0.00003
12	0.03	Pb (mg/l)	0.001	0.00003
13	0.03	As (mg/l)	0.001	0.00003

14	0.03	Cr (mg/l)	0.001	0.00003
15	0.03	Ni (mg/l)	0.11	0.0033
Total	1.00			**1506**

Table 12 WQI calculation of laboratory trial using MBBR technique

Eff				**WQI**
0	Wieght	Parameter	Results (AVG)	
1	0.1	COD	44.2	4.42
2	0.1	BOD	31.1	3.11
3	0.1	FC	3920	392
4	0.1	Ammonia	0.31	0.031
5	0.05	TN	12.1	0.605
6	0.05	TP	2.8	0.14
7	0.1	O and G	0.7	0.07
8	0.1	Phenol	0.03	0.003
9	0.1	TSS	24	2.4
10	0.05	H2S	0.3	0.015
11	0.03	Cd	0.001	0.00003
12	0.03	Pb	0.001	0.00003
13	0.03	As	0.001	0.00003
14	0.03	Cr	0.001	0.00003
15	0.03	Ni	0.014	0.00042
Total	1.00			**78**

4. Conclusions

- Toxic compounds, pollutants, and other chemical contaminants in water that harm the environment and public health must be controlled through waste management. The ability to reuse treated water in a variety of applications and to recycle water for both natural and human uses can both be enhanced by the treatment of waste in water. Other physical, chemical, and biological techniques can be used to treat the waste, and four distinct processes for treating urban, municipal, and industrial waste effluent can lead this treatment. Many nations, including Iraq, are adopting sewage water treatment technology. By doing so, they can minimise waste and preserve sustainable water supplies for the water cycle, which will benefit them in the future. The water's processed waste can be used for a variety of things, including urban and agricultural settings as well as the environment. As a result, the garbage that was removed from the water can be retrieved and securely dumped into the surroundings.
- The WQI calculation based on the guideline values (max permissible limits), was 519, the WQI for raw wastewater was 4247, and the Al-Aziziya WWTP effluent was 1506. The WQI for the trials using MBBR technology was 78.
- The study concluded that the MBBR technology when applied in the Al-Aziziya WWTP, can be reach to enough efficiency and quality to allowed the using the produced treated wastewater for agricultural purposes with a very low human risks.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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