REGRESSION ANALYSIS OF PERMANGANATE VALUE (PV) ON SUSPENDED SOLIDS (SS), BIOCHEMICAL OXYGEN DEMAND (BOD), AND CHEMICAL OXYGEN DEMAND (COD) IN DOMESTIC SEWAGE OBTAINED FROM AN ESTATE IN WARRI, NIGERIA.

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Abstract
Samples of domestic sewage obtained from a sewage treatment plant located in Warri, Nigeria were analysed for some pollution characteristics such as permanganate value (PV), suspended solids (SS), biochemical oxygen demand (BOD) and chemical oxygen demand.Values obtained from the analysis were used to assess any relationship between the pollution characteristics using correlation and regression analysis.
Mean values of the pollution characteristics had the following range of values: PV (162.20-286.00)mg/L, SS (200.00-380.00)mg/L, BOD (163.70-220.74)mg/L, and COD (286.22-355.56)mg/L. The relationships assessed (i.e. PV/SS, PV/BOD and PV/COD), regression equations and correlation coefficients obtained were: PV=0.6962SS+21.973; r = 0.938, PV=1.0853BOD – 16.751; r = 0.593 and PV=1.174COD – 177.7 ; r = 0.730 respectively. The analysis revealed that strong and significant linear relationship exists between suspended solids and permanganate value in the domestic sewage.

Keywords: Regression analysis, Correlation, SS, PV, BOD, COD, Domestic Sewage, Pollution.

Introduction

Municipal sewage includes every sewage obtained from both domestic and industrial environment [1]. The common constituents of domestic sewage include organic and inorganic matter, solids (both suspended and dissolved) and microorganisms [2]. These substances are present as contaminants and the concentration is normally expressed in milligrams of contaminants per litre of the mixture.

Over the years man has experienced serious environmental impact of wastewater discharged from various sources. Typically sewage contains bacteria, viruses and other parasites which are pathogenic [3]. Such pathogenic organisms are disease causing which grow and multiply fast in the intestinal tracts of their hosts for example, man and animals [4]. The faeces of such infested host or carriers can get into a water supply or swimming area easily by direct discharge of raw sewage into the receiving water (river, stream, lake, ocean etc) [5],[6]. Such direct discharge causes sewage pollution and serious epidemics. Examples of such diseases transmitted due to direct sewage disposal are water borne diseases (cholera, dysentery, diarrhoea, typhoid, hepatitis etc) and water contact diseases like schistosomiasis, leptospirosis, tularemia [7].

Permanganate value is a measure of the amount of oxygen obtainable from potassium permanganate (in acid or alkaline medium) [8]:

$2Mn0_4^- + 6H^+ \longrightarrow 2Mn^{2+} + 3H_20 + 5\ (0)$

$2Mn0_4^- + 20H^- \longrightarrow 2Mn0_2 + H_20 + 5\ (0)$

The oxygen released is useful for the oxidization of easily oxidizable inorganic and organic pollutants in sewage samples. Discharge of sewage into a water body reduces the water quality due to pollution by the wastes in the sewage. The greater the pollution load, the poorer the quality of water [9].

Permanganate value, suspended solids, biochemical oxygen demand and chemical oxygen demand are pollution characteristics used to assess the pollution strength of domestic sewage based on oxygen requirements [10].

All matter except the water contained in liquid is classified as solid matter. Dissolved solids can be differentiated from suspended solids by filtration. Suspended solids present in domestic sewage are insoluble organic and inorganic particles. They are mainly materials that are too small to be collected as solid wastes. Discharge of suspended solids increases the turbidity of water and causes a long term demand for oxygen because of the slow degradation rate of the organic fraction of the material [11].

Solids in water are undesirable because they degrade the quality of water. When the solid content of any water is high, additional mechanical and chemical treatment is required and cleaning process becomes more expensive [10] [12].

High levels of solids in water also increase the density of water and reduce the solubility of gases like oxygen. Proteins, carbohydrates and fats are biodegradable contaminants which constitute 90% of the organic matter in domestic sewage. The sources of these

biodegradable contaminants include excreta and urine from humans; food wastes from sinks; soil dirt from bathing, washing and laundering; plus various soaps, detergents and other cleansing products. The natural biodegradation of proteins (e.g. milk, eggs, meat etc.) will eventually lead to the discharge of ammonia. Ammonium oxidation into nitrite and nitrate by nitrifying bacteria lead to an extra consumption of oxygen present in the sewage. Therefore the amount of suspended solids in waters therefore increases with the degree of water pollution [13]. BOD is a measure of the quantity of oxygen required by microorganisms to decompose organic matter under aerobic conditions at 20^0C for 5 days. If the organic pollution present in a water body is too high, the BOD will be consequently very high and then DO (dissolved oxygen) may be too low to support aquatic life. Thus highly polluted untreated wastewater discharged into nearby rivers or streams can cause death of aquatic organisms in the receiving river or stream due to oxygen depletion [13].

BOD test is used to determine the pollution strength (or pollution level) of wastewaters and the quality of receiving surface waters. It is a very important measurement in water treatment plants, where it is used to access approximate quality of oxygen required to stabilize organic matter biologically in wastewater [14]. The chemical oxygen demand test measures the oxygen equivalent of the organic matter in a sample that is susceptible to oxidation to carbon (IV) oxide and water by a strong oxidizing agent. It is widely used to measure the organic strength of domestic and industrial wastewaters [8].

Studies have shown that biochemical oxygen demand in wastewater samples is strongly related to the magnitude of suspended solids present in them [10] [11]. The methods of determination of these characteristics are based on the amount of oxygen required to convert oxidizable materials to stable end products. Since the oxygen used is proportional to the oxidizable materials present in the sewage, oxygen measurement therefore serves as a relative measure of the strength of domestic sewage [15].

This study seeks to assess the relationship between permanganate value, which is based on oxygen demand, and other oxygen demand characteristics such as suspended solids, biochemical oxygen demand and chemical oxygen demand. Some pollution characteristics of sewage such as permanganate value, suspended solids, biochemical oxygen demand and chemical oxygen demand and their relationship with each other were studied using correlation and regression analysis. The aim is to possibly establish an empirical relationship between these characteristics using regression analysis, such that one parameter can provide information about the other. It is believed that the information obtained from this study will assist in wastewater management and control.

Materials and Methods

Raw domestic sewage used

The raw sewage was collected from a steady stream of sewage arriving at a Sewage Treatment Plant through a conventional central sewerage system (CSS) in an Estate in Warri, Delta State, Nigeria.

Sampling Techniques

Samples were obtained and analysed from the treatment plant every week for twelve months. The samples were collected in both dry and wet seasons between the months in April and march Six samples were collected per day at one hour intervals starting at 7.00am and ending at 12.00pm. Sampling was most convenient during this period.

The day of sampling in each week was different from that of the preceding week so that the sampling exercise would give an account of the cyclic and intermittent variations occurring at the works site. Each sample was collected in a clean, well labelled plastic bottle and kept in a refrigerator maintained at 4^0C.

The rate of flow was determined with a flow meter each time a sample was collected. At the end of the sampling period, a composite sample was made by adding together volumes of samples proportional to the rate of flow.

Sample analysis

The pollution characteristics were determined as recommended by the Standard Methods for the Examination of Water and Wastewater[16], Standard methods for Water and Effluents Analysis [8] and Bureau of Indian Standards [17]. Permanganate value was determined using acidified potassium permanganate solution. The temperature of the water bath used was maintained at 37 ± 1^0C .Titration was carried out at the end of four hours using sodium thiosulphate solution. Suspended solids were determined by gravimetric analysis using glass fibre filter paper and a drying oven operated at $(103\text{-}105)^0$C. BOD was determined by incubating the samples in the dark for 5 days at 20^oC. Results were calculated as follows:

$$\text{BOD (mg/l)} = \frac{\text{IDO} - \text{DO}_5}{\text{P}}$$

Where:

IDO = Initial dissolved oxygen in the sample

DO_5 = Dissolved oxygen in the sample after five days of incubation

P = Percent dilution

The COD was determined by closed reflux titrimetric method [16]. The well mixed samples were refluxed for 2 hours 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. The COD was calculated as follows:

$$\text{COD (mg/l)} = \frac{(A - B) \times M \times 8000}{\text{ml of sample}}$$

Where:
A = ml of FAS used
B = ml of FAS used for sample
M = Molarity of FAS

Data Analysis

The results obtained were subjected to statistical analysis. A correlation and regression test was used to assess any relationship which may exist between PV,SS, BOD and COD Assuming the pairs of characteristics i.e. PV/SS, PV/BOD and PV/COD are represented as x and y. The regression equation of y on x for the pairs of characteristics above was represented as:
y = ax + b ; 'a' being the slope and 'b' the intercept on the y axis [18] [19].
result in Table 1 depicts the mean values and standard deviations obtained from the analysis at the studied site

Results and Discussion

Results of the sewage analysis obtained for determinations are as shown in Table 1 below. The
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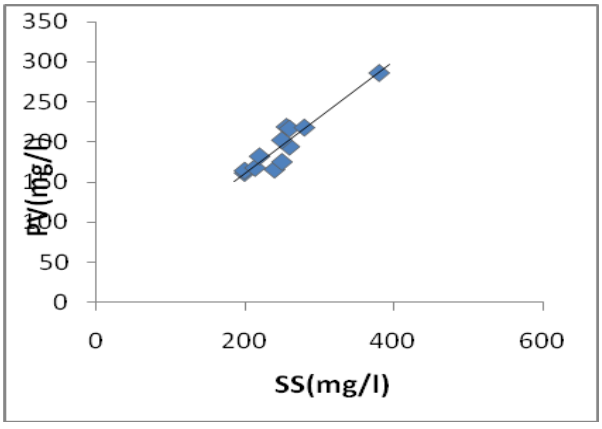
Table 1. Mean Values of Pollution Characteristics obtained from the Sewage Analysis

S/NO	SS (mg/l) MEAN ± SD	PV (mg/l) MEAN ± SD	BOD(mg/l) MEAN ± SD	COD(mg/l) MEAN ± SD
1	380.00 ± 1.89	286.00 ± 34.10	216.30 ± 6.96	344.89 ± 8.43
2	260.00 ± 2.11	194.80 ± 0.43	204.07 ± 6.83	334.22 ± 5.33
3	240.00 ± 271	166.40 ± 1.26	190.37 ± 6.37	323.56 ± 7.06
4	200.00 ± 2.31	162.20 ± 0.80	194.08 ± 2.22	286.22 ± 5.33
5	250.00 ± 189	175.80 ± 5.12	220.74 ± 3.44	318.22 ± 9.61
6	256.00 ± 2.98	219.27 ± 0.85	211.85 ± 5.56	355.56 ± 25.02
7	260.00 ± 4.99	217.27 ± 0.19	200.37 ± 3.67	321.78 ± 12.51
8	200.00 ± 2.83	165.00 ± 0.85	163.70 ± 9.09	298.67 ± 19.23
9	214.00 ± 9.09	168.53 ± 0.44	166.61 ± 1.68	286.22 ± 12.51
10	220.00 ± 11.03	182.73 ± 0.64	180.74 ± 4.38	302.22 ± 21.83
11	250.00 ± 1.33	202.73 ± 0.34	189.63 ± 9.09	318.22 ± 18.67
12	280.00 ± 6.11	218.40 ± 0.57	220.37 ± 4.83	336.00 ± 8.00

Results of the sewage analysis are as shown in Table 1 above. For SS levels ranged of values obtained were from 200.00mg/l to 380.00mg/l, while PV levels were from 162.20mg/l to 286.00mg/l.
Also BOD has values ranging from 163.70mg/l to 220.74mg/l while COD values were from 286.22mg/l to 355.56mg/l respectively. SS values reflect the magnitude of undissolved organic and inorganic substances present in the sewage samples. This reveals the amount of oxygen that will be needed to stabilize the wastes in the sewage. Also results of PV shows the amount of suspended solids present in the sample. PV values therefore indicates the amount of oxygen that will be need to breakdown the readily oxidizable wastes in the sewage. BOD results reflect the amount of oxygen needed for microbial degradation of pollutants present in the sewage whereas COD reflects the amount of oxygen required for biodegradable and non-



biodegradable oxidizable pollutants present in the sewage.

Figure 1: Linear regression of PV on SS of the domestic sewage

Figure 1 shows the relationship between permanganate value and suspended solids in the domestic sewage. The resulting linear equation was PV = a SS + b. The slope of the graph a, was 0.6962 and intercept on the PV axis b, was 21.973mg/l. Also the correlation coefficient 'r' was 0.938. The value of the correlation coefficient (r = 0.9308), showed that the relationship between PV on SS for the wet season was strong and positive.

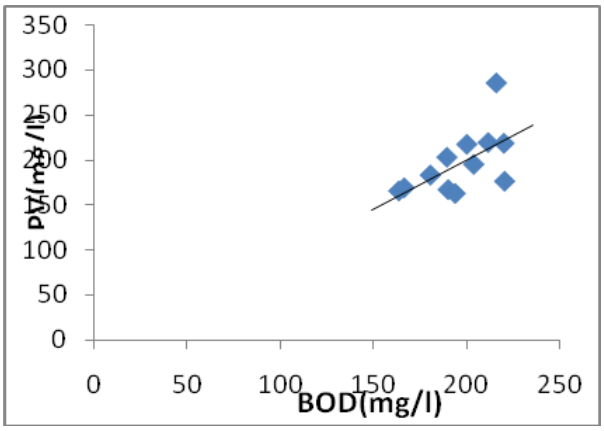


Figure 2: Linear regression of PV on BOD of the domestic sewage

Figure 2 shows the relationship between permanganate value and biochemical oxygen demand of the domestic sewage. The Linear equation was PV = a BOD + b. the slope of the graph a, was 1.0853 and the intercept b on the PV axis was -16.751. The correlation coefficient 'r' was 0.593. This also showed significant correlation.

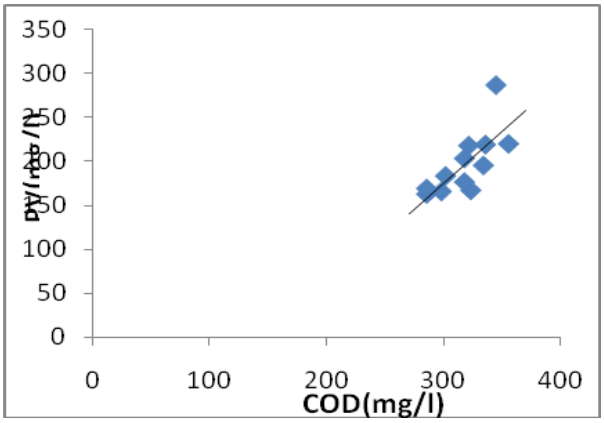


Figure 3: Linear regression of PV on COD

Figure 3 shows the linear regression analysis permanganate value and chemical oxygen demand in the domestic sewage.

The slope of the graph a, was 1.174, the intercept on the PV axis b, was -177.7mg/l and the correlation coefficient 'r' was 0.930. This also showed strong correlation between permanganate value, PV and chemical oxygen demand in the sewage.

Conclusion

The regression analysis showed significant relationship between the paired characteristics such as:

(a) Permanganate value / Suspended solids (PV/SS).

(b) Permanganate value / Chemical oxygen demand (PV/COD).

(c) Permanganate value / biochemical oxygen demand (PV/BOD). Stronger relationship was observed for the regression analysis between PV/SS. The strength of the relationship was in the order: PV/SS > PV/COD > PV/BOD. The linear regression equations obtained from the regression analysis were:

PV = 0.6962SS + 21.97

PV = 1.0853BOD – 16.75

PV = 1.174COD – 177.7

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