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# Optimisation of sewage treatment process at Pagla

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THE SEWAGE TREATMENT plant of the Dhaka Metropolitan, known as Pagla Sewage Treatment Plant (PSTP) was designed to treat a maximum flow of 120,000 $m^3$/day of domestic sewage generated from about 18 per cent population of the metropolitan. The final effluent from the treatment plant is discharged into the adjacent Buriganga River. The treatment process in application is basically a low cost option consisting of grit chamber, primary sedimentation tank, facultative lagoon, chlorination system and sludge lagoon (Figure 1). There has always been a general complaint of shortcomings of the overall performance of the plant, which is in fact evident from an obnoxious and foul smell even at the fag end of the plant.

In quest of optimisation of treatment process; a study was undertaken where both qualitative and quantitative aspects of sewage with particular emphasis on the characteristics of influent, effluent and sludge were checked and determined with laboratory aids. The hourly as well as seasonal variations of various parameters were also studied. This paper highlights some significant aspects of the study and aims at drawing conclusions in order to facilitate optimising the sewage treatment operation of the plant.

**Table 1. Design criteria of the existing plant**

| | |
|---|---|
| **Grit Chamber** | |
| Surface loading rate | 3600$m^3/m^2$/d |
| Detention time | 60 sec. |
| Average velocity | 0.30 m/sec. |
| **Primary Sedimentation Tank** | |
| Surface loading rate | 35$m^3/m^2$/d |
| Detention time | 2.0 hours |
| Weir loading rate | 3600$m^3$/m/d |
| **Facultative Lagoon** | |
| Influent BOD concentration | 120ppm |
| Ambient temperature | 21°C |
| Pond depth | 2.0m |
| Detention time | 7 days |
| **Chlorination** | |
| Chlorine dosage rate | 3.0ppm |
| **Sludge Lagoon** | |
| Lagoon volume rate | 50kg/year/$m^3$ |
| Digesting time | Over the 90 days |
| Content of volatile solids | 60% |
| Reduction rate of volatile solids | 35% |
| Moisture rate of dried sludge | 80% |

## Salient features of the existing plant

Table 1 and Table 2 present the salient features entailing design criteria and designed wastewater quality of the existing treatment plant (NJSCL 1987).

## Characterization of influent, effluent and sludge

Different parameters like flow rate, pH, dissolved oxygen content, biochemical oxygen demand, chemical oxygen demand, suspended solids, total nitrogen, total phosphorus, chloride and faecal coliform count were determined for the samples collected six times a day for the influent and three times a day for the final effluent of both wet season (June 1997) and dry season (December 1997). The heavy metal concentrations in the sludge from the treatment plant and in the septic tanks of individual households as well were determined. All these laboratory determinations were carried out following standard methods (APHA 1989 and AWWA 1985).

## Findings from the study

### Flow rate

In the present study, the average flow rate at the inlet was estimated as 163,000 $m^3$/day in wet season. However, in the dry season the rate dropped at 122,250 $m^3$/day, which was even higher than that of the designed maximum flow rate. At the outlet point of the plant, the flow in the wet season was estimated as 38,163 $m^3$/day while that in the dry season was 31,780 $m^3$/day.

### Influent characteristics

- The pH was found to be almost neutral during the dry season. However, in the wet season, it was recorded to be a little bit basic.
- The dissolved oxygen content was found to be higher in the dry season (0.41-1.2 ppm) than that of the wet season (0.20-0.52 ppm).
- The $BOD_5$ values at $20^0$C and COD values were found to be excessive (of the range of 500 ppm to 2500 ppm) in both the seasons, which are very unusual in domestic sewage.

- The concentration of the suspended solid particles was also detected to be on the higher side (Max. 960 ppm) than the normal domestic sewage.
- The total nitrogen (T-N), total phosphorus (T-P) and chloride (Cl) loadings were found to be consistent throughout the whole day. However, the T-P and Cl loadings were distinctly found to be low in the wet season than that of dry season.
- The faecal coliform count was very high in both the seasons with the highest values during night-time ($3.0 \times 10^{5}$-$2.9 \times 10^{6}$ n/100ml).

### Effluent characteristics

- The pH of the effluent was found to be on the basic range (7.6 – 8.8) in both seasons. A higher value was observed in the wet season.
- The dissolved oxygen content was found to be higher in the winter (1.01-2.27 ppm), but very low (0.42-1.2 ppm) in the other season.
- The $BOD_5$ values (at $20^0$C) and COD values throughout the whole day of the rainy season were found to be very high (Max. 455 and 475 ppm respectively) and exceed the limits of Bangladesh Environmental Quality Standard (GOB 1997) for discharge into a surface water body. This situation was found to be worse in the winter (Max. 720 and Max. 830 ppm respectively).
- The suspended solids concentration at noon-afternoon was found to be the highest (Max. 180 ppm) and also to exceed the limits of Bangladesh Environmental Quality Standard (GOB 1997) for discharge into a surface water body.
- The T-N, T-P and chloride concentrations were found to be higher in the winter.
- The faecal coliform count was found to be excessively high ($3 \times 10^{4}$-$2.5 \times 10^{5}$ n/100 ml) exceeding the limit of Bangladesh Environmental Quality Standards (GOB 1997).

### Sludge bed

The concentrations of heavy metals in the sludge bed, particularly lead, chromium, copper, zinc and nickel were found excessively high in comparison to sludges of domestic septic tanks of different communities of the Dhaka City.

Table 3 presents a comparative picture of heavy metals' concentration of the sludges of the treatment plant and domestic septic tanks.

**Table 2. Designed Wastewater Quality of the Treatment Plant**

| Parameter | Influent sewage quality (ppm) | Primary tank removal rate (%) | Sedimentation effluent water quality (ppm) | Facultative lagoon removal rate (%) | Effluent water quality (ppm) | Total removal rate (%) |
|---|---|---|---|---|---|---|
| $BOD_5$ | 200 | 40 | 120 | 59 | 50 | 75 |
| Suspended solids | 200 | 60 | 80 | 25 | 60 | 70 |

**Table 3. Heavy Metal Concentrations in the Sludges of Different Locations**

| Heavy Metals | Concentration (ppm) | |
|---|---|---|
| | Sludge bed of PSTP | Domestic septic tanks |
| Cadmium | 0.15 | <0.01 – 0.015 |
| Mercury | 0.23 | 0.01 – 0.03 |
| Arsenic | 0.40 | <0.05 – 0.06 |
| Lead | 28.70 | <0.01 |
| Chromium | 66.66 | <0.01 – 0.03 |
| Copper | 461.88 | 0.75 – 1.75 |
| Zinc | 1193 | 0.025 –0.050 |
| Nickel | 23.00 | 0.01 – 0.03 |

**Figure 1. General flow of pagla sewage treatment plant**

## Conclusion

The following conclusions are drawn from the study:

- The wastewater quality of the final effluent of the treatment plant exceeds the allowable limits of environmental quality standards for discharge into a surface water body.
- The abnormally high figures of BOD, COD, TDS and a very low level of DO content indicate the presence of pollutants having origins other than usual domestic sewage.
- Presence of heavy metals at objectionable levels particularly in the sludge bed, indicates contaminations from industrial pollutants particularly from tanneries, textiles, zinc & nickel plating and other chemical industries that are located within and outskirts of the city (Rahman 1997).
- Decomposed sludge materials are not suitable for use directly as fertiliser or in land filling operation.

## Recommendations

A rapid assessment is required to be made in regard to the locations and settings of dispersed as well as cluster of industries, qualitative and quantitative nature of industrial effluent and disposal methods of industrial wastes.

As a long-term strategy, upon completion of rapid assessment, industrial effluents are to be prevented from entering into the domestic sewer network of the PSTP. Industries are to be responsible for treating their wastes.

As short term and interim measures the surface loading at the grit chamber is required to be reduced and the retention period in the primary sedimentation tank should be increased.

Dosage of disinfectant is to be monitored and applied accordingly prior to discharging the final effluent into the Buriganga River.

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**Figure 2. Variation of pH in the influent and final effluent**