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Short Communication

The effect of sand-bed filtration on the oxygen demand characteristics of wastewaters from domestic, institutional and industrial sources

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Wastewaters from three different sources, private residence (domestic), medical clinic (institutional) and polymer industry (industrial) were characterised for their pollution potentials. The results of analysis show pH of 7.6, 6.5 and 6.3 for domestic, institutional and industrial wastewater, respectively. The DO, BOD and COD was found to be 4.01, 66 and 114 mg/l for the domestic wastewater, 3.70, 88.6 and 196.8 mg/l for the institutional wastewater and 3.60, 234 and 567 mg/l for the industrial wastewater. Solids concentration were 391.8 mg/l TS, 381 mg/l TSS and 10.8 mg/l TDS for the domestic wastewater; the institutional wastewater gave 1123 mg/l TS, 893 mg/l TSS and 230 mg/l TDS; while the solids present in the industrial wastewater are 674 mg/l TS, 554 mg/l TSS and 120 mg/l TDS. The total bacteria count (TBC) per 100 ml sample was 3.5×10^3, 4.6×10^6 and 6.0×10^6 for domestic, institutional and industrial wastewater respectively. The effect of sand-bed filtration on these characteristics were also studied and it was found that while sand-bed filtration increases the values of DO, while the values of BOD and COD were reduced accordingly. It is however recommended that oxygen demand tests should be combined with other test like bacteriological to ascertain the quality and hence the portability of water abstracted for uses.

Key words: Wastewaters, sand-bed, filtration, oxygen demand, domestic, institutional, industrial, pollution.

INTRODUCTION

In any system where organic matter is present, the organic matter can be broken down (biodegraded) to simpler ones by bacteria action. Oxygen is utilized during the biodegradation process. It has been found that the rate of biodegradation of the organic matter at any given time is proportional to the amount of organic matter and also the microbial population present in the system at that time (Tchobanoglous, 1979; Ademoroti, 1987). Dissolved oxygen is the amount of oxygen in the gaseous form present in water available for aerobic organisms to carry out their life processes. A healthy body of water should have a dissolved oxygen concentration of 5 – 7 mg/l (Henry and Heinke, 1989). A well balance warm water where fish can thrive for example requires a dissolved oxygen level of not less than 5 mg/l. The dissolved oxygen in highly polluted wastewater is near zero because the oxygen present is used up by microorganisms (Ademoroti, 1996).

The parameter used as a measure of the amount of oxygen required by microorganisms is “biochemical oxygen demand” (BOD). This parameter also measures the strength of any given wastewater (Ademoroti, 1984). The BOD is an empirical biological test in which the water condition such as temperature, oxygen concentration or type of bacteria plays a decisive role. These and other factors cause the reproducibility to be much less than that of pure chemical tests. Inspite of the disadvantage, the BOD is of special importance in the assessment of pollution in wastewater. The Chemical Oxygen Demand (COD) is used to measure the oxygen equivalent required to oxidise the organic matter using a strong chemical oxidising agent in an acidic medium. The oxidising agents commonly used are potassium dichromate and potas-

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Table 1. Characterization of raw wastewater from domestic, institutional and industrial sources.

Parameter	Domestic	Institutional	Industrial
DO (mg/l)	4.01	3.70	3.60
BOD (mg/l)	66	88.6	234
COD (mg/l)	114	196.8	567
pH	7.6	6.5	6.3
TS (mg/l)	391.8	1123	674
TSS (mg/l)	381	893	554
TDS (mg/l)	10.8	230	120
Electrical conductivity	2.10	6.10	112
Turbidity (FTU)	401	638	540
Total bacteria count/100 ml	3.5×10^3	4.6×10^6	6.0×10^6

All values are mean mkjof triplicate determinations.

sium permanganate. The COD of a waste is in general higher than the BOD because more components can be chemically oxidised than can be biologically oxidised (Ademoroti, 1984). Inorganic substances that are oxidised by dichromate increase the apparent organic content of the sample. Also, certain organic substances may be toxic to the micro-organism used in the BOD test, from an operational point; one of the main advantages of the COD test is that it can be completed in about 2 h compared to five days for the BOD test (Ademoroti, 1980). A high DO is an indication of a high state of purity of water and a low DO is an indication of pollution. Conversely a high BOD and COD is an indication that the water is polluted whereas a low BOD and COD indicate high quality (Ademoroti, 1980).

In this work, oxygen demand tests (DO, BOD and COD) were carried out on three wastewater samples collected from domestic, institutional and industrial sources. The wastewaters were treated using a sand-bed, and the characteristics of the raw wastewater and the treated effluent were compared using oxygen demand tests as index of pollution measurement. This was done by comparing their values to the values of other parameters like solids concentration, turbidities and total bacteria counts.

MATERIALS AND METHODS

Sampling techniques

The wastewaters used were obtained from three sources; domestic (in private residential quarters, institutional (in a private clinic in Ekpoma) and industrial (in a polymer processing factory in Benin City). Wastewater samples were collected at the discharge points in their various sources. Samples were collected from 7 different spots within the flow line of the wastewater in the discharge points and mixed together to form a composite sample. A total of 49 samples (weekly sampling) were collected for analysis. Samples were collected separately for some parameters so as to preserve the composition. pH, temperature, and dissolved oxygen (DO) were determined *in situ* on the field.

The day for sample collection in the new week was different from that of the preceding week. This was done so that the total exercise might account for the cyclic and intermittent variations occurring at the work site. Samples were collected from the sources once a week for seven weeks and analysed. Where analysis could not be carried out immediately, samples were preserved in a refrigerator maintained at 4°C. At this temperature, microorganisms in the sludge are inactivated to prevent biodegradation.

Analyses

All samples were analyzed as described in the Standard Methods for the Examination of Water and Wastewater and Standard Methods for water and effluents analysis APHA, (AWWA, WPCF, 1985; Ademoroti, 1996). Where analysis was not immediately possible, they were preserved to inhibit biodegradation.

All the reagents used for the analysis were of analytical grade and obtained from BDH Chemicals Limited, Poole, England.

RESULTS AND DISCUSSION

The results of characterisation and treatment of the wastewaters are shown in Tables 1 and 2. Table 1 shows the characteristics of wastewater from three sources; domestic, institutional and industrial. From the results, the pH of the wastewaters were 7.6, 6.5 and 6.3 for domestic, institutional and industrial, respectively. The dissolved oxygen (DO) is found to be 4.01, 3.70 and 3.60 mg/l for the domestic, institutional and industrial, respectively. The BODs and CODs were 66 and 114 mg/l, 88.6 and 196.8 mg/l and 234 and 567 mg/l for the domestic, institutional and the industrial wastewaters, respectively.

The turbidities are 401 FTU for the domestic wastewater, 638 FTU for the institutional and 540 FTU for the Indus-trial wastewater. These turbiduties values indicate that the wastewaters contain some solids. The amounts of solids contain in the domestic wastewater were 391.8 mg/l total solids (TS) 381 mg/l total suspended solids (TSS) and 10.8 mg/l dissolved solids (DS). Institutional wastewater gave 1123 mg/l TS, 893 mg/l TSS and 230 mg/l DS. The amount of solids in the industrial wastewater are 674 mg/l TS, 554 mg/l TSS and 120 mg/l DS. The microbial populations as given by the total bacteria counts were 3.5×10^3, 4.6×10^6 and 6.0×10^6 per 100 ml

Table 2. Effect of sand-bed filtration on wastewater characteristics from domestic, institutional and industrial sources.

Parameter	Domestic	Institutional	Industrial
DO (mg/l)	4.22	3.85	3.72
BOD (mg/l)	5.08	48.73	117
COD (mg/l)	98	125.95	368.5
pH	6.9	6.1	6.8
TS (mg/l)	10.93	46.36	6.74
TSS (mg/l)	3.81	17.86	5.54
TDS (mg/l)	7.12	28.50	12.0
Electrical conductivity	1.86	5.8	126
Turbidity (FTU)	160.4	223.4	145.8
Total bacteria count/100 ml	15×10^3	1.84×10^6	2.1×10^6

All values are mean of triplicate determinations.

sample for the domestic, institutional and the industrial wastewaters, respectively.

A comparison of Tables 1 and 2 reveal the effect of sand-bed filtration on the quality parameters of the wastewaters. The DO rose from 4.01 to 4.22 mg/l for the domestic wastewater. A rise in DO of 3.70 to 3.85 mg/l was observed for the institutional wastewater and Industrial wastewaters DO rise from 3.60 to 3.72 mg/l. This marginal increase was expected because filtration only removes suspended particles. Conversely, was about 40 – 50% BOD reduction. The same observation was made for the COD, with about 30 – 35% reduction. Results for the TBC shows a reduction of about 55 – 65% after filtration. The suspended solids observed in the filtered wastewater were very low. Filtration achieved up to 90 –98% SS reduction. As would be expected only marginal change in total dissolved solids (TDS) was observed upon filtration. Similar observation was also noted for the electrical conductivity since the ions responsible for the conductivity are not affected by filtration. It is also observed that the pH fell for all the wastewater after filtration. This could be due to the nature of the sand-bed; it is likely that it contain some slightly acidic constituents. The drop in pH could also have resulted from the products of biodegradation as a result of it being exposed to air. Two products of aerobic biodegradation suspected to have lowered the pH are carbon (IV) oxide and hydrogen ions. The reactions taking place in the process is approximately described by the equation (Metcalf and Eddy, 1975,1979; U.S. EPA, 1985, 1989):

$$C_5H_7NO_2 + 7O_2 \xrightarrow{\text{Bacteria}} 5CO_2 + 3H_2O + NO_3 + H^+$$

The CO_2 and H^+ formed in the reaction medium could lower the pH of the filtered wastewater.

Conclusion

The results of this study show that as DO increases, BOD and COD reduces and other parameters like TS, TSS, TDS, turbidity, TBC reduces as well. It has been asserted that a high DO level is an indication of a high state of purity of water and a low DO is an indication of pollution. Conversely, a high BOD and COD is an indication that the water is polluted whereas a low BOD and COD indicate high quality (Ademoroti, 1980). Oxygen demand tests (DO, BOD, and COD) therefore prove to be very successful in monitoring the quality of water. It is however necessary to combine these tests with others like, physiccochemical, toxicology and microbiological. However, detailed biophysicochemical test results must be combined to completely ascertain the safety of potable water.

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