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Short Communication

Prediction of Five-day Biochemical Oxygen Demand (BOD_5) from Chemical Oxygen Demand (COD) Values in Raw and Biologically Treated Domestic Sewage

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Abstract. The functional relationship between BOD_5 and COD was evaluated using domestic sewage samples collected from a sewage treatment plant in an estate in Warri, Delta State, Nigeria. Two types of samples were collected: raw domestic sewage,(influent) and biologically treated domestic sewage (effluent).The correlation coefficient 'r' between the BOD_5 and COD was determined and values were 0.99 and 0.94, respectively for different sewage samples. The regression analysis carried out showed very strong correlation . The linear correlation established was: COD = 1.62 BOD_5 + 15.82 ; r^2 = 0.978; COD = 1.58BOD_5 + 9.21; r^2 = 0.878. Results obtained above were also judged as significant at 95% and 99% confidence levels. Confidence intervals obtained were: 1.53≤ a ≤1.71 at 95% and 1.49≤ a ≤1.75 at 99% for the raw sewage; 1.37≤ a ≤ 1.80 at 95% and 1.27≤ a ≤1.90 at 99% for the biologically treated sewage.

Keywords: prediction, BOD_5, COD, correlation, regression analysis, domestic sewage, wastewater

Water pollution and sewage disposal is a major global problem (Porteous, 2000; Miroslav and Vladimir, 1999). Treatment of sewage before disposal has become a challenge in Nigeria and steps are being taken to restrict indiscriminate disposal so as to reduce pollution and create a good and healthy environment.

Fish and other aquatic life require dissolved oxygen for survival and should normally be at least 5 mg/L. Water with less than 2 mg/L dissolved oxygen will support mainly worms, bacteria, fungi and other detritus feeders and decomposers. The dumping of oxygen demanding wastes such as sewage to water bodies stimulates oxygen decomposers. The water body may become oxygen depleted that fish and other aquatic life find it difficult to survive (Akpofure, 2009).

The amount of oxygen consumed by these microorganisms in decomposing organic matter in a body of wastewater is referred to as biochemical oxygen demand (BOD) (Hogan, 2010; Tchnobanoglous and Burton, 2001).

Chemical oxygen demand (COD) measures the amount of oxygen required for complete oxidation of the organic matter in the wastewater to carbon (IV) oxide and water (Uwidia and Ademoroti 2011; Sawyer *et al.,* 2003). COD and BOD_5 tests are used by Rustum *et al.* (2008) to measure oxidation of wastes and oxygen consumed by microorganism.

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This study focuses on appraising COD of raw and biologically treated domestic sewage intended for organic load determination against BOD_5 at different stages of the treatment (primary and secondary treatment). The aim is to possibly design a model for quick prediction of BOD_5 values from COD values which are available in less than 3 h in raw and biologically treated domestic sewage.

The domestic sewage used in this study was obtained from a sewage treatment plant in an estate located in Warri, Nigeria. The amount of sewage generated per day was estimated at an average flow rate of $2.0x10^5$ litres. It was made up of toilet, urinal, bathroom and kitchen wastes arising from the estate. The plant is a conventional treatment plant that operates on activated sludge principle. The treatment plant serving an average population of about 3,000 inhabitants, is designed as a continuous process to receive and treat wastewater (sewage) generated within the estate. However, many of the principles operated in the treatment plant also apply to large treatment plants.

Sample collection and analysis. Two types of sewage samples (raw and biologically treated domestic sewage) were collected at different stages of treatment: the inlet and outlet points (in the central sewage system and collection chamber) of a primary treatment process designed to remove coarse/solid particles and the outlet pipe of a more rigorous treatment process(aerobic

treatment in an aeration tank via pressure pipes) designed to remove high organic load.

Water used was demineralised by Barnstead demineraliser and then distilled in all-glass apparatus to ensure that the distilled water used did that not contribute to the BOD_5 and COD values.

All the glassware used were cleaned by soaking over-night in chromic acid followed by rinsing in tap water and finally in distilled water.

Two parameters (BOD; 24 composite samples and COD; 24 composite samples) were determined as recommended by the Standard Methods for the Examination of Water and Wastewater (Lenore *et al.,* 2005). Dissolved oxygen (DO) was determined using the Azide modification of Winkler's method; BOD_5 was determined by incubating the samples in the dark for 5 days at 20 ºC.

The COD was determined by closed reflux titrimetric method. The well mixed samples were refluxed for 2 h with standard potassium dichromate digestion solution in the presence of sulphuric acid reagents. After digestion, the excess dichromate was titrated against standard ferrous ammonium sulphate titrant (FAS) using ferroin indicator. Blank determinations were also carried out and the COD was calculated. Results obtained were subjected to correlation and regression analysis (Murray and Larry, 2009; Nathabandu and Renzo, 1998).

Results obtained from the analysis are presented in Tables 1-2, and also Fig. 1-2. Table 1 presents some characteristics of the domestic sewage studied, their range of values and mean. A breakdown of results obtained from analysis of the raw and treated sewage is included in Table 2. A comparison of the results obtained for the two types of sewage in Table 2 shows that, as the sewage progress through primary and secondary treatment processes, some organic matter would have been biodegraded. Also lower 'r' value was obtained for the relationship examined between BOD_5 and COD in the biologically treated domestic sewage. COD values obtained were higher than the BOD_5 values. This may be attributed to the fact that the BOD_5 test measured oxygen demand of the biodegradable pollutants whereas the COD test measured the oxygen demand of biodegradable pollutants plus oxidizable pollutants. Therefore determination of BOD_5 is necessary to know the biodegradable organic fraction for the sewage since COD will not exactly give idea whether the organic matter present is biodegradable or not.

Table 1. Some characteristics of the domestic sewage studied

Parameters	Raw domestics sewage		Treated domestic sewage	
	Range	Mean	Range	Mean
Temperature	24.20-27.30	25.81	27.90-31.40	29.78
pH values	6.60-7.16	6.92	7.01-7.29	7.12
Suspended solids				
SS (mg/L)	140.10-207.30	164.20	56.30-67.00	61.13
BOD_5 (mg/L)	160.30-230.10	188.74	72.90-85.00	78.77
COD (mg/L)	269.00-39.50	321.82	120.80-145.20	133.94

Table 2. BOD_5 and COD determinations for the raw and biologically treated domestic sewage

S. no.	Raw domestic sewage		Biologically treated domestic sewage	
	BOD_5 (mg/L) mean ± SD	COD (mg/L) mean ± SD	BOD_5 (mg/L) mean ± SD	COD (mg/L) mean ± SD
1	160.30 ± 3.26	269.00 ± 0.08	76.10 ± 0.34	130.50 ± 0.16
2	164.20 ± 1.00	289.81 ± 0.31	79.70 ± 0.25	137.60 ± 0.37
3	168.72 ± 0.71	288.10 ± 0.09	82.00 ± 0.05	143.00 ± 0.17
4	162.50 ± 0.17	281.33 ± 0.21	80.60 ± 0.21	138.30 ± 0.22
5	218.74 ± 1.31	367.00 ± 0.71	79.80 ± 0.25	136.50 ± 0.16
6	230.10 ± 0.89	390.50 ± 0.44	85.50 ± 0.14	145.20 ± 0.13
7	170.00 ± 1.01	288.50 ± 0.65	76.10 ± 0.34	130.56 ± 0.26
8	176.10 ± 0.75	298.20 ± 0.09	83.50 ± 0.14	140.60 ± 0.54
9	184.10 ± 0.38	320.00 ± 1.64	76.50 ± 0.34	130.50 ± 0.26
10	170.20 ± 0.40	287.75 ± 0.46	72.90 ± 0.09	122.80 ± 0.49
11	184.50 ± 0.31	310.70 ± 0.52	74.50 ± 0.22	125.90 ± 0.46
12	190.82 ± 0.66	322.82 ± 0.26	81.70 ± 0.17	137.80 ± 0.23
13	178.00 ± 0.20	300.00 ± 0.41	78.90 ± 0.46	135.30 ± 0.16
14	188.33 ± 0.17	330.10 ± 0.10	79.10 ± 0.14	131.30 ± 0.21
15	200.20 ± 0.10	344.00 ± 0.09	78.80 ± 0.33	135.40 ± 0.39
16	184.00 ± 0.11	305.67 ± 0.38	70.90 ± 0.13	120.80 ± 0.09
17	202.50 ± 0.19	348.62 ± 0.11	80.90 ± 0.11	133.89 ± 0.45
18	218.10 ± 0.18	373.38 ± 0.10	82.80 ± 0.35	142.50 ± 0.19
19	164.10 ± 0.15	292.36 ± 0.20	75.38 ± 0.25	131.17 ± 0.20
20	172.60 ± 0.56	290.12 ± 0.05	76.24 ± 0.11	130.60 ± 0.07
21	211.20 ± 0.26	360.01 ± 0.08	78.90 ± 0.14	130.50 ± 0.26
22	189.48 ± 0.09	328.22 ± 0.09	75.40 ± 0.26	130.70 ± 0.47
23	212.42 ± 0.02	355.00 ± 0.28	80.11 ± 0.41	131.73 ± 0.20
24	228.50 ± 0.31	382.60 ± 0.84	84.68 ± 0.75	141.56 ± 0.15

Relationship between COD and BOD_5 in the raw and treated domestic sewage. Using all of the data obtained for BOD_5 and COD, linear correlations were determined and results were compared by a t - test. Values of r^2 were significant at 95% and 99% confidence levels.Confidence intervals obtained were: $1.53 \leq a \leq 1.71$ at 95% and $1.49 \leq a \leq 1.75$ at 99% for the raw sewage; $1.37 = a = 1.80$ at 95% and $1.27 = a = 1.90$ at 99% for the biologically treated sewage. The specific equations for the linear

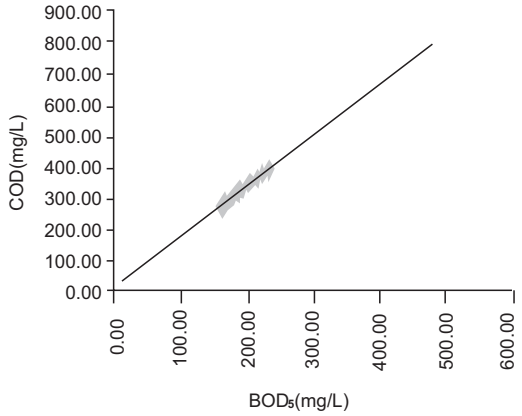

Fig. 1. Linear regression of COD on BOD_5 for raw domestic sewage.

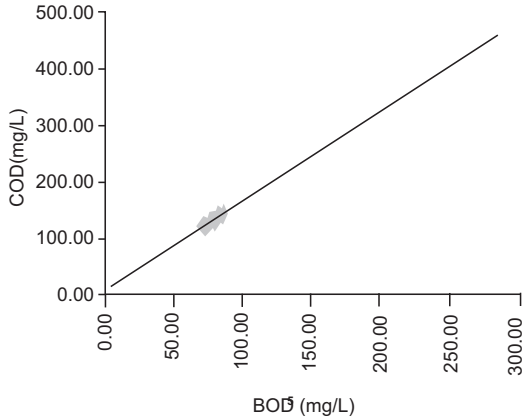

Fig. 2. Linear regression of COD on BOD_5 for treated domestic sewage.

correlations determined in the raw and biologically treated sewage (Fig. 1-2) are as shown below:

$COD = 1.62BOD_5 + 15.86$; $r^2 = 0.978$; $r = 0.989$
$COD = 1.58BOD_5 + 9.21$; $r^2 = 0.878$; $r = 0.937$

The relationships enable reasonable and good estimation of BOD_5 using quicker, easier and quantitatively more reliable method compared with the classical conventional BOD_5 test for raw and biologically treated domestic sewage.This will also ease the calculations of BOD/COD ratios in order to predict the biodegradability of water since high BOD/COD ratios indicates that a water body is polluted and relatively biodegradable.

The linear regression of COD on the BOD_5 values which were found to be positive and strongly related will be useful for predicting BOD_5 from the corresponding COD values in raw and biologically treated domestic sewage.

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