

## STUDIES ON THE CORRELATION OF SOME AGGREGATE PARAMETERS IN THE DRAINS OF A SERVICE FACILITY

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(Received 30 June 2010; Revision Accepted 20 July 2010)

### ABSTRACT

Real composite samples from industrial waste drains were obtained from four different worksites in an oil company waste management facility, Warri Nigeria. The sites include: Recycle Waste Deport drain, Petroleum Chemistry Laboratory drain, Tubo Scope Yard drain and Fuel Filling station drain. For each sample, four aggregate water quality parameter: Turbidity, Total Dissolved Solids (TDS), Chemical Oxygen Demand (COD) and 5-day Biochemical Oxygen Demand (BOD<sub>5</sub>), were determined weekly, and monthly averages were taken over a period of seven months. TDS and Turbidity were well correlated in each case and Pearson's correlation coefficient for the seven months for each of the drain samples were respectively: -0.78, - 0.24, 0.58 and 0.42. BOD<sub>5</sub> was also well correlated with COD and Pearson's correlation coefficient for each drain sample for the period was respectively: 0.97, 0.90, 0.49 and 0.93. Regression analysis gave equations of a straight line:  $y = a + b + c$  for the eight plots. In each case the Pearson's coefficient of determination,  $R^2$ , shows that each regression model is adequate for future prediction of one water quality parameter regarded as the dependent variable from another, a determined independent variable.

**KEY WORDS:** Correlation, aggregate parameters, wastewater drains, environment.

### INTRODUCTION

Statistical evaluations of analytical data have been known to give more meaning to data generated in the laboratory or in the field. Such operations minimize errors whether systemic or personal; they improve the reliability and reproducibility of results. While direct determinations of results give originality to data, it exposes it to errors of procedures and conditional variability. This has placed some demands on the skills of the environmental scientist whose responsibility it is to unravel the facts of the biophysical environment against the backdrop of industrialization, and also define and evaluate how it affects human health. The ambit of environmental analysis via the environmental quality parameters (EQP) increases in scope by the day as industries respond to their social and economic obligations to meet man's needs of food, water energy ,conveniences and aesthetics. In midst of all these drives, environmental challenges continue to issue out; the challenges of clean air, clean water, stable and diversified ecosystem, sustainable development etc . Research into these environmental components of concern has intensified and the need of accurate and precise environmental evaluation increases. The scope of environmental study methodologies need to incorporate predictive capacities and options; these will help in developing environmental models, scenarios and simulations for problem solving and forecasting environmental conditions and characteristics (Maier and Dandy, 2000; Phan, *et al*, 2010).

Cost and time have also become critical issues in these environmental evaluation studies particularly where more than a dozen parameters may need to be determined before an impact could be established.

Correlation studies have long been a means of circumventing cost, saving time, directing analytical objectives and ensuring reliability of results of analysis. And more recently it is being used to determine the type of treatment technique to apply to a given wastewater in midst of several options (Metcalf and Eddy, 2003).

Relationships amongst stoichiometric properties of ions and compounds have been in the literature for decades. For example specific conductance or electrical conductance (EC) is a useful tool to estimate the concentration of total dissolved solids (TDS) and related effects ( Metcalf and Eddy, 2003 and APHA , 200

$TDS \propto EC$

$TDS = k \cdot EC$  ..... (1)

where , k varies from 0.55 to 0.90 , EC is in  $\mu\text{mhos/cm}$  or  $\text{mS/m}$  and TDS is  $\text{mg/l}$

EC is related to the sum of charge carriers both positive and negative in solution. A physical property of ionic solution is ionic strength ( $\mu$ ) which is also related to the sum total of all charged species in the solution :

i.e  $\mu = \frac{1}{2} \sum C_i z_i^2$  .....(2)

where,  $C_i$  is molar concentration of the  $i$ th ion and  $Z_i$  is the charge on the  $i$ th ion.

Langlier (1936 in Metcalf and Eddy, 2003 ), determined a correlation between ionic strength ( $\mu$ ) and TDS as

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$$\mu = 2.5 \times 10^{-5} \text{ (TDS)} \dots\dots\dots(3)$$

where TDS is in mg/l

Equation (3) is often used to estimate the ionic strength of treated wastewater in groundwater recharge applications.

Russel (1976 in Metcalf and Eddy, 2003) derived another correlation between EC and  $\mu$  as ,

$$\mu = 1.6 \times 10^{-5} \text{ EC} \dots\dots\dots(4)$$

These relationships give approximate estimations of TDS as there are non-ionic species dissolved in solution and these do not contribute to ionic strength. Again individual ionic species have different masses.

Presently, the EC of water is one of the important parameters used to determine suitability of water for irrigation. The salinity of treated water to be used for irrigation is estimated by measuring its electrical conductivity (Walley, 1996; Metcalf and Eddy, 2003; ). Correlation between aggregate parameters in wastewater / water studies is scanty in the literature; this is understandably due to their non- stoichiometric and widely varying composition and nature. Biochemical Oxygen Demand (BOD) has always been fairly correlated with Chemical Oxygen Demand (COD) as,  $BOD \leq COD \dots\dots\dots(5)$

This is widely dependent on the nature of wastewater and even the time of assay (Lowden, 1981). Total Organic Carbon (TOC), another aggregate parameter has also been severally correlated with BOD and COD. Typical values for the ratio of BOD/COD for untreated municipal waste water are in the range of 0.3 to 0.8. If the BOD/COD ratio for untreated wastewater is 0.5 or greater, the water is considered easily treatable by biological means. If the ratio is below about 0.3, either the waste has some toxic components or acclimated microorganism may be required in its stabilization. Also the corresponding BOD/ TOC ratio for untreated wastewater varies from 1.2 to 2.0 (Metcalf and Eddy, 2003).

These ratios get narrower in range as the degree of treatment of the wastewater gets finer. Linear relationships could exist in environmental quality parameters; this should plausibly describe to a reasonable degree the Pearson's correlation coefficient,  $r$  (Mendham, *et al*, 2006).

In continuation of our studies in the correlation of Environmental Quality Parameters (EQP), reported here are the correlation studies carried out over a period of seven months, January to December, to benchmark the characteristics of the relation ships that could exist between the following

aggregate parameters: TDS and Turbidity; BOD<sub>5</sub> and COD, in the service facility of an oil company in Warri , Delta state of Nigeria.

**MATERIALS AND METHODS**

**Materials**

**Samples:** Wastewater Sample was the liquid drains from an industrial service facility which comprises of a Recyclable Waste Dumpsite (RWD), Tubo Scope Yard (TSY), Petroleum Chemistry Laboratory (PCL) and Fuel Filling Station (FFS) . The four locations where separately sampled.

**Reagents:** Reagents for the determination of the parameters were obtained according to the methodologies prescribed by APHA (2001) and Rump (1999).

**METHODS**

**Parameters:** The water quality parameters examined were, Turbidity, Total Dissolved Solids (TDS), Chemical Oxygen Demand (COD), 5-day Biochemical Oxygen Demand (BOD<sub>5</sub>) .

**Sample Collection:** Grab samples were collected daily at a rate of 1 litre over five working days and made into a composite in refrigerated storage in batches of 5 litres per week. The sample was analysed at the end of the week. The results were averaged on monthly basis for seven months. The determinations were effected according to the methodologies prescribed by APHA, (2001) and Rump (1999). All the determinations were carried out in the laboratory after proper preservation at the site of collection.

**Statistical Evaluations:** The collated data were subjected to Pearson's correlation coefficient,  $r$  , stated as

$$r = \frac{n\sum x_1y_1 - \sum x_1\sum y_1}{\sqrt{[n\sum x_1^2 - (\sum x_1)^2][n\sum y_1^2 - (\sum y_1)^2]}}$$

where, n is the number of data point.

**RESULTS AND DISCUSSION**

Table 1.0 shows the results of the seven month period study. The data shown are the averages of the weekly readings that were taken for the seven month period, June to December. Drains like run-offs are important source of aquatic and groundwater pollution.They differ from daily rejects in their composition . These discharges have some specific characteristucs; they generate high level of pollution in a very short time and lead to cases of acute pollution (Magaud ,1997) .

Table 1.0 : Results For The Aggregate Water Quality Parameters Per Sampling Location For Seven Months.

Location	Aggregate Parameter	Averaged Results Of Analysis Per Location							r
		JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	
Recycle Waste Depot (RWD) Drain	Turbidity, NTU	15.45±0.01	13.18±0.01	12.84±0.01	12.27±0.01	12.01±0.01	13.60±0.01	25.90±0.02	-0.78
	TDS, mg/l	201.85±0.03	147.50±0.02	188.91±0.02	233.56±0.02	182.63±0.02	218.30±0.04	96.13±0.02	
	BOD <sub>5</sub> mg/l	62.13±0.01	50.52±0.02	39.95±0.02	35.61±0.03	72.34±0.02	76.90±0.02	87.50±0.04	0.97
	COD mg/l	117.92±0.02	96.25±0.01	62.92±0.03	51.81±0.02	100.63±0.03	146.80±0.05	163.63±0.03	
	BOD <sub>5</sub> /COD	0.527	0.525	0.645	0.687	0.71±0.019	0.524	0.535	
Petroleum Chemistry Laboratory (PCL) Drain.	Turbidity, NTU	9.27±0.01	8.12±0.01	8.48±0.01	10.60±0.01	9.31±0.01	14.82±0.02	7.68±0.01	-
	TDS, mg/l	363.33±0.04	630.88±0.07	785.00±0.05	948.42±0.01	718.67±0.04	148.75±0.02	93.55±0.03	
	BOD <sub>5</sub> mg/l	35.73±0.02	9.25±0.01	14.11±0.01	16.91±0.02	24.24±0.01	43.94±0.02	7.93±0.02	0.90
	COD mg/l	67.92±0.02	22.50±0.01	29.17±0.01	24.17±0.01	34.19±0.02	52.84±0.02	15.93±0.02	
	BOD <sub>5</sub> /COD	0.526	0.411	0.483	0.699	0.709	0.832	0.498	
Tubo Scope Yard (TSY) Drain	Turbidity, NTU	9.89±0.01	9.24±0.01	12.3±0.01	19.24±0.02	14.60±0.01	9.27±0.01	9.88±0.01	0.58
	TDS, mg/l	113.88±0.04	79.13±0.03	266.92±0.04	489.58±0.04	463.58±0.04	26.0±0.002	44.43±0.02	
	BOD <sub>5</sub> mg/l	48.99±0.02	47.79±0.01	56.29±0.02	85.52±0.02	61.12±0.02	47.90±0.02	14.19±0.01	0.49
	COD mg/l	107.00±0.02	95.00±0.02	78.33±0.01	119.17±0.02	96.69±0.02	58.58±0.02	32.95±0.01	
	BOD <sub>5</sub> /COD	0.458	0.503	0.719	0.718	0.632	0.818	0.431	
Fuel Filling Station (FFS) Drain	Turbidity, NTU	7.80±0.01	7.85±0.01	8.59±0.01	9.98±0.01	8.21±0.01	8.03±0.01	9.13±0.01	0.42
	TDS, mg/l	204.08±0.02	207.75±0.02	350.75±0.03	372.25±0.05	288.75±0.03	248.25±0.02	139.78±0.02	
	BOD <sub>5</sub> mg/l	33.77±0.02	20.28±0.01	38.83±0.01	24.18±0.01	37.01±0.01	28.64±0.01	13.37±0.01	0.93
	COD mg/l	59.17±0.01	41.25±0.01	58.75±0.02	33.33±0.01	56.08±0.02	48.67±0.02	27.37±0.01	
	BOD <sub>5</sub> /COD	0.571	0.492	0.661	0.726	0.660	0.588	0.488	

r = Pearson's Correlation coefficient

Turbidity assesses the degree of clarity of a wastewater body. The RWD recorded, in all the months studied, comparable (12 NTU – 15.45 NTU) mean values for turbidity except in December where  $25.45 \pm 0.02$  NTU was recorded. This could possibly be attributed to the upsurge in waste generation associated with end of year activities. Besides, turbidity levels for RWD for all the months were generally higher than for other locations in the study. The highly diverse waste components and the large catchments area of the waste deport may be responsible for this.

This trend was not the case for TDS in the sample locations. PLC recorded higher levels of TDS for the months of June – October. There was a dramatic drop in TDS for November and December in PCL. This drop was attributed to reduced laboratory activities because of a preponderance of staff vocation this period. The same lower TDS values characterized all the sample locations for these months of November and December.

BOD<sub>5</sub> and COD are oxygen function parameters which measure amount of pollutants via oxygen stabilization / degradation which is mediated through microorganism in the case of BOD<sub>5</sub> and through strong chemical oxidants in the case of COD. The RWD

recorded the highest for the same reason of diversity in composition and pollution load. It is observed that the high value of TDS in the PCL from June to November was not reflected in the BOD and the COD values. It is plausible therefore that the reason is because greater percentage of the wastewater stream from the laboratory is inorganic, stemming from analytical reagents and possibly organic components that resist oxidation. The BOD/COD ratio when averaged per location gave results of about 0.59 for drains from RWD, PCL and FFS and 0.68 for TSY (all >0.5). These generally indicate that to a large extent the wastewaters can be biostabilized (Metcalf and Eddy, 2003).

The four aggregate parameters chosen for study are the most commonly applied parameters in wastewater management. It is generally observed that the presence of a pollutant in a medium elaborates itself in all these aggregate parameters. This study tries to determine the extent of this elaboration and tries to relate them.

Turbidity evaluates clarity and TDS, the quantity of matter dissolved in a water sample. All the plots on TDS against Turbidity are shown in Figs. 1, 2, 3 and 4. Figs 1 and 2 show negative correlation between the two parameter while Figs 3 and 4 show positive correlation.

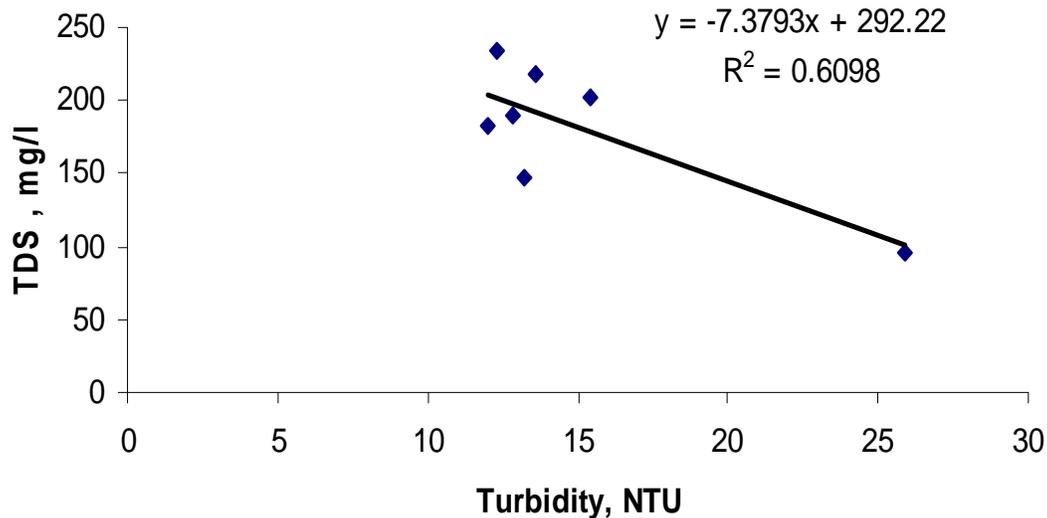
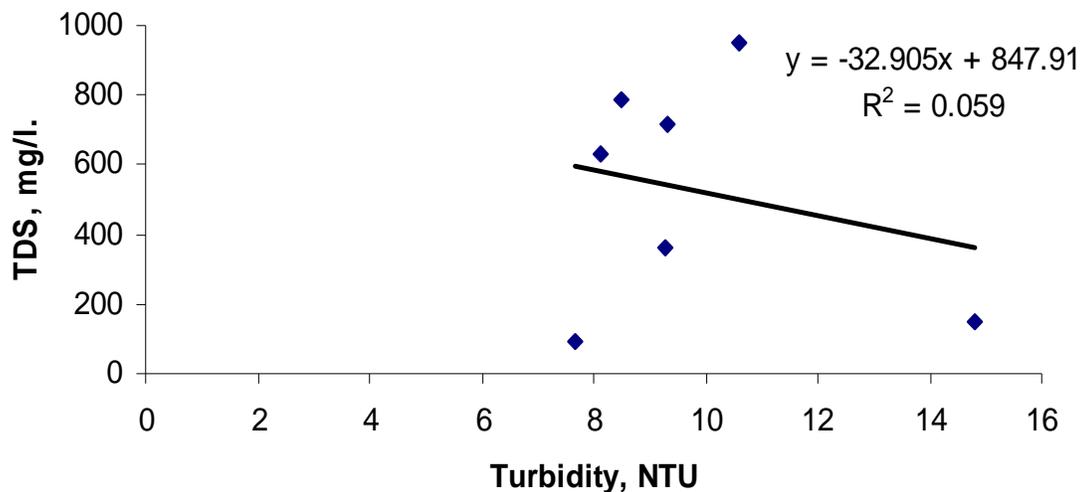
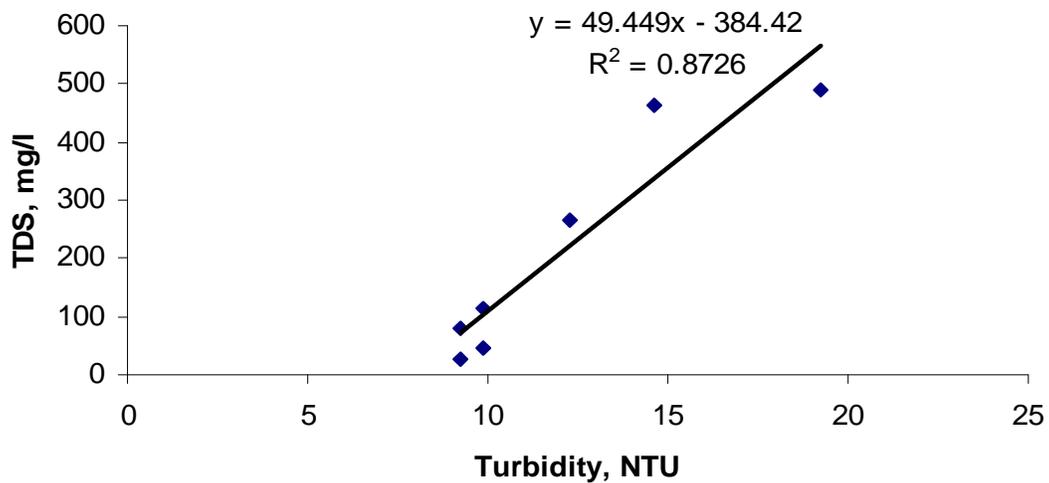


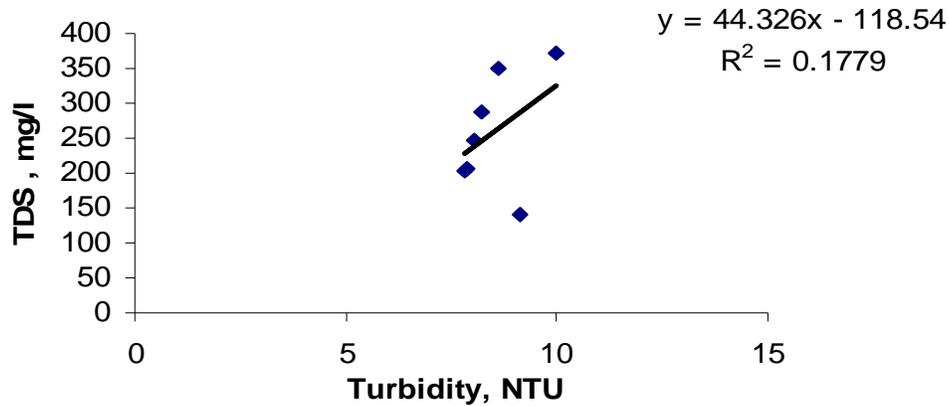
Fig.1: Linear Regression of TDS and Turbidity in Waste Recycle Deport (RWD) Drain.



**Fig. 2: Linear Regression of Turbidity and TDS in Petrochemical Chemistry Laboratory (PCL) Drain.**



**Fig.3: Linear Regression of TDS and Turbidity in Tubo Scope Yard (TSC) Drain.**



**Fig.4: Linear Regression of TDS and Turbidity in Fuel Filling Station (FFS) Drain.**

The reasons for the observed positive and negative correlations for the same parameters, if not due to artefacts, may be attributed to the nature of the wastewater media.

The literature shows a preponderance of studies in the correlation between suspended solids(SS) and turbidity (Metcalf and Eddy, 2003). Since SS and TDS are fractions of the total solids (TS), their partitioning in a liquid medium depends to a large extent on the partition coefficient of the solute in the solvent medium. The alteration of the partitioning by removal of one alters the level of turbidity. Since SS and turbidity are first and foremost strongly related to aesthetics, they are easily visualized and tend to be studied together. Correlation of TDS with turbidity is likely to give projections on turbidity

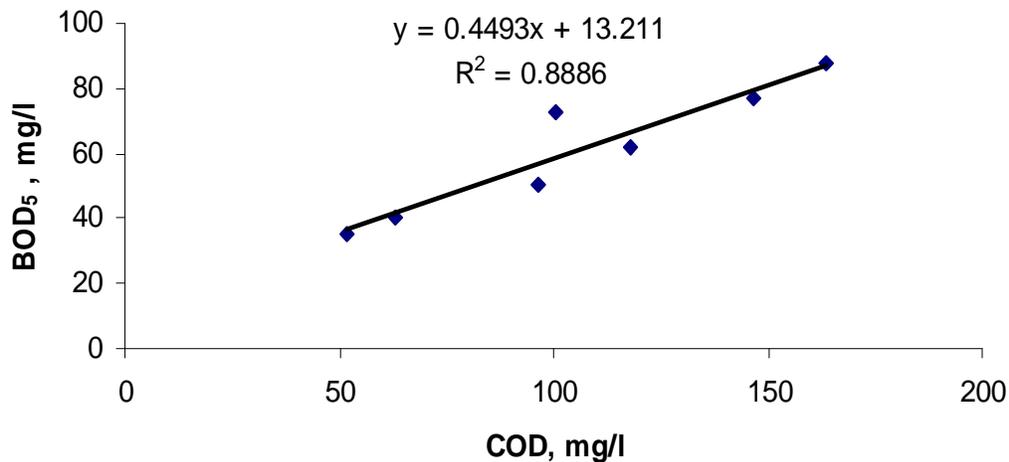
levels even at low direct turbidity presence, less detectable by instruments.

Nonetheless the regression lines shows significance in correlation and shows a high degree of reliability in future predictions of one parameter from the other.

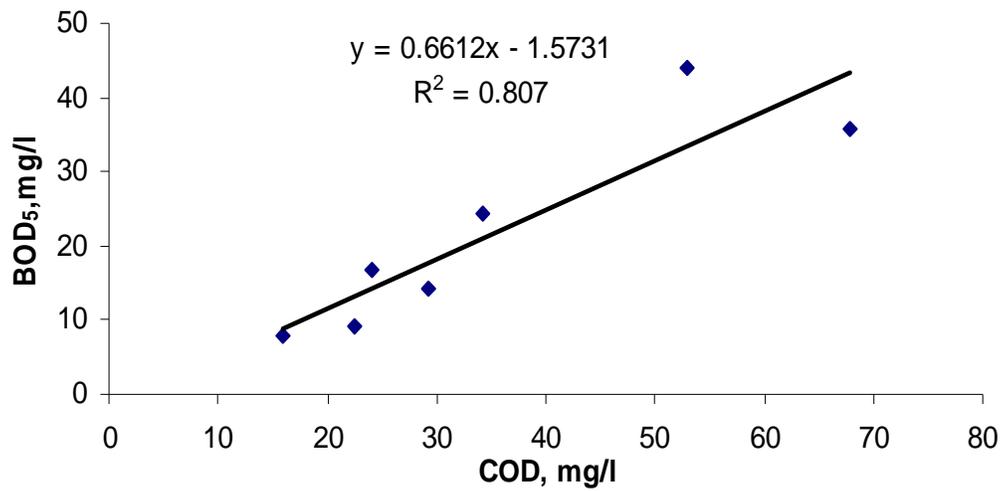
BOD<sub>5</sub> and COD are well correlated parameters in effluent studies and their relative amount depends on the nature of the effluent. In effluents with largely biodegradable

pollutants, COD = BOD<sub>5</sub> approximately, while in largely nonbiodegradable effluent COD > BOD<sub>5</sub>.

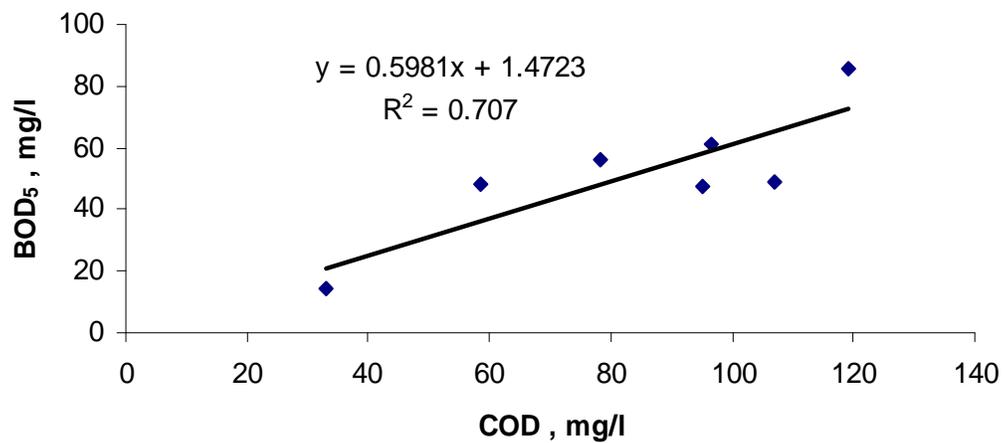
In the plots shown above (Figs 5, 6,7 and 8.0) BOD<sub>5</sub> is well correlated with COD and the correlation is significantly positive.



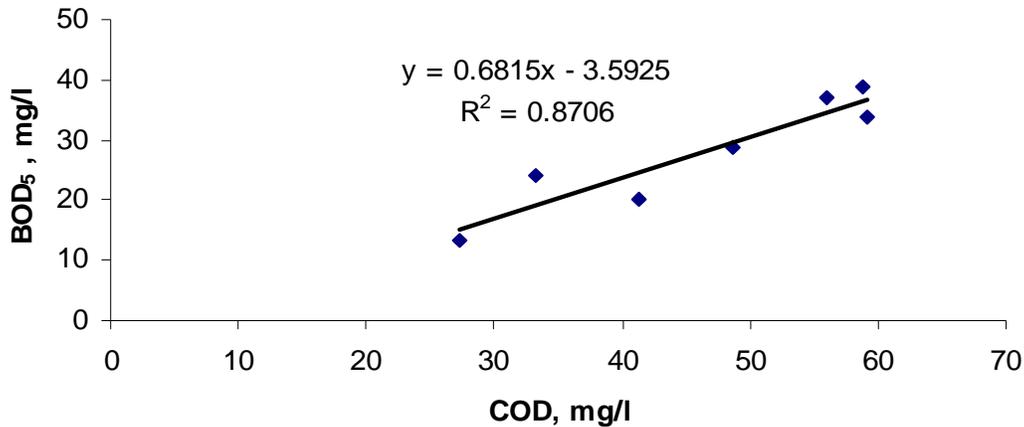
**Fig.5: Linear Regression of BOD<sub>5</sub> and COD in Recycle Waste Deport (RWD) Drain.**



**Fig.6: Linear Regression of BOD<sub>5</sub> and COD in Petroleum Chemistry Laboratory (PCL) Drain.**



**Fig.7: Linear Regression of BOD<sub>5</sub> and COD in Tubo Scope Yard (TSY) Drain.**



**Fig.8: Linear Regression of BOD<sub>5</sub> and COD in Fuel Filling Station (FFS) Drain.**

Inclusive of compliance to strict regulation as in water for potability or some semifine industrial processes either BOD<sub>5</sub> or COD can simply be deduced from the other and future prediction of one from the other, easily enabled.

#### CONCLUSION

The Figures show that each set of compared variables are highly related. Most of them positively, and only Figs 1.0 and 7.0 negatively related. The obvious fact of all the regression lines is that one variable can be used to predict the other. Of particular significance is the application of correlation findings in environmental study service contracts in the Niger – Delta region of Nigeria where social challenges may millitate against the ability of environmental consultants to carry out the full rung coverage of environmental quality parameters assessment specified in contract terms of references.

In each of the Figures above, the coefficient of determination, R<sup>2</sup> shows that each regression model is adequate for prediction. It will be auspicious and resource saving if predictions of one or more of the aggregate parameters are enabled from one or a few determined parameters. It will aid desktop predictions by managers without the encumbrances of the vigors of laboratory determination and protocols that are dispensable thereby. It will make quick decisions to be reached and effected in general environmental quality management.

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