PJN
ISSN 1680-5194

PAKISTAN JOURNAL OF NUTRITION

ANSInet
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Pakistan Journal of Nutrition 9 (6): 574-576, 2010
ISSN 1680-5194

Waste Water Treatment Using Sequential Batch Reactor and Development of Microbiological Method for the Analysis of Relative Toxicity

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Abstract: Pharmaceutical industry is a very progressing sector in Pakistan with over 400 Pharmaceutical manufacturing in the country. The pharmaceutical industry in Karachi is discharging thousands of gallons of waste per day carrying with itself huge quantities of antibiotics, other pharmaceutical synthetics and solvents as its major constituents. These substances are not only harmful to the aquatic flora and fauna but may also contribute to development of resistance to antibiotics. We designed a sequential batch reactor (SBR) after a series of experiments. The effluent met the NEQS specifications after 21 days of treatment in the SBR. The changes in pH, BOD, COD, TDS, TSS, Ammonia levels, Oil and grease levels were found to be significant ($p < 0.05$).

Key words: Biodegradation, bioremediation, toxicity, waste, sequential batch reactor

INTRODUCTION

Karachi has country's biggest industrial estate, the Sindh Industrial Trading Estate (SITE), with an estimated 2000 industrial units. Industries are also located in Federal-B area, North Karachi, Landhi and Korangi Industrial area. The industries include textile, chemical, tanneries, pharmaceuticals, etc. Under the Factories act (1934), the industrialists are expected to discharge only treated industrial effluent in the city infrastructure (UNIDO, 2000).

The body load of Lyari and Malir rivers is very high from this waste water and to the tune of 1000 tons/day and 500 tons/day respectively. Sewage flows in Lyari river channel have reduced tremendously during last two years due to intercepting trunk sewer laid by KW&SB in the river bed taking sewage to Mauripur Treatment Plant (TP-3) - commissioned in December 1997. The sewers connected with storm water drains terminating Layri / Malir river have also been rapidly switched upon trunk sewers under Khushal Pakistan Program.

To improve the environmental conditions in the city and to dilute concentration of raw sewage flowing into sea, three (03) sewage treatment plants (STPs) are operating in the city:

TP-1 at SITE, TP-2 at Mehmoodabad and TP-3 at Mauripur (source: Karachi water and sewage board).

Pharmaceutical industry is a very progressing sector in Pakistan. This industry is experiencing positive growth since last one decade. In Karachi alone, there are over 100 registered Pharmaceutical manufacturing units, whereas Pakistan resides over 400 Pharmaceutical manufacturing units which produce over 19,000 dosage forms. The industry in Karachi is dumping approximately thousands of gallons of waste per day.

This growth is being achieved at the cost of continuous addition of potent and hazardous chemicals into our waste waters. In turn, these chemicals prove to be deleterious for the natural flora and fauna. While many of the countries started working on small and large scale treatment plants for specific sectors, as early as in 1980s and 90s (Reed, 1990), we are yet to establish treatment options and expertise in this vast field of environmental science. Keeping in pace with the modern day needs, we have undertaken the task of designing and experimenting with a most suitable treatment option keeping in mind, the constituents of the waste and the fate of the effluent. We cannot over look the fact that the pharmaceutical effluent also carries with it, antibiotics into wastewater stream. The emergence of resistance to antibiotics can also be attributed to the fact that the pharmaceutical and hospital waste is carried into natural water via sewage without being treated.

MATERIALS AND METHODS

Effluent collection: The effluent under consideration was collected from a Pharmaceutical finished product manufacturing facility. The plant was mainly involved in the manufacture of anti-TB products, multi-vitamins, antacids, antibiotics, anti-tussive and attapulgite. The constituents of effluent were; Rifampicin, Isoniazid, Pyrazinamide, Ethambutol, Aluminum oxide, Magnesium oxide, Gel magma, multi vitamins such as B_1, B_2, B_6, B_{12} and sugar syrups (liquid glucose, malt extract).

Table 1: NEQS specifications

Parameters	NEQS standard values*
pH[1]	6-9
Biological Oxygen Demand (BOD)	250 (mg/L)
Chemical Oxygen Demand (COD)	400 (mg/L)
Total Sedimentation Solids (TSS)	400 (mg/L)
Total Dissolved Solids (TDS)	3500 (mg/L)
Ammonia	40 (mg/L)
Oil & Grease	10 (mg/L)

*Pakistan National Environmental Quality Standards; [1]pH adjusted between 6-9. Note: The values are based on 24 hours period.

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Table 2: Summary of results (commercial scale batch reactor)

	pH[1]	BOD (mg/L)	COD (mg/L)	TSS (mg/L)	TDS (mg/L)	Ammonia (mg/L)	Oil and Grease (mg/L)
NEQS specifications	6-9	250	400	400	3500	40	10
Control	6.62	799.00	907.00	592.33	2976.67	14.77	2.94
7 days post treatment	6.69	462.33	592.33	298.33	2876.67	14.17	2.63
14 days post treatment	6.79	300.33	370.33	202.00	2916.67	12.97	2.33
21 days post treatment	6.90	250.33	302.00	191.00	2800.00	12.40	1.94

Table 3: Statistical analysis of NEQS results for SBR (at 14 days)

One-sample statistics	N	Mean	SD	SEM
pH	5	6.7240	0.11524	0.05154
BOD	5	499.6000	273.43244	122.28271
COD	5	585.2000	295.98936	132.37046
Total sedimentation solids	5	356.6000	212.08206	94.84598
Total dissolved solids	5	2936.0000	29.66479	13.26650
Ammonia levels	5	13.6400	1.35019	0.60382
Oil and Grease levels	5	2.5620	0.44690	0.19986

Sample collection: Waste water analysis was carried out at different production times with full production load. In case of lab scale experiment, observations were based on 24-hour values, while samples were collected and tested at different time intervals.

In case of pilot scale and commercial scale reactors, composite samples were collected on 24-hour basis and submitted for testing against NEQS specifications. Samples from batch reactors were drawn for consecutive 3-months.

The experiment was scaled up to a commercial scale Sequential batch reactor (SBR) after successful design qualification using lab and pilot scale designs. The process comprised of aeration, settling, reacting and decanting (Metcalf and Eddy, 2003). The reduction in toxicity was measured using National Environmental Quality Standards (1999).

Design of sequential batch reactor (SBR): A sequential batch reactor (SBR) was first designed on lab-scale to determine the functional specifications. This lab scale project was then expanded to a pilot scale project for the determination of effects of various factors on the biodegradation and waste treatment process on a comparatively larger scale, after which a full scale SBR was constructed and made operational. The general design of SBR (Fig. 1) consisted of the following:

i Equalization tank — ii. Neutralization tank
iii. Sequential batch reactor — iv. Drying bed

Equalization tank: Homogenization of waste water was achieved in 4000L concrete tank with air supplied through SS304 pipes for mixing.

Neutralization tank: Waste from equalization tank was transferred to neutralization tank (of 4000L capacity), where pH adjustment was performed using 1N HCl and/or 1N NaOH. pH was adjusted in a range of 6 to 8.

Sequential batch reactor: The waste was then transferred from neutralization tank to SBR. Aeration was performed for 8 hours on daily basis using atmospheric air. Dissolved oxygen was maintained at 2.0 mg/L in the flask during operation.

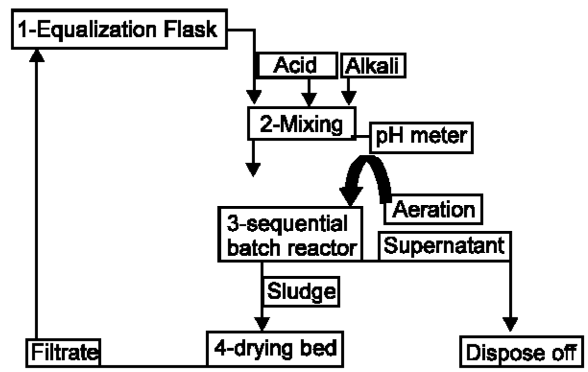

Fig. 1: Design of sequential batch reactor

Sedimentation/Clarification: The liquid was allowed to settle in order to facilitate solid-liquid separation, thus providing a clear supernatant. It took almost 2 days for settlement.

Decant: The supernatant was then carefully decanted using level switch pump, back into the equalization tank.

Drying bed: The sludge was manually lifted and placed on concrete base where it was manually pressed so that the filtrate was collected and circulated back to the equalization tank, using a drain pipe while sludge was dried under sun-light, thereafter it was disposed off.

Commercial scale plant was built totally under covered condition, as that of pilot scale condition.

NEQS testing: Testing of effluent for NEQS specifications were analyzed at different time points. Treated and untreated wastes were analyzed for NEQS specification at baseline, 7 days, 14 days and 21 days. The NEQS specifications are listed in Table 1.

RESULTS

The samples were found to be in compliance with the NEQS (1999) specifications at 21 days for pilot scale and commercial scale study designs. Preliminary information was collected from the lab scale designs.

In pilot scale studies, the effluent samples were found to be in compliance with the NEQS specifications. The changes in BOD, COD and Total sedimentation solids were observed, though they were not statistically significant. However, all results were found within NEQS limits after the treatment period.

The NEQS compliant results were observed after a period of 2 weeks upon using the same filtrate as obtained from the commercial scale experiment (Table

Table 4: One sample t-test for NEQS results of SBR (at 14 days)

	Test value = 0.05					
	t	df	Sig. (2-tailed)	Mean Difference	95% confidence interval of the Difference	
One-sample test	Lower	Upper	Lower	Upper	Lower	Upper
pH	129.501	4	0.000	6.674	6.5309	6.8171
BOD	4.085	4	0.015	499.550	160.0388	839.0612
COD	4.421	4	0.012	585.150	217.6307	952.6693
Total sedimentation solids	3.759	4	0.020	356.550	93.2153	619.8847
Total dissolved solids	221.306	4	0.000	2935.950	2899.1163	2972.7837
Ammonia levels	22.507	4	0.000	13.590	11.9135	15.2665
Oil and Grease levels	12.569	4	0.000	2.512	1.9571	3.0669

2). These results showed statistically significant improvement ($p < 0.05$) at 14 days (Tables 3 and 4). Significant change in pH, BOD, COD, Total sedimentation solids (TSS), Total dissolved solids (TDS), Ammonia and Oil and grease levels were observed (Mahvi *et al.* 2004). The analysis was performed on SPSS version 15.0 using one sample t-test. These changes are consistent with the findings of Mahvi *et al.* (2004); Sandhya (2004).

In all study designs, a discoloration of effluent was also observed, from dark red color (characteristic of Rifampicin) to almost colorless (Elias, 2000).

DISCUSSION

The toxicity levels were reduced and observed to be within the limits defined by NEQS (1999) using Sequential batch reactor (SBR) as a waste water treatment model.

The preliminary findings from lab scale experiments revealed that the selected design is rational. This led to further experiments by scaling up the design to pilot scale and then commercial scale. The effluent samples were found to be in compliance with the specifications laid down by NEQS. The test results improved and the duration of treatment was also reduced as we inoculated the filtrate into the re-circulation stream. The results are consistent with the previous studies carried out by different scientists in their different environmental conditions meeting their local regulatory requirements. Most of the studies suggest that there is a reduction in the levels of BOD, COD, Ammonia, Total sedimentation solids (TSS) and Organic pollutants and in few cases discoloration may also be observed (Buitron *et al.,* 2003; Elias, 2000; Sandhya *et al.,* 2004).

The statistical analysis of results suggests that there is a significant change ($p<0.05$) in BOD, COD, TSS, Ammonia and Oils and Grease levels (Mahvi *et al.* 2004).

Generally, Sequential batch reactors are suitable for areas for confined spaces, stringent treatment requirements, and small wastewater flows. This system is very useful for treating pharmaceutical, brewery, dairy, pulp and paper, and chemical wastes. SBRs are also suitable for sites that need minimum operator attendance and have a wide range of inflow and/or organic load. Industries with high BOD load, such as chemical or food processing plants, find SBRs useful for treating wastewater. These systems are also suitable for facilities requiring nitrification, denitrification, and phosphorous removal. Most significantly, SBRs are applicable for areas where effluent requirements can change frequently and become stricter, as these systems have tremendous flexibility to change treatment options (US-EPA fact sheet, 2000).

Work on biodegradation of pharmaceutical effluent has not been very wide and spread throughout the globe especially in Pakistan where there is no data that describes the model of SBR for the treatment of effluents. This work provides a good starting model of different study designs and their implementation and outcome. It also highlights the use of aerobic treatment of waste and development of new and economical methods for analysis that are comparable with conventional methods and consistent with NEQS specifications.

It is now very much imperative that other industries also establish a central waste management site, and take initiative towards greener environment so that the effluent is treated to a safer level before introduction into natural water sources.

REFERENCES

Buitron, G., R.M. Melgoza and L. Jimenez, 2003. Pharmaceutical wastewater treatment using an anaerobic/aerobic sequencing batch biofilter. J. Environ. Sci. Health., 38 (Part A): 2077- 2088.

Elias, A., 2000. Decolourization and detoxification of textile dyes with laccase from trametes hirsute. Applied Environ. Microbiol., 66: 3357-3362.

Mahvi A.H., A.R. Mesdaginia and F. Karakani, 2004. Feasibility of continuous flow sequencing batch reactor in domestic wastewater treatment. Am. J. Applied Sci., 1 : 348-353.

Metcalf and Eddy, Inc. Wastewater Engineering: Treatment and Reuse, fourth edition. New York: McGraw-Hill, 2003.

National Environmental Quality Standards (NEQS), 1999. Pak. Environmental Protection Committee.

Reed, S.C., 1990. Natural Systems for Wastewater Treatment. Manual of Practice FD-16. Arlington, Virginia: Water Environment Federation, 1990.

Sandhya, S., S. Padhmavathy, V.Y. Subrahmanyam and S.N. Kaul, 2004. Microaerophilic-aerobic sequential batch reactor for treatment of azo dyes containing simulated waste water. J. Process Biochem., 40: 885-890.

UNIDO, 2000. Industrial Policy and the Environment in Pakistan. Prepared and issued by UNIDO experts.

US-EPA fact sheet, September 2000.