http://www.pjbs.org

PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences 4 (11): 1400-1402, 2001

Chemical Evaluation of Treated Sewage Effluents in Karak Province and its Suitability for Irrigation Purposes

Anwar G. Jiries
Chemistry Department, Faculty of Science, Mutah University, Karak, Jordan

Abstract: The use of treated wastewater in agriculture is widely used in Jordan due to scare water resources. Therefore evaluation of the effluent from two wastewater treatment plants (site 1, Karak wastewater treatment plant, and site 2, Mutah university treatment plant) was made on the basis of combination of electrical conductivity (EC), sodium adsorption ratio (SAR) and soluble sodium percent (SSP), boron concentration and heavy metal content. It was found that the quality of the treated wastewater of both sites meets the criteria and standard governing the use of effluents in irrigation and agriculture. However, a slightly high boron concentration in some samples was detected at site 2. The heavy metal content at site 1 was higher than site 2, which was attributed to anthropogenic activities from educational laboratories.

Key words: Wastewater, irrigation, heavy metals, cation, anion

Introduction

Jordan depends mostly on treated wastewater for irrigation purposes to meet the ever-increasing demand of water due to its scarce water resources. Irrigation with sewage effluent comprises large fraction of land, being irrigated in Karak province with the effluent treated water.

It has been estimated that irrigation water use about 70% of the total demand for water in Jordan (Arar, 1991). Therefore, several wastewater treatment plants had been established in Jordan since 1945. Usually the effluent treated wastewater is usually rich in nutrients, thus can reduce fertilizer expenses (Avemelech, 1993).

In Karak province, which is located in central part of Jordan, two wastewater treatment plants were established treating around 2150 m^3/day (Salameh, 1996). Its water is being used in agricultural activities especially in dry summer season, where the highest demand for water is required. There are no polishing ponds, as these water resources are used for agricultural purposes.

A university complex of Mutah university, (Site 1), is located at around 10 Km to the south of the city of Karak (Fig. 1), serving around 17000 inhabitants. The water entering this plant comes from various sources at the university such as laboratories, automobile service, dry clean, laundry, clinic as well as to household activities. The treated wastewater is used mainly for irrigation purposes; however, the excess water during low irrigation practice is being discharged along a valley to the east of the wastewater treatment plant, where it vanishes within 200 meter from discharging site, recharging the groundwater below.

Other wastewater treatment plant has been established at about 4 Km to the west of Karak city (Site 2) serving around 9000 inhabitants. Its wastewater resources originate from household activities, as very limited industrial activities exist in the province. A high portion of the treated wastewater is being used for agricultural activities along Wadi El-Karak area, mainly tree type, and the remaining quantities are discharged in Dead Sea.

Domestic wastewater sources are found to be possible sources of heavy metal pollution (Juanico *et al.*, 1995, Klein *et al.*, 1974). Jiries *et al.* (1998) found that iron and manganese in sediments were higher concentrations in the coarse sediment (arenaceous) than fine fraction (argillaceous), while all elements on the contrary, were found in fine fraction at higher levels. Jiries *et al.* (2000) found that wastewater treatment plants in Karak province are capable of reducing the polycyclic aromatic hydrocarbon residues in treated wastewater. University laboratories are responsible for elevated heavy metal content in untreated wastewater (Hussein *et al.*, 2000). Shatnawi and Fayyad (1997), investigated the quality of irrigation water in the central Jordan valley. These authors reported that the treated waste water from Amman waste water treatment plant has adversely affected that water quality of Yarmouk river.

In a semi-arid region, such as Jordan, the quality of treated wastewater is important for irrigation purposes. For these reasons, it is important to evaluate the quality based on its suitability for irrigation purposes especially in the dry summer season where the demand for such water is at it's maximum.

Materials and Methods

Treated wastewater samples from two sites (Fig. 1), were collected in duplicate during summer 2000, using pre washed polyethylene containers. Sampling was collected twice every month from each wastewater treatment effluent. One sample was used for major cations and anions, whereas the other was acidified with few drops of HNO_3 after being filtered through 0.045 μm filter paper. The water samples were kept refrigerated in polythene bottles and were analyzed within 72 hours after collection.

Electrical conductivity and hydrogen ion activity were measured in the field using WTW-525 pH meter and WTW conductivity meter (LF-320), respectively.

Anions (Cl^-, NO_3^-, SO_4^{-2}) were analyzed by ion chromatography on Dionex-100 equipped with AG4A-SC guard column, AS4SC separating column, and SSR1 anion self – regenerating suppressor and conductivity meter. The sample was injected through 25 μl sample loop and eluted at 2.0 ml/min, using Na_2CO_3 in milli-Q water. Data were collected by 4400 integrator from Dionex.

Major cations (K^+, Mg^{+2}, Na^+ and K^+) were measured with the same instrument used for anion analysis; however, the column was CS12 (250x4 mm ID), CG guard column (50 x 4 mm ID) and CDM-2 detector from Dionex. For carbonate and bicarbonate determination, titration with 0.01 hydrochloric acid was used and it was done at the same day of sampling.

Heavy metals (Cd, Co and Pb) were analyzed with graphite furnace using Varian 800 AA with deuterium lamp background correction. Quantification was done for Cd, Co and Pb using their standard solutions in the same acid matrix.

Results and Discussion

Results of chemical analysis of the effluent from the wastewater treatment plants in Karak province are presented in Tables 1 and 2.

The average EC of the two sites ranged from 1007 to 1046 $\mu S\ cm^{-1}$ for site 1 and from 1585 to 1950 $\mu S\ cm^{-1}$ for site 2. The lowest EC was at the beginning of the summer season. These findings might be explained due to two factors 1) The evaporational effect of the water in the ponds and 2) No dilution effect from rainfall at this period of the year. Similar results were observed in Amman treated effluent (Shatnawi and Fayyad, 1997)

The concentration of Ca^{+2}, Mg^{+2} and HCO_3^- resulted in the highest contribution of the total mass of ions, comprising 55.2% of the total ionic species at site 1 and 42.7% at site 2. The elevated concentrations of these ions reflect their highest concentrations in drinking water.

Chloride concentration was higher at site 2 than site 1. It ranged from 110-167 ppm with an average value of 134.5 ppm at site 1 and from 197-237 ppm with an average concentration of 214.5 ppm. This can be attributed to the higher salinity at site 2. A high chloride concentration of Cl^- in wastewater might be due to human excrement and not to chlorination of municipal water.

The present findings showed that SAR (Sodium adsorption ratio) values were found to be 2.62 with an average salinity of 1021.5 μS/cm for site 1 and 3.61 with an average salinity of 1799 μS/cm for site 2. The quality of the treated wastewater of both sites fall under the category C3-S1, US classification of irrigation water (US Department of Agriculture, 1969) i.e. water of high salinity and low sodium content is considered marginal for human consumption.

When soluble sodium percent with electrical conductivity is considered, both sites will be good to permissible type. However, site 2 is located near the edge of permissible to doubtful. This suggests that any slight increases in salinity for site 2 will tolerate the water type. The effluents of both sites have Mg: Ca ratio less than 4 and SAR less than 10; therefore they are not likely to pose Mg hazard.

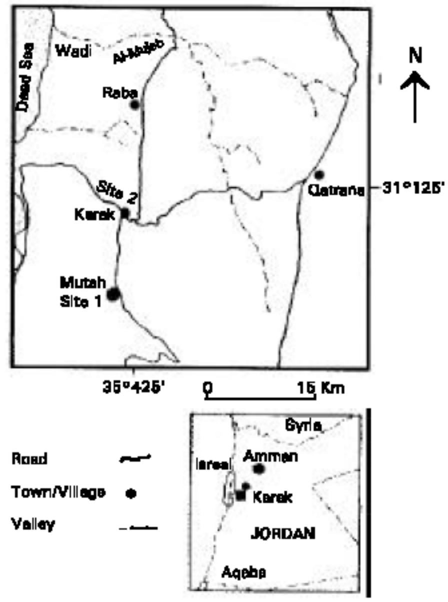

Fig. 1: Location map

Calcium and carbonates were the predominant ions at the two sites. They comprised around 51.4 % and 39.3% of the total dissolved solids. The statistical significance for the mean differences for each ion concentration with respect to each site were computed using one-way ANOVA. It has been shown that there are significant differences in all parameters except for Ca^{+2} and HCO^-_3, which might be due to the same source of groundwater used at both sites.

Table 1: Average concentration of ionic composition in ppm of treated wastewater at sites 1 and 2. (*EC = Electrical conductivity, **BOD_5 = Biochemical oxygen demand after five days, *** COD = Chemical oxygen demand).

Parameter	Site (1)				Site (2)			
	Min	Max	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.
*EC (in μS/cm)	1007.0	1046.0	1021.1	13.4	1585	1950	1799	152.7
pH	6.9	7.3	7.1	0.15	7.8	8.6	8.1	0.32
HCO^-_3	244.0	346.6	291.1	39.6	222.7	323.3	267.4	36.0
Cl^-	110.3	167.0	134.5	23.3	197.5	237.2	214.3	13.7
NO^-_3	10.0	88.6	35.9	28.3	90.0	108.8	99.4	9.4
SO_4^{-2}	8.2	86.6	50.4	25.1	62.7	104.4	83.6	16.6
Ca^{+2}	51.8	82.7	61.9	10.7	59.3	93.7	79.2	12.6
Mg^{+2}	23.5	25.7	24.8	0.8	34.1	38.5	35.7	1.5
Na^+	80.8	121.5	96.2	13.4	14.8	166.3	130.3	57.1
K^+	16.2	39.8	23.5	8.6	24.0	51.1	37.9	9.6
** BOD_5	9	24.5	13.6	7.3	70	85	75.4	7.1
*** COD	60.0	101.0	82.8	20.4	317.0	767.0	535.0	292.8

Table 2: Average concentration of heavy metals composition (ppm) and their standard deviation from the mean value of treated wastewater at sites 1 and 2.

Ionic species	Site (1)				Site (2)			
	Min	Max	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.
B	700	2000	1133	450.2	500	2800	1816	849
Fe	41	1270	389	477	13	85	57	26
Cd	14	19	16	2	7	22	16	7
Mn	1	72	38	36	10	54	30	14
Cu	260	380	330	45	10	55	31	18

Heavy metal concentrations of B, Fe, Cd, Mn and Cu for the same period are summarized in Table 2. The effluents from both sites have high pH; affecting metal ion solubility. The average concentration of heavy metals in effluent wastewater was low (Table 1), which can be due to enhancing precipitation under high pH value (Adams *et al.*, 1984), bounded to the sludge, (Bouwer *et al.*, 1974 and Boller, 1997) and most probably ends in the sediments (Jiries *et al.*, 1998). Similar findings were also reported on treated wastewater in Karak, Jordan (Jiries *et al.*, 1998), in Cairo/Egypt (El-Nennah *et al.*, 1983) and in Israel (Avemelech, 1993). Site 1 showed higher values of heavy metals than site 2 due to effluents from laboratory buildings (Hussein *et al.*, 2000).

Boron is considered as an essential element for plants, it becomes toxic when exceeds its limit (Radstake *et al.*, 1988). The boron content in the effluent water ranged between 0.51 to 0.69 mg/L that is below the American standards of 0.75 to 2 mg/L (EPA).

Generally, heavy metal concentrations of treated wastewater effluents are within the safe limit, due to low level of industrialization in investigated area.

The wastewater qualities from both Karak wastewater treatment plant as well as Mutah wastewater treatment plant are suitable for irrigation purposes in terms of salinity and its high sodium content.

In a term, boron and heavy metals in soil and their uptake by plants should be considered as a potential problem, especially at site 1 and site 2.

References

Adam T. McM and J.R. Sanders, 1984. The effect of the release to solution of Zinc, Copper and Nickel from metal loaded Sewage Sludge, Env. Poll., (Ser. B) 8: 85-99.

Arar, A., 1991, Wastewater reuse for irrigation in the near east region, Wat. Sci. Technol., 23: 2127-2134.

Environmental Protection Egency (EPA), 1991, Water quality criteria, EPA R3-033.

Avemelech, Y., 1993. Irrigation with Sewage Effluents: The Israeli Experience, Env. Sci. Technol., 27: 1278-1281.

Boller, M., 1997. Tracking heavy metals reveals sustainability deficits of urban drainage systems, Wat. Sci. Technol., 35: 77-87.

Bouwer, H., J.C. Lance and M.S. Riggs, 1974. High rate land treatment. II. Water quality and economic aspects of the flushing Meadows Project. J. Wat. Pollut. Cont. Fed., 46: 844.

El-Nennah, M. and T. El-Kobbia, 1983. Evaluation of Cairo Sewage Effluent for irrigation Purposes. Env. Poll., 5: 233-245.

Hussein, H., A. El-Alali, A. Jiries and Gh. Aharonian, 2000. Chemical Evaluation of waste produced from a Jordanian University, a case study. Waste Manage. Res., 18: 94-98

Jiries, A., H. Hussein and J. Lintelmann, 2000. Determination of some Selected Polyaromatic Hydrocarbons Residue in Wastewater Sediments, Sludge and Plants in Karak Province, Jordan. Water, Air and Soil Poll., 121: 217-228.

Jiries, A.G., K.A. Momani and Q.M. Jaradat, 1998. Trace element distribution in sediments and water from a domestic wastewater treatment plant in Karak, Jordan, accepted for publication in Abhath El-Yarouk.

Juanico, M., R. Ravid and Y. Azov, 1995, Removal of Trace Elements During Long-Term Storage in Seasonal Reservoirs: Water air and Soil Pollution, 82: 617-633.

Klein, L. A., M. Lang, N. Nash and S. L. Kirschner, 1974. Source of trace metals in New York City Wastewater. J. Water Poll. Cont. Fed., 46: 2653-2662.

Radstake, F., F. A. R. Attia and A. B. M. Lennaerts, 1988. Forecasting Groundwater Suitability For Irrigational Purposes- A Case Study in The Nile Valley, Egypt, J. Hydrol., 98: 103-119

Salameh, E. and H. Bannayan, 1993. Water Resources of Jordan Present Status and Future Potentials, Friedrich Ebert Stiftung, Amman.

Shatnawi, M. and M. Fayyad, 1997. Effect of Kherbet As-samra treated effluent on the quality of irrigation water in the central Jordan valley, Wat. Res., 12: 2915-2920.

US. Department of Agriculture, Salinity Laboratory Staff, 1969, Diagnosis and improvements of saline and alkaline soils, Washington DC, US Government Printing Office.