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RESEARCH ARTICLE

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Analysis of total suspended solids, total dissolved solids, electrical conductivity of domestic sewage

Abstract:
The total suspended solids (TSS), total dissolved solids (TDS) and electrical conductivity (EC) of domestic sewage obtained from a sewage treatment plant were determined and their values compared. A regression test was used to analyse any relationship between the pairs: EC/TSS and EC/TDS. Results showed strong positive correlation. Correlation coefficients were r = 0.75, r = 0.95 respectively. The correlation between EC and TDS was very strong and positive. Regression analyses show that electrical conductivity of the domestic sewage is strongly related to the solids present in it. The suspended solids content revealed that the sewage was polluted and of medium strength. Analysis showed that electrical conductivity is directly related to total suspended solids and total dissolved solids. However, results on TDS will give better information on EC of the sewage compared with results of TSS.
Keywords: Total suspended solids, total dissolved solids, electrical conductivity, domestic sewage, correlation, and regression.

Introduction:
Domestic sewage discharged daily into the environment contains a wide variety of substances. Domestic sewage has been defined as a complex mixture containing water and common constituents such as organic and inorganic matter and microorganisms. The amount of solids (both organic and inorganic) in a body of domestic sewage determines its strength. The most important part of this strength is the amount or concentration of these organic solids and their capacity to undergo decomposition. The greater the concentration of organic or volatile solids, the stronger the strength of the sewage. A strong sewage can be defined as one containing a large amount of solids particularly organic solids. A weak sewage is one which contains only a small amount of organic solids [12].

Although the solid components of domestic sewage can be classified in a number of ways, such categorization could be based on several operational procedures used in wastewater treatment laboratory. Solids could be classified with regard to their chemical make- up. Solids are however present in dissolved or suspended form [10, 7]

Suspended solids are those solid particles which are visible and in suspension in water. They can be removed by physical or mechanical means. More precisely suspended solids are solids which are retained in the filter mat or glass fiber pad in a Gooch crucible. Such solid will include the larger particles and consist of sand, grit, clay, faecal solids, pieces of wood, particles of food and garbage, and similar materials. The suspended solids portion of domestic sewage consists of settleable solids and colloidal solids. They are 70 percent organic and 30 percent inorganic [11, 4].

The principal organic compounds present in domestic sewage are proteins, carbohydrates and fats together with products of their decomposition. These compounds are biodegradable and combustible. Since these organic fractions can be driven off at high temperatures they are sometimes called volatile organic compounds. Inorganic solids are substances that are inert and not subject to decay. Exceptions are some mineral compounds or salts such as sulphates (which can be broken down under certain conditions). Inorganic solids are frequently called mineral substances and include sand, gravel and silt as well as mineral salts in the water supply which produce the hardness and mineral content of the water. They are generally non-combustible [6].

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Dissolved solid contents in sewage consist of inorganic, organic substances and dissolved gasses. Technically, total dissolved solids refer to all of the solids which pass through the filter paper of a Gooch crucible. It is a measure of all dissolved substances present in water. Measurement in laboratory is reported in mg/l. Total dissolved solids are about 40 percent organic and 60 percent inorganic. About 90 percent of these solids are present in true solution while 10 percent are colloidal. Organic solids are subject to decay and they constitute the main problem in wastewater treatment [9].
Electrical conductivity or specific conductance is defined as a measure of the ability of a water sample to convey an electric current.

The electrical conductivity of industrial wastewaters, treatment plant effluent and polluted waters is due to the presence of ionic solutes [8]. Therefore, conductivity can be used as an approximate measure of the total concentration of inorganic substances in water. The magnitude of the conductivity is a useful indication of the total concentration of the ionic solutes present in the water. Ions that have a major influence on the conductivity of water are H^+, Na^+, K^+, Ca^{2+}, Al^{3+}, SO_4^{2-}, Cl^- other ions such as Fe^{2+}, Fe^{3+}, Mn^{2+} etc and dissolved gases have a minor influence on the conductivity. The unit of conductivity is μScm^{-1}. [5]. This study is aimed at determining the concentration of total suspended solids and total dissolved solid contents of domestic sewage from the sewage treatment plant and comparing values of these parameters with values of electrical conductivity of the water. The essence is to obtain a better and functional relationship between the three parameters which may serve as a quicker and cheaper measure of solid pollutants which may have serious pollution implications on the receiving river water in that environment.

Materials and Methods:

The domestic sewage used for the analysis was obtained from a steady stream of sewage arriving at a sewage treatment plant in an estate located in Warri.

Description of the sewage treatment plant:

The treatment plant is designed as a continuous process to receive and treat sewage generated within the estate. It serves an average human population of 4000 inhabitants. All the sewage systems from each house and office in the estate were sewered and connected to the central sewage system (CSS) main stream through a pipe. The pipe consists of a grid which helps to remove coarse particles. The raw sewage is carried by the CSS and discharged into the collection chamber at an average flow rate of 204 cubic meter per day. From the collection chamber the sewage is pumped through a pressure pipe into the treatment plant which comprises three units which are: Aeration, sedimentation and stabilization tanks. The raw sewage is discharged into the aeration tank (for treatment to begin) through an inlet Pipe at intervals of three minutes. Biodegradation of the organics in the sewage by aerobic bacteria takes place in the aeration tank after which the sewage flows into the sedimentation tank where the sludge flocks settle by gravity and are transported to the centre by means of a rotating scraper – mechanism. The settled sludge is returned to the aeration tank through pressure pipes and excess sludge is transferred to the stabilization tank. In the stabilization tank the excess sludge is mineralized by an aerator and discharged to sludge drying beds. The supernatant purified sewage is discharged into a sump through an outlet pipe and from there it flows through drainage into a nearby river.

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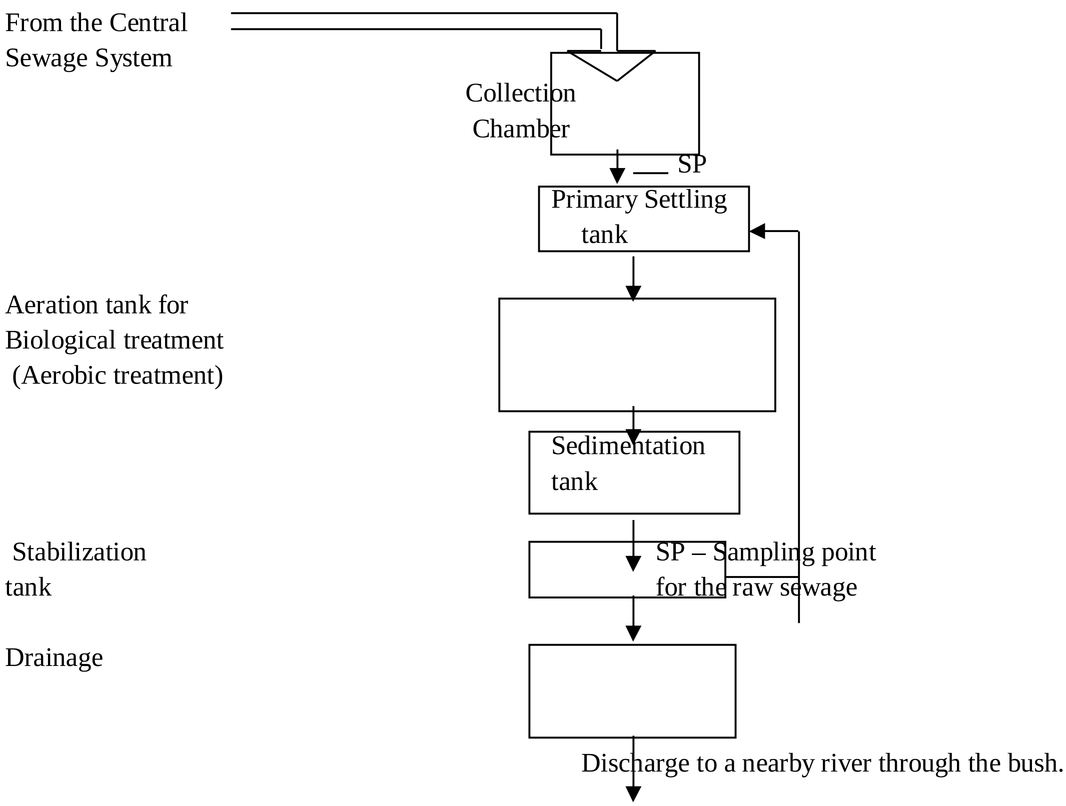

Fig1. Flow diagram of sewage treatment plant

Sampling Techniques:

Samples were collected once a week for twelve weeks and analysed. Sampling period was for over 12hours at 1-hour interval. This started at 07:00hr and ended at 19.00hr each day. This time was found to be the peak (optimum) period for work and sampling was most convenient during this period. This was done on different days of the week from Monday-Saturday. 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.

During sampling each sample was collected in a clean, well labeled colourless plastic bottles of 1litrecapacity and kept in a refrigerator maintained at 4^0C. The rate of flow was determined using a flow meter each time the samples were collected.

At the end of each sampling period, a composite sample was made by adding together volumes of the samples proportional to the rates of flow. Altogether twelve composite samples (one composite sample per week) were prepared and used for analysis.

Methods of analysis:

All samples were analyzed as described in the standard methods for the examination of water and wastewater [3] and standard methods for water and effluents analysis [1]. Suspended solids and dissolved solids were determined gravimetrically. For TSS, each sample was filtered through a Whatman glass fiber filter disc (5.5cm in diameter), using an air

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pump. Each filter was then placed on a tin tray (the tin trays and glass fiber filter were previously dried at 105^0C and weighed in the oven) placed in the oven and dried at 105^0C for not less than 2 hours. The trays and used filters were weighed again. The difference between the final weight and initial weight gave the amount of suspended solids in the sample. TSS mg/l was calculated as follows:

mg/l suspended solids = (A-B) X1000/sample volume used.

Where A =Weight of glass fibre filter + dried residue in mg

B = weight of filter paper in mg

Sample volume used = 100ml.

For TDS, the filtrate obtained from TSS determination was taken and transferred to an evaporating dish (the evaporating was previously heated in the oven to 180^0C for 1 hr cooled to room temperature in desiccator and weight noted) this was evaporated to dryness on a steam bath. Evaporated sample was dried in the oven for 1hour, cooled in desiccator to balance temperature and weighed. The drying process was repeated until a constant weight was achieved. TDS was calculated as follows:

mg/l Dissolved Solids =(A-B) X 1000/sample volume used.

Where, A=weight of dried residue = dish in mg

B=weight of dish in mg

Sample volume = 100ml

Electrical conductivity was determined in situ by electrochemical method using the Hach conductivity meter.

Results and Discussion:

Table 1 represents the summary of some characteristics of domestic sewage obtained from the treatment plant.

The pH value ranged from 6.76 – 7.16 with a mean value of 7.02. This shows that the sewage was weakly alkaline. The temperature range which was from 24.20ºC – 27.00ºC with a mean value of 25.81 reflects the ambient temperature of the sewage during the time of sampling.

The values of electrical conductivity ranged 220.57 – 367.00µscm^{-1}with a mean value of 275.45µscm^{-1}. This showed the level of concentration and mobility of ions in the domestic sewage. Ionic solutes (salts) in the sewage would have dissolved into anions and cations e.g. K^+, Ca^{2+}, Mg^{2+}, SO_4^{2-}, HCO_3^-e.t.c. The presence of these ions in the sewage sample influences the rate at which it will conduct electric current. Total Suspended Solids (TSS) increased with values ranging from 214.00 – 380.00mg/l with a mean value of 250.83mg/l and total dissolved solids (TDS) which ranged from 100.00 – 206.00mg/l with a mean value of 145.28mg/l.

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Sewage Characteristics	Unit	Range of Values	Mean
pH		6.76 – 7.16	7.02
Temperature	°C	24.20 – 27.00	25.81
Electrical Conductivity	μScm^{-1}	220.57 – 367.00	275.45
TDS	mg/l	100.00 – 206.00	145.28
TSS	mg/l	214.00 – 380.00	250.83
TS	mg/l	300.00 – 580.00	396.11
PV	mg/l	162.20 – 286.00	196.59
BOD	mg/l	163.70 – 220.37	196.57
COD	mg/l	286.22 – 355.56	318.82

Table 1. Some Characteristics of Domestic Sewage from the Treatment Plant

Increase in levels of TSS indicated that more TSS were created as the water flowed through the system. There could also be several other reasons for the increase. One possibility was storm water run – off into open collection chamber in the sewage treatment plant. Some of the samples were analysed during the rainy season. Therefore, storm water would have possibly washed or introduced more suspended solids into the open collection chamber. Other possibilities were that some algae in the sewage would have decomposed and released some particles which became suspended in the water and moved along with the flow of the system. Also there may have been increase in bacteria in the sewage, or molasses was not completely used up by the bacteria. All of these and other possibilities could have been responsible for the increase in suspended solid levels. The increase in values of TDS is an indication that reasonable amount of suspended solid substances were present as dissolved matter in the domestic sewage. Substances dissolved in the sewage often contain proteins, carbohydrates, esters and mineral salts. Amount of these organic substances in the sewage could have also been increased due to storm water run – off during rainfall. All these substances would have been broken down and dissolved in the water and therefore increased the TDS levels. Regression test was used in order to determine whether EC levels were dependent on TDS and TSS levels in the sewage. The values of the parameters showed that the sewage was at medium strength. The plots are as shown in Figures 2a, 2b and 3a, 3b.

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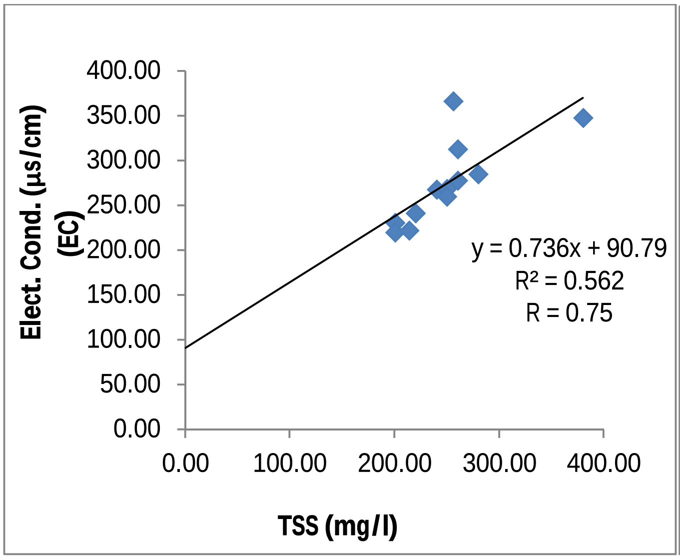

Figure 2a. Regression of EC on TSS

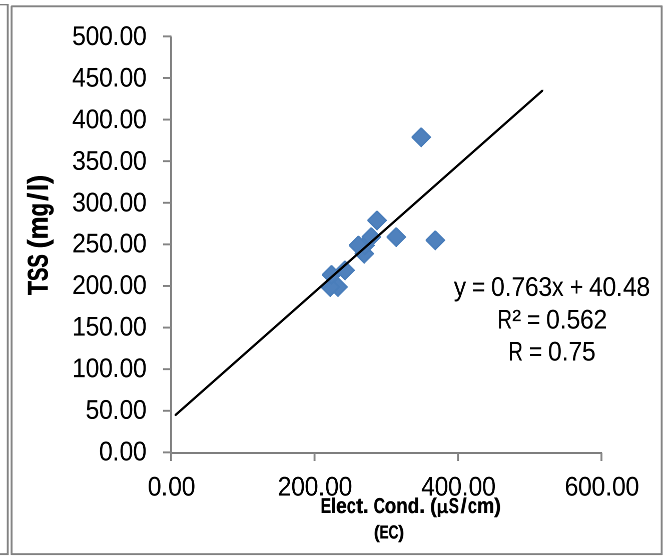

Figure 2b. Regression of TSS on EC

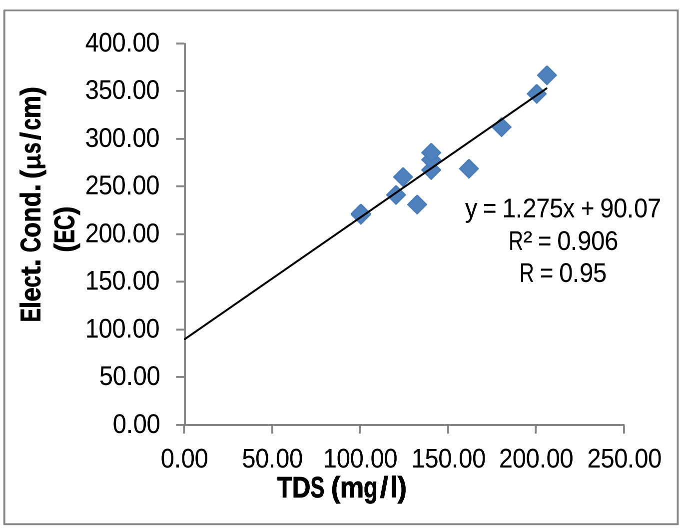

Figure 3a. Regression of EC on TDS

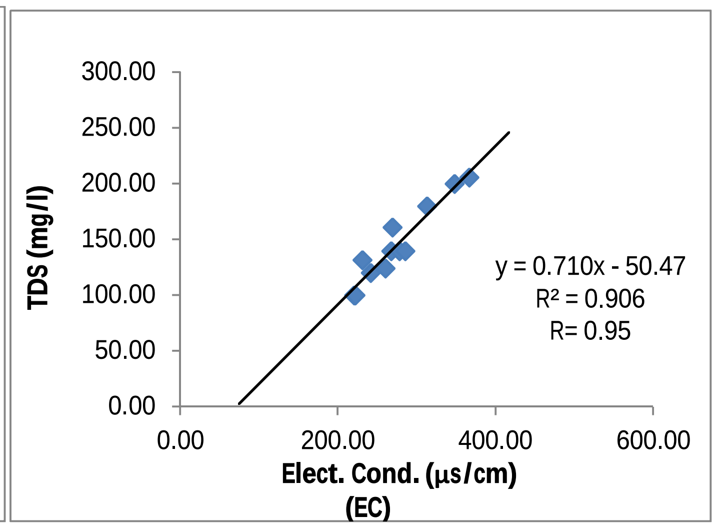

Figure 3b. Regression of TDS on EC

The regression plot in Fig. 2a showed a positive regression line, indicating that there was positive relationship between EC and TSS. This meant that as TSS increased so did the EC levels. R value was 0.75. This meant that the relationship between EC and TSS was strong with 75% correlation. Also in Figure 2b, positive correlation with R value of 0.75 was obtained for the regression of TSS on EC. The plots in Figure 3aand 3b show the regression of EC on TDS and that of TDS on EC.

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Positive correlations were observed with R values of 0.95 in both cases. The meaning of this was that there was proportional increase in both parameters. R value was 0.95 showing that the relationship between EC and TDS was very strong with 95% correlation.

The positive correlation which exists between the pairs showed that both parameters compared in each case increased in the same direction. A perfect positive correlation is a coefficient of +1. The R value obtained for the plot of EC/TDS was 0.95. This was near perfect correlation compared with the R value of 0.75 for EC/TSS. Therefore, the relationship between EC and TDS was stronger than EC and TSS. This also means that TDS values will give better representation of EC in the sample of domestic sewage.

The analysis shows that Electrical conductivity is directly related to solids contents i.e. total suspended solids and total dissolved solids of domestic sewage.

However, results obtained also show that electrical conductivity is directly and more strongly related to the concentration of salts dissolved in the domestic sewage.

Conclusion:

Total dissolved solids measure all dissolved substances in water including organic and suspended particles that can pass through a very small filter. Therefore, the analysis revealed that from the relationships (EC/TSS, EC/TDS) values of TDS will give a better representation of EC compared with TSS.

The following regression equation will be useful to predict EC from TDS: $y = 1.28x + 89.71$ .In which y = EC and x = TDS. This equation will serve as a useful time management and cost reduction technique in treatment plant operations and quality laboratories for environmental analysis.

References:

1. Ademoroti, C.M.A, (1996b). Standard Methods for Water and Effluents Analysis. Foludex Press Ltd. Ibadan, pp 44-49.
2. Akpofure, R (2009). Environmental Science, An introduction. Krafts Books Ltd. Ibadan. p 237.
3. APHA. (2005). Standard Methods for the Examination of Water and Wastewater. 23rd Edition, American Public Health Association(APHA). Washington D.C.
4. Apkofure, R., Ikhifa, G.O., Okokoyo, P (2005). Physico-chemical characteristics of some Waters for Drinking and Domestic Purposes in the Niger Delta, Nigeria. Environment Monit. Assess. DOI 10.1007/s/0661-006-9340-4 (2007)
5. Csuros, M (1997). Environmental Sampling and Analysis. CRC Press LLC, New York, pp 215-216.
6. Miroslav, B.N. and Vladimir, R (1999). Practical Environmental Analysis. The Royal Society of Chemistry, Cambridge, UK p 163.
7. Moldan, R and Cherry, J (1994). Biochemistry of small Catchments, scope 51, Willey and Sons, New York, pp 164-188,2007-223
8. Sawyer, C.N and McCarthy, G.F., (2003). Parkin, Chemistry for Environmental Engineering.5th Ed. McGrawHill, New York, pp 143.
9. Tchnobanoglous, F., Burton, L., Stensel, H.D (2003).Wastewater Engineering (treatment, Disposal, Reuse), 4th Edition, Metcalf and Eddy Inc. McGraw-Hill Book Co p 134.
10. Uwidia I. E and Ademoroti, C.M.A (2012). Correlation of Five-day Biochemical Oxygen Demand (BOD_5) and Suspended Solids (SS)Concentration in Wastewaters. Niger. J.Appl. Sci.**30**:119-127.
11. Uwidia, I. E (2011). Prediction of Five-day Biochemical Oxygen Demand (BOD_5) From More Readily Determinable Pollution Characteristics. PhD Thesis, University of Benin, Benin City, p.42.

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RESEARCH ARTICLE

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12. Uwidia, I.E and C.M.A Ademoroti, C.M.A (2011). Characterization of Domestic Sewage from an Estate in Warri, Nigeria. Int. J. Chem.**3:**3.

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