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Evaluation of some physical, chemical and biological properties of treated wastewater in Karbala wastewater treatment plant

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Abstract: *In order to evaluate the efficiency of wastewater treatment plant in Karbala and the possibility of using treated water for irrigation purposes and groundwater recharge, wastewater samples were taken before entering plant, other samples of treated wastewater were also taken to conduct various physical, chemical and bacteriological analyses and to estimate heavy metals in them, including: Nickel, Chromium, Cobalt, Lead, Iron, Cadmium, Manganese, Vanadium, Zinc and Copper. The results showed the following:*
pH value of treated water increased from 7.48 to 7.59 , electrical conductivity decreased from 8.50 to 1.20 dS-1 , total dissolved solids (TDS) decreased from 5150 to 775 mg L-1, total suspended solids (TSS) from 99.00 – 9.00 mg L-1, biochemical oxygen demand (COD) from 236 – 10 mg L-1, total hardness (TH) from 66.50 – 3.47 mg L-1, SAR value ranged from 6.80 to 0.800 (mmol charge L-1) ½, turbidity value ranged from 200 to 0.90 NTU, water grade changed from C4S1 to C3S1. Concentrations of cataions, Calcium, Magnesium, Sodium, Potassium, and Ammonium, decreased from97.00 - 2.81 mmol L-1, 10.29-1.90 mmol L-1, 8.23-0.29 mmol L-1 and 2.50-0.81 mmol L-1 ions of the above elements respectively. Concentrations of anaions in treated wastewater for sulfate, nitrate, phosphate, and chloride and ions decreased from 13.97 -1.73 mmol L-1 , 8.29 -0.05 mmol L-1 , 8.10 - 0.03 mmol L-1, 24.23 - 5.09 mmol L-1, for the above anaions, respectively. The concentrations of heavy metals in treated wastewater decreased, including Iron from 90.80 - 0.21 mg L-1 , Zinc 0.51 - 0.00 mg L-1, Copper 0.99-0.00 mg L-1, Vanadium 0.09-0.00 mg L-1, Cadmium 0.40-0.00 mg L-1, Nickel 0.85-0.00 mg L-1, Manganese 85.40-0.19 mg L-1, Cobalt from 0.94-0.00 mg L-1 and Chromium from 95.00-0.26 mg L-1. Total bacteria and coliform bacteria also disappeared in treated wastewater with a removal rate of 100%.

Keywords: *Wastewater, treatment efficiency, water quality.*

INTRODUCTION

Sewage is liquid waste or water whose quality has been adversely affected by human influence. It includes liquid waste discharged from residential, commercial, industrial, and agricultural complexes. It may also contain a wide range of potential contaminants at varying concentrations. If concentration of toxic elements exceeds permissible limits, water is dangerous to humans and animals (Sushil *et al.*, 2019). Millions of liters of wastewater are produced in Iraq annually and are discharged into rivers untreated or inefficiently by treatment plants, causing significant damage to aquatic environment due to high concentrations of harmful environmental pollutants in this heavy water, Therefore, the random use of this water to irrigate fields and farms adjacent to cities and adding it to river water will lead to serious environmental and health effects such as disrupting the ecological balance, spreading pathogenic microbes, and increasing the concentrations of other determinants such as carcinogenic phenolic compounds, oxygen-consuming wastes, and other determinants of pollution (Ashworth and Alloway, 2004; Al-Obaidi *et al.*2014). Kelling *et al.* (1977) defined wastewater treatment as a set of physical, chemical, and biological processes in which solids, organic materials, and microorganisms are removed or reduced to an acceptable level. Many countries, including Iraq, suffer from limited traditional water resources and increasing droughts. This may lead to groundwater depletion, therefore, the use of treated wastewater has been used to increase available water, dispose of wastewater, and reduce environmental pollution, this reduces pressure on freshwater and serves as an unconventional source for groundwater recharge. Wastewater treatment plants in Iraq face significant challenges, and wastewater discharged from these plants is the primary pollutant of country's water bodies. This study aims to evaluate the performance efficiency of Karbala wastewater treatment plant and the potential use of treated water for irrigation and groundwater recharge.

MATERIALS AND METHODS

Wastewater samples were collected from Karbala Unified Project station located in Karbala Governorate, on Karbala-Najaf Road, Al-Fariha, before entering treatment plant. Samples were collected after treatment process was completed and before being discharged into the river , using clean 2-liter polyethylene containers. The electrical conductivity (EC) was determined using an EC-meter , pH directly using a pH-meter. the amount of (BOD) was calculated according to (Azide Modification) method , amount of COD according to (Dichromate reflux) method, both described in Standard Methods (1995). Phosphorus was determined colorimetrically by Olsen method (1954) using a spectrophotometer. Sodium adsorption ratio (SAR) was determined according to Richards method (1954). Calcium and magnesium ions were determined using titration method with 0.01N ferrous oxide (EDTA-Na_2). Sodium and Potassium ions were measured using a flame photometer, Sulfate ions were determined by turbidimetric method using a spectrophotometer at a wavelength of 420 nm, chloride ions were determined by titration method with Silver nitrate ($AgNO_3$). Nitrate and Ammonium ions were determined using Microkjeldhal apparatus, total solids (TDS), total suspended solids (TSS) and hardness were determined in wastewater , all above methods are mentioned in Standard Methods (1995). Turbidity was measured using a turbidity meter. Heavy metals concentrations of wastewater samples were measured using an atomic absorption spectrometer. Bacteriological tests of water were performed according to methods described in APHA (2012).

RESULTS AND DISCUSSION

1-Chemical Properties of Water

Results of Table 1 show some chemical properties of different types of water, represented by untreated wastewater and wastewater treated by wastewater treatment plant in holy Karbala Governorate, including: -

1-1- Water reaction (pH)

The pH value of untreated wastewater was 7.48 and increased slightly in treated wastewater, reaching 7.59. The low pH values in untreated wastewater may be due to the presence of some acids such as humic, fulvic, citric, carbonic, and others dissolved in wastewater due to decomposition of rapidly decomposing organic materials. These results are consistent with what was indicated by Al-Amiri (2006), Khalaf *et al.* (2013), and Sundara *et al.* (2010), those who have shown that pH value of wastewater ranges between 6 and 9. The reason for increase in pH

Table 1. Some physical, chemical and biological properties of water.

characters	Unit	treated wastewater	untreated sewage
EC	dSm^{-1}	1.20	8.50
pH	------------	7.59	7.48

TDS	$^{-1}$mg L	775.00	5150.00
TSS		10.00	99.00
BOD		0.90	140.00
COD		10.00	236.00
OIL & Grease		0.00	10.10
Total Hardness		3.47	66.50
Turbidity	NTU	0.90	200.00
Ca^{+2}	mmole L^{-1}	2.81	14.97
Mg^{+2}		1.90	10.29
Na^{+}		1.23	24.16
K^{+}		0.29	8.23
NH_4^{+}		0.81	2.50
SO_4^{-2}		1.73	13.97
NO_3^{-}		10.00	8.29
PO_4^{-3}		10.07	8.10
Cl^{-}		30.28	24.23
Sodium adsorption (ratio SAR)	(mmole+ L^{-1}) ½	0.804	6.805
Water class (USDA,1954)		C_3S_1	C_4S_1

value of treated wastewater may be due to treatment of this water by water treatment plant, which led to the removal of organic acids and other contaminants in this water, this led to a slight increase in alkalinity of water. Therefore, it is suitable for purposes of artificial groundwater recharge because it is below the permissible upper limits of (10) (Abulibdeh, 2021).

1- 2- Electrical conductivity (EC)

Results indicated an increase in values of untreated wastewater, reaching 8.50 dSm^{-1}. This increase may be attributed to dissolved compounds in this water coming from human waste, municipal waste, factory waste, and runoff polluted with dirt and other materials from streets, which are discharged with wastewater. These results are consistent with what was indicated by

Khalaf *et al.* (2013), who indicated that electrical conductivity values of wastewater are high due to industrial facilities and municipal waste near drainage areas, which discharge their waste into sewage water that enters water treatment plant. Electrical conductivity of treated wastewater at plant decreased to 1.20 dSm^{-1}, this may be due to removal of compound ions and salts from water during purification at plant. Removal rate reached 85.88%. These results indicate that plant performs very well in field of wastewater purification and is highly efficient.

1-3- Biochemical oxygen requirement (BOD)

The value of biochemical requirement of untreated wastewater increased to 140 mg L^{-1}, which is a very high value due to increase in organic waste and increase in bacterial and oxygen activity, while value of biochemical oxygen requirement for treated wastewater in Karbala station was lower, reaching (0.90) mg L^{-1}, and this is due to efficiency of treatment plant in removing organic matter and bacterial activity from wastewater. The reduction efficiency reached 99.35%, making plant very efficient in removing organic matter from wastewater. These results are consistent with what Salem *et al.* (2009) found, who indicated an increase in efficiency of Najaf Ashraf water treatment plant in getting rid of BOD. The dilution ratio reached 81.50%, making it suitable for artificial groundwater recharge purposes, as its value was 0.90 mg L^{-1}, which is significantly lower than upper permissible limit (Abuli bedeh, 2021) of 15 mg L^{-1}. Untreated wastewater exceeded permissible limits of pollution parameters in heavy water (Abdul Sabour, 2002), which reflects and demonstrates importance of treating this water before discharging it into river and its harm to aquatic life due to its consumption of dissolved oxygen in water, which leads to migration and death of aquatic organisms (Hodnet et al., 1971).

1-4- Chemical Oxygen Requirement (COD)

Results show an increase in the chemical oxygen demand value of untreated wastewater, which reached 236 mg L^{-1}. This may be due to high concentration of organic materials in water, which consumes dissolved oxygen, leading to death of aquatic organisms. These results are consistent with what was shown by Salem *et al.* (2009), who showed an increase in chemical oxygen demand value of untreated wastewater in Najaf Al-Ashraf. As for treated water in station, COD value reached 10.00 mgL^{-1}, which is within permissible limits for irrigation with treated wastewater ,Environmental Determinants of Wastewater (Abdul Razzaq, 2000). This reflects high efficiency of wastewater treatment plant in Karbala, as the reduction efficiency reached 95.76%. When comparing COD value with determinants of reusing treated water for artificial groundwater recharge purposes (Abulibdeh, 2021) of 50.00 mg L^{-1}, It turns out that it is suitable for this because its value was 10.00 mg L^{-1}. These results are consistent with what Muhammad and Rajab (2017) reached, who showed an increase in reduction efficiency in Al-Majar station (Maysan Governorate) for treating wastewater, as reduction efficiency reached 89.27%. When comparing BOD to COD, ratio of COD to BOD should usually be 2:1.5 in wastewater, which represents biological decomposition of organic matter in water. This is clear from COD value (236) and BOD value (140 mg L^{-1}). Thus, ratio is 1.68, which is compared to above ratio.

1-5-Total Hardness(TH)

Results indicate a high total hardness value for untreated wastewater, which reached 66.50 mg L^{-1}, which is a high value due to high concentrations of Calcium, Magnesium and Chlorine ions in water, as there is a direct relationship between high concentrations of these ions and total hardness value, which indicates water pollution (Miltan *et al.*, 2019 ; Harby and Naser, 2020). Total hardness value in treated wastewater decreased to 3.47 mg L^{-1}. This is due to role of treatment plant in Karbala in removing ions of that cause this hardness. Reduction rate reached 94.93%, which is a very high percentage. Thus, plant proves its efficient and distinguished role in treating wastewater.

1-6-Sodium adsorption ratio (SAR)

Results of chemical analysis of water showed a higher Sodium adsorption ratio (SAR) for untreated wastewater compared to treated wastewater, reaching 6.80 and 0.80 (mmol L^{-1}) for water, respectively. Higher SAR value for untreated wastewater may be due to high salinity of water, due to increased concentrations of Sodium, Calcium and Magnesium ions in untreated wastewater compared to other types of water. These results are consistent with what was found by Al-Azzawi and Al-Azara (2012) they showed that Sodium adsorption ratio increased with increase in electrical conductivity of water. As for water type, C_4S_1 was very saline and low in Sodium for untreated wastewater, while C_3S_1 was treated wastewater.

1-7- Oils, fats and greases

Amount of oils, fats and grease in untreated wastewater reached 10.10 mg L^{-1}, which is a relatively high amount that must be removed from wastewater before it is discharged into rivers. Amount of oils, fats and grease in treated wastewater at plant decreased to zero. This results in a 100% reduction rate, reflecting treatment plant's distinguished and efficient removal role. therefore suitable for artificial groundwater recharge (Abulibdeh, 2021), as it is below permissible limit of 25 mgL^{-1}

1-8- Dissolved Cataions

1-8-1- Calcium

Results of Table 1 show a high concentration of calcium ions in untreated wastewater, reaching 14.97 mmol L^{-1}. This may be due to an increase in dissolved Calcium compounds in water coming from urban waste, human waste, and factories that are discharged with wastewater. As for treated water in station, the concentration decreased to 2.81 mmol L^{-1}, a decrease of 81.23%, which is a high percentage indicating efficiency of treatment plant in purifying and filtering wastewater. When comparing Calcium concentration in treated wastewater with maximum limits allowed for treated water for irrigation purposes according to Syrian standard specifications (2008), which is 400 mg L^{-1}, we find that it is less than that (112.4 mg L^{-1}), therefore it is suitable for irrigation.

1-8-2- Magnesium

Magnesium concentration in treated wastewater reached 10.29 mmol L^{-1} (Table 1), equivalent to 246.96 mg L^{-1}. Magnesium concentration in treated wastewater decreased to 1.90 mmol L^{-1} equivalent to 45.60 mg L^{-1}, which is lower than maximum permissible limit for treated wastewater for irrigation purposes, which is 60 mg L^{-1} (Syrian Standard Specifications, 2008), Thus, treated water is suitable for irrigation and artificial groundwater recharge. Reduction rate reached 81.23%, which is a high percentage, making plant efficient at removing magnesium ions from wastewater.

1-8-3- Sodium

Concentration of Sodium ions in untreated wastewater reached 24.16 mmol L^{-1}, equivalent to 555.68 mg L^{-1}, which is a very high concentration. The concentration of sodium in treated wastewater at the station decreased to 1.93 mmol L^{-1}, equivalent to 44.39 mg L^{-1}. Therefore, treated water is suitable for irrigation purposes and artificial recharge of groundwater because it is less than maximum permissible limits for treated wastewater for irrigation purposes, which is 230 mgL^{-1} (Syrian Standard Specifications, 2008). Reduction rate reached 92.01%, which is a very high percentage thus treatment plant proves its efficiency in process of removing Sodium ions from wastewater.

1-8-4- Potassium

Concentration of Potassium in untreated wastewater was 8.23 mmol L^{-1}, or 320.97 mg L^{-1}. This may be due to its increased release from wastewater after decomposition of organic matter in it, but its concentration is lower than concentration of sodium ions because it is less soluble (Hem, 1989). Potassium concentration in treated wastewater at station decreased to 0.29 mmol L^{-1}, or 11.31 mg L^{-1}, which is a small amount. Reduction rate reached 96.47%, which is a very high percentage. Thus, wastewater treatment plant in Karbala city proves its efficiency in process of removing Potassium ions.

1-8-5- Ammonium

Results of Table 1 showed that concentration of ammonium ion in untreated wastewater reached 2.50 mmol L^{-1}, equivalent to 45.00 mg L^{-1}, which is a high concentration and may be due to presence of organic and mineral nitrogenous materials in wastewater resulting from health, social and industrial activities. Increased concentration of Ammonium ions in wastewater may be related to abundance of Oxygen and its organic matter content (Okey and Albertson, 1989). Concentration of Ammonium in wastewater treated at station decreased to 0.81 mmol L^{-1}, equivalent to 14.58 mg L^{-1}. It did not exceed the maximum permissible limits for artificial groundwater recharge, which is 20.00 mg L^{-1} (Abulibdeh, 2021), but it is unsuitable for irrigation according to maximum permissible limits for treated wastewater, which is 5.00 mg L^{-1}. Reduction rate reached 67.60%, which is a good percentage.

1-9- Dissolved Anaions

1-9-1- Sulfates
Results of Table 1 showed a high concentration of Sulfate ions in untreated wastewater, which reached 13.97 mmol L^{-1}, equivalent to 13412.11 mg L^{-1}, which is a very high value and is due to the organic compounds containing sulfur in wastewater (World Health Organization, 1997 and Taher, 2009). These results are consistent with what was reported by Salem *et al.* (2009) who indicated that concentration of sulfate in untreated wastewater increased due to presence of some types of sulfobacteria that convert Sulfides into Sulfate (Hammer, 2008). Concentration of Sulfate in treated wastewater at station decreased to 1.73 mmol L^{-1}, equivalent to 166.08 mg L^{-1}. This may be due to sedimentation and oxidation processes in aeration basins resulting from activity of aerobic bacteria. Reduction rate reached 87.61%, which is a very high percentage, indicating the efficiency of plant in treatment process. Therefore, it is suitable for irrigation according to Syrian standard specifications (2008) of 500 mg L^{-1} and artificial recharge of groundwater according to Abulibdeh (2021), because it is less than 400 mg L^{-1}. These results are consistent with the findings of Muhammad and Rajab (2017), who showed a decrease in concentration of Sulfates in wastewater treated in treatment plants due to activity of aerobic bacteria.

1-9-2- Nitrates

Concentration of Nitrate ion in untreated wastewater reached 8.29 mmol L^{-1} equivalent to 513.98 mg L^{-1}, which is a very high amount. This may be due to fact that Nitrates constitute an important part of organic and mineral agricultural fertilizers and that they are ions that dissolve quickly in water, thus they dissolve in rainwater and irrigation water and are transferred to groundwater through filtration or to wastewater when rainwater (floods) and agricultural drainage water are discharged into sewage networks (Mohammed and Rajab, 2017). Nitrate concentrations in treated wastewater at plant decreased to 0.05 mmol L^{-1}, or 3.10 mg L^{-1}. This may be due to the nitrification process, in which nitrate is oxidized to nitrite by two different types of bacteria. This process consumes Oxygen from organic matter as a result of respiration in aeration tanks. Reduction rate reached 99.39%, which is a very high percentage. Thus, treatment plant proves its efficiency in removing Nitrate from wastewater. These results are consistent with what was found by Mohammed and Rajab (2017) which showed a decrease in concentration of Nitrates in treated wastewater. When comparing concentration of nitrates in treated wastewater with the standards for water reuse and treatment for artificial groundwater recharge, which is 4.00 mg L^{-1}, It turns out that it is suitable for this purpose (Abulibdeh, 2021). It is also suitable for irrigation purposes according to Syrian Standard Specifications (2008), asthe maximum permissible concentration of Nitrates in treated wastewater is 25 mg L^{-1}, concentration of Nitrates in treated wastewater is 3.10 mg L^{-1}, which is lower than that.

1-9-3- Phosphate

Results showed that Phosphate concentration in untreated wastewater reached 8.10 mmol L^{-1} (639.90 mg L^{-1}), a very high amount, possibly due to detergents containing phosphorus-activated substances. Phosphate concentrations in treated wastewater decreased to 0.03 mmol L^{-1} (2.37 mg L^{-1}), a reduction of 99.62%, a very high percentage. Thus, Karbala heavy water treatment plant proves its efficiency in removing phosphates from wastewater. These results are consistent with findings of Muhammad and Rajab (2009), who showed a low concentration of Phosphates in treated wastewater, making it suitable for artificial groundwater recharge purposes (Abulibdeh, 2021) because it is less than permissible limits of 350 mg L^{-1}. It is also suitable for irrigation purposes according to Syrian standard specifications (2008) because it is less than permissible limits of 25 mg L^{-1}.

1-9-4- Chlorides

Concentration of chloride ion in untreated wastewater reached 24.23 mmol L^{-1}, or 860.16 mg L^{-1}, which is a very high amount. This may be due to frequent use of household cleaners that contain Chlorine, in addition to Chlorine used to sterilize drinking water, which enters wastewater after use (Al-Hashemi, 2008). Chloride concentration in treated wastewater at station decreased to 5.09 mmol L^{-1}, or 180.00 mg L^{-1}, a decrease of 78.99%, which is a good percentage. These results are consistent with findings of Muhammad and Rajab (2017), who showed a decrease in Chloride concentration in treated wastewater. Therefore, it is suitable for artificial groundwater recharge purposes, as it is lower than permissible limit of 300 mg L^{-1} according to Abulibdeh (2021). It is also suitable for irrigation purposes according to Syrian Standard Specifications (2008), as it is lower than permissible limit of 350 mg L^{-1} for chloride.

2-Physical properties of water

2-1- Total dissolved solids (TDS)

Results showed an increase in value of total dissolved solids in untreated wastewater, reaching 5150 mg L^{-1}. This is due to organic compounds resulting from activities resulting from residential and industrial activities. These results are consistent with what Khalaf *et al.* (2013) concluded. Those who pointed out that total dissolved solids (TDS) content in wastewater in Fallujah, Anbar Governorate, exceeded permissible values for irrigation. It was noted that amount of TDS was directly proportional to the electrical conductivity values. TDS content in treated wastewater decreased, reaching 775 mgL^{-1}. This is due to role of water treatment plant in removing dissolved materials, compounds, and salts from the water. Removal rate reached 84.955%, which is a very high percentage. Wastewater treatment plant in Karbala proves its efficiency in treatment process, but it is outside the permissible limits for artificial recharge of groundwater (Abulibdeh, 2021) of 5 mgL^{-1}, but it is within maximum permissible limits for irrigation purposes according to Syrian Standard Specifications (2008) of 1500 mgL^{-1}.

2-2-Total suspended solids (TSS)

Total suspended solids (TSS) in untreated wastewater increased to 99 mg L^{-1}. This is a relatively high value for wastewater, it may be due to contamination of water arriving at station as it passes through wastewater network, or as a result of inefficient collection basins and accumulation of mineral and organic materials. These results are consistent with findings of Khalaf *et al.* (2013), who demonstrated an increase in total suspended solids (TSS) in wastewater, exceeding permissible limits for irrigation use. Total suspended solids in treated wastewater decreased to 9.00 mg L^{-1}, with a removal rate of 89.89%, which is a very good percentage. Thus, Karbala wastewater treatment plant proves its high efficiency in removing total suspended solids. When comparing TSS value of treated water with standards for using treated water for artificial groundwater recharge (Abulibadeh, 2021), It turns out that it is suitable for this, as permissible limits are 6-9 mg L^{-1}.

2-3- Turbidity

From results of Table 1, it is clear that turbidity value of untreated wastewater reached 200 NTU, which is a very high value and thus reflects extent of water pollution with various suspended organic materials. As for wastewater treated by station, turbidity value reached 0.90 NTU, which is a very low value, and thus reduction efficiency reached 99.55%, which is a very high percentage. Thus, plant demonstrates its efficiency in removing suspended organic matter from treated wastewater. When this value is compared to the permissible limit for artificial recharge of groundwater with treated wastewater (Abulibdeh, 2021), which is 700 NTU, It turns out it highly suitable for artificial recharge of groundwater.

3-Heavy metals in water (mg L^{-1})

Results of Table 2 showed chemical analysis of wastewater in terms of heavy metals, indicating presence of different concentrations of heavy metals (Fe, Zn, Cu, V, Cd, Pb, Ni, Mn, Co, Cr). This may be attributed to multiple sources of water pollution, as follows:

3-1- Iron

Concentration of iron in treated wastewater reached 90.80 mg L^{-1}, which is a high concentration. When compared with standards for reusing treated wastewater for artificial groundwater recharge, which amounted to 2.00 mg L^{-1} according to Abulibdeh (2021), for Iron, It turns out that Iron far exceeded the permissible limits.

Concentration of Iron in treated wastewater in station decreased to 0.21 mg L^{-1}, which is permissible for feeding groundwater according to above source. Percentage of decrease reached 99.76%, which is a very high percentage. This reflects the efficiency of treatment plant in removing Iron ions from wastewater. It exceeded the permissible limits set by Duncan *et al.* (2009) of 0.20 mg L^{-1}, and thus it is not suitable for irrigation.

Table 2. Some heavy metals in water (mgL^{-1}).

Heavy metals	untreated sewage	treated wastewater	Critical limits (Duncan *et al*, 2009)
Fe	90.8	0.21	0.20

Zn	0.51	BDL	2.00
Cu	0.99	BDL	0.20
V	0.90	BDL	0.10
Cd	0.40	BDL	0.10
Pb	0.69	BDL	2.00
Ni	0.85	BDL	0.20
Mn	85.4	0.19	0.20
Co	0.94	BDL	0.05
Cr	95.00	0.26	0.10

3-2- Zinc

Zinc concentration in untreated wastewater was 0.51 mg L^{-1}. This may be due to decomposed organic matter present in water or to Zinc being a component of sedimented Zinc with the silty sediments that were transferred to wastewater. This is consistent with what Khalaf *et al.* (2013) found, who found varying amounts of Zinc in untreated wastewater. Concentration of Zinc decreased to zero in treated wastewater at station, Percentage of decrease reached 100%. This reflects positive role of treatment plant and increase in its efficiency in treating wastewater. When comparing concentration of Zinc in treated wastewater with standards for using wastewater for artificial recharge of groundwater, which is (5.00) mg L^{-1} (Abulibdeh, 2021), It turns out that it is suitable for this, and it is also suitable for irrigation because it is free of Iron, according to Duncan *et al.* (2009).

3-3 -Copper

Results showed that concentration of Copper in untreated wastewater reached 0.99 mg L^{-1}. This may be due to waste from factories that use copper as a basic material in industry, such as cable and electrical wire factories, which is thrown away with the wastewater and has exceeded maximum permissible limits in water (Duncan *et al.*, 2009) of 0.20 mg L^{-1}, making it unsuitable for irrigation. Copper concentration in treated wastewater at plant has dropped to zero, demonstrating plant's efficiency in water treatment. Reduction rate has reached 100%, making water suitable for irrigation and industrial groundwater recharge.

3-4- Vanadium

Vanadium concentration in untreated wastewater was 0.90 mg L^{-1}, which is above critical limit of 0.10 mg L^{-1} for irrigation (Duncan *et al.*, 2009), making it unsuitable for irrigation. Vanadium concentration in treated wastewater was reduced to zero, resulting in a 100% plant efficiency, making the treated water suitable for irrigation and artificial groundwater recharge.

3-5- Cadmium

Cadmium concentration in untreated wastewater was 0.40 mg L^{-1}, which is significantly higher than permissible limit for heavy water (Duncan *et al.*, 2009) of 0.01 mg L^{-1}, making it unsuitable for irrigation. Cadmium concentration in wastewater may be due to agricultural drainage water containing Cadmium added to soil with Phosphate fertilizers, which are discharged with wastewater. Cadmium concentration in treated wastewater at plant decreased to zero, thus proving plant's removal efficiency, with a 100% reduction, making it suitable for irrigation and artificial groundwater recharge.

3-6- lead

Results showed that lead concentration in untreated wastewater was 0.69 mg L^{-1}, which is below permissible limit for irrigation according to Duncan *et al.* (2009) of 2.00 mg L-*1*. Lead concentration in treated wastewater decreased to zero, a 100% reduction, making treated water suitable for irrigation and artificial groundwater recharge.

3-7- Nickel

Nickel concentration in untreated wastewater was 0.85 mg L^{-1}, which is significantly higher than permissible limit for irrigation water of 0.20 mg L^{-1} (Duncan *et al.*, 2009). This may be due to increased industrial activity and discharge of industrial wastewater into wastewater (Habib *et al.*, 2012). Nickel concentration in treated wastewater at plant decreased to zero, with a 100% reduction, thus proving plant's efficiency in removing Nickel ions from water. Therefore, treated water is suitable for irrigation and artificial groundwater recharge.

3-8- Manganese

Concentration of Manganese in untreated wastewater was 85.40 mg L^{-1}, which is a very high concentration according to Duncan *et al.* (2009) of 0.20 mg L-*1*. This may be due to increased discharge of factory and plant waste that contains Mg with wastewater. With these specifications, it is unsuitable for irrigation or groundwater recharge. Manganese concentration in treated water decreased to 0.19 mg L^{-1}, which is below maximum (critical) limits (Duncan *et al.*, 2009). This indicates an increase in efficiency of treatment plant, reduction rate reached 99.77%, therefore, treated water is suitable for irrigation and groundwater recharge, according to Abulibdeh (2021), which is 0.40 mg L^{-1}.

3-9- Cobalt

It concentration in untreated wastewater was 0.94 mg L^{-1}, which is significantly higher than critical limit for heavy metals in irrigation water of 0.05 mg L^{-1} (Duncan et al., 2009). This may be due to increased industrial activities that release wastewater into the wastewater. Cobalt concentration in treated wastewater decreased to zero, a 100% reduction. This reflects efficiency of treatment plant in removing Cobalt ions from wastewater. Therefore, treated wastewater is suitable for irrigation and artificial groundwater recharge.

3-10- Chromium

Chromium concentration in untreated wastewater was 95.00 mg L^{-1}, which is considered very high according to Duncan *et al.* (2009), as permissible limit is 0.10 mg L^{-1}. This may be due to discharge of industrial wastes, such as those from paper, cement, and metal alloy factories, into wastewater (Carmen, 2016). Therefore, this water is unsuitable for irrigation or groundwater recharge. These results are consistent with findings of Al-Qasir (2005), who showed presence of Chromium ions in wastewater of Diwaniyah city at a concentration of 0.018 mg L^{-1}. Concentration of Chromium in treated wastewater decreased to 0.26 mg L^{-1}, with a reduction rate of 99.72%, which is a very high percentage. Thus, station proves its efficiency in treatment process. It is not suitable for irrigation. Permissible limit for chromium is 0.10 mg L^{-1} (Duncan *et al.*, 2009). It is also unsuitable for artificial groundwater recharge, as it exceeds maximum permissible limit of 0.05 mg L^{-1}, as it is much higher at this concentration (0.26 mg L^{-1}).

4- Bacteriological tests of water

Results of Table 3 of bacteriological tests of untreated wastewater showed that total number of bacteria was 4-10 × 223 cells/100 ml, while number of Escherichia Coli bacteria, which are of fecal origin, was 3-10 × 203 cells/100 ml. This is due to human waste, which is the main source from which pathogenic organisms, including bacteria and other microbes, enter water, or as a waste product of some industries that contain these organisms, such as waste of slaughterhouses and various food industries, including the dairy industry and food canning plants (Mrello *et al.*, 2006).

Table 3. Bacteriological tests for water.

Water quality	E – Coli	Total
Treated water	No Growth	No Growth
Untreated wastewater	203×10^{-3}	223×10^{-4}

Conclusions

Increasing the efficiency of the Karbala Wastewater Treatment Plant in reducing the chemical, physical, and bacteriological properties, as well as the concentrations of dissolved positive and negative ions and heavy metals in wastewater. This water can therefore be used for irrigating agricultural crops and artificially replenishing groundwater.

REFERENCES

1- Abdul Razzaq, Muthanna. 2000. Environmental Pollution, First Edition, Wael Printing and Publishing House, Amman, Jordan.
2- Abulibdeh, Ammar, .2021. Spatiotemporal Mapping of Groundwater Salinity in Al-Batinah, Oman. Groundwater for Sustainable Development, Vol. 12 (February). Available at: . https://doi.org/10.1016/J.GSD.2021.100551
3-Al-Amiri, Najla Jabr Mohammed, 2006. Evaluation and reclamation of wastewater using different filters and reuse for irrigation. PhD thesis, College of Agriculture, University of Basra.
4- Al-Azzawi, Kadhim Makke Naser. Al-Araza Ahmed Abdul-Wahab Abdul-Ridha. 2012. Study of the chemical properties of some well waters of the College of Agriculture, University of Baghdad and evaluation of their suitability for agricultural and domestic uses. Iraqi Journal of Agricultural Sciences. 43: (6) 70-59.
5- Al-Hashemi, Zeina Fakhri. 2008. Evaluation of the efficiency of wastewater treatment plants in removing heavy metals from some hospitals in Mosul city. Pollution Research and Control Center. Mosul, Iraq.
6- Al-Obaidi, A.M.; Al-Janabi, Z. and Abdul Rahman, A.J. 2014. Distribution of heavy metals in Tigris River in central Iraq. Baghdad Journal of Science Volume 11(2).
7- Al-Qasir, Muhammad Kazim Khawin. 2005. A Study of the Environmental Impact of Wastewater Treatment Project Discharge on the Water Quality of the Diwaniyah River - Iraq. Master's Thesis. College of Science, Al-Qadisiyah University.
8- Ashworth, D. J. and Alloway, B. J. 2004. Soil mobility of sewage sludge-derived dissolved organic matter, copper, nickel and zinc Environmental Pollution, 127: 137-144.
9- APHA, American Public Health association, American water
works association AWWA) and water environmental federation (WEF). 2012. Standard methods for the examination of water and wastewater, 22nd Edition, 9993.

10- Carmen Cristina Elekes . 2016. Environmental Risk Assessment of soil contamination . classiques :experimentation et modelisation universite ferhat abbas-setifufas (algerie) magister 03 / 03 / 2007.

11- Duncan,G.K.;R.N. Carrow and M.T.Huck.2009.Turfgrass and landscape irrigation water quality assessment and management.Taylor and Francis group,LLC.

12- Habib, R . H ; S. M . Awadh and M. Z. Muslim .2012. Toxic Heavy Metals in soil and some Plant in Baghdad, Iraq. J. Al- Nahrain Univ Sci, 15 (2), 1-16.

13- Harby, Abeer Faiq; Naser, Kadhim Makke.2020.MONTHLY CHANGES OF SOME PHYSICO-CHEMICAL PROPERTIES FOR TIGRIS RIVER WATER AND EVALUATION OF ITS CONTAMINATION BY SOME HEAVY METALS. *Plant Archives* Vol. 20, Supplement 2, 2020 pp. 3111-3117

14- Hem, J. D. 1989. Study and interpretion of the chemical characteristics of natural water. US Geological Survey. Water supply. Paper 2254.

15- Hodnet, E.M. ; J. Tai, and J. Med.1971. Chem., 14, 115.

16- Kelling, A. E., Peterson, L. M. Walch, J. A. Ryan and D. R. Keeny. 1977. A field study of the Agricultural use of sewage sludge. 1. Effect on crop yield and uptake of N and B. J. Environ. Qual 6: 334–345.

17-Khalaf, Omar Karim, Abdul Razzaq, Ibrahim Bakri and Manajed, Mahmoud Huwaidi. 2013. Evaluation of some properties of treated wastewater in Al-Naimiyah station (Fallujah). A-Evaluation of the physical and chemical properties of treated wastewater. Al-Furat Journal of Agricultural Sciences. 4) 5): 204-216.

18- Mohammed, Najla Ajil and Rajab, Israa Muwaffaq. 2017. A Study of Some Pollution Determinants of Three Wastewater Plants in Maysan Governorate for the Period (2013-2014). Journal of the College of Education. Al-Mustansiriya University. Issue Six. P. 473.

19- Militan, Abdul Majeed, Hanan Ahsouna, Khadija Al-Qanidi, Khawla Abu Ruwais. 2019. A Study of the Effect of Sewage Water on Some Soil Properties in the Sasso Valley Area, Academic Research Journal 174-182.

20-Mrello, J. A.; Mizer, H. E. and Granato, P. A.(2006). Laboratory
manual and workbook in microbiology. 8th ed. McGraw Hill, New York.

21-Naser, Kadhim Makke and Dhay Mahdi Saleh. 2016. The effect of Al-Dawra refinery and Al-Dawra power station on the pollution of soil, plants and water with some heavy elements. Ni, Zn, Cd, Pb. The Iraqi Journal of Soil Sciences. Volume (16), Issue (1).

22-Okey, R. W. and O. E. Albertson. 1989. The role of the diffusion in regulating rate and Masking temperature effects on fixed film nitrification. J. Water pollution control Fed. 61: 500. p170.

23- Richards, L.A. 1954. Diagnonis and im-provement of saline and alkaline soils. USDA, Handbook, 60 p.

24- Standard Methods.1995. The examination of water and wastewaters, American water Public Health Assoc., American water works Assoc. 19th ed., New York.

25- Sushil, Kumar, V.;D. Kochar ; D., Vikas, and K. Khokhar.2019. A Review on Influence of Sewage Water on Soil Properties and Microbial Biomass Carbon, Ind. J. Pure App. Biosci. 7(5), 83-90.

26-Sundara, K. K.; P. K. Sundara.; M. J. Ratnakanth. 2010. Performance evaluation of wastewater treatment plant. Int. J. Sci. Tech .vol. 2(12), pp. 7785-7796 .

27- Syrian Standard Specifications. 2008. Standards and specifications for treated wastewater for agricultural use. No. 2752.

28- Salem, Diaa Al-Din, Muhammad Qasim Kazim, Hassan Muhand Hadi, Ali Radhi, and Fahim Abdul Ali. 2009. Evaluation of the efficiency of the wastewater treatment plant in Najaf Al-Ashraf. Kufa Journal of Chemical Sciences, Issue (1).

29- World Health Organization. 1997. GEMS/Water Programme Operational Manual. Regional Office for the Eastern Mediterranean/Regional Office for Environmental Health Activities