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ORIGINAL ARTICLE

Performance of municipal Waste Stabilization Ponds in Bushehr Wastewater Treatment Plant

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ABSTRACT
Use of stabilization ponds is one of the natural methods of municipal wastewater treatment. Utilization of these ponds is considered a simple, low-cost, and easy governance process for municipal wastewater treatment that does not require substantial quantities of equipment. This research was carried out with the purpose of studying the performance of waste stabilization ponds at the inlet and outlet of the wastewater treatment plant in Bushehr, which has an average inflow of 32,000 cubic meters of wastewater produced at different areas of Bushehr per day. This inflow is pumped into the treatment plant via a pipeline with pipes having a diameter of one meter. After passing through the inflow channel, the wastewater enters first into 2 anaerobic ponds, then into 2 facultative ponds and finally, into 4 maturation ponds that are arranged in series. Forty- eight weekly wastewater samples were taken during 2015 from 2 points at the inlet of the anaerobic ponds and at the outlet of the maturation ponds to measure the BOD, COD, and TSS parameters following the instructions in the standard laboratory method. Results indicated that the average value of BOD decreased from 216 mg/l in the inflow wastewater to 69 mg/l in the outflow effluent (reduction efficiency of 68%), that of COD from 375 mg/l to 165.5 mg/l (reduction efficiency of 55.8%), and that of TSS from 145 mg/l to 82.1 mg/l (reduction efficiency of 43.3%). Moreover, there were statistically significant differences between the inflow and outflow data related to the BOD, COD, and TSS parameters (P value <0.05).
Keywords: *waste stabilization pond, natural treatment, municipal wastewater, anaerobic pond, maturation pond*

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INTRODUCTION

Due to the presence of various microbial and chemical pollutants in wastewater, disposal of untreated wastewater into the environment, or its use in agriculture, will pollute water and soil resources, and even agricultural products which will eventually endanger human health. To reduce the adverse effects resulting from wastewater disposal into the environment, and to upgrade the level of public health, wastewater must be treated [1]. There are various processes for removing pollutants from wastewater each with its own advantages and shortcomings. In addition to the costly chemical systems, there are inexpensive biological processes that are included among natural treatment processes. Waste stabilization ponds (WSPs) are an example of natural wastewater treatment processes that require a minimal level of energy, mechanical and electrical equipment, and largely solve the problems related to sludge disposal [2]. However, the large land area required for WSPs is considered among their shortcomings. Mburu et al. (2013) studied the performance, effluent quality, required land area, and operational costs of stabilization ponds and constructed wetlands. Results indicated that both systems performed considerably well in reducing organic matter and suspended solids, and their operational costs were a function of the related population. Moreover, it was found stabilization ponds required three times more land area compared to constructed wetlands [3]. Ragush *et al.* (2015) studied the performance of stabilization ponds in Polar Regions during four successive summers and reported that these ponds were able to reduce CBOD5 and TSS with an efficiency of more than 80% [4]. Song *et al.*

(2008) conducted a study to evaluate the use of stabilization ponds for treating rural wastewater and concluded the average efficiencies of stabilization ponds in reducing COD, BOD, and SS were 75.1-87.3%, 75.2-94.3%, and 90.2-97.6%, respectively, and noticed this system had features such as suitable performance, easy utilization, and low maintenance costs [5]. Shao-yong et al. (2004) studied the performance of stabilization ponds in treating drainage water from agricultural lands and found that their efficiency in reducing COD, TN, and TP was higher than 57% [6]. In general, based on the presence or absence of oxygen, there are three types of stabilization ponds: anaerobic, facultative and maturation. Precipitation of solids followed by their anaerobic digestion in the sludge layer happens in anaerobic ponds, and the gradual accumulation of the digested solids necessitates periodical removal of sludge [7, 8]. Many of the compounds in industrial wastewater are toxic for algae present in facultative and maturation ponds, while anaerobic ponds are capable of removing them. Therefore, wastewater must enter into anaerobic ponds and be treated with them before entering into facultative and maturation ponds [8]. Ghazy *et al*. (2008) studied efficiencies of combined stabilization ponds that included anaerobic, facultative and maturation ponds in treating municipal wastewater, and concluded that stabilization ponds were able to reduce BOD, COD, and TSS, with efficiencies of 50.65%, 48.95%, and 44.3%, respectively [9]. Stabilization of wastewater pollutants in facultative ponds takes place by a combination of aerobic and anaerobic bacteria. In facultative ponds, the smallest quantity of required oxygen is provided through contact between the surface of wastewater and the free air. Therefore, most of the needed oxygen is supplied through the photosynthetic activity of the algae [10, 8]. Abis and Mara (2003) studied the effects of the organic load on the performance and maintenance of the aerobic-anaerobic conditions in facultative ponds, and noticed that these stabilization ponds were able to reduce BOD and SS with efficiencies of about 90% and 95% [11]. Maturation ponds are widely used for removing most pathogenic agents such as some species of bacteria, fungi, and viruses. However, maturation ponds can never serve as the primary treatment units of wastewater treatment, but instead they are always located after a facultative pond, which may be a primary or secondary pond. The combination often used is to have an anaerobic pond and a facultative pond located before one or more maturation ponds [12, 5]. Al-Hashimi and Talee Hussain [13] studied combined stabilization ponds that included one facultative pond, one aerobic pond, and an aeration pond that contained sand filters. Results showed that passage of the effluent leaving stabilization ponds through sand filters, considerably reduced BOD, COD, and TSS [13]. Ouazzani *et al*. [14] studied the performance of combined stabilization ponds that included one anaerobic pond, two facultative ponds, and two ponds containing aquatic plants in treating raw municipal wastewater. Results indicated that the highest efficiency in reducing TSS and COD (90% and 78%, respectively) belonged to the pond with aquatic plants [14].

MATERIALS AND METHODS

The wastewater treatment plant in Bushehr is located 10 kilometers to the east of the Bushehr Port at an altitude of three meters, and use of waste stabilization ponds is the current treatment method at this plant. The wastewater produced in different urban areas is collected by 12 pumping stations and enters the final pumping station, which is located about 14 kilometers from the wastewater treatment plant. The wastewater is pumped to the plant via a pipeline with pipes having a diameter of one meter, and passes through the main entrance channel.

Table 1: Characteristics and dimensions of the various ponds at Bushehr wastewater treatment plant

Characteristics of the ponds	Anaerobic ponds	Facultative ponds	maturation ponds
Number	2	2	4
Effective volume (m^3)	64,837.5	141,840	41,904
Surface area (m^2)	18,525	56,736	27,936
Effective depth (m)	3.5	2.5	1.5
Length (m)	200	400	200
Width (m)	100	150	150
Dimensions at ground level (m)	200 × 100	400 × 150	200 × 150
Dimensions at of the middle section of the pond (m)	195 × 95	394 × 144	194 × 144
Slopes of the walls	1.5 to 1	1.5 to 1	1.5 to 1
Free height (m)	0.9	1	1
Effective surface area (m^2)	37,050	113,472	111,744
Effective volume (m^3)	129,675	283,680	167,616
Hydraulic retention time (day)	4	9	6

It first enters into two anaerobic ponds, then into two facultative ponds and, finally, into four maturation ponds. The ponds are arranged in series, and the wastewater is a mixture of domestic and industrial wastewater. Table 1 presents the dimensions and physical characteristics of the various units of the stabilization ponds at Bushehr wastewater treatment plant.
Using standard methods, the biological oxygen demand (BOD), the chemical oxygen demand (COD), and the total suspended solids (TSS) parameters were studied at the inlet of the wastewater into the anaerobic ponds and at its outlet from the maturation ponds. SPSS was used to determine significance and the normality of the data, and EXCEL was employed to draw the figures. Wastewater samples were taken at the inlets of anaerobic ponds and at the outlets of the maturation ponds using special containers. The samples were transferred to the laboratory in less than two hours and kept at 4°C to prevent the occurrence of undesirable reactions. In all, 48 weekly samples were taken following the standard laboratory instructions during 2015 [15].

RESULTS AND DISCUSSION

P-values of all the data were more than 0.05; i.e., the qualitative parameters of this treatment plant enjoyed normal distribution at the significance level of 0.05. Moreover, results indicated that there were significant differences between the inflow and outflow data related to BOD, COD, and TSS (P-value <0.05). Figures 1, 2, and 3 show the results concerning the values of BOD, COD, and TSS in the inflow wastewater into the anaerobic ponds and in the outflow effluent from the maturation ponds separately in mg/l. Based on the results shown in Figure 1, the minimum and maximum values for the BOD are 140 and 282.5 mg/l, with the average of 216 mg/l and standard deviation of 43.51 for the inflow, and 37.7 and 105.4 mg/l, with the average of 69 mg/l and the standard deviation of 24.12 for the outflow. Minimum and maximum efficiencies in reducing BOD are 51.5% and 82.7% with the average of 68%. Results show the minimum efficiency in reducing BOD is observed in early winter and the maximum in summer. In most samples, efficiency in reducing BOD was a function of temperature, and decreased and increased with decreases and increases in temperature. Iran's Environmental Protection Organization has suggested 100, 30, and 30 mg/l as the maximum values for BOD in outgoing effluent that is used for irrigation and other agricultural activities, discharged into surface waters, and discharged into absorbing wells, respectively. Therefore, the outgoing effluent which leaves Bushehr wastewater treatment plant by having an average BOD value of 69 mg/l, can only be used for irrigation and other agricultural activities.

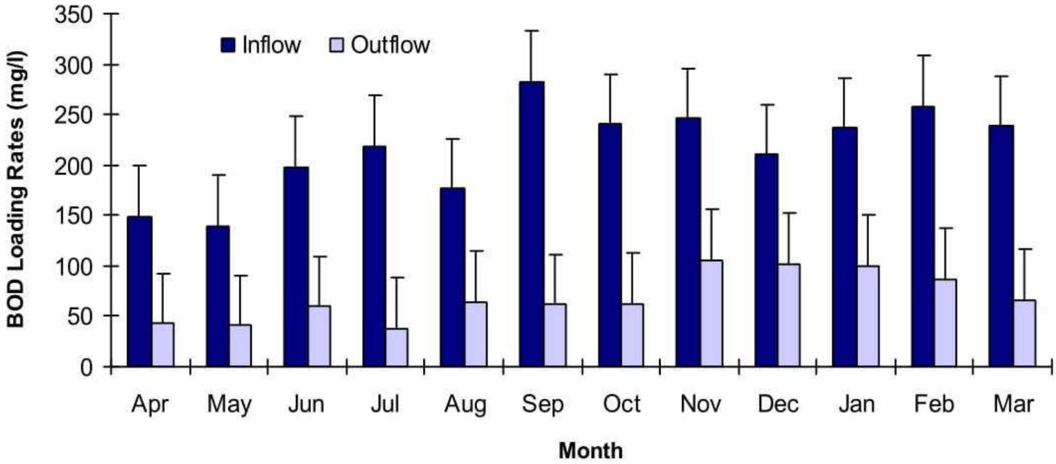

Fig. 1. Changes in the BOD values of the inflow entering into anaerobic ponds and the outflow leaving maturation ponds

Based on the results shown in Figure 2, the minimum and maximum COD values are 292.5 and 490.3 mg/l, with the average of 375 mg/l and standard deviation of 52.94 for the inflow, and 115.2 and 313.2 mg/l, with the average of 165.5 mg/l and standard deviation 0f 54.33 for the outflow. The minimum and maximum efficiencies in COD reduction are 34.5% and 71.1%, with the average of 55.8%. The minimum efficiency in reducing COD was observed in early winter and the maximum in summer. In most samples, efficiency in reducing COD was a function of temperature, and decreased and increased with decreases and increases in temperature. Iran's Environmental Protection Organization has suggested 200, 60, and

60 mg/l as the maximum values for COD in outgoing effluent that is used in irrigation and other agricultural activities, discharged into surface waters, and discharged into absorbing wells, respectively. Therefore, the outgoing effluent which leaves Bushehr wastewater treatment plant by having an average COD value of 165.5 mg/l, can only be used in irrigation and other agricultural activities.

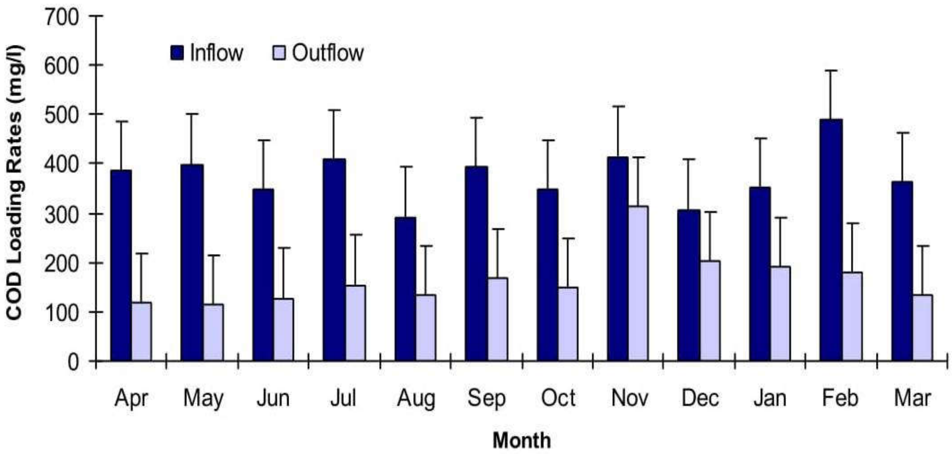

Fig. 2. Changes in the COD values of the inflow entering into anaerobic ponds and the outflow leaving maturation ponds

Based on the results shown in Figure 3, the minimum and maximum TSS values are 108.5 and 226.5 mg/l, with the average of 145 mg/l and the standard deviation of 34.40 for the inflow, and 36.3 and 128.5 mg/l, with the average of 82.1 mg/l and the standard deviation of 34.02 for the outflow. The minimum and maximum efficiencies in reducing TSS were 8.21% and 79.5%, with the average of 43.3%. Results show the minimum efficiency in reducing TSS was observed in early winter and the maximum in summer. In most samples, the efficiency in reducing TSS was a function of temperature, and decreased and increased with decreases and increases in temperature. The noteworthy point is the low efficiency in reducing TSS. One of the main reasons is the untimely discharge of sludge from the anaerobic ponds that causes the sludge to rise to the surface and escape from the outlet of these ponds. Iran's Environmental Protection Organization has suggested 100, 40, and 40 mg/l as the maximum TSS values for outgoing effluent that is used in irrigation and other agricultural activities, discharged into surface waters, and discharged into absorbing wells, respectively. Therefore, the outgoing effluent which leaves Bushehr wastewater treatment plant by having an average COD value of 82.1 mg/l, can only be used in irrigation and other agricultural activities.

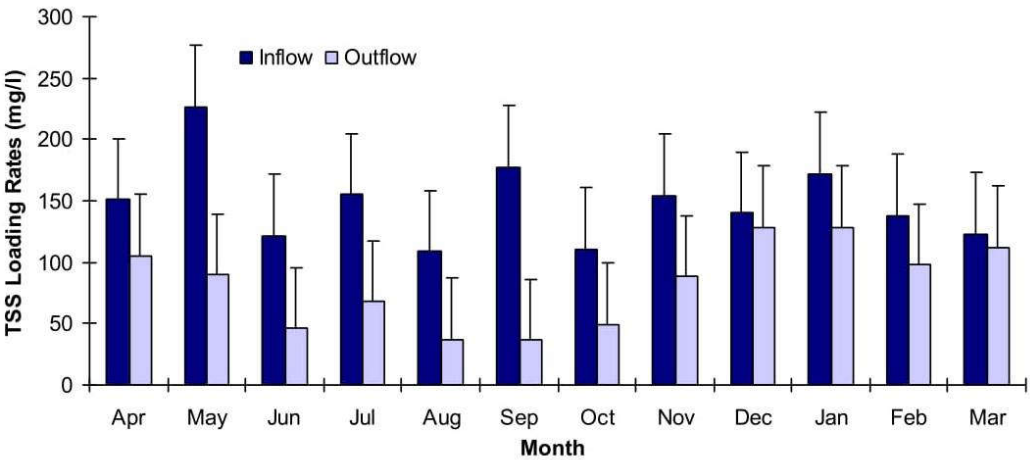

Fig. 3. Changes in the TSS values of the inflow entering into anaerobic ponds and the outflow leaving maturation ponds

In general, the type of wastewater pretreatment, the organic load of the inflow entering into the ponds, the unsuitable design of the ponds, the insufficient retention time, the unsuitable distribution of wastewater, and the heterogeneous distribution of bacteria are among the factors that may result in unsuitable performance of stabilization ponds. Moreover, extreme changes in PH, temperature, and light intensity can also change efficiencies of stabilization ponds. The Results of this research show that, based on standards established by Iran's Environmental Protection Organization, the outgoing effluent which leaves Bushehr wastewater treatment plant, can only be used in irrigation and other agricultural activities, and cannot be discharged into surface waters or into absorbing wells.

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