Monitoring the Wastewater Treatment Efficiency of Oxidation Ponds at Chokera, Faisalabad

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ABSTRACT

Treatment efficiency of the sewage stabilization ponds at Chokera, Faisalabad was carried out with respect to the parameters (i.e. BOD_5 (Five Days Biochemical Oxygen Demand), COD (Chemical Oxygen Demand), pH, Turbidity, TS (Total Solids), TDS (Total Dissolved Solids), Copper, Lead, etc.). Parameters under investigation were monitored at six different locations (i.e. Influent of treatment plant, Influent of anaerobic Ponds, Effluent of Anaerobic Ponds, Effluent of Facultative Ponds, Drain before disposal of treated sewage and Drain after mixing with treated sewage). The testing was done during the low flow season i.e. from December 2015 to January 2016 in Environmental Engineering Laboratory, Department of Civil Engineering, The University of Lahore, Pakistan. BOD_5 removal efficiency of the treatment plant was found 30.08 against designed value of 90% removal. The removal efficiency of COD, TS, TDS, pH, Turbidity, lead and Copper was found 36.56, 22.43, 30.40, 3.43, 73.50, 34.13 and 41.15%, respectively. The maximum removal was of turbidity which is 73.50% but still none of the parameters of the effluent were meeting the PEQS (Punjab Environmental Quality Standards) 2012 except pH and TS. The reasons of low efficiency included lack of funds by government for operation and maintenance of the ponds, increased population, mixing of industrial sewage with domestic and less attention to maintain the performance of Ponds.

Key Words: Domestic Sewage Treatment Plant, Waste Stabilization ponds, Efficiency, Upgrading, Faisalabad.

1. INTRODUCTION

The problem of water pollution is being experienced by both developing and developed countries. Various categories of substances are being introduced by anthropogenic activities which give rise to water. Organic and inorganic substances, pathogenic organisms, plant nutrients and oxygen demanding substances are the common types of pollutants [1]. Ground water and surface water pollution is due to the industries that are based on wet processes, add the considerable amount of treated and untreated wastewater into environment [2].

Surveys conducted by the World Bank [3] have mentioned that at present, few industrial estates, worldwide, have an inadequate environmental plan or have poor environmental management capability at estate level. Globally, it is anticipated that industries are responsible

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for discharging about 300-400 million tons of solvents, heavy metals, toxic sludge, and other waste into receiving water Bodies [3].

In recent years, reuse of treated effluent is getting a mounting awareness as a reliable source of water. In developed countries, the major consideration for treated wastewater reuse is planning and implementation of water resources. To reuse the treated effluent, some countries like Singapore, Saudi Arabia and Jordan have their national policies through which they have made extensive improvement in this regard [4].

Various Treatment Systems are being used worldwide such as suspended growth and attached growth processes. Sewage Stabilization Ponds are one of the suspended growth process which are normally employed to treat domestic sewage but they can also be used to treat industrial wastewater. Waste stabilization ponds are considered to be economical and best treatment option for a developing country like Pakistan where 61% population lives in rural and semi-urban areas. These are cost effective due to little use of mechanical equipment, low maintenance, less requirement of skilled labor, less power requirement, use of local materials of construction and less land cost because they are usually constructed in rural areas of the developing countries [5-8].

Oxidation process is directly proportional to the addition of organic matter that indicates increase in consumption of DO (Dissolved Oxygen). Strength of wastewater and requirement of DO is usually measured in terms BOD_5 due to the relationship of oxidation process and organic matter. Greater number of species available in the aquatic system require DO in high concentration [9].

In wastewater treatment, through waste stabilization ponds, two types of processes (i.e. methanogenesis and acidogenesis) can occur that can affect the pH. Methanogenesis process controls the pH within neutral range and acidogenesis causes the drop in pH due to growth of fatty acids [10]. Hodgson, [11] and Ayisah [12] also reported the neutral range of pH [11-13].

WWTP (Wastewater Treatment Plant) based on waste stabilization ponds, is located at Chokera, Faisalabad, Pakistan. It was initially designed to treat domestic sewage. The plant came into operation in 1998 when population of Faisalabad was around 15 million. After experiencing continuous population explosion, the population of Faisalabad reached up to 35.47 million in 2015 [14]. The plant was designed to control environmental degradation by complying with the NEQS (National Environmental Quality Standards), 1997. Continuous increase in urbanization and industrial development within city are main factors which resulted in overloading of the sewage treatment plant, which ultimately resulted in decrease in its treatment efficiency. The treated effluent is finally disposed off in PHARANG drain which also receives untreated domestic and industrial effluent along its way [15].

This treatment system consist of only primary (i.e. Anaerobic Ponds) and secondary treatment (i.e. Facultative Ponds) while tertiary treatment (i.e. Maturation Ponds) to yield high quality effluent is missing. The primary and secondary ponds are lined with impermeable soil to secure the groundwater below treatment system. The treated effluent quality is not fit for crops due to the absence of maturation ponds [16].

Present study was carried out to monitor the performance of WSPs as well as to give some recommendations to improve the pollutant removal efficiency of ponds. The study was based on comprehensive literature review and analysis of collected wastewater samples to examine variation in winter season of the year. The results can be used to suggest various technical as well as administrative measures that can likely improve the quality of treated wastewater.

2. MATERIALS AND METHOD

2.1 Site Specifications

The coordinates of treatment plant are 31° 27' 32" N and 73° 0' 20" E which is 14 km away from Centre of Faisalabad. Fig. 1 shows the layout of under study treatment plant which consists of four sludge drying ponds, six anaerobic ponds and six facultative ponds. Table 1 shows the physical aspects of domestic sewage treatment plant of Chokera, Faisalabad. As shown in Table 1 the total area specified for sludge ponds, anaerobic ponds and facultative ponds is 45414, 182409 and 497500 m^2, respectively. The total volume of sludge ponds, anaerobic ponds and facultative ponds is 68420, 396900 and 541274.4 m^3, respectively. Total detention time of anaerobic ponds is 7.5 days and of facultative ponds is 16.2 days. The capacity of the treatment plant is 20 MGD (Million Gallon/Day). Design was based on influent BOD_5 of 380 mg/l and BOD_5 of treated effluent was 40 mg/l i.e. 90% removal of BOD_5. Table 2 represents the location of sampling points and the reason for their selection.

2.2 Sampling

Composite samples were collected from six locations (i.e. influent of treatment plant, influent of anaerobic ponds, effluent of anaerobic ponds, effluent of facultative ponds and PHARANG drain i.e. before and after mixing with treated wastewater) of treatment plant by taking into consideration the detention time (i.e. 7.5 days for Anaerobic Ponds and 16.2 days for facultative ponds). Date of Sampling at each sampling point is given in Table 1. Sampling was done during cold season (i.e. December 2015 and January 2016) of the year.

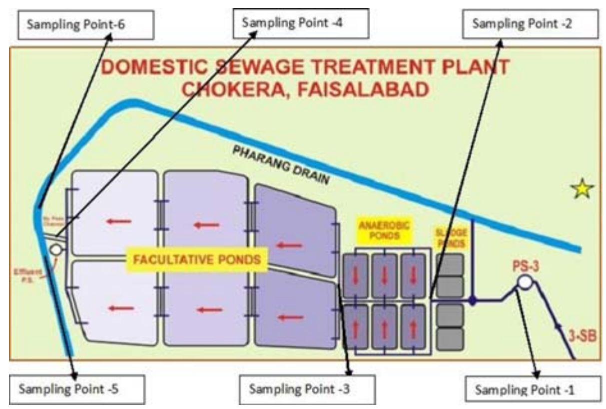

FIG. 1. LAYOUT OF SEWAGE TREATMENT PLANT WITH SAMPLING LOCATIONS

TABLE 1. PHYSICAL CHARACTERISTICS OF CHOKERA WSPS

No.	Component	Area (m2)	Depth (m)	Volume (m3)	Detention Time (days)
1.	Sludge Pond (1 and 3)	11403.33	1.5	17105	NA
2.	Sludge Pond (2 and 4)	11403.33	1.5	17105	NA
3.	Total of sludge pond	45414	NA	68420	NA
4.	Anaerobic Pond (1 and 4)	26460	2.5	66150	2.5
5.	Anaerobic Pond (2 and 5)	26460	2.5	66150	2.5
6.	Anaerobic Pond (3 and 6)	26460	2.5	66150	2.5
7.	Total of Anaerobic Pond	182409	NA	396900	7.5
8.	Facultative Pond (1 and 4)	149466	1.5	218902	4.86
9.	Facultative Pond (2 and 5)	174025.6	1.5	25417.6	5.67
10.	Facultative Pond (3 and 6)	174025.6	1.5	25417.6	5.67
11.	Total of Facultative Pond	497500	NA	541274.4	16.2
Grand Total		725523	NA	1006594.4	23.7

2.3 Climate

In Faisalabad the intensity of rainfall is about 408 mm/year. Recorded highest and lowest temperature in this city are 45and 12^{0}C, respectively. The maximum wind speed recorded was 94 mph [17].

2.4 Analyzed Parameters

Table 3 presents the results of analyzed parameters and equipment/method used for analysis of various parameters and quality of effluent in comparison with PEQS. It also describes removal efficiency of selected parameters. The tests were performed according to Standard Methods for the Examination of Water and Wastewater [18].

3. RESULTS AND DISCUSSION

Table 4 presents the results of monitored parameters and their variation at different sampling locations, to evaluate treatment efficiency of treatment plant for further use of its effluent. Fig. 2 also presents removal efficiency of various pollutants, which was 30.08, 36.56, 22.43, 30.40, 3.43, 73.50, 34.13 and 41.15 of BOD_5, COD, TS, TDS, pH, Turbidity, Lead and Copper respectively. The removal efficiency of ponds is much poor. Equations (1) used to determine the efficiency. The treated wastewater had BOD_5, COD, TS, TDS, pH, Turbidity, lead and copper values 360.16, 628, 2984, 2317.5 mg/l, 7.58, 52.2 NTU, 2.2 and 1.124 mg/l, respectively against prescribed limits 80, 400, 1000, 3500 mg/l, 6-9, <5 NTU, 0.5 and 1.0 mg/l,

TABLE 2. SAMPLING POINTS WITH JUSTIFICATION FOR SELECTION

No.	Sampling Location	Remarks
1.	Influent	Selected to assess the characteristics which will be used to determine the efficiency of plant.
2.	Influent of anaerobic pond	Selected to assess the removal efficiency of primary ponds.
3.	Effluent of anaerobic pond	Selected to assess the removal efficiency of primary as well as secondary ponds.
4.	Effluent of Facultative pond	Selected to assess the characteristics which will be used to determine the efficiency of plant as well as facultative ponds.
5.	Drain before mixing of treated effluent	Selected to assess the characteristics of PHARANG drain and to check the effects of treated sewage on this drain.
6.	Drain after mixing of treated effluent	Selected to assess the characteristics of PHARANG drain and to check the effects of treated sewage on this drain.

TABLE 3. COMPARISON OF EFFLUENT WITH PUNJAB ENVIRONMENTAL QUALITY STANDARDS, 2012

No.	Parameters	Instrument/Method Used	Influent of Treatment Plant	Effluent of Facultative Ponds	Efficiency (%)	NEQS
1.	BOD5 (mg/l)	Titrimetric Method	515.13	360.16	30.08	80
2.	COD (mg/l)	NOVA 60 (NOVA Photometer)	990	628	36.56	400
3.	TS (mg/l)	Gravimetric Method	3847	2984	22.43	3500
4.	TDS (mg/l)	Gravimetric Method	3330	2317.5	30.40	1000
5.	pH (H+ ions)	Potentiometric Method	7.85	7.58	3.43	6-9
6.	Turbidity (NTU)	Nephelometric Method	197	52.2	73.50	<5
7.	Lead (mg/l)	Spectrophotometer	3.34	2.2	34.13	0.5
8.	Copper (mg/l)	Spectrophotometer	1.91	1.124	41.15	1.0

correspondingly. The result indicated that WWTP is not complying with PEQS, (2012) except the pH and TS. Treatment Plant needs implementation of technical and administrative measures to improve the quality of effluent.

$$\text{Efficiency}\,(\%) = \frac{\text{Conc}_{in} - \text{Conc}_{out}}{\text{Conc}_{in}} \times 100 \qquad (1)$$

Figs. 3-10 presents variations in tested parameters at each sampling point. At Sampling Point No. 1 (before screening)the values of BOD_5, COD, TDS, pH, Turbidity, Lead and Copper were found 515.13, 990, 3330 mg/l, 7.85,197 NTU, 3.34 and 1.91, respectively. At Sampling Point No. 2 (Inlet of anaerobic ponds)the values of BOD_5, COD, TDS, pH, Turbidity, Lead, Turbidity and Copper were 520.66, 682, 2848, 7.7, 2.86 mg/l, 197 NTU, and 1.34, respectively. At Sampling Point No. 3 (Outlet of anaerobic ponds) the values of BOD_5, COD, TDS, pH, Turbidity, Lead and Copper were found 418.4, 426, 2462.5 mg/l, 7.4, 163 NTU, 2.65 and 1.21, respectively.

The values of BOD_5, COD, TDS, pH, Turbidity, Lead and Copper at Sampling Point No. 4 (Effluent of facultative ponds) were 360.16 mg/l, 628 mg/l, 4317.5 mg/l, 7.58, 52.2 NTU, 2.2 mg/l and 1.124 respectively. At Sampling Point No. 5 (Before the disposal of treated sewage in drain) the values of BOD_5, COD, TDS, pH, Turbidity, Lead and Copper were found 472 mg/l, 414 mg/l, 1757.4 mg/l, 6.23,

TABLE 4. TESTED PARAMETERS AND THEIR RESULTS

No.	Parameters	Sampling Points With Sampling Dates					
		Influent (18.12.2015)	Influent of Anaerobic Ponds (18.12.2015	Effluent of Anaerobic Ponds (26.12.2015	Effluent Facultative Ponds (12.01.2016)	Drain before Disposal of treated Effluent (12.01.2016)	Drain after mixing with Effluent (12.01.2016)
1.	BOD5 (mg/l)	515.13	520.66	418.4	360.16	472	395.6
2.	COD (mg/l)	990	682	426	628	414	442
3.	TS (mg/l)	3847	3543	3356	2984	3356	3154
4.	TDS (mg/l)	3330	2848	2462.5	2317.5	1757.5	2022.5
5.	pH	7.85	7.7	7.4	7.58	6.23	7.19
6.	Turbidity (NTU)	197	192	163	52.2	224	163.8
7.	Lead (mg/l)	3.34	2.86	2.65	2.2	1.9	1.98
8.	Copper (mg/l)	1.91	1.34	1.21	1.124	0.88	1.03

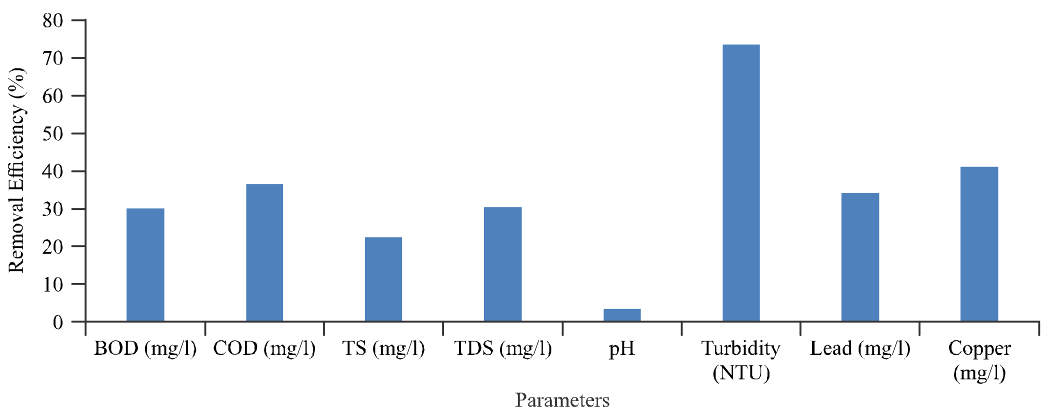

FIG. 2. REMOVAL EFFICIENCY AGAINST EACH PARAMETER

224 NTU, 1.91 mg/l and 0.88 respectively. Before receiving the treated effluent of Chokera wastewater treatment plant, the Pharang drain carries mostly untreated industrial and domestic wastewater therefore it has increased value of turbidity and slightly decrease in pH of the wastewater flowing in it. After receiving the treated effluent of treatment plant, the value of turbidity decreases from 224 to 163.8NTU.Whereas the values of BOD_5, COD, TDS, pH, Turbidity, Lead and Copper at Sampling Point No. 6 (After the disposal of effluent in drain) were found 395.6, 442, 2022.5 mg/l, 7.19, 163.8 NTU, 1.98 and 1.3 mg/l respectively.

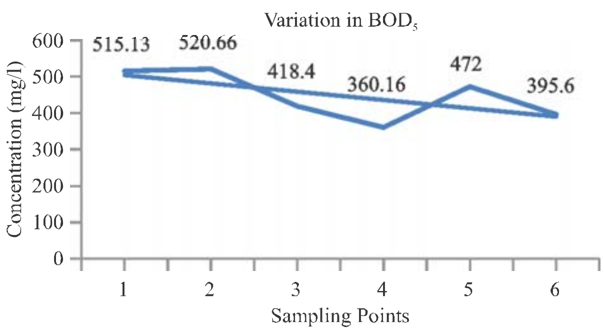

FIG. 3. BOD_5 VARIATION AT 1-6 LOCATIONS

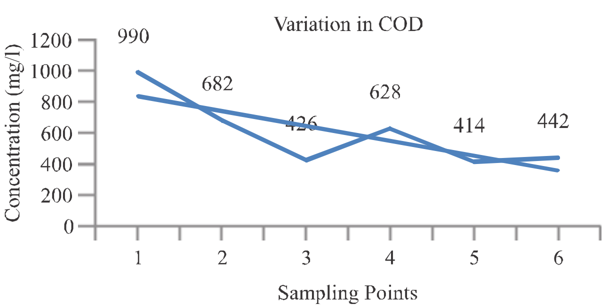

FIG. 4. COD VARIATION AT 1-6 LOCATIONS

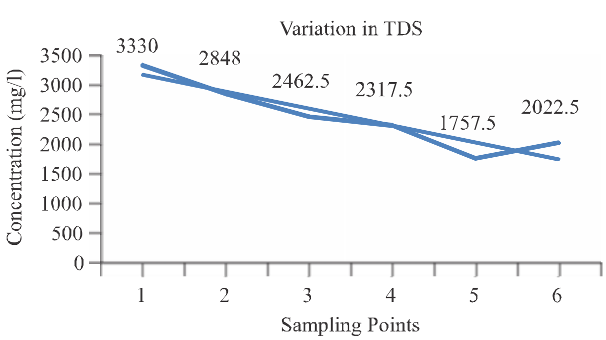

FIG. 5. TDS VARIATION AT 1-6 LOCATIONS

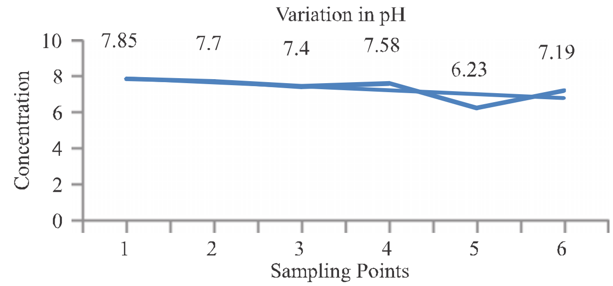

FIG. 6. pH VARIATION AT 1-6 LOCATIONS

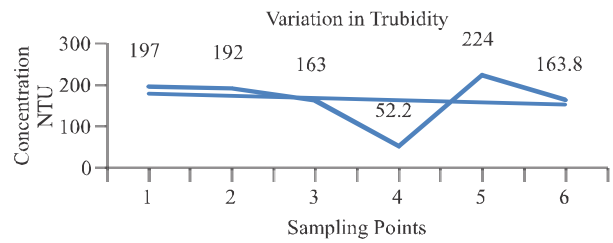

FIG. 7. TURBIDITY VARIATION AT 1-6 LOCATIONS

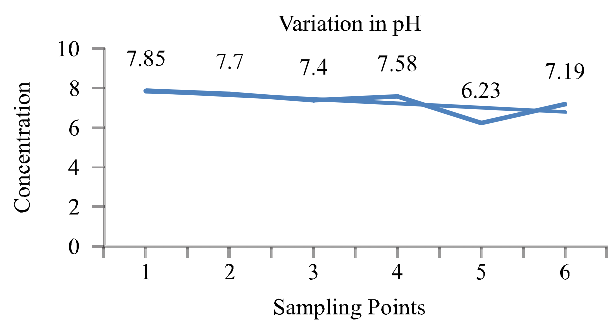

FIG. 8. LEAD VARIATION AT 1-6 LOCATIONS

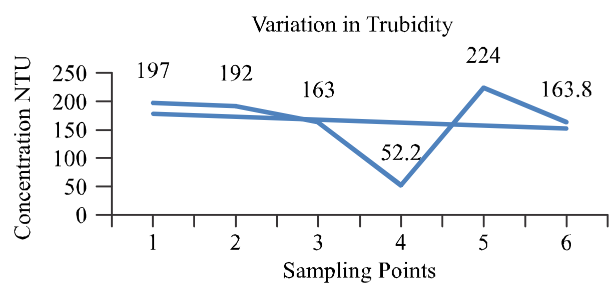

FIG. 9. COPPER VARIATION AT 1-6 LOCATIONS

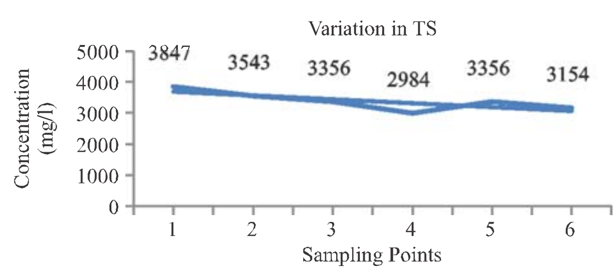

FIG. 10. TS VARIATION AT 1-6 LOCATIONS

4. CONCLUSION

(i) Effluent from WSPs is not complying with PEQS, 2012.

(ii) Septic Tank may be provided to reduce the load on WSPs.

(iii) WWTP is designed for domestic sewage so Industrial effluent should not be mixed with domestic sewage.

(iv) Overloading, poor workmanship, etc. are the factors causing low efficiency.

(v) Final disposal from the treatment plant is being mixed with industrial sewage so there is not much effect of treated wastewater on PHARANG Drain.

(vi) It is very difficult to find out the efficiency of the treatment systems without flow measuring devices.

(vii) Due to the absence of iron gates provided in the WWT system to control and distribute the WW for treatment in the system, proper detention time is not maintained.

(viii) Decrease in effective depth of anaerobic pond (i.e. from 2.5-1.5 on average) has ultimately reduced the detention time to impart treatment of the effluent in anaerobic pond.

(ix) Mixing industrial effluents has further increased the strength of influent which is another factor offering hindrance in the WW treatment.

(x) Disposal of treated effluent in PHARANG drain is reducing the BOD_5 of drain to some extent i.e. from 472-395.6 mg/l.

5. RECOMENDATIONS

(i) Depth of Anaerobic ponds should be maintained according to design by de-slugging of ponds periodically.

(ii) Effluent can be improved by upgrading WSP with different (treatment (constructed and natural) wetlands, Rock filters, land applications, intermittent sand filtration, hyacinth and duckweed, attached growth waste stabilization ponds, pond aeration and baffled filter) upgrading options

(iii) Flow measuring device should be available to have controlled loading of wastewater for treatment and to make its inventory.

(iv) Sand filter can be used to improve the final effluent which will improve the removal of TDS, BOD_5 and COD.

(v) Gates which were provided on stream within the treatment system to give wastewater discharge periodically in oxidation ponds were not available. These should be provided again to have proper control on treatment.

(vi) Government of Punjab must plan to shift the industrial units present in urban areas to designated industrial estates to avoid mixing of industrial effluent with domestic sewage.

(vii) Faisalabad development authority may consider to notify the mandatory provision of septic tank in all existing as well as new residences to reduce pollution load on treatment plant.

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