

Evaluation of Wastewater Treatment Plant Efficiency and Suitability of Treated Wastewater for Irrigation Purposes at Sirte city, Libya

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ABSTRACT: This study aims to evaluate the efficiency of wastewater treatment plant and the quality of treated wastewater for irrigation purposes at Sirte city in Libya, during November 2012. Samples of wastewater were collected before and after treatment at 8 am and 4 pm of the each day of November. The official methods were followed in collection and analysis of the wastewater samples. The average values of purification efficiency were varied across the measured parameters, where as the lowest and highest values of purification percentage were 3.16 % and 33.45%, recorded for phosphorus (P) and bicarbonates (HCO_3), respectively. On the other hand, the values of pH and chloride were increased by 5% and 33% after treatment, respectively. The most parameters of treated wastewater were found to conform to FAO standards for irrigation water. However, the electrical conductivity (EC), chloride (Cl), sulfate (SO_4), chromium, manganese and molybdenum were found exceeding the severe restriction zone according to FAO standards. The study concluded that using of treated wastewater of Sirte plant for irrigation purposes need appropriate soil–water–crop management strategies as to be used safely.

Keywords: Wastewater, Water Quality, Efficiency, Irrigation, Purification

INTRODUCTION

In many arid and semi-arid areas water is becoming an increasingly scarce resource and the planners are forced to consider any source of water which might be used economically and effectively to promote further agricultural development (Widaa and Saeed, 2008). Recycling of wastewater has emerged as a realistic option to overcome problems related to water shortages and its adverse environmental impacts. However, water-scarce countries will have to rely more on the use of wastewater resources to partly alleviate water scarcity (Qadir *et al.*, 2007). Wastewater reuse could free huge amounts of fresh water currently used for irrigation and make this resource available to meet the growing needs for fresh water for domestic uses.

Municipal wastewater is marginal quality water because of the associated health hazards. It is mainly comprised of 99.9% water together with relatively small concentrations of suspended and dissolved organic and inorganic solids (Pescod, 1992). Wastewater is needed suitable pre-use treatment and appropriate soil–water–crop management strategies when used for irrigation (Qadir *et al.*, 2007).

Water quality refers to the characteristics of water supply that will influence its suitability for specific use. Quality is defined by certain physical, chemical and biological characteristics as stated by Ayers and Westcot (1985). Scherer *et al.*, (1996) reported that water quality for irrigation purposes is determined by its salt content. They also stated that the analysis of water for irrigation should include the cations: calcium, magnesium, and sodium, and anions; bicarbonate, carbonate, sulfate, and chloride. Water high in N can cause quality problems in crops such as barley and sugar beets and excessive vegetative growth in some vegetables (Bauder *et al.*, 2011).

In Sirte City substantial quantities of wastewater are usually discharged to Mediterranean Sea. This amount of water increases day by day due to the increase of population and industrial sector in such towns, so planners and authorities should thinking seriously to find safe disposal of this water instead of to be dumped in the sea. Reuse of this water in Agriculture represents one of safe disposal solution. This study specifically aims to assess the efficiency of the wastewater treatment plant at Sirte city and to investigate the quality of treated wastewater for irrigation purposes.

MATERIAL AND METHODS

The study was conducted at wastewater treatment plant of Sirte city which located at 31.21° E, and 16.59° N, Libya. The area is characterized by 14.1 C° as minimum temperature and 28.2 C° as maximum, while the annual average wind speed is 5 knot and the annual average rainfall is 20 mm.

Composite waste water samples were taken from the effluent before entering the treatment plant and at the final treatment point during November 2012. Samples were taken every two hours starting at 8.00 am and ending at 4 pm during the day. The bottles used for sample collection were cleaned with hot water and suitable detergent, which rinsed with hot water to remove all traces of detergent, and finally were sterilized in an autoclave. The collected samples were brought to the laboratory, filtered and the analysis was done for the determination of bicarbonate and carbonate (HCO_3^- and $\text{CO}_3^{=}$) ions, sulfate ($\text{SO}_4^{=}$), chloride (Cl^-), nitrate (NO_3^- -N), phosphors (P), other major and minor nutrients and heavy metals according to the methods described by Gupta (2007). Also the analysis included pH, electrical conductivity (EC) and (B). SAR and adjSAR were calculated using the following equations according to Ayers and Westcot (1985):

$$SAR = \sqrt{\frac{Na}{\frac{Ca + Mg}{2}}}$$

$$adjSAR = \sqrt{\frac{Na}{\frac{Ca + Mg}{2}} [1 + (8.4 - pHc)]}$$

Where Na, Ca and Mg are in meq/l and pH_c was measured using the following equation as stated by Ayers and Westcot (1985):

$$\text{pH}_c = (\text{pK}_2 - \text{pK}_c) + \text{p}(\text{Ca} + \text{Mg}) + \text{p}(\text{A1K})$$

The treatment efficiency in wastewater treatment plant of Sirte city was evaluated using the average values of influent parameters before treatment as (input), and the average values after treatment as (output) using the following equation according to Duangporn *et al.* (2009):

$$\text{Efficiency\%} = \frac{\text{input} - \text{output}}{\text{input}} \times 100$$

The success of the process, determined by measuring the size of which indicate the quantity of treated wastewater at the exit, as well as water quality, which leads to the entrance facility for treatment. The relationship between these parameters, at the entrance and exit process in order to obtain data on the same level of success of implementation, is called the degree of efficiency of waste water.

RESULTS AND DISCUSSION

The parameters EC, SAR, N, Mg, SO₄, HCO₃ and P of wastewater effluent before and after treatment were detected and used to evaluate the treatment plant efficiency (Table 1). The result showed a great variation in purification of the wastewater constituents. The highest efficiency (33.45%) was recorded for bicarbonate (HCO₃) ions and the lowest one for phosphorus (3.16%). On the other hand, pH and Cl values revealed increment after treatment, (Figures 1, and 3). This results may be attributed to absent or ineffective monitoring system, unskilled labors, weather conditions, weeds and sedimentation (Ball and Widaa, 2013). The increased percentage of Cl after treatment may be attributed to the added chloride material before the final stage as a part of treatment processes. In the same time no noticed variation in the K values (Figure 2).

As presented in Table(2), the quality of Sirte treated wastewater in comparison with FAO standards for irrigation water, showed that the concentrations of EC, NO₃-N, and Cl and SO₄ ions were exceeded the restriction sever level of the FAO standards. Also, the values of Co, Cr, Mn and Mo ions exceeded the levels of the FAO standards (Table 3). The values of pH (figure 1), SAR, adj.SAR (Figure 4), Boron (Table 2), calcium, magnesium and other trace elements (Table 3) were found to conform to FAO standards for irrigation water (Ayers and Westcot, 1985) . The increasing levels of previous mentioned parameters may be due to the variations in the sources of

Table 1: The monitored parameters and purification efficiency of Sirte treatment plant

Parameter	Unit	Before Treatment	After Treatment	Efficiency %
EC	dS/m	4.25	3.654	0.014
SAR	Indicator	6.73	5.83	13.37
N	mg/l	488	403	17.42
Ca ⁺²	mg/l	200	180	10.00
Mg ⁺²	mg/l	122	109	10.66
SO ₄ ⁼	mg/l	787	576	26.81
HCO ₃ ⁻	mg/l	293	195	33.45
P	mg/l	1.012	0.98	3.16

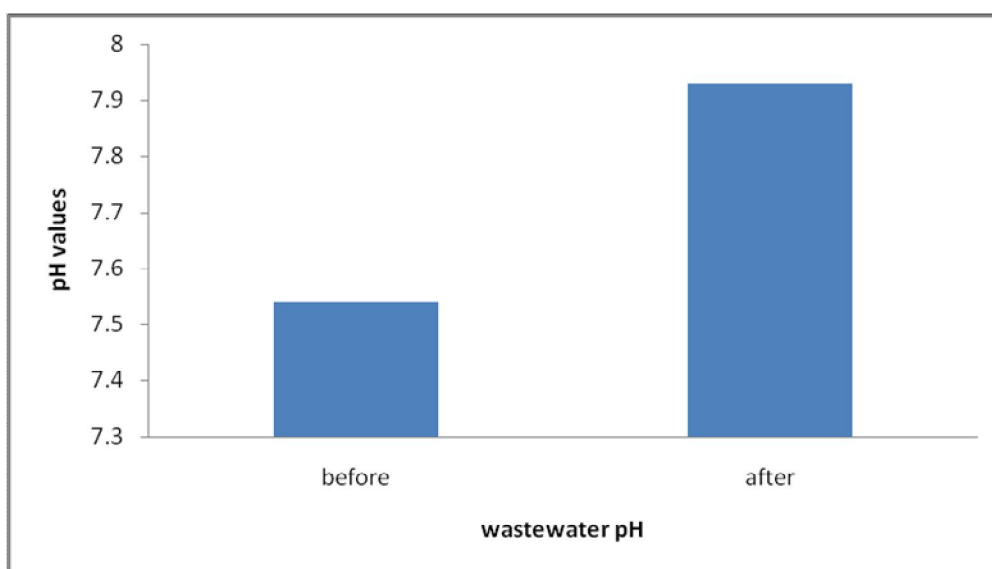


Figure 1: pH values before and after wastewater treatment

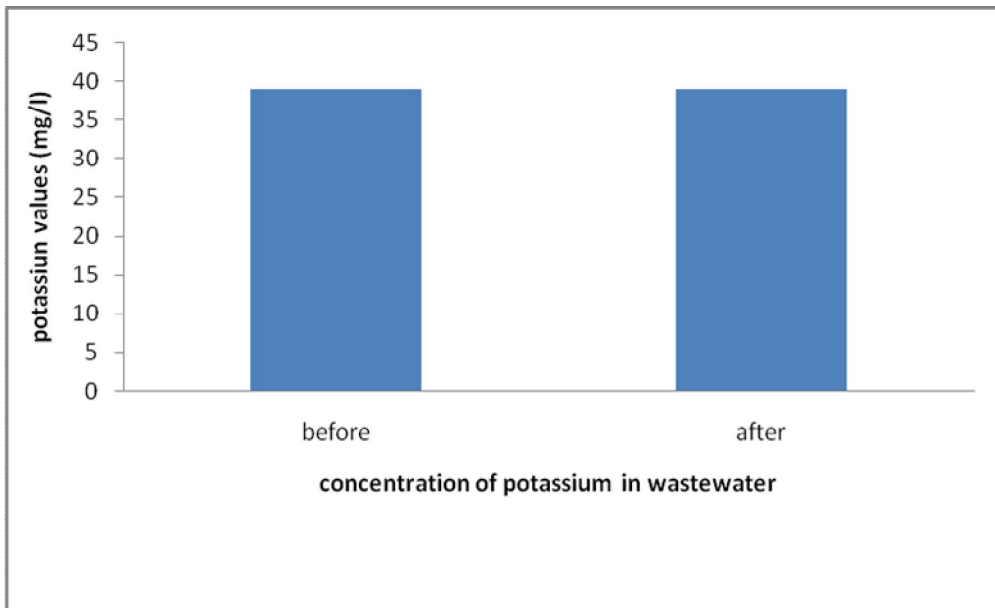


Figure 2: Concentration of Potassium before and after wastewater treatment

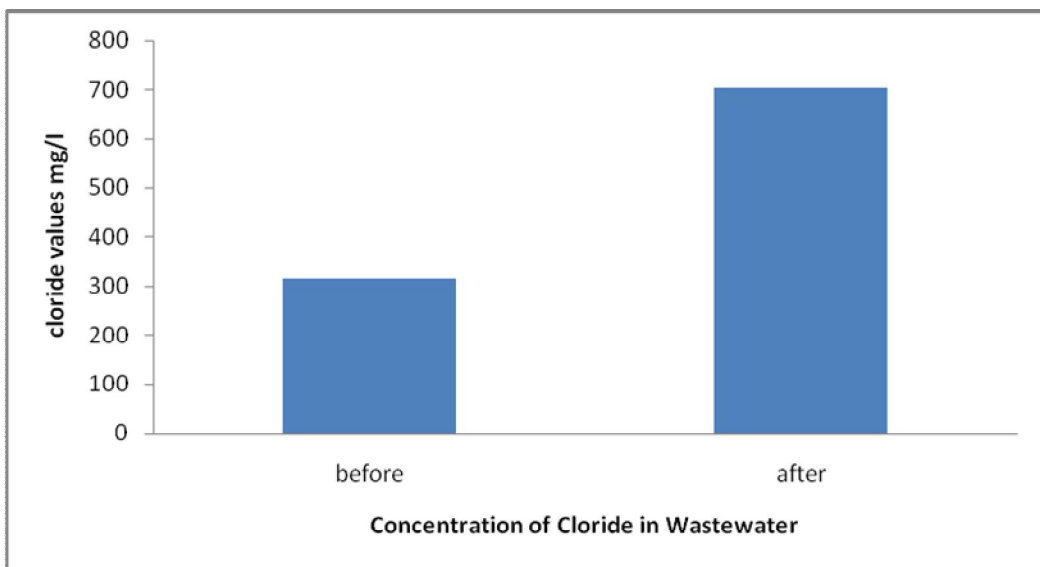


Figure 3: Concentration of chloride before and after wastewater treatment

wastewater, as well as the addition of chloride after treatment to control microorganism in wastewater. This result supported by Commission on Geosciences Environment and Resources (1996).

**Table 2: The parameters of Sirte treated wastewater in comparison with
FAO standards for irrigation water**

Parameter	Unit	Treated wastewater	FAO standards		
			None	Slight to Moderate	Severe
EC	dS/m	3.65	< 0.7	0.7- 3.0	> 3.0
pH	Indicator	7.93	Normal Range 6.5-8.5		
SAR	Indicator	5.83	<3	3-9	>9
NO₃⁻-N	mg/l	403	<5	5-30	>30
B	mg/l	0.70	<0.7	0.7 – 3.0	>3.0
Cl⁻	mg/l	704	<142	142-355	>355
HCO₃⁻	mg/l	195	<92	92-519	>519
SO₄⁼	mg/l	576	Maximum recommended concentration <250		

Table 3: The concentration of different element in Sirte treated wastewater in comparison with FAO standards for irrigation water

Element	Symbol	Unit	Sirte	FAO standards	Exceeding Amount
Mercury	Hg	mg/l	0.02	0.05	
Calcium	Ca	meq/l	9.00	10.0	
Magnesium	Mg	meq/l	10.0	5.00	
Cobalt	Co	mg/l	0.06	0.05	+0.01
Chromium	Cr	mg/l	0.40	0.10	+0.30
Copper	Cu	mg/l	0.03	0.20	
Iron	Fe	mg/l	0.60	5.00	
Silver	Ag	mg/l	0.06	2.50	
phosphorus	P	mg/l	0.98	3.70	
Manganese	Mn	mg/l	6.00	0.20	+5.80
Molybdenum	Mo	mg/l	0.05	0.01	+0.04
Nickel	Ni	mg/l	0.04	0.20	
Lead	Pd	mg/l	0.03	5.00	
Selenium	Se	mg/l	0.02	0.02	
Zinc	Zn	mg/l	0.01	2.00	

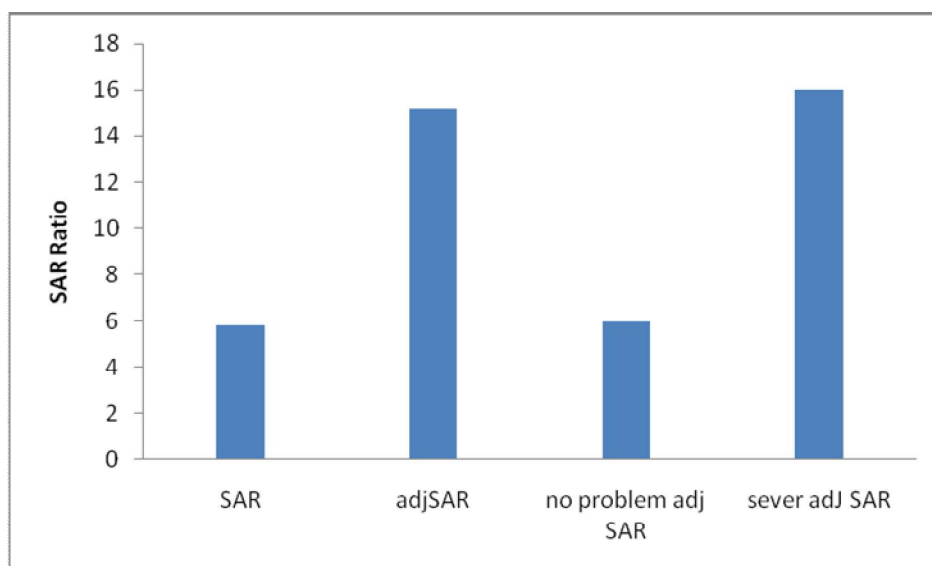


Fig. 4: Comparison of SAR and adj. SAR of treated wastewater with permissible levels of the FAO irrigation water standards

CONCLUSION

From standpoint of that irrigation water quality refers to its suitability for use, the Sirte treated wastewater according to the report of Ayers and Westcot (1985); it can be classified as saline water. These because the electrical conductivity (EC) is exceeding the permissible level as recommended by FAO for irrigation water and at the same time lowers values of bicarbonate and calcium were recorded. The toxicity problem is expected when water used to irrigate crops sensitive to Chloride, Cobalt, Chromium, and Manganese. Also the excessive quantities of nitrate- N is present, which upset the production or delay the crop maturity (Bauder *et al.*, 2011). Therefore any plan of using Sirte treated wastewater for irrigation purposes need appropriate soil–water–crop management strategies.

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المخلص العربى

تقييم كفاءة المعالجه فى محطة معالجه المياه العادمة وملائمة المياه المعالجه

لأغراض الري فى مدينة سرت بلبيبا

رمضان على ميلاد

قسم الأراضى والمياه- جامعه سرت- ليبيا

هدفت هذه الدراسة لتقييم كفاءة المعالجه فى محطة معالجه المياه العادمة وجودة مياه الري فى مدينة سرت بلبيبا، خلال شهر نوفمبر 2012. وقد جمعت عينات المياه العادمة قبل وبعد المعالجه عند الساعة 8 صباحا و 4 بعد الظهر فى كل يوم من شهر نوفمبر. واستخدمت طرق قياسية فى تجميع و تحليل عينات المياه. و قد أظهرت متوسط قيم كفاءة التنقية تباين فى العوامل المقاسة، حيث كانت أقل و أعلى قيمة للكفاءة هى 3.6 % و 33.45 % مع الفسفور (P) و البيكربونات (HCO_3) على التوالي. ومن جهة أخرى زادت قيم ال pH و الكلور بنسبة 5 % و 33 % على التوالي بعد المعالجه. وقد وجدت معظم مكونات المياه العادمة المعالجه متوافقه مع معايير منظمة الأغذية و الزراعة (FAO) لمياه الري. بينما كانت قيم التوصيل الكهربى (EC) و الكلور و الكبريتات و الكروم و المنجنيز و الموليبدنيم متجاوزة الحد الأقصى المسموح به حسب معايير منظمة الأغذية و الزراعة لمياه الري. و قد خلصت هذه الدراسة إلى أن الإستخدام الآمن للمياه العادمة المعالجه لمدينة سرت يحتاج لاستراتيجيات مناسبة لإدارة التربة و المياه و المحصول.

