SOME CHARACTERISTICS OF DOMESTIC WASTEWATER

by Mrs. N. Ratnayake and S. Sandanam

Introduction

The domestic wastewater is composed of human body wastes (faeces and urine) and sullage which results from personal washing, laundry work, etc. The constituents present in it are complex and diverse and is composed of 3 main categories, namely, carbohydrates, nitrogenous compounds and lipids. This usually gets diluted by some infiltrated stormwater. The domestic wastewater causes environmental and health and nuisance hazards and will have to be adequately treated to abate these hazards. Fresh sewage is a grey turbid liquid and is of inoffensive odour. But as soon as it loses its dissolved oxygen, it becomes septic and will have an offensive smell. The septicity is usually minimised by suitable oxidation of the carbonaceous organic matter present in the sewage. The oxidation of nitrogenous matter is then looked into if it is necessary to limit the nitrate level of the receiving water. The treated domestic wastewater is then disinfected to kill pathogens and then disposed into the receiving body. The usual treatment methods are a combination of physical and biological processes, though some chemical methods are also adopted occasionally. The biological treatment is effected by certain types of bacteria, which while decomposing the waste get food for their livelihood. This is an economical method and is favourably carried out in tropical climates. Hence to study the physical and biological characteristics, samples of domestic wastewater were collected from the Wellawatte and Bambalapitiya pumping stations of the Colombo Municipality. The Colombo Municipality is divided into 11 regions and each region has independent sewer network that leads sewage to the corresponding pumping station in the region. These eleven regions are divided into two zones, namely, northern zone and southern zone. The southern zone consists of the area covered by Wellawatte, Bambalapitiya and Thimbirigasyaya pumping stations and the entire sewage of this zone is disposed into the sea via Wellawatte pumping station. The other pumping stations feed the sewage to the Madampitiya pumping station from where it is discharged into the Kelani estuary and subsequently into the sea. The wastewater collected in this sewerage system is mainly or domestic origin except for the waste from the food

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processing complex at Narahenpita and that from the slaughter houses, etc. Owing to practical difficulties (pertinent to the facilities of testing) in collecting composite samples, only "grab samples" were collected from both stations at about 9.30 a.m. on each day of testing.

Scope

If the basic treatment parameters given in foreign text books,is adopted in the design of wastewater treatment plants in Sri Lanka, the cost of construction, operation and maintenance of the treatment plant may not be economical and the desired results may not be achieved. Hence it is very essential to study the physical and biological characteristics of domestic wastewater of our country. The concentration of suspended solids is a useful yardstick to estimate the type and extent of physical treatment. The amount of oxygen required for the aerobic biochemical oxidation of the carbonaceous matter is called the 1st stage B.O.D. The parameter B.O.D. is an index of the pollution lead. Per capital B.O.D. is an important design parameter in the biochemical treatment of sewage.

The quality of effluent is stipulated by B.O.D., conc. of S.S. and by other less important parameters. The Royal Commission on sewage disposal in the United Kingdom has stipulated limiting values for B.O.D.$_5^{20}$ and conc. of S.S. of 20 mg./litre and 30 mg./litre respectively for a dilution of not less than 1;8. A committee appointed to formulate a standard for Sri Lanka has proposed an interim effluent quality standard for industrial wastes with the respective upper limits of B.O.D.$_3^{28}$ and conc. of S.S. of 30 mg./litre and 50 mg./litre respectively. This has to be finalised. Hence the estimation of values of B.O.D. and conc. of S.S. will be useful.

A study was carried out on the samples of domestic wastewater collected in two parts. Part I (or Test I) consisted of the assessment of the daily variation of B.O.D. and the conc. of S.S. for a week and a study of the inter-relationship between the two. An estimation of the per capita B.O.D. was also done. Part II (or Test II) consited of B.O.D. measurements of filtered and unfiltered samples over several days with a view to estimate the K, values for the filtered and unfiltered samples and also to estimate the ratios of B.O.D.$_5^{20}$/L_o and dissolved B.O.D.$_5^{20}$/ total B.O.D.$_5^{20}$

Testing Programme

Test I: Samples of wastewater from Bambalapitiya and Wellawatte were collected daily over a period of 7 days. B.O.D.$_5^{20}$ determinations were made for two dilutions (50 and 100) for each sample, two samples being tested for each dilution. Thus, for samples from each pumping station on any day, 4 B.O.D.$_5^{20}$ determinations were made.

Dilution water was prepared and the dissolved oxygen concentration was determined using the Winkler method with the aside modification according to the "Standard Methods" for the examination of water and wastewater by A.P.H.A. (1981). In all the tests carried out, no attempt was to suppress nitrification but instead evident points of nitrification were identified and these readings were discarded in the calculations. The determination of the conc. of S.S. was carried out using glass fibre filter paper, employing vacuum filtration.

Test II: Samples of wastewater from Bambalapitiya and Wellawatte were collected for 4 days at an interval of 2 weeks. Four long term trials were carried out with the collected samples. Samples from each pumping station were tested separately and B.O.D. determinations were made. The first two trials were with unfiltered samples. The last two trials were carried out with filtered samples and along with those, the unfiltered waste was also tested to assess the corresponding B.O.D.$_5^{20}$. A dilution factor of 100 was adopted. The conc. of S.S. of the samples was also determined.

Experimental Results

Test I.

Average values of BOD_5^{20} and conc. of.SS

Using Students's "t" distribution (No: of samples of 28 $<$ 30), it was found that there is no statistical difference between the values of B.O.D.$_5^{20}$ at 0.01 and 0.05 levels of signficance.

Average B.O.D.$_5^{20}$ = 245.8 mg/1
(Refer Figure I)

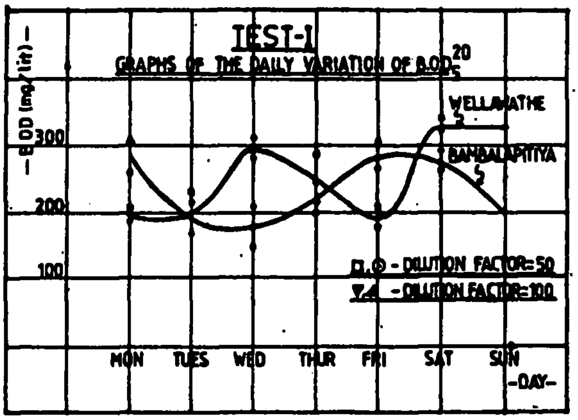

FIGURE-I

By similar analysis, it was found that there is no statistical difference between the values of conc. of S.S. at 0.01 level of significance only.

Average conc. of S.S. = 122.3 mg/1
(Refer Figure II).

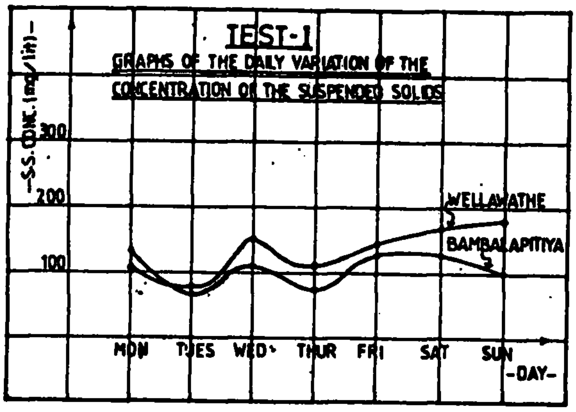

FIGURE-II

Per capita B.O.D.

This was estimated to be 37.0 gms./head/day for the Bambalapitiya tributary.

Variation of B.O.D.$_5^{20}$ with conc. of S.S

It was found that above relationship could be approximated to the form: B.O.D.$_5^{20}$ = 1.3 x conc. of S.S. + 87.5 (Refer Figure III).

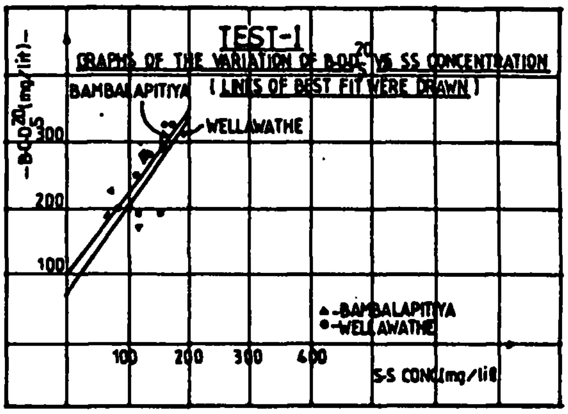

FIGURE-III

Test II.

Values of k_1 and L_o

A specimen curve for the variation of B.O.D. with time is presented in Figure IV. Graphs of $(\frac{t}{y})^{1/3}$ vs t were plotted and K_1 and L_o values were based on this least square line. (For a specimen curve refer Figure V).

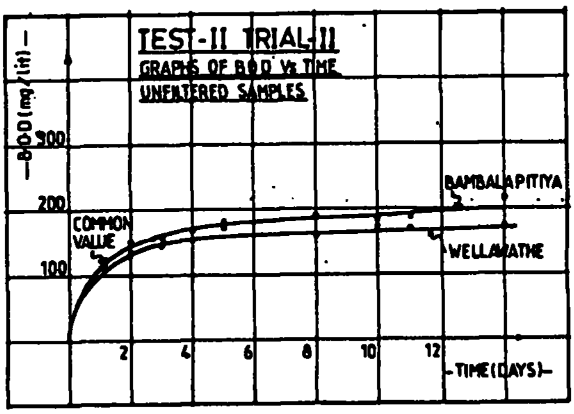

FIGURE-IV

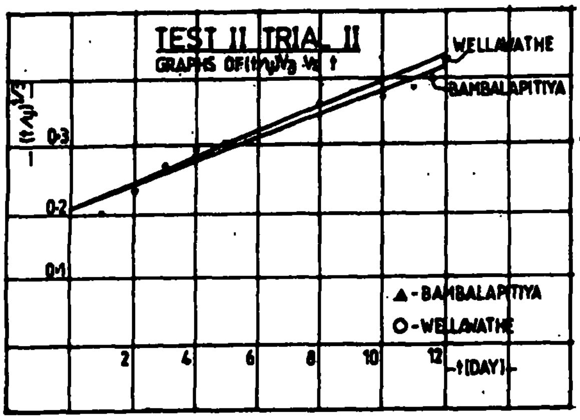

FIGURE-V

The values of K_1 and L_o are presented in Table A.

Average value of K_1 at 20^o C (base 10)

The average value of K_1 (for Table A) was 0.21 per day.

Ratio of B.O.D.$_5^{20}$/L_0

This was found to have an average value of 77.3%.

Ratio of dissolved B.O.D.$_5^{20}$/Total B.O.D.$_5^{20}$

This was found to have an average value of 46%.

TABLE A

TEST II	STATION		TYPE OF SAMPLE		K_1 per day at 20^oC (base 10)	L_0 mg/litre
	Wellawatte	Bambalapiti-ya	Unfiltered	Filtered		
TRIAL I	X		X		0.206	333
		X	X		0.195	195
TRIAL II	X		X		0.231	200
		X	X		0.230	220
TRIAL III	X			X	0.193	100
		X		X	0.198	155

Check on the first order kinetics.

The respective correlation coefficients for the graphs of $(\frac{t}{y})^{1/3}$ vs t were between 0.98 and 0.99. This showed that the assumption that the domestic wastewater samples obeyed 1st order kinetics, was quite acceptable.

Conclusions

The variations in the daily values of B.O.D.$_5^{20}$ of the domestic wastewater samples from Bambalapitiya and Wellawatte pumping stations were not substantial. The same was the case with the daily variation of the conc. of S.S.

The domestic wastewater samples from Wellawate and Bambalapitiya could have come from the same population to a level of significance 0.05, as measured by their $B.O.D._5^{20}$ values. The average value of $B.O.D._5^{20}$ of 245.8 mg/l, though less than that reported in advanced countries, was within the acceptable range of $B.O.D._5^{20}$ values for the domestic wastewater in developing countries. The average value of the conc. of S.S. was 122.3 mg./l.

The average value of the per capita B.O.D. for the Bambalapitiya tributary was 37.0 gm./head/day. This was within the acceptable range for domestic wastewater in developing countries.

Though not of much significance, a correlation of the form, $B.O.D._5^{20}$ = A + B (conc.of S.S.), appeared to exist between the daily values of $B.O.D._5^{20}$ and the conc. of S.S. The probable value of A and B were 87.5 and 1.3 respectively.

No lag time was noticed in any of the trails with both filtered and unfiltered samples.

No significant sign of nitrification was noticed upto the 10th day in any of the samples tested.

The regression line obtained on the assumption of the 1st order kinetics had very high coefficient of correlation (close to unity) which confirmed that the B.O.D. exertion in domestid wastewater samples had obeyed 1st order kinetics. Further, the values of the 1st stage ultimate B.O.D. (L_o) obtained on the basis of this assumption were in conformity with the experimentally projected values.

There was no siginificant difference in the value of the deoxygenation rate constant (K_1) obtained for the filtered and unfiltered samples.
The average value of 0.21 per day (base 10) at 20°C was somewhat higher than in advanoed countries, even though it was in the acceptable range. This implied that the local domestic wastewater samples biochemically degraded more rapidly.

The value of the ratio of $B.O.D._5^{20}/L_0$ of 77.5% was correspondinglv higher. This implied that a major portion of the domestic wastewater degraded biochemically within the first 5 days.

Suggestions

More elaborate study of the characteristics of domestic wastewater of Sri Lanka could be carried out from composite samples collected Islandwide.

The parameters (other than B.O.D. and conc. of S.S.) like colour, turbidity, temperature, p_H, radioactivity, concentration of toxic materials, number of faecal coliforms, algae, etc. could also be incorporated in the study.

An assessment of the parameters at a temperature of 28^o C, which will probably be the future Sri Lankan standard temperature, will be useful.