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RESEARCH ARTICLE

ASSESSING WASTEWATER STABILIZATION PONDS FOR AGRICULTURAL USE: A CASE STUDY FROM IRAN

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ABSTRACT

This study was conducted out in the stabilization ponds of Birjand city for two seasons; autumn, 2007 and winter, 2008. For this reason, quality parameters, such as pH, TSS, BOD_5, COD, total chloroform and pathogen egg in the influent and effluent of wastewater stabilization ponds, and heavy metals such as As, Hg, Pb, Cd, Zn and Cr in the effluent of wastewater were determined. The mean levels of these parameters were measured: 8.0 for pH, 76.2 mg/L for TSS, 68.67 mg/L for BOD_5, 163.0 mg/L for COD, 1600 < MPN/100ml, while no mean level was found for pathogen egg. Also, the mean concentrations of heavy metals were measured: 0.091 mg/L for As, 0.005 mg/L for Hg, 0.001 mg/L for Cd, 0.020 mg/L for Zn and 0.125 mg/L for Cr. According to Standards of Environmental Protection Agency of Iran, the effluent of wastewater stabilization ponds is found to be useful for irrigation. The results also showed that the removal efficiencies of biological factors were high, so that the amounts of BOD_5, COD and TSS were decreased 78.84%, 75.25% and 72.15% in the effluent of wastewater compared to the influent of wastewater.

INTRODUCTION

In desert regions like the East of Iran, where fresh water is scarce and costly, it may be economically viable to re-use the produced water for both domestic and agricultural purposes. However, the produced water contains pollutants such as total dissolved solids (TDS), ammonia, nitrite, and heavy metals, and hence must be treated before use (Shpiner et al., 2009a). The contamination of the environment by heavy metals is of growing concern because of the numerous health risks to animals and humans following exposure (Costly and Wallis, 2001). Common sources of metal polluted wastewaters include metal finishing operations, such as electroplating plants, as well as many mining, nuclear and electronics industries (Neytzell-De Wildes, 1991). Wastewater treatment plants (WTPs) serving both municipal and industrial districts, receive complex mixtures of nutrients and organic and inorganic micropollutants, which are treated to reduce their concentrations so that they do not impact the environment (Üstün, 2009). Wastewater stabilization ponds (WSPs) are a treatment method on which there is considerable successful experience in wastewater treatment, especially in hotter climates (Mara and Pearson, 1998).Wastewater stabilization ponds have been extensively used over the world for treating wastewater and their effluent and sludge are often of sustainable value; require little if any energy, and could play an important role in the removal of pollutants (Lai, and Lam, 1997; Kehl et al., 2009; Shpiner et al., 2009b).

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Wastewater stabilization ponds are a simple, low-cost, low-maintenance process for treating wastewater (Cauchie et al., 2000; Zimmo et al., 2003; Nelsona et al., 2004; Kerstens et al., 2009). Because of their low cost and simplicity of operation and maintenance, wastewater stabilization ponds dominate among the small and large wastewater treatment systems. A typical system consists of several constructed ponds operating in series; larger systems often have two or more series of ponds operating in parallel. The clean water act prohibits the discharge of toxic pollutants in large amounts into water courses or open lands (Mijinyawa and Nurudeen Samuel Lawal, 2008). Stabilization pond effluent is an immediate resource for irrigation in semi-arid region. Recognition of this has resulted in large ponds with better capacity to provide for local needs and improved treatment efficiency (Hosetti and Frost, 1995). The objectives of this study were: (1) to determine whether pH, TSS, BOD_5, COD, total chloroform and pathogen egg in the influent and effluent of wastewater stabilization ponds, and, also, heavy metals such as As, Hg, Pb, Cd, Zn and Cr in the effluent of wastewater were determined are suitable for agricultural irrigation and (2) to detect the significance of seasonal changes of these parameters on the wastewater stabilization pond.

MATERIALS AND METHODS

Study area description: The study wastewater stabilisation pond is located in East of Iran, Birjand, and the capital city of Southern Khorasan province. It is situated at latitude of 32˚ 86' N and longitude of 59˚ 21' E and about 1490 m above sea

Table 1: Concentrations of parameters mans from effluent and influent of wastewater stabilization pond

Parameters	Autumn 2007			Winter 2008			Over all Mean	SD
	Oct	Nov	Dec	Jan	Feb	Mar		
Effluent								
pH*	7.8	7.9	7.8	7.8	7.9	7.9	7.85	0.05
TSS**	297.5	232.5	250	307.5	262	297	247.41	54.29
BOD_5**	365	447.9	433.5	340.4	320	350	367.13	44.68
COD**	583.6	644.3	700.1	695.8	624.4	668	652.7	30.47
NTU***	242.7	246.1	239.5	302.5	239.4	273	257.26	25.5
pathogen egg	0	0	0	0	0	0	0	0
total chloroform	1600<	1600	1600	1600	1600<	1600<	1600<	-
Influent								
pH	8.2	8.1	8.0	7.9	7.9	7.9	8	0.12
TSS	80.0	92.5	90.0	75.0	45.0	75.0	76.25	42.66
BOD_5	51.7	61.0	60.0	64.5	90.0	80.0	68.67	13.17
COD	105.5	98.5	120.4	209.9	213.3	230.2	162.96	17.01
NTU	36.2	43.0	58.8	181.0	173.2	202.7	115.81	77.43
pathogen egg	0	0	0	0	0	0	0	0
total chloroform	1600<	1600<	1600<	1600<	1600<	920	1600<	-

Significant at the 0.05 level*; Significant at the 0.01 level**; Significant at the 0.001 level ***, respectively

Table 2: Concentrations of heavy metals means from effluent of wastewater stabilization pond

Element	Autumn 2007			Winter 2008			Over all Mean
	Oct	Nov	Dec	Jan	Feb	Mar	
As	0.014	0.011	0.015	0.017	0.014	0.02	0.091
Hg	0.007	0.004	0.008	0.006	0.003	0.002	0.005
Pb	0.0002	0	0	0	0	0	0
Cd	0.004	0.002	0	0	0.001	0	0.001
Zn	0.02	0.005	0.008	0.01	0.03	0.05	0.020
Cr	0.02	0.09	0.08	0.09	0.07	0.4	0.125

Table 3: Mean removal efficiencies of biological Physico-chemical parameters of wastewater stabilization pond

Parameters	Autumn 2007			Winter 2008			Over all Mean	SD
	Oct	Nov	Dec	Jan	Feb	Mar		
TSS	73.10	68.85	65.64	75.60	82.0	67.74	72.15	6.04
BOD_5	85.83	82.57	81.25	81.05	79.23	63.16	78.84	9.18
COD	81.92	85.25	80.71	69.83	69.53	64.27	75.25	8.44

Table 4: Pearson's correlation coefficients of Physico-chemical parameters and metals influent wastewater stabilization pond

	pH	TSS	BOD_5	COD	NTU	As	Hg	Pb	Cd	Zn	Cr
pH	1										
TSS	0.51	1									
BOD_5	-0.64	-0.89*	1								
COD	-0.89*	-0.67	0.77	1							
NTU	-0.68	-0.77	0.97**	0.81	1						
As	-0.62	-0.13	0.32	0.74	0.49	1					
Hg	0.46	0.53	-0.80	-0.60	-0.81	-0.24	1				
Pb	0.77	0.10	-0.32	-0.46	-0.37	-0.18	0.41	1			
Cd	0.88*	0.08	-0.27	-0.63	-0.38	-0.57	0.21	0.86*	1		
Zn	-0.41	-0.50	0.75	0.67	0.85*	0.68	-0.69	-0.01	-0.17	1	
Cr	-0.49	-0.01	0.41	0.58	0.60	0.76	-0.65	-0.37	-0.49	0.77	1

Correlation is significant at the 0.05 level*; Correlation is significant at the 0.01 level**

Table 5: Standards of the effluent wastewater out of the refinery (Environmental Protection Agency of Iran)

Parameters*	pH	TSS	BOD_5	COD	As	Hg	Pb	Cd	Zn	Cr	Cu
Agricultural/ Irrigation uses	6-8.5	100	100	200	1.0	-	1.0	0.05	2.0	2.0	2.0

*mg/l

level. The site designed for wastewater treatment of 10,500 m^3/day at a BOD loading of about 2,520 kg/day. The wastewater stabilization pond was put into operation in 2006, consisting of 3 ponds in parallel. The ponds are used to treat domestic wastewater from parts of Birjand (for 64000 inhabitants with the city population of 157000).

Sample processing: In this study, pH was measured on a daily basis, while BOD, COD and TSS were measured weakly. Heavy metals, total chloroform and pathogen egg were measured monthly. The wastewater samples were analyzed for pH using a pH meter. The COD, BOD and TSS were determined as per standard methods (APHA, 1995) and the wastewater samples were analyzed for heavy metal concentrations were determined by Polarography instrument. One-way analysis of variance (ANOVA) was used to evaluate differences between the parameters pH, TSS, BOD_5, COD, total chloroform and pathogen egg of the influent and effluent wastewater and As, Hg, Pb, Cd, Zn and Cr in the effluent of wastewater samples collected from stabilization pond at two seasons; autumn, 2007 and winter, 2008 by Tukey's Honest. Pearson's correlation coefficients were used in order to find the correlation among the parameters. Data analyses were carried out using the statistical package SPSS (Release 16).

RESULTS AND DISCUSSION

The results of the experiments on the influent wastewater of ponds are shown in Table 1. The results show that the pH, TSS, BOD_5, COD means are 7.85, 247.41, 367.13 and 652.7 respectively, the total chloroform mean is higher than 1600 while there is no pathogen egg. Table 1 also shows the results of the analyses on the effluent wastewater out of the refinery. The results indicate that the pH, TSS, BOD_5 and COD are 8.00, 76.25, 68.67 and 162.96 respectively. The total chloroform mean is higher than 1600 while there is no pathogen egg. Also, the Table shows that in effluent wastewater, the As, Hg, Pb, Cd, Zn and Cr means are 0.091, 0.005, 0, 0.001, 0.020 and 0.125 respectively. According to data inserted in Table 1, the elimination level of study pollutants in this refinery is shown in Table 3. Based on the results, the elimination mean of these pollutants are 72.15 % for TSS, 78.84 % for BOD_5, 75.25 for COD. Also, Table 2 shows the analysis results of heavy metals out of effluent wastewater of wastewater stabilization ponds and the comparison between these results and the results got by the Environmental Protection Agency of Iran is shown in Table 5; it indicates that the levels of heavy metals are lower than the limit. Table 4 shows the correlation level between physico-chemical parameters and the heavy metals out of the effluent wastewater of the stabilization ponds.

Preventing the pollution and considering the problems caused by heavy metals entering into the waters, soil, plants and at last the human food chain is of great importance. Today, it is a necessary to consider these noxious materials in order to employ efficient methods to reduce the risks caused by them. The studies on the wastewater stabilization ponds support this reality that a systematic leadership is the most effective factor in performance of these indicators. Although the necessary proceedings in utilization and desirable maintenance of ponds are very easy, inattention towards them may cause some problems such as scent production, insect rally and effluents with poor quality (Nemerow, 1997; Eckenfelder, 1989). The results contain the impure samples; the last BOD_5 showed that the wastewater stabilization ponds have the capability to remove the noxious materials in ponds from 70% to 80%. This capability may increase up to 90% about the pure samples (WHO, 1983). The reduction level of TSS in wastewater stabilization ponds is possible because of the presence of algae in effluent wastewater in lower levels of BOD_5, however the numbers of viruses reduce up to 99.99% and the numbers of pathogen egg and beam cyst up to 100%. (WHO, 1983; Mara and Pearson, 1998). According to the results contained in Table 3, the percentage means of pollutants elimination in Birjand wastewater stabilization ponds are 78.84% for BOD_5, 75.25% for COD and 100% for pathogen egg, respectively. The comparison between the results got for COD= 75.25%, BOD_5= 78.84% and the acceptable amount of pollutant elimination in this process represents the relatively good performance in the given ponds. In this study the variance analysis between influent and effluent has a significant difference in the parameters pH, TSS, BOD_5, COD and NTU (Table 1). The amount of P for pH is lower than 0.05, for TSS, BOD_5, COD is lower than 0.01, and for NTU is lower than 0.001. Mexico, Vietnam, china and many other Arabian, Indian and Pakistani countries are among those countries used the wastewater in agriculture (Alshameri et al. 2005). Irrigating a wide range of crops, like sugar mills, with effluents got from treatment stabilization ponds is a common practice in Maharashtra and Karnataka states of India and some crops as sugar-cane coconut in Nagpur and Dharwad (Shinde, 1989; Hosetti and Frost, 1995). Lemon and eucalyptus have better growth and production than those irrigated with well water (Kale and Bal, 1987). In Israel, 70% of conventional treatment plants' effluents are used for agriculture during the hot season (Shelef et al., 1987). Employing the wastewater instead of waters in channels causes improvements in soil physical properties such as permeability, porosity and emersion the sponge construction. (Delibasika et al. 2009)

Table 4 shows the Pearson's correlation coefficients for all observed influent Physico-chemical parameters and metal values. The Pearson's correlation analysis for Physico-chemical parameters and metals are obtained from samples taken in autumn, 2007 and winter, 2008, is shown in Table 4. There was a highly positive relation between BOD_5 and NTU ($P< 0.01$). A moderately positive correlation was found among pH and COD, pH and Cd, TSS and BOD_5, NTU and Zn, and for Pb and Cd ($P< 0.05$). We may hypothesize that Physico-chemical parameters and metals with a high positive correlation are possibly from the same pollution source. There was no highly or moderately negative correlation between any of the metals. Therefore, all metal pollution is attributed to industrial wastewaters. One of the effective methods in realizing the performance quality of refineries is comparing the data means and the defined standards. Hence the comparison between the amount of pollutants in effluent and the standards of Environmental Protection Agency, used in irrigating, is presented in Table 5. These results show that the amount of remaining pollutants in effluent wastewater is, in Iran, lower than the limit. The results of statistical analysis also, showed that there is no difference between the pollutants concentration means in effluent wastewater and the standards of the Environmental Protection Agency, so using the effluent wastewater in irrigation is not a contradictory to the standards of this system.

Conclusion

At the end, way may come to the conclusion that, on one hand, by considering the dry continental situation of Iran (more than 2/3 lands are dry and half dry) and especially the amount of rainfall and drought in this area (171 mm in a year) and on the other hand because of irreparable losses to the environment, water and soil sources and lack of permanent or seasonal rivers, water sources as one of those limitative factors are seen as main problems in developing the social and economic foundations in Birjand; hence the optimum utilization of all water resources including the wastewaters is justified. However, the results of physico- chemical parameters and the heavy metals out of the stabilization ponds showed that using the effluent wastewater has no problem in agricultural usages.

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