Article

Performance evaluation of waste stabilization pond in Birjand, Iran for the treatment of municipal sewage

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Abstract
The objective of this research was to evaluate the performance of stabilization ponds in wastewater treatment of the city of Birjand. The samples were taken from influent, anaerobic pond effluent, facultative pond effluent and maturation pond effluent for a year (April 2011 to March 2012). Laboratory analysis was carried out following standard methods for the analysis of temperature, pH, BOD5, COD, TSS and turbidity. Results of these investigations showed that the average effluent concentrations of BOD5, COD and SS taken from maturation pond were 109.17, 241.67, 74.65mg/L, respectively and effluent turbidity was 138.83 NTU. Also these results indicated that maturation pond effluent was not match with the Standards of Environmental Protection Agency of Iran for agricultural reuse in terms of BOD5, COD and turbidity. Hence based on this research, performance of Birjand stabilization ponds was poor and it need to upgrade.

Keywords domestic wastewater; effluent; stabilization ponds; upgrade.

1 Introduction

Assessment of wastewater treatment processes demonstrate that the stabilization ponds is the most simple, reliable, economical and low maintenance process that can be used as an appropriate alternative for wastewater treatment and ponds are systems that effectively stabilize wastewater by reducing BOD (Wiley et al., 2009; Mozaheb et al., 2010). Wastewater treatment in stabilization ponds reaches to its maximum with proper selection of organic load, time and depth of the pond and atmospheric conditions for maximum growth of microorganisms (Khosravilaghab et al., 2009). Waste stabilization ponds in most cities in Iran are valuable treatment systems due to suitable climatic conditions and land availability (Ehrampoush et al., 2007).Waste stabilization pond is divided into three types based on type of biological activity occurring in a pond. Three types are renowned: anaerobic, facultative and maturation ponds, anaerobic and facultative ponds are employed for BOD removal, while the primary function of maturation pond is to remove excreted pathogens (Gawasiri, 2003).

Anaerobic ponds may receive volumetric organic loadings in the range of 100 to 350 g BOD5/m^3/day, depending on the design temperature (Miguel and Mara, 2004). Facultative ponds are designed for BOD5 removal based on their surface organic loading. A relatively low surface organic loading is used (usually in the range of 100-400 kg BOD5/ha/d, depending on the design temperature) which allow for the development of active algal population (Shah Teli, 2008; Mara, 2004). Facultative ponds which are properly designed and maintained can give a BOD reduction ranging from 75% to 90% for domestic wastewater (Gray, 2004). Based on design temperature (<10) is volumetric organic loading 100-350 g BOD5/m^3/day and surface organic loading is kg BOD5/ha/day for city of Birjand (Mara, 2004).

The objectives of this research were to evaluate the performance of stabilization ponds in wastewater treatment of the city of Birjand; the reason of this evaluation is that there are several problems in ponds operation such as: odor problem and undesirable effluent quality**,** then we desire to set up a scheme of its upgrading.

2 Materials and Methods

2.1 Site specifications

The study wastewater stabilization 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 level. Birjand city has a cold and dry climate. The average annual temperature is 16.35°C with the warmest time in June (average 27.5°C) and the coldest in February (average 3.2°C).The annual mean evaporation and wind speed 321.74 mm/month and 12.92 m/s respectively. Birjand wastewater Treatment Plant has been constructed with a capacity of 10 500 m³ per day for a population of 64 000 people and in two modules in parallel. The classical pond configurations are divided to anaerobic and facultative and maturation ponds (Fig. 1). The operation of the module1 has started with a capacity of 60 l/s in 2005 but the structure of module 2 has performed. The wastewater treatment plant of Birjand has pretreatment units that include grit chamber and screens that followed by the WSP systems. Table 1 shows the physical characteristics of the BWSP systems.

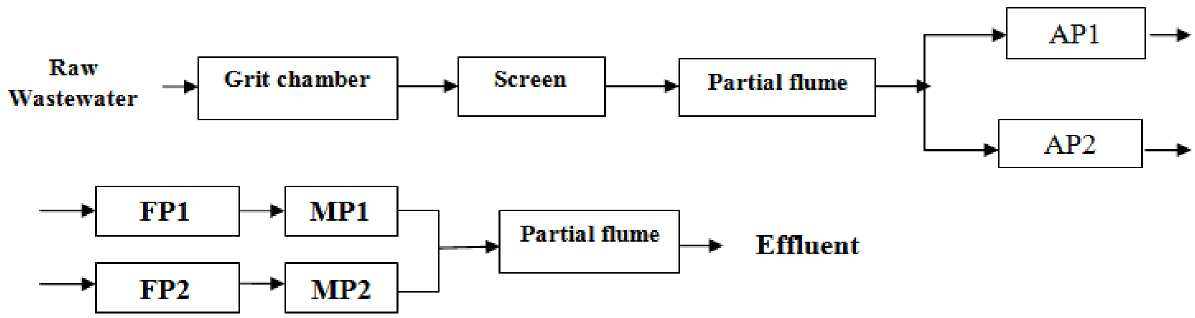

Fig. 1 Schematic flow diagram for M1 and M2 BWSP. AP=Anaerobic Pond; PF=Facultative Pond; MP=Maturation Pond

Table 1 Physical characteristics of the BWSP system

Component	Anaerobic pond	Facultative Pond	Maturation Pond
Useful volume of each pond(m^3)	38902	106600	18258
Useful depth(m)	4.5	2	1
The number of pond	2	2	2
Planning detention time(day)	7.5	20.5	3.5
The high dimensions(m)	104×108	541×108	185×108
The floor dimensions(m)	82×86	529×96	177×100
Floor covering	Asphalt	The clay crushed	The clay crushed
Pond wall	Geomembrane	Geomembrane	Geomembrane
Wall slope	1/2	1/2	1/2
Free height (m)	1	1	1
Load Design(kg/d)	1244	1244	1244

2.2 Sample processing

In this study, pH was measured on a daily basis, while BOD5, COD, TSS and turbidity were measured weakly. Samples were taken from the raw wastewater and anaerobic, facultative and maturation ponds effluent. Laboratory analysis was carried out following standard methods for the analysis of temperature, pH, BOD5, COD, TSS and turbidity (APHA, 1995). Data of each sampling point were analyzed based on the objective of the study by using MS – Excel spreadsheet and SPSS version 16 software package. Average percentage removal efficiencies for each parameter was calculated according to equation

$$\% \text{ removal} = [100 - (\text{Ceffluent} / \text{Cinfluent}) \times 100] \qquad (1)$$

3 Results

The average inlet BOD5 of anaerobic pond is 463.5 mg/l. Because of low average water use, the wastewater in Birjand is stronger than the typical values for average strength domestic wastewater of about 250 to 300 mg of BOD5 per liter. The outlet BOD5 ranged from 169.75 mg/l to 215.33 mg/l with average value of 201.58 mg/l as well as the volumetric BOD5 loading ranged from 76.85 $g/m^3/d$ to 123.35 $g/m^3/d$ with average value of 96 $g/m^3/d$ (Table 2).

Inlet BOD5 to facultative pond ranged from 169.75 mg/l to 215.33 mg/l with average value of 201.58 mg/l. The BOD5 removal ranged from 15.2% to 47.3% with average value of 32.81 % (Table 3).

The mean values and removal percentage of BOD5, COD, TSS and Turbidity is shown in Table 4. The overall removal efficiency of Birjand municipal wastewater stabilization ponds was 76.16% for BOD5, 67% for COD, 67.44% for TSS and 26.3% for turbidity. The removal efficiency of Birjand capacity for BOD5 and TSS were higher than the removal efficiency of another study that were conducted in Arak, as 69% and 39% respectively (Naddafi et al., 2008) .However, the removal efficiency of COD of that study was more than in Birjand (76%). In a study that was carried out in Egypt the rate of BOD, COD and TSS removal were 50.65%, 48.95% and 44.3% respectively (Mahassen et al., 2008), much less than that in Birjand.

According to Table 5, almost seasonal performance with the overall performance of treatment plant for parameters of listed table (except turbidity) has the same process. One of the reasons for poor performance of water treatment plant in removal of turbidity is seasonal changes.

Table 2 Volumetric loading and BOD5 removal of M1 anaerobic pond of Birjand

Month	Avg. pH	Avg. temp, ^0C	DT, d	Avg. flow, m^3/d	Inlet BOD, mg/l	Volumetric loading, g $BOD5/m^3/d$	Outlet BOD, mg/l	BOD5 removal, %
April	7.9	21	5.63	6912	432.5	76.85	192.5	55.59
May	7.8	24.5	5.18	7517	357.5	69.1	181	54.41
June	7.8	26.1	4.8	8035	430	88.81	169.75	60.52
July	7.7	28.7	5	7776	498.25	99.59	192.5	61.36
August	7.6	28.6	4.6	8467	485	105.6	263.6	45.64
September	7.6	28	4.8	8035	432	89.23	203.33	52.93
October	7.7	26.5	4.8	8035	445	91.91	210.33	52.73
November	7.6	25.2	4.9	7949	491.3333	100.4	215.33	56.17
December	7.6	22.5	4.9	7949	496	101.3	194.75	60.74
January	7.8	20.2	4.5	8586	499.25	110.2	202	59.54
February	7.8	19.7	4.8	8122	461.25	96	195.75	57.56
March	8.1	19.0	4.33	8986	534	123.35	198	62.92
Average	7.75	24.2	4.85	8030.75	463.5	96	201.6	56.5

Table 3 Surface loading and BOD5 removal of M1 facultative pond of Birjand

Month	Avg. pH	Avg. temp, ^{0}C	DT, d	Avg. flow, m^3/d	Inlet BOD, mg/l	Surface loading, kg/ha/d	Outlet BOD, mg/l	BOD5 removal %
April	7.1	18.7	15.42	6912	192.5	249.64	107.67	44.1
May	7.3	24	14.18	7517	181	255.3	140.75	22.24
June	7.2	24.8	13.3	8035	169.75	256	103.75	38.9
July	7.2	25.5	13.7	7776	192.5	280.84	163.25	15.2
August	7.3	25	12.6	8467	263.67	418.85	139	47.3
September	7.1	24.3	13.3	8035	203.33	306.52	160.67	20.98
October	7.1	22.5	13.3	8035	210.33	317.1	153	27.26
November	7	21.3	13.4	7949	215.33	321.14	152	29.4
December	7.2	17.3	13.4	7949	194.75	290.44	125.75	35.43
January	7.2	13.8	12.4	8586	202	325.4	118.75	41.2
February	7.3	12.3	13.12	8122	195.75	298.3	127.5	34.87
March	7.2	13.3	11.86	8986	198	333.8	125	36.86
Average	7.2	20.2	13.33	8030.75	201.6	304.44	134.8	33

Table 4 Average (standard deviation) and removal percentage of the parameters in BWSP system

Sampling site	BOD5 (mg/L)	COD (mg/L)	TSS (mg/L)	NTU
AP :Influent	463.5 (47.07)	735.08(66.7)	223.54(32.7)	213.33(84.1)
Effluent	201.6(16.2)	372.82(25.16)	98.44(33.08)	60(11.21)
Removal (%)	56.5	49.3	56	71.87
FP: Influent	201.6(16.2)	372.82(25.16)	98.44(33.08)	60(11.21)
Effluent	134.8(17.2)	293.47(24.94)	83.54(28.12)	201(88.51)
Removal (%)	33	21.3	15.14	-235
MP: Influent	134.8(17.2)	293.47(24.94)	83.54(28.12)	201(88.51)
Effluent	(5.4)109.17	241.67(27.9)	74.65(30.54)	138.83(87.4)
Removal (%)	20	21.4	10.64	30.93
Overall: Influent	(47.07)463.5	735.08(66.7)	223.54(32.7)	213.33(84.1)
Effluent	(10.6)109.17	241.67(27.9)	74.65(30.54)	138.83(87.4)
Removal (%)	76.16	67	67.44	26.3

Table 5 Seasonal variations in performance waste stabilization ponds of Birjand compared to the overall performance of ponds

Percent removal	BOD	COD	TSS	NTU
Spring	73.3	59.42	54.23	-12
Summer	75.08	65.86	60.56	68.68
Autumn	78.04	70.65	79.84	6.64
Winter	78.21	72.14	75.14	50
Overall removal	76.16	67	67.44	26.3

4 Discussion

At present, technologies natural for wastewater treatment such as stabilization ponds are paid much attention due to low cost, easy maintenance, long life and desirable ability for effluent recycling (Baraei et al., 2010).

Temperature, detention time and volumetric BOD5 loading rate are main factors affecting BOD5 removal efficiency of anaerobic pond (Alexiou and Mara, 2003). For anaerobic pond, based on Table 2, loading volumetric was more than 100 g BOD5/m^3/d, because of high fluctuation in concentration of inlet BOD5.The average detention time (DT) in anaerobic pond is 4.56 d. For domestic wastewater hydraulic detention time is usually 3 to 6 days. With the longer detention time more than 6 days, the anaerobic pond can behave occasionally as a facultative pond which is undesirable and consequently the presence of oxygen is detrimental to methane-forming bacteria. BOD5 removal efficiency of anaerobic pond is 50-70 %. Average BOD removal is 56.5% in anaerobic pond of Birjand (Shah Teli, 2008).

The anaerobic ponds are designed based on volumetric organic loading, and their apposite operation will continue as long as their treatment volume is not reduced by solids accumulation. In Birjand, the sludge removal has not occurred (2005, 2012). Hence odor problem in BWSP including: overloading and lack sludge discharge

BOD removal efficiency (33%) of Facultative pond is poor; Because of over surface BOD5 loading consequently the oxygen required is not sufficient for the degradation of organic materials (Shah Teli, 2008).

Effluents which have high concentration of BOD and COD can cause depletion of oxygen in the aquatic environment or in the receiving water bodies. Therefore, the BOD/COD removal and the consequent quality of the effluent depend on the amount of oxygen present, retention time and temperature of the ponds (Hodgson, 2007).

Although optimal operation and maintenance of the ponds is very simple but ignorance of them cause many problems such as odor production, accumulation of insects and effluent with low quality (Farzadkia and Khosravi, 2003).With respect to the effluent quality of the WSP in comparison with the Iranian treated wastewater standards (IEPA) for agricultural irrigation that has indicated BOD5, COD, SS and Turbidity concentrations should be less than 100, 200, 100 mg/L, and 50 NTU respectively. The results of this research imply that although the average concentrations of TSS (74.65 mg/l) comply with Iranian Standard wastewater reuse for agriculture, but in case of BOD5 (109.17mg/l), COD (241.67mg/l) and turbidity (138.83) terms it did not comply with standards. Results of the study Moazheb et al (2010) on WSPY (Wastewater Stabilization Ponds of Yazd) showed that concentration of BOD_5, COD and TSS effluent has been 100.7, 270.25 and 78.2

mg/l respectively. Hence BOD5 and COD concentration of effluent do not match with the Iranian standards. According to Dargahi et al. (2010) on WSP of Gylangharb determined that the average concentration of BOD5 (43.12mg/l), COD (82.2mg/l) and TSS (43.4mg/l) effluent complies with the standards.

Based on this research, Birjand stabilization ponds cannot meet the lowest quality of Iranian Standards, consequently with such a poor performance, it requires upgrading. In order to improve quality of effluent from Birjand wastewater treatment plant proposed solution that was practical and with low cost, easy operation and maintenance, as well as good potential has for application in developing countries, including: (1) rock filters (RF) are a well-established technology for 'polishing' maturation pond effluents to provide high-quality effluents in terms of BOD and total suspended solids (TSS); (2) wetland due to the climatic conditions of the study area seems that this method has high potential to improve final effluent quality in reduction of suspended solids, nutrients, algae, BOD and TSS.

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