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RESEARCH ARTICLE

Assessment of the physicochemical and toxic trace metals of sewage effluents: A case study from Sohag governorate, Egypt

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Abstract

The objective of this study was to assess the physicochemical parameters of effluents from sewage treatment plant effluents: A case study from Sohage Governorate, Egypt. Additionally, the levels of heavy metals were evaluated. The quality of effluent from the sewage treatment plant was assessed to determine the effect that may have appeared on environmental pollution. Effluents were sampled before treatment and after treatment were collected and analyzed for pH, total dissolved solids (TDS), biochemical oxygen demand (BOD), dissolved oxygen (DO), nitrates, phosphate, oil and grease. After treatment, the average values were 7.4 and 8.08 for pH, 523 and 484 for TDS, 45 for NO_3, 8 and 9 for NO_2, 171 and 24.1 for BOD, 227 and 72.5 for COD, 22 and 5.5 for oil and grease, 5.4 and 9.2 for TKN, and 2.8 and 0.19 for PO_4, 3.9 and 0.22 for H_2S, and 0.5 and 4.28 at west Sohag and El-Cola treatment plant, respectively. Most of these parameters, including BOD, COD,total Kjeldahl nitrogen (TKN), PO_4, H2S and oil and grease at west Sohag sewage treatment plant, DO at El-Cola, NO_2 and NO_3 at two treatment plants, were above the Egyptian standards. However, the results indicate that the estimated concentration of heavy metals (Al, Cu, Fe, Li, Mn, Ni, Pb, Se, Cd, Zn, Cr, Hg, V, Co, Br, Mo) in waste disposal (final seepage) are generally low at the two treatment plants and they do not exceed the permissible limits for the Egyptian code. It could be concluded that caution must be taken during the discharge of poor-quality effluent (especially from west Sohag treatment plant) into the environment.

Keywords: Physicochemical characteristics; Sewage treatment; Heavy metals; Biochemical oxygen demand; Dissolved oxygen .

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Introduction

Water is essential to life. Yet water pollution is one of the most serious ecological threats the world face today. Water pollution is defined as the occurrence of changes in the nature, quality and properties of water, which makes it unfit to our use, this occurs by mixing with polluted substances such as: chemical or bacterial contaminants, or even in the form of thermal or radioactive energy for different aquatic ecosystems, whether they are groundwater or Surface water such as lakes, streams, rivers, estuaries and soils , addition to the waste floating on its surface, but in other cases it does not show any signs indicating Contaminate it ,because it is saturated with chemicals which cannot be seen .

Due to progressive industrial developmental activities and increasing population growth, resources are declining day to day throughout the world, all current studies, recycling and reuse to reduce the existing load on resources, instead of polluting them through discharging wastes by its initial form on water and land. The reuse of wastewater for agricultural irrigation purposes reduces the amount of water that needs to be extracted from water resources (USEPA 1992).

This work aimed to study the acceptance of treated wastewater (final seepage) from the main two plants compared to the Egyptian standards. However, such wastewater exerts most of the nutrient load and could be used as irrigation water for certain crops, trees and plants which may lead to an increase in agricultural produce and plantation. It has the potential to supply (organic) carbon nutrients (NPK) and (inorganic) micronutrients to support crop/plant growth. In agriculture practices, irrigation water quality is believed to have an effect on the soil characteristics, crops production and management of water (Gregory 2000; Sheinberg 1987) Particularly. The sewage treatment plants aim to convert the water from the toxic shape to the degree that can be used in the irrigation and growth of some plants, in addition to the optimum utilization of the quantities of water in its correct place, by passing through the following treatment stages: 1) A primary treatment:

using screen to the large volumes of waste received (FAO 2006), 2) Secondary treatment, was done by using either oxidation lakes or using activated sludge to break down and treat particles, The efficiency of treatment in the plants is about 65%, and 3) Tertiary treatment: which is water filtrated and chlorine addition., then this water is used to irrigate some types of woody trees of economic value (Yerasi 2013).

Due to mining, smelting, manufacturing, use of agricultural fertilizers and pesticides, municipal waste, traffic emissions, and industrial effluents Contamination of soils by heavy metals is now widespread (Al Naggar 2013) Land degradation caused by heavy metals has significant adverse effects on the environment and ecosystem worldwide (Li 2013; Chen 2015).

Materials and methods.

Four samples analysed, Size of the one sample is 1000 ml, 750 analysed for physicochemical properties and 250 refrigerated to analysing the heavy metals, four samples resembling (untreated sewage El Cola) (Treated seepage El Cola) (untreated sewage El Deir) (Treated seepage El Deir), analysed according to standards methods for water and wastewater - version 23 edition, 2017, PH - Temperature - Odor- TDS by Measured by THERMO SCIENTIFIC – USA – Orion 2-Star Oil and grease according to (S.M. part 5520, p 5- 41 2017) Total Suspended Solids Dried at 103–105°C according to (S.M. Part 2520, p 2-59 2017) Sulphides S- according to (S.M Part 4500, p 4-181 2017) Ammonia NH_3 according to (S.M. part 4500, P 4-114 2017) Nitrite NO_2 according to (S.M. part 4500, p 4-124 2017) Nitrate NO_3 according to (S.M. Part 4500, p 4-26 2017) Phosphorus according to (S.M. Part 4500, p4 -156 2017) Dissolved oxygen by WTW – Germany - Oxi 730 Chemical oxygen demand according to (S.M. Part 5220, 5-17 2017) Lovibond – Germany- Check it Direct RD 125 Biological oxygen demand according to (S.M. Part 5000 ,5-5 2017) Bod bottles of a known capacity.

Results and discussion

Wastewater is a complex of mixed liquid generally containing many types of pollutants, the greatest threats arise from heavy metals, nitrate, pathogens, toxic organic and inorganic materials and salts.

Physicochemical characteristics:

Result of the physicochemical analysis of 12 parameters to the one site, wastewater final seepage resembling fig (1), (2), (3) from (a) to (d) show significant variability on the two sites as they are semi-variable on the treatment process, compared to the Egyptian standard (Egyptian code 2013), recording that the values of physicochemical parameters in the two sites have no effective risks, except 9 parameters of them show moderate-higher percentage, value recording as the following: -

pH degree

pH value of untreated seepage is 7.26 and treated seepage on EL Deir records 7.4 these values is acceptable While treated seepage on EL cola is moderate-high it records 8.08 at the time the Egyptian standard is 8.0 PH is important as precipitation of heavy metals from the wastewater is a achieved through several values of pH-solution depending upon the nature of ions, Soil pH affects the amount of nutrients and chemicals that are soluble in soil water, and therefore the amount of nutrients available to plants. Some nutrients are more available when a plant's soil

pH increases, if pH is too high, the plant's ability to absorb certain nutrients is disrupted., As a result, some nutrients cannot be absorbed properly, including calcific limestone (which is mostly calcium carbonate), and dolomitic limestone (which also adds magnesium to the soil). Both work equally well at raising soil pH (Mc Cauley et al. 2017) But in our study, the soil may be affected by becoming alkaline, alkali soil can treat with gypsum (Anonymous 1954).

Total Dissolved Solides (TDS)

TDS on the untreated seepage is 578 mg per liter, El Deir record 523 mg per liter, El Cola record 484 mg per liter, treatment of seepage success removing about 55-90 mg per liter T.D.S the Egyptian standard is 2000 mg per liter TDS, this value acceptable according to the Egyptian standard.

Biochemical Oxygen Demand (BOD)

BOD is a measure of the amount of oxygen required to remove waste organic matter from water in the process of decomposition by aerobic bacteria (those bacteria that live only in an environment containing oxygen), treated seepage on El Deir 171 mg per liter this value is high according to the Egyptian standard, treated seepage on El cola 24.1 mg per liter while the Egyptian standard is 60 mg per liter on the treated seepage. BOD depends on the activity of bacteria in the sewage. These bacteria feed on and consume organic matter in the presence of oxygen, BOD can also be defined as the amount of oxygen required by the micro-organisms in the stabilization of organic matter, BOD of raw sewage is 300-600 mg/liter. BOD on untreated water is 362 mg per liter.

Chemical Oxygen Demand (COD)

COD is the chemical oxygen demand (COD). COD on the untreated water record 641 mg per liter, on treated El Deir 227 mg per liter, this value is non-accepted to the treatment process, treated El Cola 72.5 mg per liter and the Egyptian standard is 80 mg per liter. The COD test is often used to monitor water treatment plant efficiency. The COD is the amount of oxygen consumed to chemically oxidize organic water contaminants to inorganic end products, Higher COD levels mean a greater amount of oxidizable organic material in the sample, which will reduce dissolved oxygen (DO) levels, A reduction in DO can lead to anaerobic conditions, which is deleterious to higher aquatic life forms.

Oil and grease

Oil and grease include fats, oils, waxes, and other related constituents found in water, generally, wastewater, these compounds in the untreated wastewater is 70.8 mg per liter, treated seepage in El Deir is 22 mg per liter this value is high and should raise the efficiency of oil and grease removal unit, treated seepage in El cola is 5.5 mg per liter, Egyptian standard is 10 mg per liter. Oil and grease floating oil is removed by either skimming the surface in the skim tank or by gravity separation, occur putting the liquid into a container and begin slowly draining the water into another container, following the unit responsible to process oil and grease on El Deir plant found that the unit is not working properly.

Total Kjeidahl Nitrogen (TKN)

TKN is a parameter used to measure organic nitrogen and ammonia, TKN untreated water is 50 mg per liter, treated seepage on El Deir 54 mg per liter it considered a high value, treated seepage on El Cola is 9.2 mg per liter, while Egyptian standard 7.06 mg per liter. The TKN content of influent municipal wastewater is typically between 35 and 60 mg/L, it also defines as the sum of organic nitrogen, ammonia (NH_3), and ammonium (NH_4+) in the chemical analysis of soil, water and wastewater The main source of ammonium is the urine, ammonium by the process of nitrification transformed to nitrite (NO_2) and then (NO_3). the leaching potential of NO_3 within the soil system depends on many factors, which the soil texture is most important (Smith et al. 1991) So, ammonium may be useful to soil fertility.

Phosphorus (PO_4)

PO_4 on untreated water is 15 mg per liter, on treated seepage El Deir 2.8 mg per liter this value is moderate-high, treated seepage on El cola record 0.19 mg per liter while Egyptian standard is 1 mg per liter. The main sources of phosphorus in wastewater are human excreta, phosphorus-containing household detergents and some industrial and trade effluents, Precipitation runoff only little contributes to loads in wastewater if combined sewer systems are applied, El Deir record a 2.8 mg per liter PO_4 this is a highly moderate value while PO_4 can be a good nutrient to the soil.

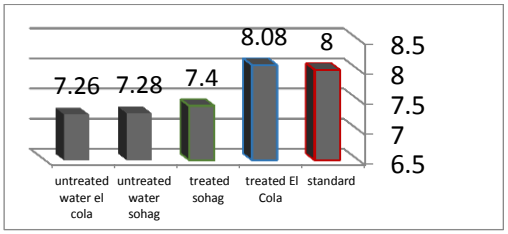
Hydrogen Sulfide(H_2S)

H_2S on the untreated water is 6.3 mg per liter treated seepage on El Deir is 3.9 mg per liter this is high amount of gas - treated seepage on El cola is 0.22 mg per liter, Egyptian standard is 1 mg per liter. Because hydrogen sulphide gas escapes rapidly from water to cause an odour, it may also be removed from the water by aeration, El Deir is 3.9 mg per liter H_2S this is a high amount and fatal problem.

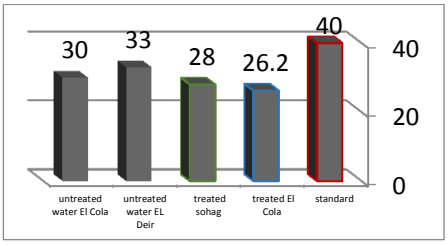
Dissolved oxygen (DO)

Dissolved oxygen (DO) is a relative measure of the amount of oxygen (O_2) dissolved in water, The oxygen content of water will decrease when there is an increase in nutrients and organic materials from industrial wastewater, sewage discharges, and runoff from the land, DO On the untreated wastewater is 0.25 mg per liter, treated seepage on El Deir is 0.5 mg per liter, treated El cola 4.28 mg per liter this value is moderate-high, the Egyptian standard is 4 mg per liter. Dissolved oxygen (DO) El Deir records a Decrease on D.O value, we can increase dissolved oxygen by aeration system, which can lead to decreased levels of biologically available oxygen we can overcome it by aeration.

These results indicate that the estimated measure of physicochemical characteristics is permeable in some and high to moderate high in others, Most of these parameters, including BOD, COD, TKN, PO_4, H_2S and oil and grease at west Sohag sewage treatment plant, DO at El-Cola, NO_2 and NO_3 at two treatment plants were above the Egyptian standards.



(a) PH



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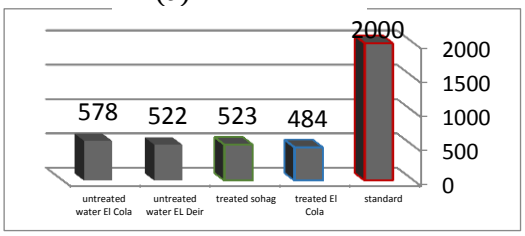
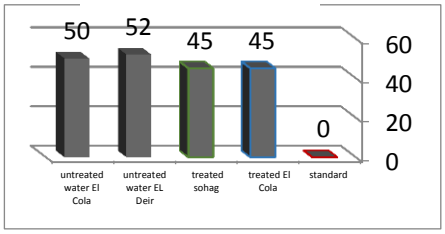
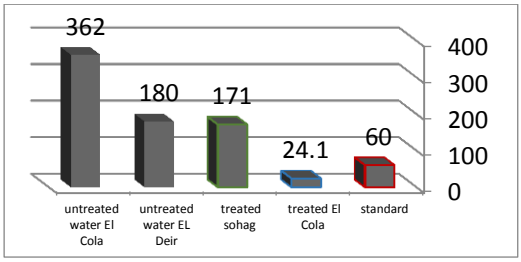


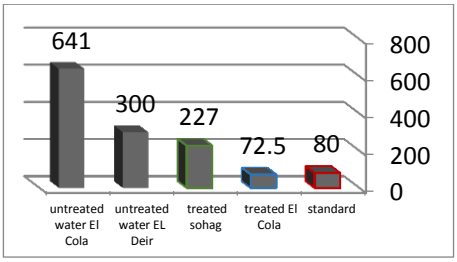
(C) T.D.S



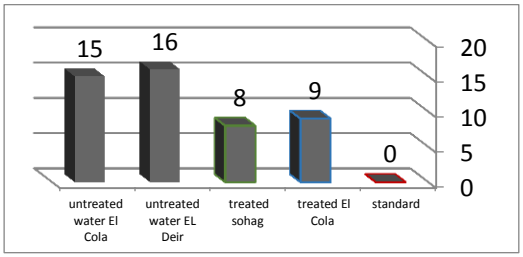
(d) NO_3



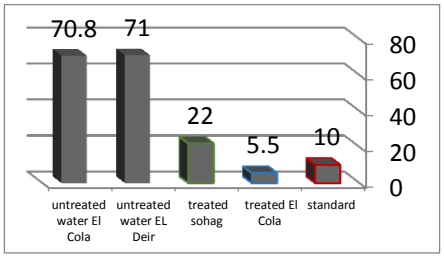
(e) B.O.D



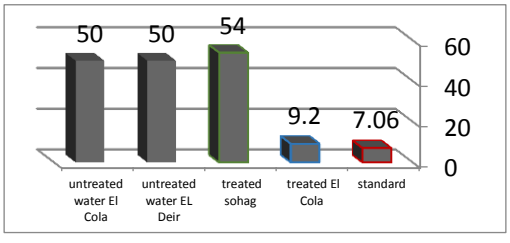
(f) C.O.D



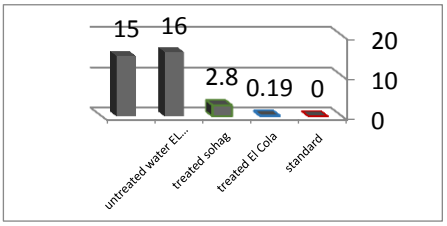
(g) NO_2



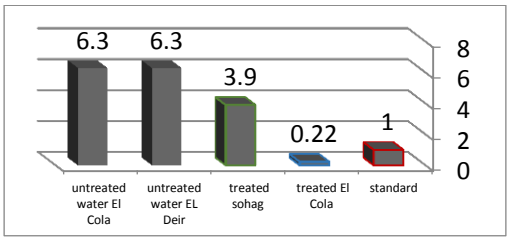
(h)Oil and grease



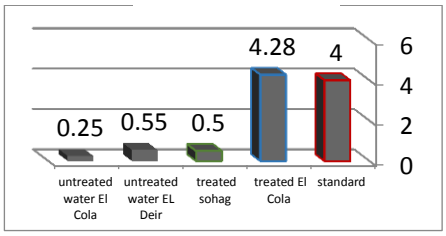
(I)T.K. N



(j)po_4



(k)H.S



(l)D. O

Figure**1.** Assessment of untreated, treated sewage physicochemical parameters and their criteria.

Evaluation of heavy metals concentrations.

The results in Table 1 showed the concentrations of Al, Cu, Fe, Li, Mn, Ni, Pb, Se, Cd, Zn, Cr, Hg, V, Co, Br, Mo at treated seepage El cola accounted for 0.05, 0.01, 0.2, 0.01, 0.05, 0.001, 0.001, 0.002, 0.001, 0.2, 0.001, 0.001, 0.001, 0.01, 0.01 and 0.01 mg/l, respectively. Meanwhile, the concentrations of Al, Cu, Fe, Li, Mn, Ni, Pb, Se, Cd, Zn, Cr, Hg, V, Co, Br, Mo at treated seepage El cola accounted for 0.15, 0.01 0.6, 0.01, 0.3, 0.001, 0.001, 0.002, 0.001, 0.05, 0.001, 0.001, 0.001, 0.1, and 0.01 mg/l, respectively. The occurrence of heavy metals, due to any reason, in the environment results in hazard ecosystem (Stoica 2020)

These results indicate that the estimated concentration of heavy metals (Al, Cu, Fe, Li, Mn, Ni, Pb, Se, Cd, Zn, Cr, Hg, V, Co, Br, Mo) of waste disposal (final seepage) are generally low at the two sites they do not exceed the permissible limits for the Egyptian code (Egyptian code 2015).

Table 1. The concentrations of trace heavy metals after treatment of sewage wastewater.

Metal	Unit	El Cola	West-Sohag	Limitation
Al	mg/l	0.05	0.15	5
Cu	mg/l	< 0.01	0.01	0.2
Fe	mg/l	0.2	0.6	5
Li	mg/l	<0.01	0.01	2.5
Mn	mg/l	0.05	0.3	0.2
Ni	mg/l	<0.001	0.001	0.2
pb	mg/l	<0.001	0.001	5
Se	mg/l	<0.002	0.002	0.02
Cd	mg/l	<0.001	0.001	0.01
Zn	mg/l	0.2	0.05	5
Cr	mg/l	<0.001	0.001	0.1
Hg	mg/l	<0.001	0.001	0.002
v	mg/l	<0.001	0.001	0.1
Co	mg/l	<0.01	0.001	0.05
B	mg/l	<0.01	0.1	1
Mo	mg/l	<0.01	0.01	0.01
Na	mg/l	125	150	230

Conclusions

A significant increase in some physicochemical characteristics was recorded on the final seepage on El Deir some of it is fatal to the environment and some is a good nutrient (NH_4, PO_4). The results indicate that the estimated measure of physicochemical characteristics are permeable in some and high to moderate high in others. Most of these parameters, including BOD, COD, TKN, PO_4, H_2S and oil and grease at west Sohag sewage treatment plant, DO at El-Cola, NO_2 and NO_3 at two treatment plants were above the Egyptian standards. The main sewage plant (El Deir) must be retreating their maintenance and operation process and must comply their treated water to their standards. These results indicate that the estimated concentration of heavy metals (Al, Cu, Fe, Li, Mn, Ni, Pb, Se, Cd, Zn, Cr, Hg, V, Co, Br, Mo) of waste disposal (final seepage) are generally low at the two sites they do not exceed the permissible limits for the Egyptian code (Egyptian code 2015). The obtained results were very much useful in the identification of problems for sewage wastewater after treatment, The overall performance of the existing was satisfactory for El Cola treatment plant but not for EL Deir treatment plant which is the source of irrigated water to timber trees. It could be concluded that caution must be taken during the discharge of poor-quality effluent (especially EL Deir region) into the environment.

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