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ASSESSMENT OF FILTER EFFICIENCY IN RECYCLING WASTEWATER FOR IRRIGATION PURPOSES USING PHYSICOCHEMICAL PROCESSES IN SEMEL DISTRICT/DUHOK-KR, IRAQ

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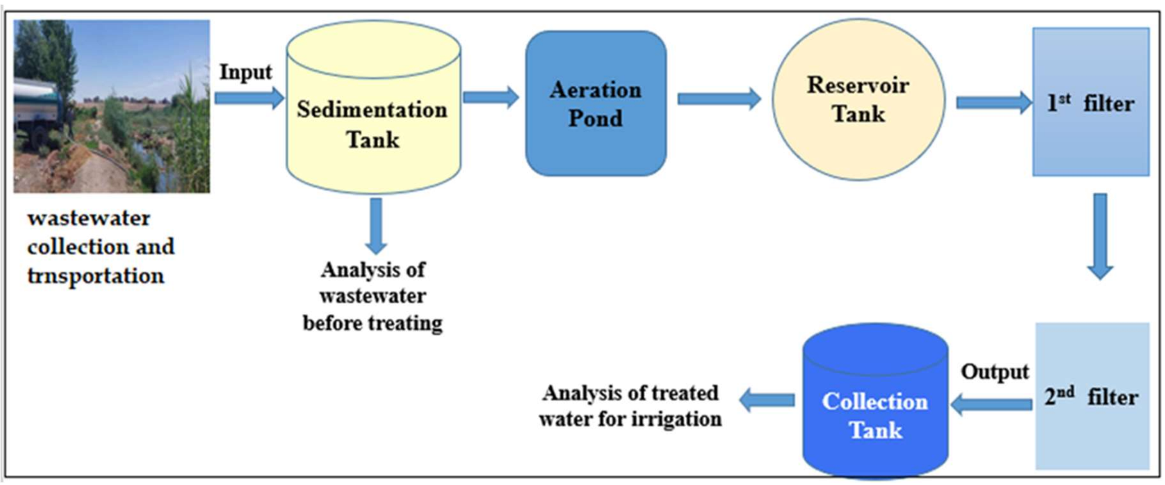
Abstract: This study was carried out to evaluate the efficiency of filter, for improving some physicochemical properties of wastewater. The wastewater sample was collected from the final meeting out let point of municipal wastewater network of Semel district and treated physically through precipitation, aeration and filtrated through a sand filter containing activated charcoal. The both wastewater (before treating) and filtrated water samples (after treating) were analyzed for (pH, EC, TDS, TSS, temperature, turbidity, DO, COD, BOD, cations (Ca, Mg, Na, and K) and anions (Cl, SO4, CO3, HCO3 and NO3), P, SAR, SP, RSC. The results indicated that the filter was efficient in reducing the turbidity (98.55) % while its efficiency for removing phosphorous from wastewater was the low (5.08) %. The filter efficiency for reducing (EC, TDS, and TSS) were (35.08, 35, and 68.21) % respectively. When for COD and BOD were (38.03 and 39.29) % respectively. The efficiency of filter for reducing the cations and anions from the wastewater ranked following trend (Cl= 57.53> Ca= 47.06> Mg =32.61> SO4 =17.97> K= 8.05 > Na= 5.10) %. Salinity potential responds to filtration better than sodium adsorption ratio and residual sodium carbonate which was reduced by 47.88%.



Keyword: Wastewater, sedimentation, aeration, Sand- charcoal filter, salinity potential,

Introduction

In any country, the surface water and groundwater resources play an important role in agriculture, hydropower generation, livestock production, industrial activities, forestry, fisheries, navigation, and recreational activities. etc. (Wetzel, 2001). The expansion in the industrial and agricultural sectors, as well as the population growth and development economy of the countries, all these increased the demands to suitable water and increased wastewater effluents which finally caused environmental polluted problems, (Metcalf and Eddy, 1991). Wastewater is considered as one of the major sources of water and nutrients for irrigation in developing countries, particularly in dry and semi-arid regions, (Blanca, 2006). Municipal wastewater is a valuable alternative source of irrigation water in many areas, especially at arid and semiarid areas and those countries that suffer from water scarcity. However, in addition to plant nutrients, it may contain a variety of potentially hazardous substances and organic debris that have serious consequences for environmental (soil, water and air) pollution, human and animal health, (Jimenez, 2005), Esmailiyan et al. 2008), (Najafi et al. 2003), (Munir and Ayadi 2005). Iraq's sewage water is believed to be millions of liters per year, and currently there is no national plan to deal with it, in accordance with the strategy of sustainable use. Indiscriminate use of this wastewater directly in the irrigating the cultivated vegetables fields and farms around the streams of these wastewater effluents in the cities and finally discharged to the downstream rivers, and causes a serious environmental and health problems to people, (Ashworth and Alloway, 2004). Therefore, our ecosystem is suffering from numerous issues as a result of the daily discharge of wastewater from our industries; these are related with growing urbanization, population growth, industrialization, and a variety of other causes. With all of the elements described above, wastewater discharge must be handled, (Marzec, 2017). For achieving sustainable wastewater reuse and contribute in the food security, the recycling projects of wastewater must be construct and develop the existence projects over time based on local needs, (Blanca, 2006). Due to the wastewater content a high organic matter, hazardous compounds, so, it is of critical to prevent environmental pollution (such as soil, water bodies, air, plant and other organisms) from these pollutants loaded in wastewater (McCarty et al., 2011).

In most arid and semi-arid areas in the world, wastewater reclamation, management and its reuses being an important element in water resources planning, because of the scarcity of the usable water, and due to the expensive cost of chemical fertilizers, high concentration of nutrients elements in wastewater, the high cost of wastewater treatment for different purposes and the availability of wastewater near agricultural lands, so wastewater treatment and management became one of the attractive practice in most development countries. Therefore, the idea of processing and using the treated wastewater has been raised. Different techniques are used in treating wastewater (physical, biological, and chemical) for reducing or mitigating its adverse effects on the environmental components (soil, water air organisms and human health, (Abedi-Koupai and Bakhtiarifar 2003). Therefore, this study came for recycling the wastewater, and identify the efficiency of the wastewater treatment unit by comparing some chemical and physical properties of wastewater entering and leaving through treatment unit.

Materials and methodology

Study area

This study was conducted at Semel District College of Agricultural Engineering Sciences Duhok of University. The Semel district is located at the west of Duhok, at latitude 36°50'57.62"N, and longitude 42°50'38.00"E and elevation of approximately 475 meter above sea level, of the area of municipal wastewater discharge, which content many hazardous components, causes environmental pollution as shown in figure (1).

Filter preparation

Two filters were prepared in two small tanks with (102) cm in height and diameter (48) cm, the filter layers of first filter were composed from layers of a coarse gravel 10cm, fine gravel 10cm, coarse sand 30cm, active charcoal 10cm, fine sand 20cm, and finally a layer of cotton 5cm. while the second filter was prepared from coarse gravel 10cm, fine gravel 30cm coarse sand 20cm, , find sand 20cm, active charcoal 5cm, wheat hay 5cm, and 5cm of cotton, and a textile sheet were placed between all these layers to prevent down wared transportation of their components, when a layer of cotton and wheat hay was placed over all layers of the filter for reservation the fatty substances.

Water sampling, precipitation, aeration

The water sample was collected from municipal wastewater area in Semel district by special transport tank. The wastewater sample was transported to college of agricultural engineering sciences by a wastewater truck, then discharged to a special tank prepared for sedimentation and left for 2 days for settle down the solids suspended materials loaded with wastewater to the bottom of the tank which was content a discharge hole in the bottom for discharging the collected sluge.

After sedimentation the wastewater was transferred to aeration basin pond opened from the top and the process of aeration was don through pumping air by electrical water pump which was placed in the bottom of the basin pond for oxygenation wastewater 48 hours working with interval time half hour 4 times per a day, for providing necessary air for aerobic bacteria for decomposing the loaded suspended organic materials in wastewater.

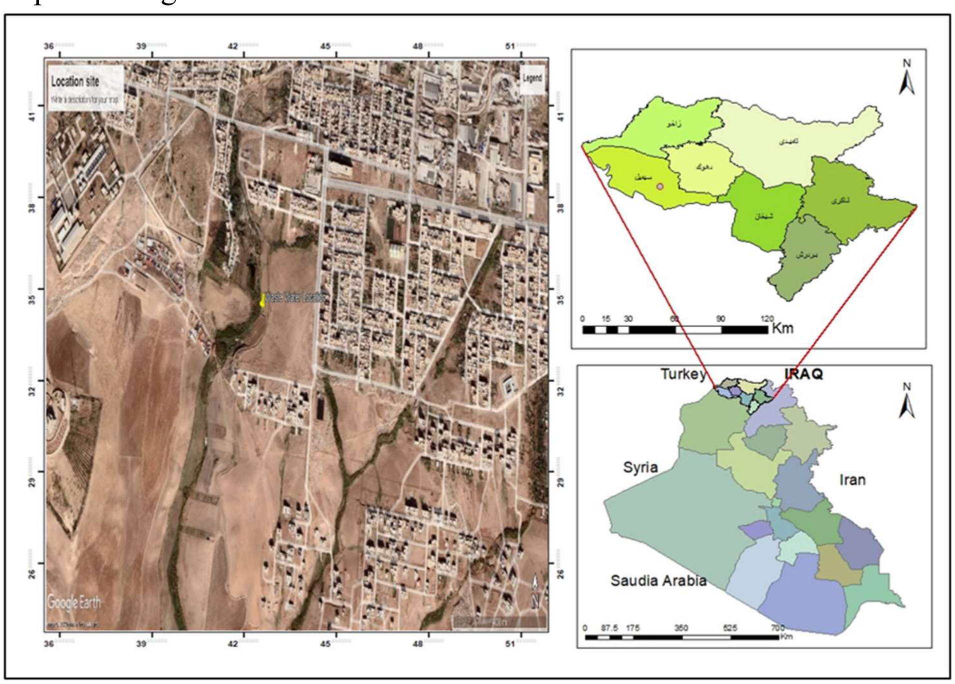


Fig. (1). The location of collecting wastewater sample and study area.

Filtration stage

After aeration process, the aerated wastewater was passed through both filters which has been prepared as mentioned previously, the filtered water was collected in a collection tank as shown in figure (2).

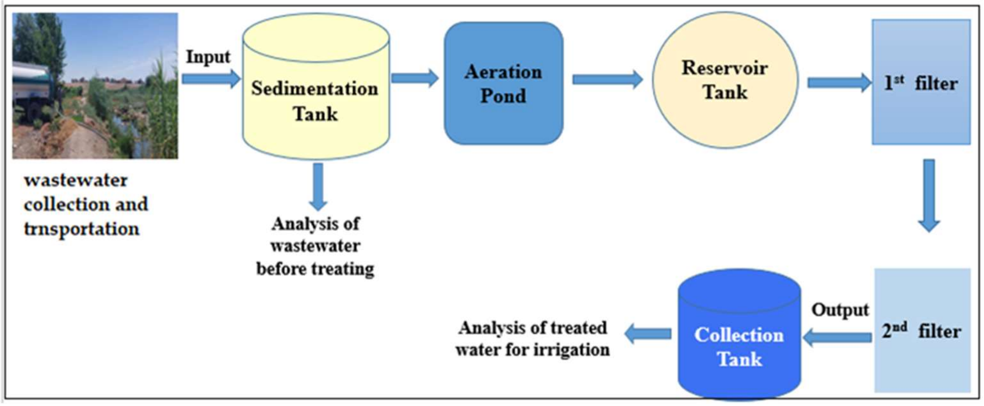


Figure 2. Scheme work flow of the of wastewater treatment steps

Analyzing of wastewater before and after treating

The studied water quality parameter of wastewater before and treated wastewater, included following physical and chemical tests, Turbidity, by turbo meter 550, pH by pH meter, electrical conductivity by conductivity meter, phosphorous (P) by spectrophotometer using ammonium vanadium, TDS, and TSS. dissolve oxygen (DO), by oximeter- multi3420, biological oxygen demand (BOD5), chemical oxygen demand (COD), according standards recommended method of (APHA 1998). Concentration of cations (Ca and Mg by titration method with FDTA 0.01N, Na and K, by flame photometer), and anions (SO4 by spectrophotometer using barium chloride, Cl by titration method with AgNO3 using potassium chromate as an indicator, HCO3, CO3 by titration method with HCl 0.01 N). The water temperature was measured by the mercury thermometer, according (APHA,2005). While, residual sodium carbonate RSC, salinity potential SP, and sodium adsorption ratio SAR, were calculated using following equations:

$RSC meq/L = (CO3 + HCO3) - (Ca + Mg)$ .... [1] (Richard, 1954)

$SP\ meq/L = \left(CL + \frac{1}{2}\ SO4\right)$ .... [2] (Doneen, 1954)

$SAR = \frac{Na}{\sqrt{Ca+Mg/2}}$.. [3] (Wilcox, 1955)

The efficiency of filter was calculated using the following equation:

$Filter\ efficiency\% = (C1 - C2/C1) * 100$ .... [4] (Bilek, 2013)

Where:

C_1= concentration of element before treating and

C_2 = concentration of element after treating

Results and Discussion

1- pH and (EC dS.m^{-1}).

Figure (3) show the pH and EC value. Electrical conductivity EC (ds.m-1) consider as an important indicator for the presence of dissolved material in water, and the EC value reduced from (1.91 to 1.24) dS.m-1 after treating wastewater because of the reducing of the concentration of ions in treated water such as sodium, chlorine, calcium, magnesium, and potassium, similar result was shown by (Hassan and Umer, 2022) for treating landfill leachate. The efficiency of the filter for reducing the value of electrical conductivity was 35.08% table (1). EC value before and after treating was located between the Permissible range for irrigation, (Ayers and Westcot 1985).Where the pH value in wastewater was 6.96 and in treated water the pH value was increased to 7.9, the increasing in pH value in treated water is may be due to the increase in some component after aeration processes such as nitrate (NO3) and activity of microorganisms that lead to an increase in alkalinity this result is in agreement with that recorded by (Suaad and Hassan, 1999). Before and after treating the pH value located between the acceptable range (6.5-8.4), (Ayers and Westcot 1985).

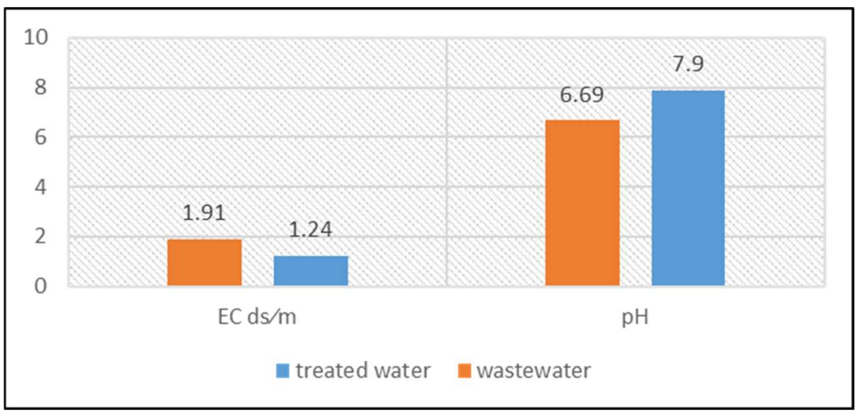


Figure 3. EC and pH value before and after treating water.

Table1. Some physicochemical of water before and after treating, and efficiency of the filter.

Parameters	Units	Wastewater	Treated water by aeration and filtration	Filter efficiency %
pH	-	6.69	7.90	-
EC	dS.m^{-1}	1.91	1.24	35.08
TDS	mg.l^{-1}	1223.6	795.3	35.00
TSS	mg.l^{-1}	440.34	140	68.21
Temperature	˚C	37	35	5.41

Turbidity	NTU	283.6	4.11	98.55
DO	$mg.l^{-1}$	0.99	6.34	-
COD	$mg.l^{-1}$	123	76.22	38.03
BOD	$mg.l^{-1}$	60.62	36.8	39.29
Ca^{2+}	$Meq.l^{-1}$	6.8	3.6	47.06
Mg^{2+}	$Meq.l^{-1}$	9.2	6.2	32.61
K^{+}	$Meq.l^{-1}$	0.87	0.8	8.05
Na^{+}	$Meq.l^{-1}$	3.14	2.98	5.10
Cl^{-}	$Meq.l^{-1}$	7.3	3.1	57.53
HCO_3^{-}	$Meq.l^{-1}$	6.6	6.8	-
CO_3^{2-}	$Meq.l^{-1}$	0.6	0.8	-
SO_4^{2-}	$Meq.l^{-1}$	4.73	3.88	17.97
NO_3^{-}	$mg.l^{-1}$	49.6	74.4	-
P_2O_5	$mg.l^{-1}$	4.13	3.92	5.08
SAR	-	1.11	1.34	-
SP	$Meq.l^{-1}$	9.67	5.04	47.88
RSC	$Meq.l^{-1}$	-8.8	-2.2	-

2- (TDS and TSS mg. L-1).

Total dissolved solid consider as a good indicator of the salt content in water, the more TDS concentration the intensive salt content in water. Fig. (4) appear that the treating processes affected on the concentration of TDS value and its value decreased from (1223.6 to 795) mg. L-1 where these values are suitable for irrigation purposes before and after treatment, according to (AFA, 1996), this may be attributed to the aeration and filtration processes, this result are in agreement with this that recorded by (Hassan and Umer, (2022). The differences between the TDS value before and after treating represent the efficiency of the filter for reducing TDS which was 35% table (1).

The value of Total suspended solids before treating was 440.34 mg. l-1 and the value of TSS after treating was 140 mg. l-1 fig. (4). The solid wastes that are excreted with the liquid wastes are the reasons for the high concentration of suspended solids in water. The decreasing in concentration of TSS may be due to sedimentation of materials in sedimentation basin and also due to filtration processes, these results are agreed with those interpreted by (Hassan and Umer, 2022). The efficiency of the filter for reducing the TSS value was 68.21 % table (1).

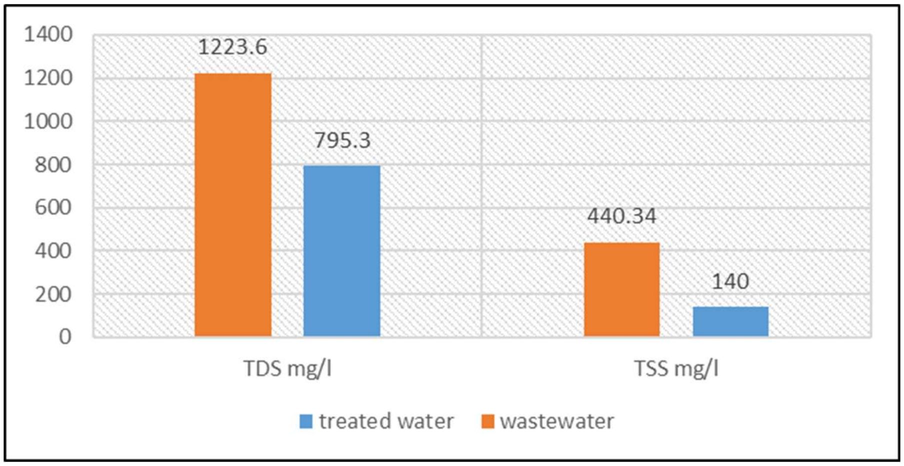


Figure. (4). TDS and TSS (mg. l-1) value before and after treating water.

3- Turbidity (NTU) and temperature °C.

Turbidity reflected the amount of total suspended solid and degree of the decomposition of organic material in wastewater, the more turbid water means content more organic compound. Also, high turbidity has variety of negative effects on various methods of water use and treatment as represented in figure (5). The turbidity of water reduced significantly from (283.6 to 4.11) NTU, this may be due to the precipitation, aeration and filtration processes also may be attributed to the effect of pH value. The turbidity removal increased with increasing pH because in higher pH there is a tendency toward sedimentation and fundamentally alkaline basic is a suitable place for sedimentation which agreed with the finding of (Koohestanian et al, 2008). The efficiency of the filter for reducing turbidity was (98.55%) figure (1), turbidity value after treating was located between allowed limit, which was 5 NTU, (WHO, 1996).

The temperature of the water reduced from (37 to 35) °C figure (5), due to the aeration processes, as well as, the water temperature affected by the weather. These results are similar to those recorded by (Hart, and Zabbey, 2005). Both processes of aeration and filtration through filters reduced the temperature value of the water by (5.41%), this may be demonstrated as the organic materials (OM) in the wastewater decomposed by aquatic microbes because of aeration process, and due to the decomposition process is exothermic which led to generate heat and increases the water boy temperature. As the quantity of decomposing materials decreased in wastewater with decomposing most of OM in wastewater, thus, the decomposing rate of OM decreased due to there is no or less amount of OM available to be composed by aquatic microbes.

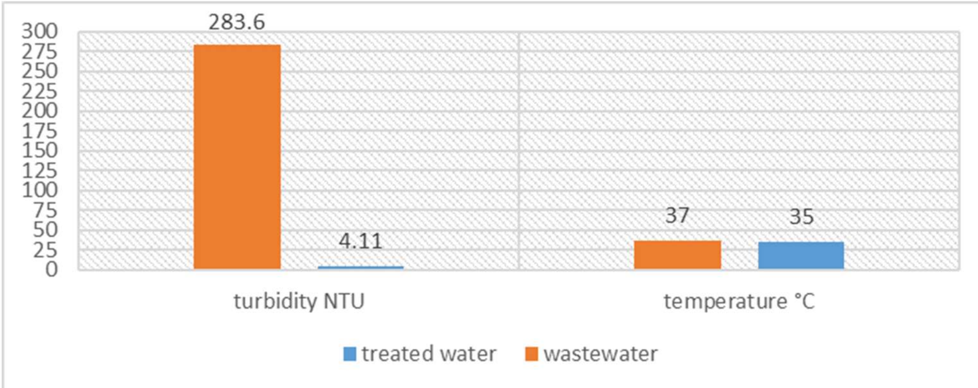


Figure 5. turbidity and temperature before and after treating water.

4- Biological oxygen demand BOD, chemical oxygen demand COD, and dissolve oxygen DO.

Biological oxygen demand considers as one of the most important indicators of the water suitability for aquatic life, as well as, the pollution of water body with organic loads, requires dissolved oxygen for decomposition by aquatic microorganisms. Figure (6) show that the BOD value reduced after treating processes and its value changed from (60.62 to 36.8) mg. l-1. The COD and DO value before treating was (123 and 0.66) mg. l-1, while the value of COD decreased to (76.22 mg. l-1) after aerating and filtration process, this may be attributed to its consumption by aquatic microbes for decomposing OM. The efficiency of filters in reducing BOD and COD was (39.29 and 38.03) % respectively table (1). The BOD, COD and DO after treating is in acceptable range for irrigation purposes according to (WHO, 1996). When the DO value increased to (6.34 mg. l-1) after treating wastewater through aeration and filtration processes. This decrease of COD in treated wastewater is refer to aeration processes which provides the aquatic microbes with their requirement from oxygen as dissolved oxygen in enough amount for decomposing OM. While, an increasing in DO in water after treating wastewater may refer to reducing the activity of aquatic microbes due to consumption most of the decomposable OM in water body through the early stages of decomposition that requires high amount of oxygen, in contrast in the late stage of decomposing OM the DO is increased due to consumption of DO in water by aquatic microbial decreased because there is no or less amount of decomposable OM in the water body, therefore the DO increased in water body. These results are in agreement with those recorded by (Hassan and Umer, (2022).

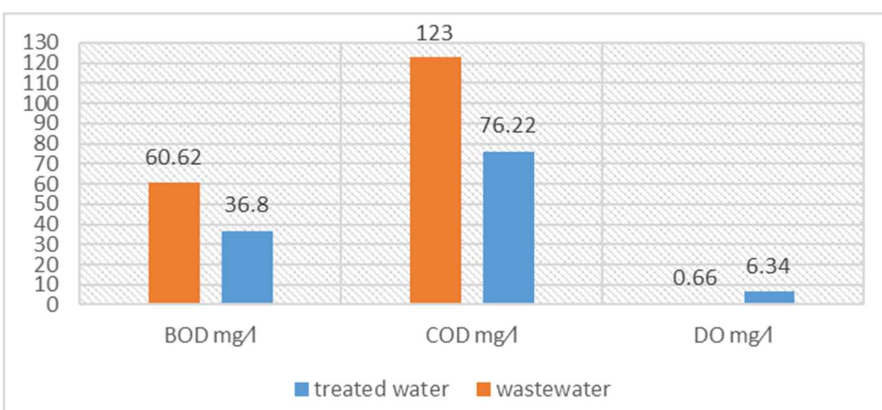


Figure 6. Biological oxygen demand, chemical oxygen demand, and dissolve oxygen before and after treating water.

5- Concentration of cations (Ca+2, Mg+2, Na+, and K+) Meq.l-1.

The excess amounts of cation in water increases the salinity of irrigation water finally effects on the soil properties. Figure (7) show the concentration of cations (Ca2+, Mg2+, Na+, and K+) in wastewater before treating and in water after treating wastewater, which were changed from (6.8, 9.2, 3.14, 0.87 to 3.6, 6.2, 2.98, 0.8) Meq. l-1. The chemical composition of wastewater was characterized by the predominance of magnesium and calcium ions. This reduction in ion concentration may be due sedimentation, aeration and filtering processes, their concentrations before and after treating were located in acceptable range suggested by (WHO, 1996). The filter efficiency for reducing the concentration of cations (Ca2+, Mg2+, Na+, and K+) was (47.06, 32.61, 5.10, and 8.05) % respectively. Thus, the processes of faltering is slightly good and efficient in removing Ca2+and Mg2+ and in lesser degree for removing of Na+, and K+, this may refer to that their original concentration in wastewater is low in comparing with concentration of Ca and Mg in wastewater that reduces their competition on the exchange sites of the active charcoal, due to the roles of cation exchange which suggested (Gouy and Chapman, 1910) Cited by (Awad, 1986), which text that higher one in concentration and valance will replaces the lower one in concentration and valance, irrespective to their hydration shell radius, when the concentration of an ion is high it will replaces the lower one in concentration and when they are same in concentration the higher one in valance will replaces the lower one, while when both concentration and valance are same the lower on in hydration shell will replaces the higher one

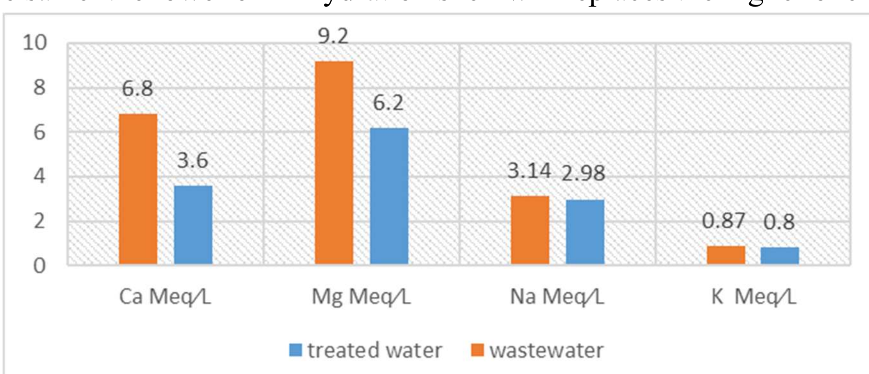


Figure 7. Concentration of cations (Ca+2, Mg+2, Na+, and K+) Meq.l-1 before and after treating.

6- Concentration of anions (CO3=, HCO3-, SO4=, and Cl-) Meq.l-1.

Figure (8) demonstrate that the concentration of CO3= and HCO3-, were increased from (0.6 and 0.8) Meq CO3=.l-1, to (6.6 and 6.8) Meq HCO3-. l-1, before and after treating processes of aeration and filtration respectively. This rises in CO3= and HCO3- concentration in waster body may be refer to the decomposition of organic material in wastewater by aquatic microbes, releasing CO2 which dissolved in water forming carbonic acids H2CO3 and the last is not stable dissociated t0 form CO3= , HCO3- and HCO3- may dissociate to form H+ and CO3= but the dissociation of

HCO3-was very low as shown in figure (8) as well as, may be due to the existence of CaCO3 in wastewater which dissociated slightly to Ca2+ and CO3= due to change in the pH value of the water toward alkalinity. After treating processes, the concentration of SO4=, and Cl- reduced from (4.73 and 3.88) Meq SO4=. l-1 to (7.3 and 3.1) Meq Cl-. l-1 respectively. The efficiency of filter for reducing Cl- concentration is much more of that SO4= which were reduced by (57.53 and17.97) % respectively. The higher reduction for Cl- concentration after aeration and filtration which increases it volatilization as well as, may refer to increase in the temperature of the water during decomposition process due to increase in the temperature which enhances its volatilization that decreased its concentration in water after treating. While the slight decrease of SO4= concentration after treating processes wastewater may be attributed to oxidation, chemical reaction with other cations especially Ca2+ and Mg2+ forming ion pairs in water and complexes that precipitated in sedimentation pond as well as due to their consumption by aquatic microbes. These results are going with those mentioned in (APHA, 2003).

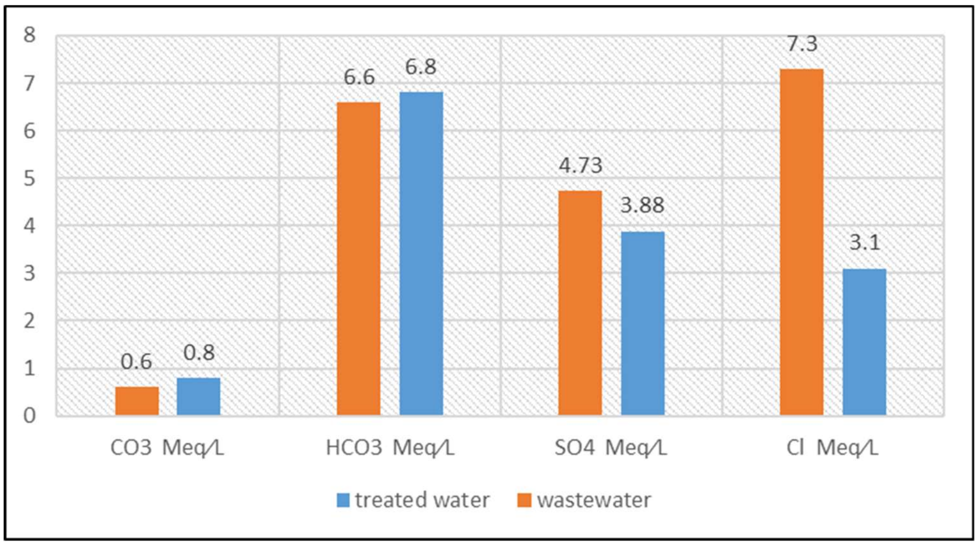


Fig. (8). Concentration of anions (CO3=, HCO3-, SO4=, and Cl-) Meq.l-1. Before and after treating.

6- Concentration of phosphorous and nitrate (P and NO3) mg. l-1.

Depending on the figure (9) the treating processes slightly influenced the concentration of P in wastewater. The P concentration changed from (4.13 mg. l-1) before treating to (3.92) mg. l-1, after treating. The removal of phosphorous did not affected by aeration and filtration processes. The differences between P concentration before and after treating was very low and the efficiency of both processes of aeration and filtration in reducing P concentration was 5.08% table (1). this may be attributed to that the effect of the pH value of the wastewater before and after treating on the P forms in the wastewater, when the pH value of the wastewater was slightly acidic (6.69) that indicated to dominant forms of P are H2pO4- while after treating the pH value of the treated water increased to (7.9) table (1), that means the H2pO4= form is the dominant, both forms are negatively charged ions, and didn’t exchange to the surface of the active charcoal which is negatively charged, due to repulsion force between both negative charges of active charcoal and P anions in the water therefore stay free in water according suggested roles of ion exchange by (Gouy and Chapman, 1910) Cited by (Awad, 1986)While the slight changes in its concentration may refer to P consumption by aquatic microbes for their activities and propagation. For removing P from wastewater need to use an advanced methods as treating with chemicals for precipitation. Similar results water recorded by (Hassan and Umer, (2022).

Nitrate concentration increased after treating processes from (49.6 to 74.4) mg. l-1, an increase in the concentration of nitrate in treated wastewater may attributed to the oxidation organic nitrogen compound and its transformation to nitrate through nitrifying NH4+ to NO3-, due to aeration process and microbial activity. These results are in consistence with those obtained by (Weiner, 2000).

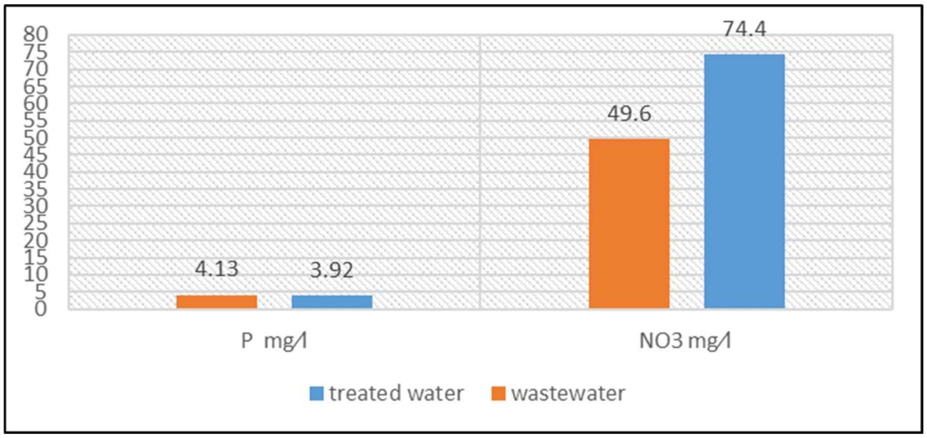


Figure 9. Concentration of (NO3 and P) Meq.l-1. Before and after treating.

7- Residual sodium carbonate RSC, salinity potential SP, sodium adsorption ratio SAR.

Depending on figure (10) the value of RSC which increased from (-8.8) Meq.l-1 to (-2.2) Meq.l-1. The lower value of RSC before treating processes refer to high concentrations of Ca2+ and Mg2+ in wastewater before treating and the an increasing in the value of RSC after treating processes may refer to reducing concentration of Ca2+ and Mg2+ in treated water after aeration and filtration processes and increasing concentration of bicarbonate after treating in comparing with HCO3- concentration before aeration and filtration processes. The RSC values before and after treating treating are located within permissible range (< 1.25 Meq. l-1) suggested by (Wilcox 1955). SP and SAR are to important water quality parameters used for identifying water suitability for irrigation purpose. The SP of the treated wastewater obviously decreased after aeration and filtration processes from (9.67 to 5.04) Meq. l-1 this may attributed to that the concentration of Cl- and SO4= reduced after treating processes due to aeration processes and filtration processes. The salinity potential after treating wastewater located within allowed value (< 7 Meq. l-1) as described by (Doneen 1954). The filter efficiency for reducing SP value was 47.88%, table (1). The SAR value after treating wastewater slightly increased and changed from (1.11 to 1.34) this small differences in its value may can be referred to the filter efficiency in reducing the amount of calcium and magnesium more than sodium due to Ca2+ and Mg2+ exchange on the cation exchange sites of the active charcoal more than Na+ as mentioned before due to the roles of cation exchange on the surface of the negatively charged substrates suggested by water (Awad, 1986).

SAR values before and after treating wastewater are located within acceptable rang for irrigation purpose according to (Ayers and Westcot, 1985) classifications.

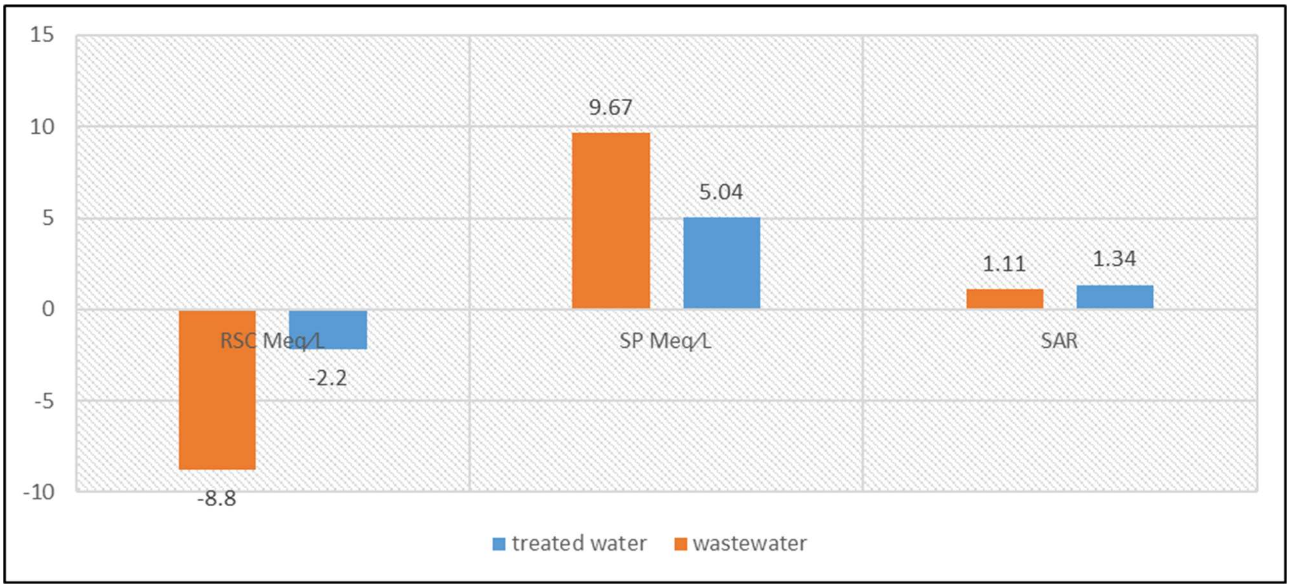


Figure 10. the value of Residual sodium carbonate RSC, salinity potential SP, sodium adsorption ratio SAR.

Conclusion

The current study provided a valuable insight into the physical and chemical properties of wastewater before and after treating, and it can concluded that treating wastewater biophysically (sedimentation, aeration and filtration with sand filter containing active charcoal), can sufficiently reduce or removing the laden impurities from organic and inorganic substrates by the wastewater and to be recycled and improve its quality to be used for irrigation purposes, due to these processes were efficient in reducing concentration of unfavorable ions and high OM to below the permissible limits of WHO and FAO for irrigation purpose, When some parameters require to be treated by additional advance physicochemical materials for flocculation and coagulation that led it to precipitate and settle down to be easily separate and removed.

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