

Performance Evaluation and Monitoring of An Appropriate Low-Cost Wastewater Treatment Technology For Small Palestinian Communities

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ABSTRACT

In Palestine, most rural areas, governmental and private schools, universities, hotels and housing projects are still lacking central sewage facilities. This paper evaluates the performance and process optimization of a newly erected WSP system in Talitha Kumi school compound located in Beit Jala City, south of East Jerusalem, West Bank. The results of lab analysis showed that the average concentrations of total BOD and total COD of the influent were 363 mg/l and 621 mg/l, respectively. Moreover, the concentrations of total phosphorus, ammonium and nitrate were 34.5 mg/l, 83.1 mg/l and 43.3 mg/l, respectively. The raw domestic wastewater from Talitha Kumi School revealed extremely high concentration in total suspended solids; the average value was 1528.5 mg/l.

Though the anaerobic pond was organically overloaded with a retention time of 1.2 days, removal rates in both total BOD of 38% and filtered BOD of 45% were achieved. Whereas removal rates of 42%, 46%, 39% and 9% for ammonium, nitrate, suspended solids and phosphorus respectively were recorded respectively.

Lab analysis on the facultative and maturation ponds effluent showed that an increase in the concentrations of total BOD, as well as total and filtered COD, due to prevailing anaerobic conditions the ponds throughout the research period. To enhance the performance of these ponds, upgrading of the existing treatment facilities at Talitha Kumi School was suggested. Upgrading process entailed the construction of a 20m³ regulating tank and two covered anaerobic ponds, with a hydraulic retention time of 2 days each. Additionally, re-arranging the existing ponds by connecting the first 7 ponds in parallel to have a total surface area of 157.5 m² of facultative ponds with a retention time of 5.7 days was considered as an essential upgrading measure. Moreover, a scheme of parallel connection between the last three ponds was suggested to increase the total surface area of the maturation ponds to 67.5 m², with a retention time of 3 days. Finally, installing a pilot filter media, for the sake of improving the effluent quality, is equally recommended.

KEYWORDS

Waste stabilization ponds, nitrogen removal, upgrading, hydraulic retention time, low-cost treatment technology, wastewater treatment

INTRODUCTION

Among many wastewater treatment alternatives, waste stabilization ponds (WSP) have become popular in small communities worldwide. Several international experts and funding agencies recommended the application of WSP in the Middle East region (EPA, 1992; Kreissl, 1993; Mara and Pearson, 1998).

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However, design data and technical information on practical experience as well as process performance of WSP under Mediterranean climatic conditions in Middle East, and particularly in Palestine, are still lacking. The design of wastewater collection, treatment and disposal systems in Palestine is usually based on assumed or imported parameters from the literature. Planners and designers, in the absence of local data, tend to adopt classical parameter values from well-known foreign textbooks. The usual result is the over sizing of the systems or sometimes under designing the system, in both cases bringing the system to failure, when put into operation. According to Amarneh (2001) the characteristics of wastewater in Palestine have not been subjected to good analysis, and hence, no enough reliable data are available.

This study will contribute to reducing the lack of basic scientific and operational data in the field of wastewater treatment using waste stabilization ponds. The results of this research study will benefit rural, educational and environmental sectors in the Palestinian society, where central sewage treatment facilities are still lacking. Hence, the main goal of this study is to evaluate the performance and process optimization of newly erected WSP system located in Talita Kumi compound in Beit Jala City, 16 km south of East Jerusalem. The treatment plant consists of a series of 10 rectangular reinforced concrete ponds with different levels forming a terrace of ponds. The first pond was designed to be an anaerobic pond, the following seven ponds were designed as facultative ponds, and the last two ponds were designed as maturation ponds.

MATERIALS AND METHOD

Methodology

Talitha Kumi Waste Stabilization Ponds had been monitored during three intervals. During the first interval, ten weeks following the commissioning date (11 March- 25 May 2000), weekly visits to the plant were performed, for the sake of monitoring the start up period, and in order to recognize the change in the performance of the system in similar conditions, measurements and samples were taken in the same hour of the same day in each week, namely, Thursdays at 15.00 hours. The second sampling interval was during the summer time at the beginning of the school semester during September. In this period, sampling was aiming at evaluating the performance of the ponds system, accordingly monitoring was performed randomly in terms of days and time. Similar methodology was performed in the winter season during January 2001. All chemical and biological parameters were conducted according to standard methods (APHA, 1992).

Results

Wastewater flow rates

Figure (1) shows the average data of 6 days of flow measurements over the inlet in the research period that extends between March 2000 and January 2001. The daily flow rate was calculated in terms of a factor times the average hourly flow (daily flow divided by 24 hours).

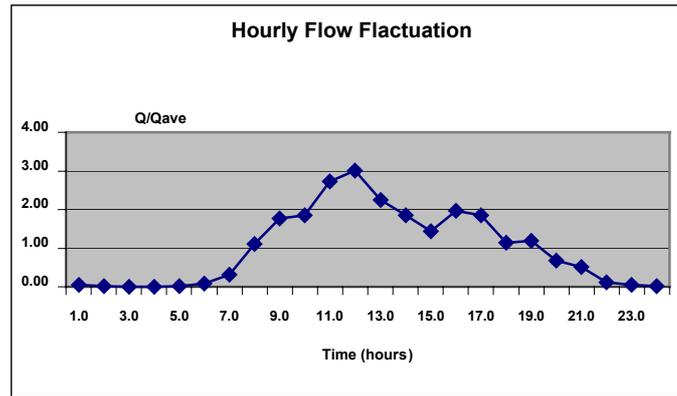


Figure 1 Average hourly fluctuation of flow for 6 days in the period from March, 2000 to January 2001

Wastewater Composition

The mean values of all the parameters for which column samples of raw sewage were analyzed are presented in Table 1. The data presented reflect the whole experimental period from March 2000 to January 2001.

Table 1: Characterization of raw domestic sewage from Talitha Kumi School.

Parameter	Unit	Min. Value	Max. Value	Mean Value
BOD ₅ (Total)	mg/l	95	631	363
BOD ₅ (Filtered)	mg/l	55	482	268.5
COD (Total)	mg/l	362	880	621
COD (Filtered)	mg/l	254	638	446
P (Total)	mg/l	15.3	34.5	24.9
TSS	mg/l	711	2346	1528.5
NH ₄ ⁺¹	mg/l	42	83.1	62.55
NO ₃ ⁻¹	mg/l	10.3	43.3	26.8
Total coliform	Number per 100 ml	160x10 ²	30x10 ⁵	15x10 ⁵
Fecal coliform	Number per 100 ml	80x10 ³	4x10 ⁵	2.4x10 ⁵

During the monitoring period, the anaerobic pond with a short hydraulic retention time of 1.2 days was able to achieve a reduction of 38% and 45% in both total BOD and filtered BOD respectively. A removal rate of 41% was also recorded for both total and filtered COD. In the same range, removal rates of nutrients were noticed. For ammonium, nitrate and total phosphate, reduction rate of 42%, 46% and 9% were achieved respectively, whereas only 39% of the TSS was achieved in the anaerobic pond. The effluent quality of the facultative and maturation ponds was very poor. There was an increase in total BOD, total COD and filtered COD concentrations in the effluent. The removal rate for phosphorus and ammonium were 30% and 12% respectively. It was noticed that there was a slight increase in the nitrate concentration. Finally, an increase in the TSS concentration was also noticed.

DISCUSSION

The obtained results from this research study showed that the performances of the anaerobic pond, facultative and maturation ponds were not satisfactory. The reasons behind the unsatisfactory results can be summarized as follows:

- All the ponds were connected in series with a very short hydraulic retention time (1.6 days per pond).

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- The ponds arrangement failed to absorb the maximum allowable BOD surface loading rate. According to Oliveria and Mara (1996), each pond in a series of facultative ponds should be able to undertake the maximum allowable BOD surface loading.
- Ponds were anaerobic during the whole period of the thesis research. Algae was washed out and increased the concentration of total suspended solids in the effluent

CONCLUSIONS

Boring holes in the baffle in the second pond to increase flow velocity and to utilize this pond as an anaerobic pond. A total volume for the anaerobic pond should be around 78 m³ instead of actual 45 m³. This will result in a reasonable organic loading rate of about 180 g/(m³.d) at 14 °C (annual average of minimum temperature of cold months). The newly hydraulic retention time in both ponds is about 2 days. Installment of additional surface area in the first 5 facultative ponds with a total liquid volume of about 113 m³ would reduce civil works. By a selected average surface organic loading rate of 15 g/(m².d) and liquid waste temperature of about 14 °C, almost an additional surface area of 350 m² must be provided. Without additional civil works and large investment costs, this can be achieved via installment of plastic chicken boxes filled with coarse and medium size gravels and stones (4 m³). The specific surface area of such fixed bed material is between 80 and 100 m²/m³. This will make about 6-8 boxes, which can be distributed within the first two facultative ponds. The total hydraulic retention time in these is about 3 days.

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