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## Evaluation of the Variation in the Level of Compliance of Kaduna Refinery and Petrochemical Company (KRPC)

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### **Abstract:**

*This study evaluates the level of compliance of Kaduna Refinery and Petrochemical Company (KRPC) to United Nation Environmental Safety Standard for effluent Management. Waste water samples were collected from eight sampling points within the study area which comprised of the following: effluent sample before treatment, effluent sample after treatment, KRPC effluent discharge point, a point downstream after the refinery facility, and 4km downstream after the refinery facility. The data collected were subjected to Laboratory analysis in the Kaduna Environmental Protection Authority Laboratory. The results generated from laboratory analysis were then subjected to statistical analysis which included ANOVA and Plots of mean variation. Research findings revealed that most of the parameters measured show a significant variation between the sampling points and within the months. The plots of mean variation on the other hand show that the concentration of these parameters varies progressively with distance from the point of the refinery facility. The following recommendations would minimize the load of pollutants on Romi River; the activities of other industries in Romi-Rido environs should be critically identified and assessed; and there is a need for the National bodies entitled with the role of assessing the activities of industries to develop a form of sanctioning against any industry that refuses to adhere to the standard environmental protection legislation, among others.*

**Keywords:** Variation, compliance, refinery, petrochemical, pollution

### **1. Introduction**

The Kaduna crude oil plant commonly referred to as Kaduna Refinery and Petrochemical Company (KRPC) was set up for the purification of crude into premium motor spirit (PMS), diesel, kerosene and other products so as to make fuels available for motor engines and host of other industrial and domestic uses. Effluent generated from the handling and treating of crude oil by concerned industries are typical of consisting large amount of products such as polycyclic and redolent organic compounds, oxybenzen, derivatives of metal, actively-surface materials, sulphides, naphthalene acids, oil and dirtin addition to other compounds, as a result of ineffectualness of post-disposal treatment systems and other ambiguities along the line. According to Adewale (2006), JICA and EEA (2000), Olusi (2000), Wastewaters may become acutely lethal as a result of the accumulation of persistent organic pollutants and heavy metals in the receiving water bodies.

There are laws, regulations and Standards guiding the disposal of effluents from Industries, petro-chemical refineries inclusive. These includes Federal Environmental Protection Act (FEPA) (1991), United Nation Environmental Program (UNEP), World Health Organization (WHO), and Food and Agricultural Organization (FAO)Standards. This regulations and standards require industrial establishments to treat their effluent properly before disposing them into public drainages. Kaduna Refinery which generates large quantities of effluents daily is required to treats effluents before it is discharged into natural water bodies, in this case, Romi River.

Even though environmental safety laws were enacted to minimize or prevent the pollution of environment from the activities of oil refining in Nigeria, the objectives of these laws are yet to be achieved successfully. In the first place, the Oil refinery was established in 1985 and has been operating in an erratic manner since 1990s due to lack of steady feedstock supply. Secondly, the refineries have been facing serious challenges of schedule turn around maintenance (TAM) due to financial constraints. These conditions affected the Company's activities, including its compliance to waste

management. A study with the aim of evaluating the process the waste water management by KRPC will therefore be of high significance as it will inform the level of compliance to environmental safety regulations and highlights environmental risk and hazards that may be associated with the pollution within the areas that are likely to be impacted by its activities.

## 2. Materials and Methods

### 2.1. Sources of Data

The sources of data that were employed for this study are primary and secondary. The secondary source includes the United Nations Environment Programme (UNEP) Safety Standards for Waste Water. Hence, the specification of the United Nations Environmental Programme (UNEP) safety standard for waste water was studied. The sources of primary data embraced by this research are analysis of water samples that was collected from sites, at the refinery waste water discharge point "sample C", upstream immediately after the facility (termed as sample D), 2km upstream (before the facility) on River Romi "sample E", 2km and 4km downstream (after the facility) of River Romi "sample F and G". Also, the record of the content of wastewater before and after treatment in KRPC treatment plant (clarifier) "samples A and B" was respectively collected and analysed for the specified period of the research.

### 2.2. Reconnaissance Survey

The study area comprises the following segments was visited; Pollution control (Monitoring and Evaluation Unit), Effluent Treatment Plant Unit and Refinery Laboratory. Special consideration was given to the monitoring and evaluation section of the Pollution Control Unit with focus on compliance to environmental safety standards.

The reconnaissance survey provided an insight to the number of personal field assistant required. This enabled the researcher and her field assistants to know the types of safety gadgets that they used for the main field investigation. It also provided the coordinate of each sampling point which assisted in subsequent sample collection enabling the researcher to collect all the samples at the same point each month.

### 2.3. Main Field Investigations

#### 2.3.1. Sampling Procedure

The process was involve collecting data from the refinery and taking water samples, along Romi River. Collection of water samples along River Romi was taken place in the morning between 8-10 am when the temperature was low because high temperature might alter the level of pollutants by enhancing chemical reaction. These sample was collected using Grab method which according to the World Bank (1988) is effective enough for surface water investigation of inland hydrological systems. Grab selection technique entails plunging a specimen from one or more sections in a river cross profile. Grab selection procedures to be used in this study was regular at every selection point.

In situ parameters (such temperature, dissolved oxygen, and pH) were taken at the site and the samples were collected in 2liter plastic containers and labeled accordingly. The samples were then taken to for analysis within 24 hours. The reason was to ensure that the result obtained give true representation of the parameters in the water at the time of collection.

All the samples were taken monthly for six months i.e. [March, April and May (Dry season) and June, July and August (Wet season)]. Samples were collected sampled six times from each location; thrice underneath steady low-flow situations and thrice at great flow. Regarding this study, high drift has been described as a situation where by shallow over flow was flowing into the stream, and volume of suspended substances in the water seemed to exceed that at low flow, High-flow samples were collected in June, July and August, 2014 (Raining season). Low-flow samples were collected in January, February and March, 2014 (Dry season). See table 3.1 below;

Sampling Points Label	Sampling Points Title	Source
A	Record of refinery effluent before treatment	KRPC safety and control unit.
B	Record of refinery effluent after treatment	KRPC safety and control unit.
C	At the refinery wastewater discharge point	Refinery effluent discharge point
D	A point upstream immediately after the Refinery facility	Romi river
E	2 km upstream (sample E) before the facility	Romi river
F	2km downstream	Romi river
G	4 km downstream	Romi river

Table 1: Low-Flow Samples Collected In January, February and March, 2014

Laboratory analysis of wastewater before treatment (before wastewater goes into the treatment plant/clarifier) and after treatment (after wastewater comes out of the treatment plant/clarifier); Sample A and B, were collected from KRPC Safety and Control Unit.

#### 2.3.2. Parameters Considered

Adeniyetal. (1981) suggested that the parameters on table 3.2 below are crucial while analyzing a substance terminated by petrochemical waste, especially as they play a major role in predicting pollution level of surface water.

Physical Properties	Chemical Properties	Anions	Heavy Metals
PH	Oil and Gas (O&G)	Phosphate (PH <sub>4</sub> <sup>-3</sup> )	Copper (Cu)
Temperature	Phenolic Compounds	Chloride (Cl) <sup>-</sup>	Lead (Pb)
Percentage Clarity	Ammonia (NH <sub>4</sub> )	Sulphate (SO <sub>4</sub> <sup>-2</sup> )	Cadmium(Cd)
Conductivity(EC)	Total Alkalinity		Zinc (Zn)
Turbidity	Magnesium(Mg)		
COD	Phosphorous (P)		
BOD	Calcium (Ca)		
DOD	Potassium (K)		
TDS			
TSS			

Table 2: Parameters Considered  
Source: Adeniyet Al. (1981)

### 2.3.3. Statistical Analysis

The results obtained from the secondary data, laboratory analysis and field measurements were then be subjected to further analysis. The following statistical techniques was employed for purpose of the research. Mean and Standard deviation, Analysis of Variance (ANOVA), The Paired sample T-test and the Clerk (1984) compliance equation.

### 2.3.4. Analysis of Variance (ANOVA)

The analysis of variance was used to test the variations among and within the five sets of values and the UNEP standard, i.e. sample C, D, E, F, G and UNEP standard. This therefore took care of research question number four (iv).

### 2.3.5. The Clerk Compliance Equation

The data generated (B, C, D, E, F and G) were compared with the UNEP safety standard for waste water to determine the effectiveness of KRPC effluent management, using Clerk (1984) equation.

$$PC = \frac{N_t \times P}{N}$$

Where;

PC = Percentage compliance

N<sub>t</sub> = Number of times parameter complied with the stated standard.

P = 100% (Assumed maximum compliance limit).

N = Total number of Measurements.

### 2.3.6. Paired Sample Student t-test

Paired Sample Student t-test was computed for pairs of data as follows: Paired Sample Student t-test for value of samples A and B representing data set 1; Paired Sample Student t-test for value of samples B and C representing data set 2; value of samples B and UNEP standard representing data set 3; and value of samples C and UNEP standard representing data set 4.

## 3. Results and Discussion

The plot below shows a graphical representation of how the mean values for temperature vary from one sampling point to another across the six observed months. Variation in values of temperature for each month from January, February, march and June, July, August 2014 and UNEP safety standard shows that the mean values for sample C and G for the month of July were above the safety limits of 30°C set by UNEP.

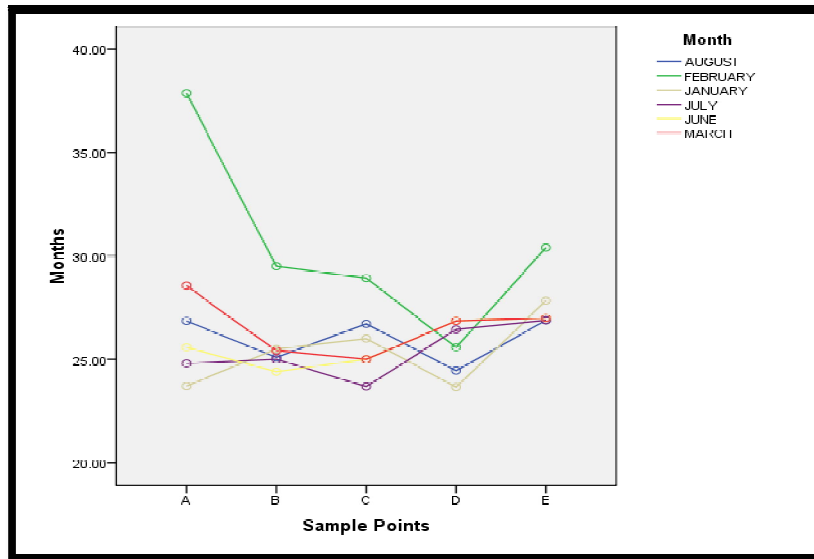


Figure 1: Plot of Mean Variation for Temperature with UNEP Standard  
Source: Fieldwork 2014

Figure 4.2 shows the variation in clarity values of the five sampled points for each month from January, February, March and June, July, August 2014 and UNEP safety standard. The figure shows that the mean values for all the samples exceeded the safety limit set by UNEP.

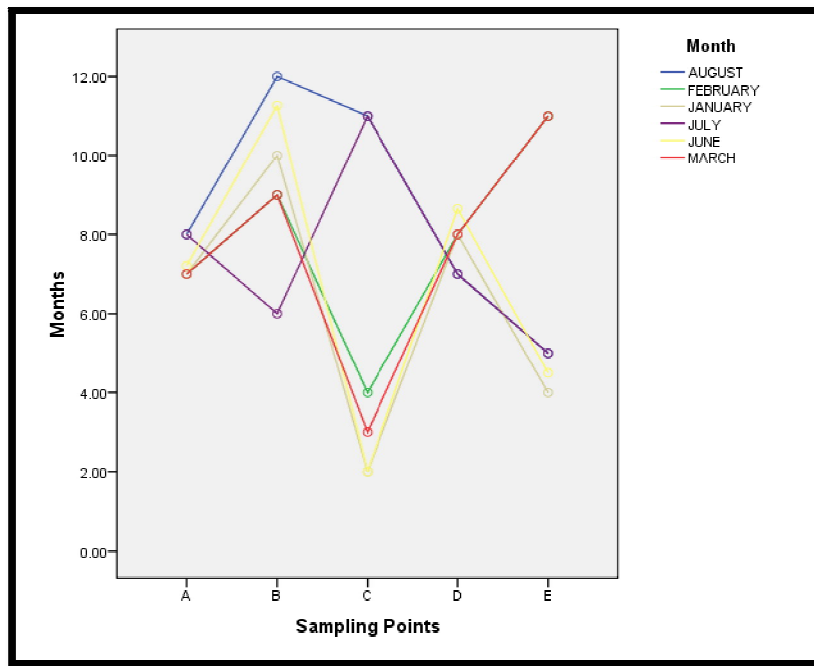


Figure 2: Plot of Mean Variation for Clarity with UNEP Standard  
Source: Fieldwork 2014

Values of Electrical Conductivity (EC) show variation for each month from January, February, March and June, July, August 2014 and UNEP safety standard (Figure 2). All the samples for the month of June complied with the UNEP safety standard for EC, apart from sample D, all other samples exceeded the standard in February. Sample G and C were within compliance in January and July respectively as against the rest of the samples for the two months. For March and August, only sample E exceeded the set limit while February has only sample D and G within the UNEP set limit.



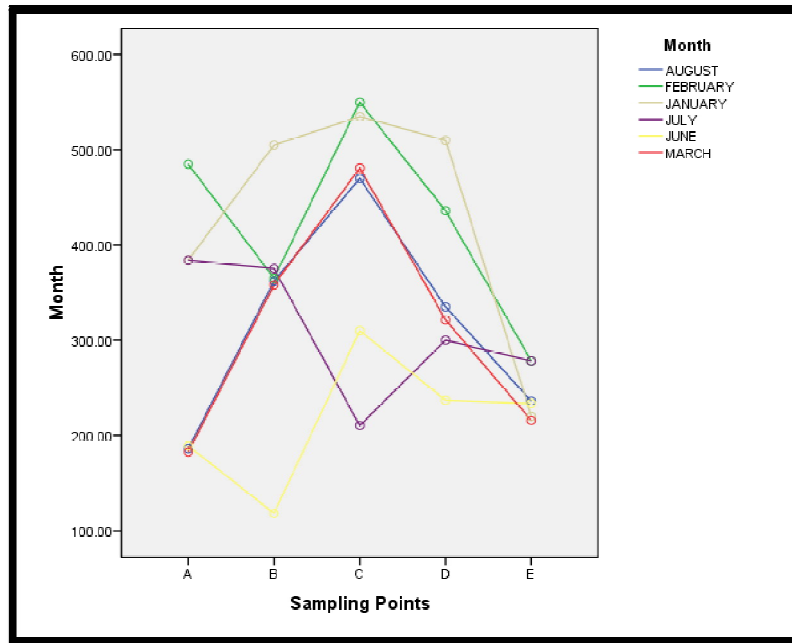


Figure 3: Plot of Mean Variation for Electrical Conductivity with UNEP Standard  
Source: Fieldwork 2014

Discrepancy in values of turbidity for each months from January, February, March and June, July, August 2014 and UNEP safety standard shows that the mean value of sample E for the month of August had the maximum variation from the safety limits set by UNEP, while samples D and G for the months of March and June respectively had the maximum compliance (Table 3.2).

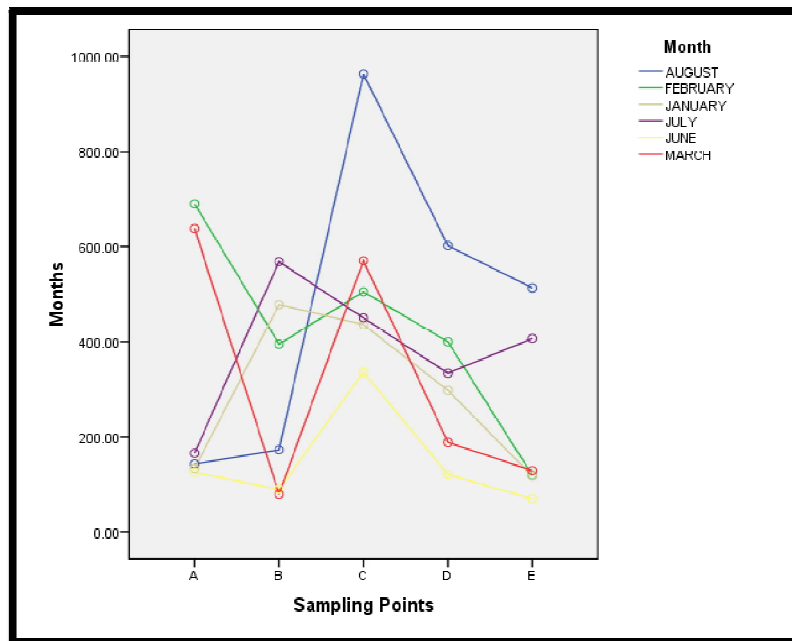


Figure 4: Plot of Mean Variation for Turbidity with UNEP Standard  
Source: Fieldwork 2014

Also values for COD shows variation for each month from January, February, March and June, July, August 2014 and UNEP safety standard. Apart from the mean values of sample F for January, February, March, July and August, sample D and E for July, and sample G for January and February, which were above the UNEP safety limits, the rest sample mean values for the various months were below or equal to the set limit (Figure 4)

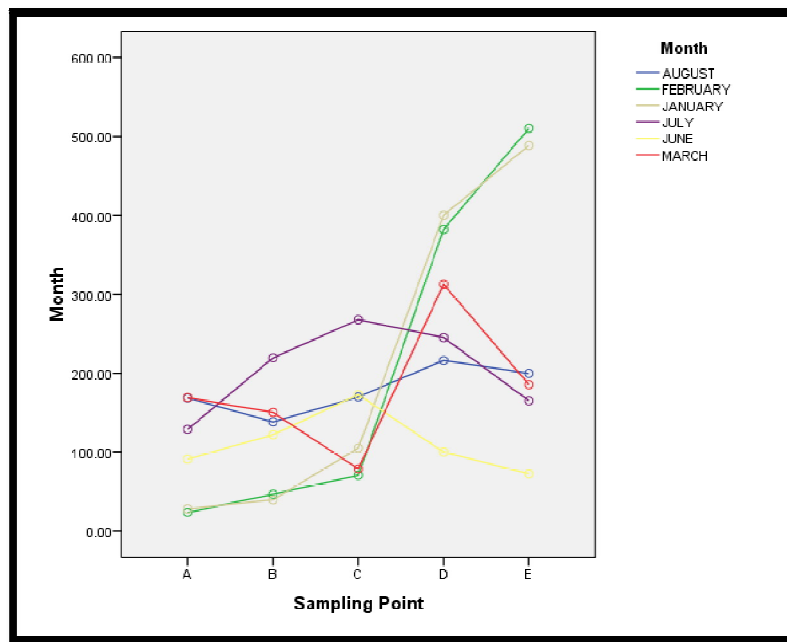


Figure 5: Plot of Mean Variation for COD with UNEP Standard  
Source: Fieldwork 2014

Figure 5 shows that the mean values of the samples for BOD from January, February, March and June, July, August 2014 and UNEP safety standard varies within the samples and between the months. The samples for most of the months were above the UNEP set limit of 25mg/l for BOD content in effluent while sample C for all the months were below the limit as well as all the samples collected in the month of July.

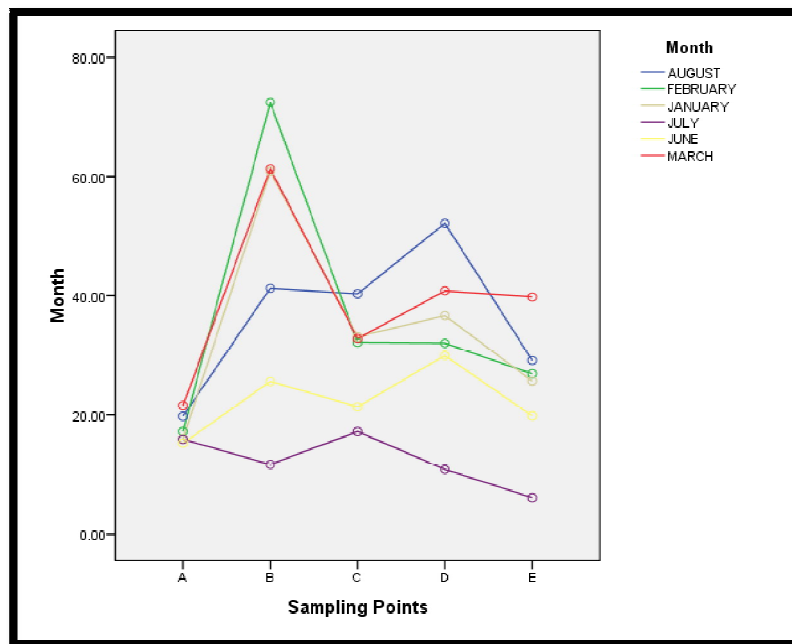


Figure 6: Plot of Mean Variation for BOD with UNEP Standard  
Source: Fieldwork 2014

The graph of mean variation for DOD shows that in January, February and March apart sample C (for the three months) and G (for January and February only), all the other samples were above the UNEP standard. In June, apart from sample C and G, all others were also above the standard whilst all the samples in July were in correspondence with it and in august only sample C matched the standard (Figure 6)

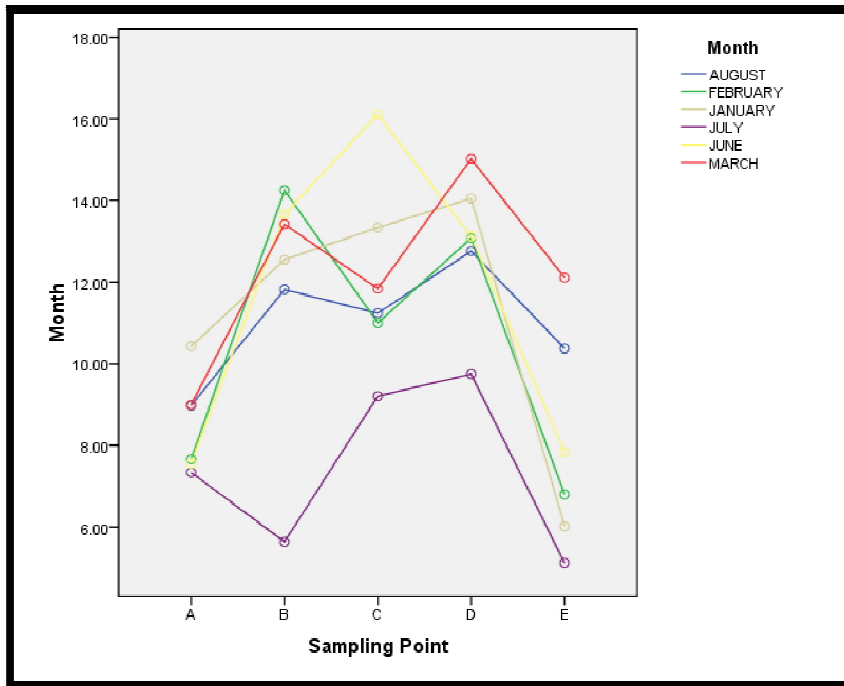


Figure 7: Plot of Mean Variation for DOD with UNEP Standard  
Source: Fieldwork 2014

Also, values for TDS on the Graph below shows variation for each month from January, February, March and June, July, August 2014 and UNEP safety standard. All the samples showed values that were below the UNEP set standard for TDS in all the months (Figure 7)

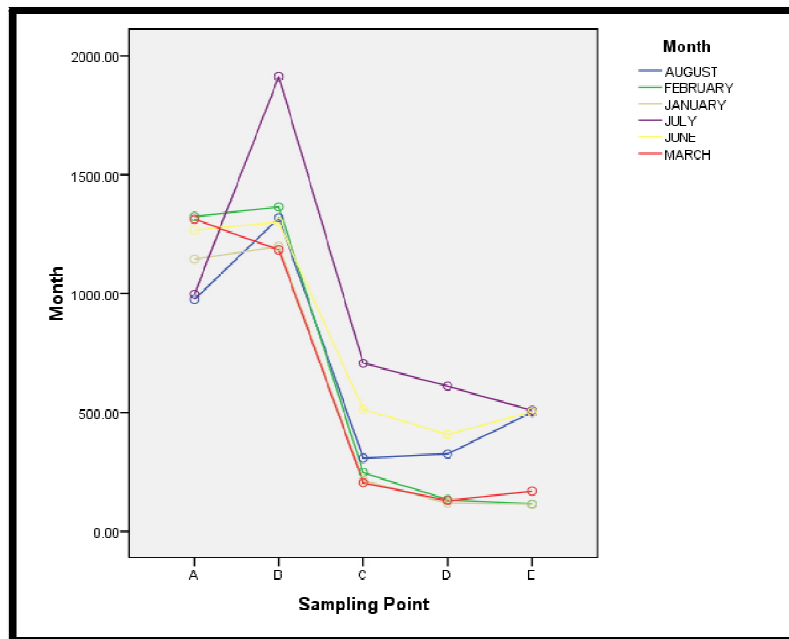


Figure 8: Plot of Mean Variation for TDS with UNEP Standard  
Source: Fieldwork 2014

Figure 8 shows mean values for TSS indicating variation for each month from January, February, March and June, July, August 2014 and UNEP safety standard. The figure revealed that, apart from sample E for January, samples D, E, F and G for June and July, all the other samples had values that were below the UNEP safety limits for this parameter.

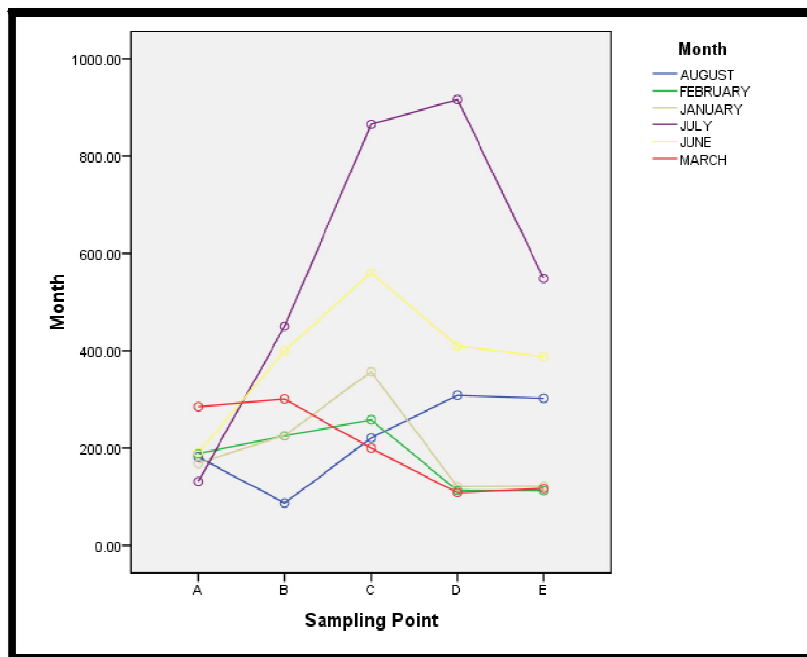


Figure 9: Plot of Mean Variation for TDS with UNEP standard  
Source: Fieldwork 2014

The mean graphical presentation for pH affirms that there is a variation in mean pH among the sampling points and UNEP standard. In January and February, all the sample values apart from sample A were below the UNEP safety limits. Sample D also exceeded the limit in July while the rest of the sample values in the observed months fell within the acceptable values by UNEP standard (Figure 9).

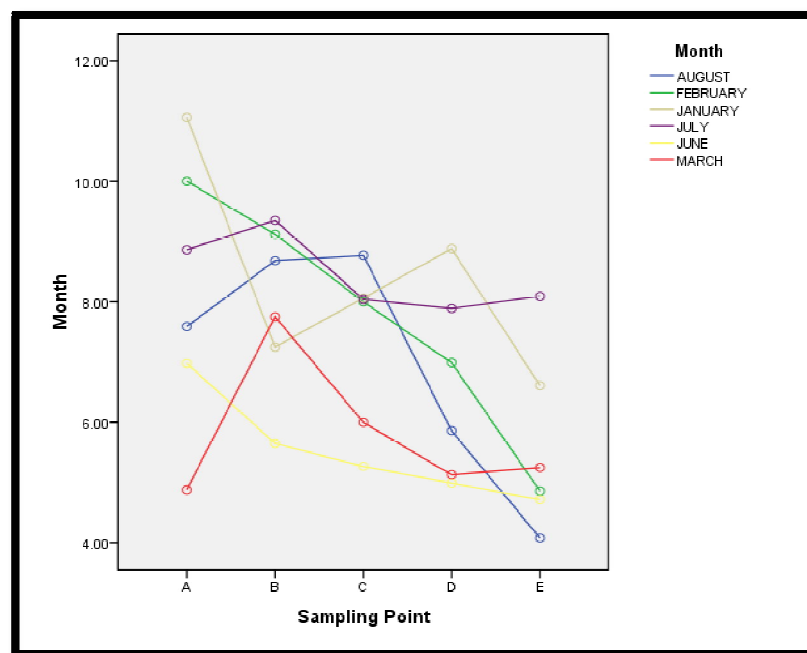


Figure 10: Plot of Mean Variation for Ph with UNEP Standard  
Source: Fieldwork 2014

Furthermore, figure 3.9 revealed series of variations across the months and between the sampling points. The mean values of the samples collected in June and August were all below the UNEP set limit value of 10mg/l. In July, samples C, D and E exceeded the UNEP admit able value whereas in January and February, two out of the five sample mean values exceeded the standard.

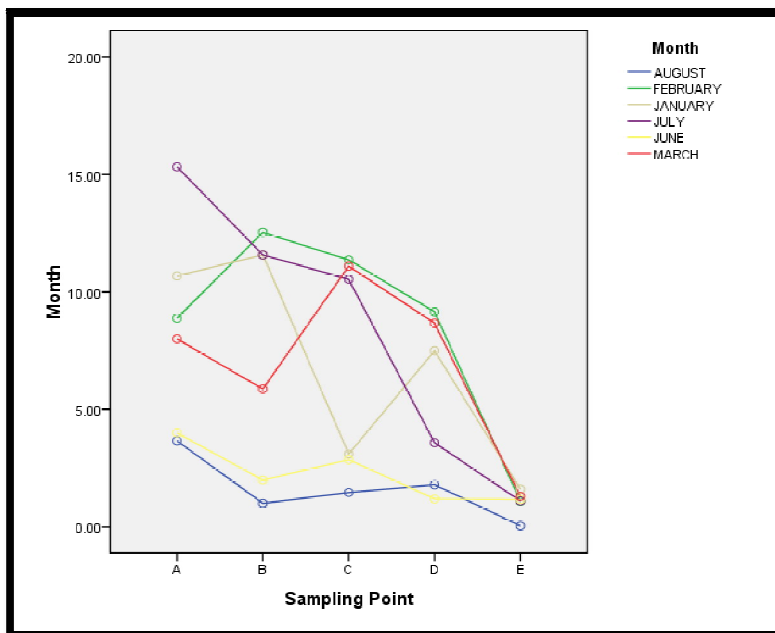


Figure 11: Plot of Mean Variation for O & G with UNEP Standard  
Source: Fieldwork 2014

The concentration of phenols in addition shows variations in values. Samples D, E, F, and G values met the UNEP safety standard in August. Samples C, D, F were higher than the set limit in January and similarly, samples C, E, F in February whereas C, D, E in July fell with the admit able value of the UNEP (1mg/l) (Figure 11)

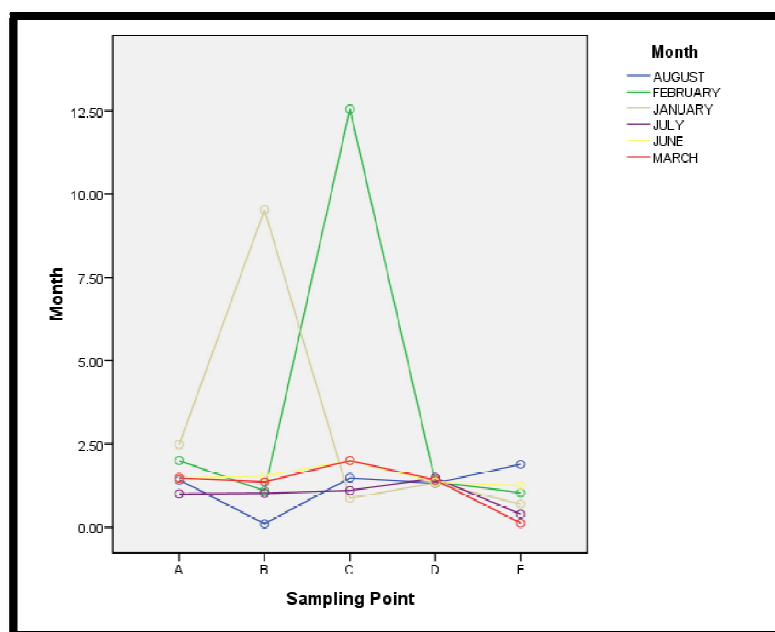


Figure 12: Plot of Mean Variation for Phenols with UNEP Standard  
Source: Fieldwork 2014

Variations in values of Ammonia (NH<sub>4</sub>) for each month from January to March and June to August 2014 show that the mean value for all the samples in January exceeded the UNEP set limit of 1mg/l. Asidesample C for all the other months, the rest of the samples were above the UNEP bench mark for ammonia in effluent discharge (Figure 12).

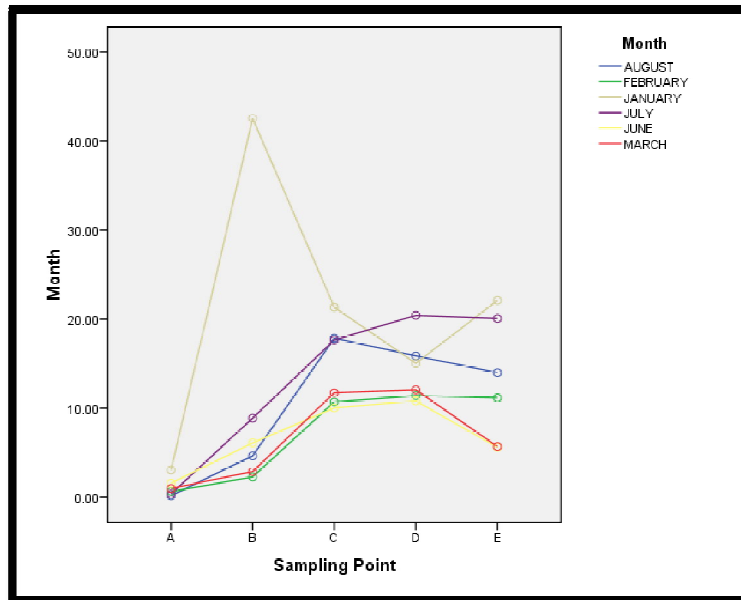


Figure 13: Plot of Mean Variation for NH4 with UNEP Standard  
Source: Fieldwork 2014

For total alkalinity, all the samples in January, March, July and August revealed an alkalinity level that were less than UNEP safety limit. This implies that the samples were in conformity with the UNEP standard. However, samples F, G in January and C, E in June had alkalinity levels that exceeded the UNEP set limit and thus failed to conform to the standard (Figure 13).

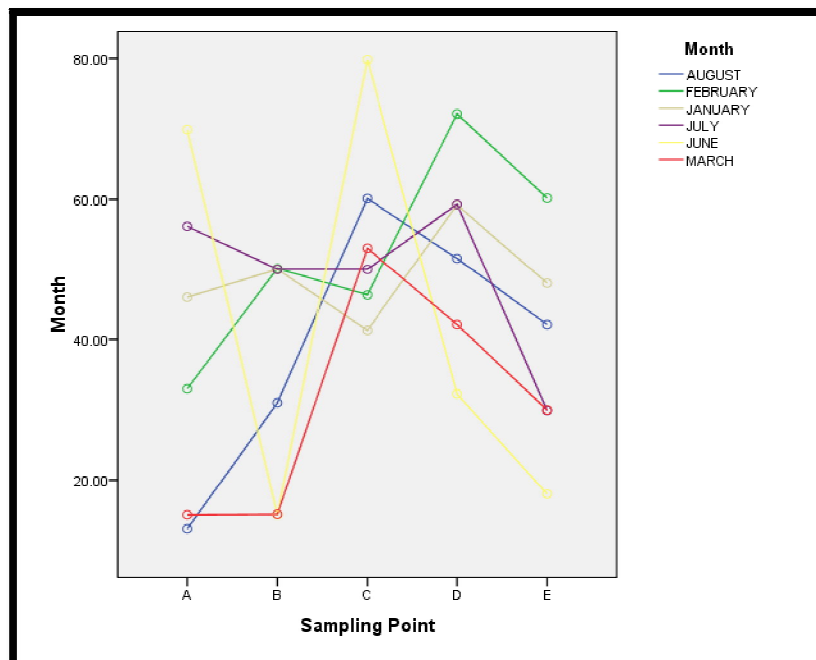


Figure 14: Plot of Mean Variation for Total Alkalinity with UNEP Standard  
Source: Fieldwork 2014

Figure 14 shows clearly that the mean values of Magnesium (Mg) varied within the samples and between the months as well. Apart from samples E and G in January and sample E in February and July, all the other samples in the observed six months were below the set limit of the UNEP for Mg content. This implies that apart from the samples that exceeded the limit, all other samples were in conformity with the UNEP standard for Mg.

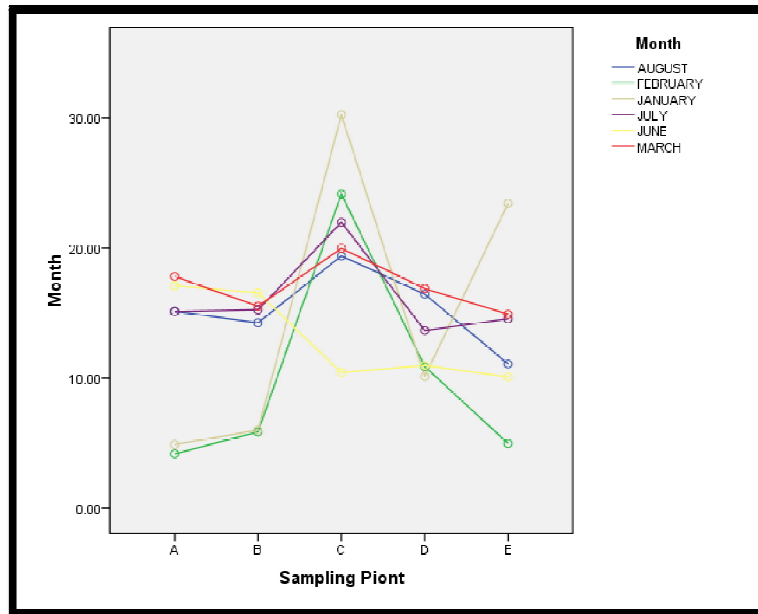


Figure 15: Plot of Mean Variation for Mg with UNEP Standard  
Source: Fieldwork 2014

The graphical presentation below shows the disparity in the mean value of phosphorous (P) across the months and among the sampling points. The graph shows that samples C (in January), C and D (February), D, E and F (in March), C (in July) and E (in August) all exceeded the UNEP bench mark of 20 mg/l for Phosphorous. The rest of the samples in the various months were below the UNEP limit value and were thus in conformity with the UNEP standard as the period of this study (Figure 15)

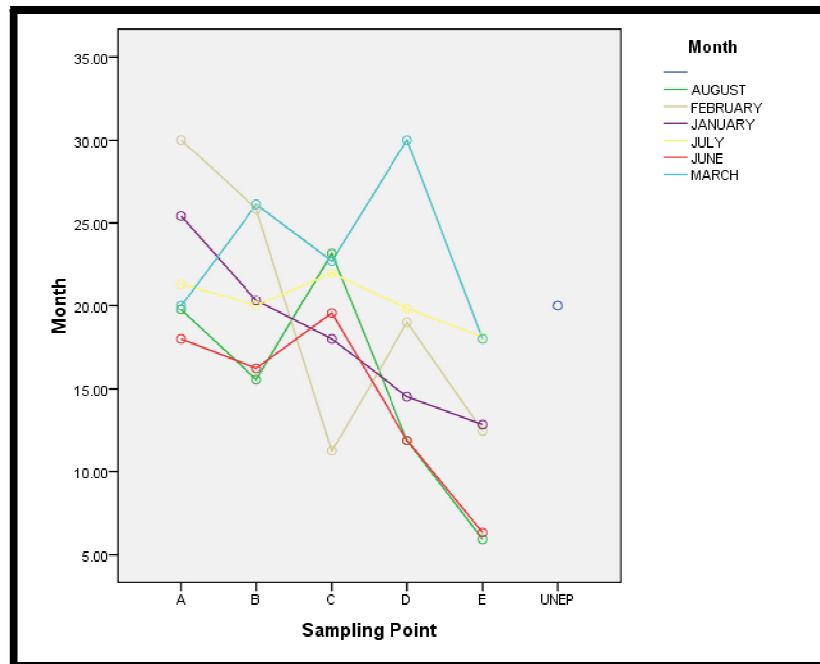


Figure 16: Plot of Mean Variation for P with UNEP Standard  
Source: Fieldwork 2014

The graph of mean variation for Calcium (Ca) also, accentuates series of variations across the months and between the sampling points. Apart from samples E and G in July, the concentrations of Ca in the rest samples all through the month were conventional with the UNEP safety standard of 30mg/l for calcium. The highest Ca content was observed in sample G in the month of July and the least was in sample C, in August (Figure 16).

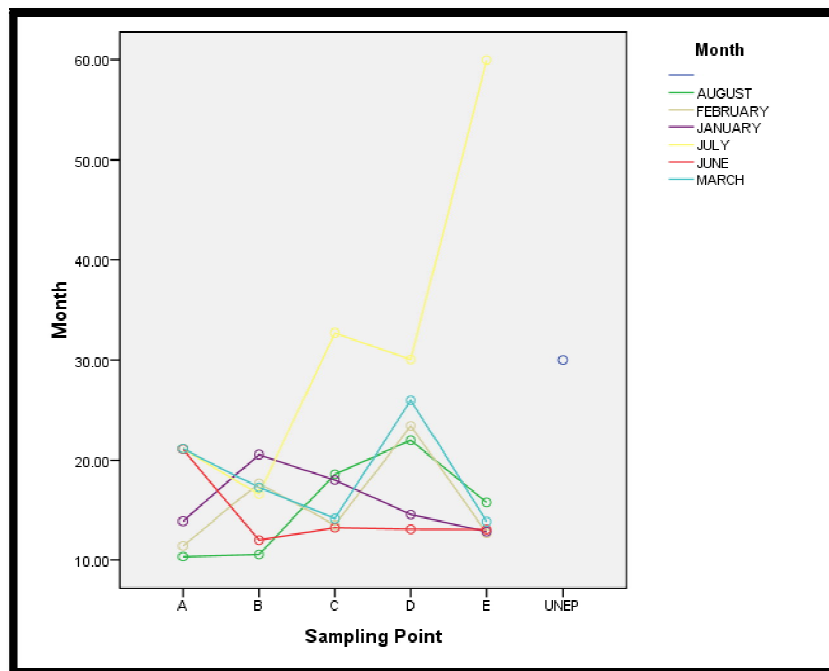


Figure 17: Plot of Mean Variation for Ca with UNEP Standard  
Source: Fieldwork 2014

In a similar way manner, Figure 17 illustrates differences across the months and among the sampling points for the mean values of potassium (K), it reveals that aside sample F in the month of January which had the highest potassium content among the samples, all other samples were below the UNEP set limit of 30mg/l and are thus in conformity with the UNEP safety standard as at the time of this study.

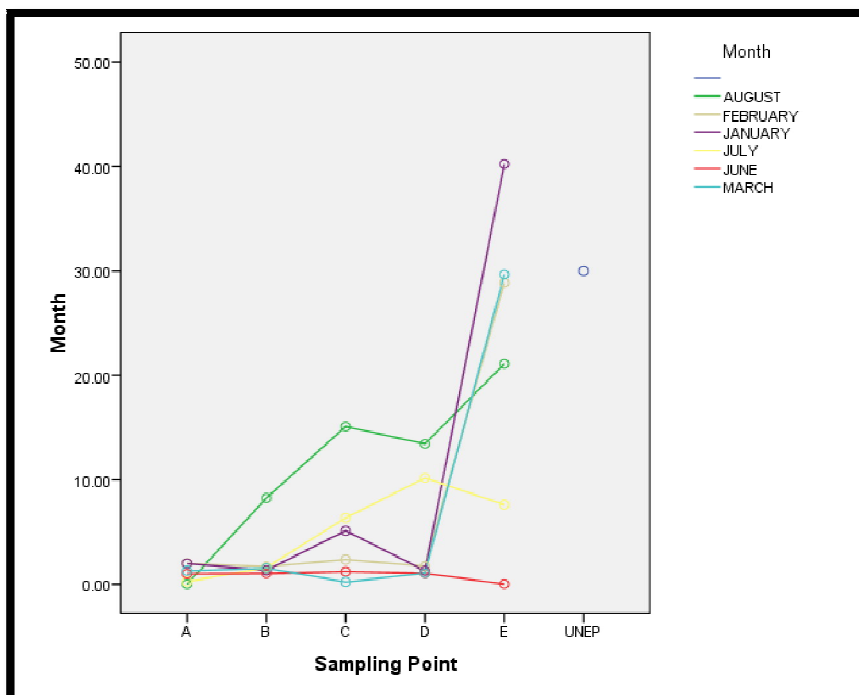


Figure 18: Plot of Mean Variation for K with UNEP Standard  
Source: Fieldwork 2014

Phosphate as well shows disparity across the months and the sampling points. The variations reveal that apart from sample C in February and June, sample G in June and July, all the other samples in the months exceeded the UNEP benchmark and the highest phosphate levels were recorded at sample F in August (Figure 18).



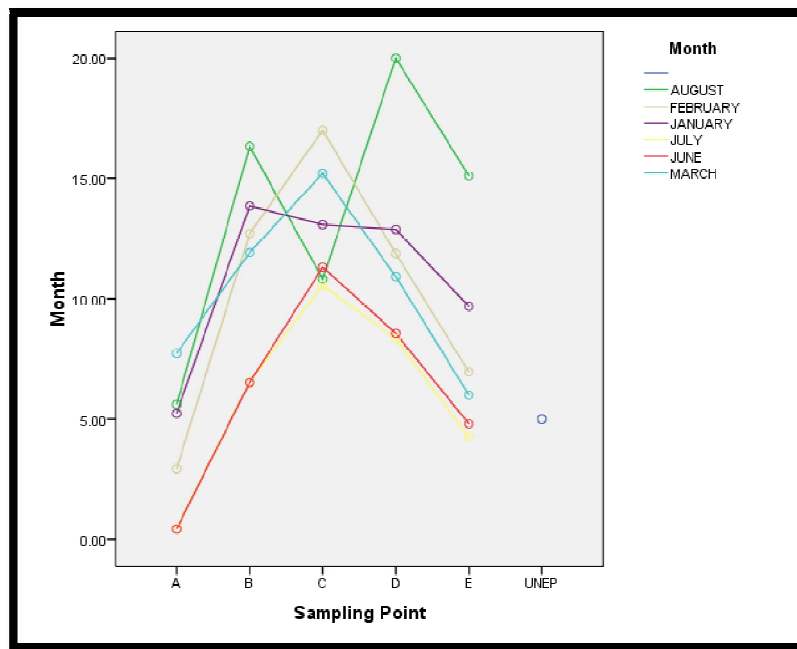


Figure 19: Plot of Mean Variation for Phosphate with UNEP Standard  
Source: Fieldwork 2014

Figure 19 shows the Variation in the concentration of sulphate within the samples and across the months and with the UNEP limit value. According to plot of the variation, all the samples in the months of January, February, March, June, July and August had values that were below the UNEP safety limit. This implies that the concentrations sulphate in the samples were all in conformity with the UNEP safety standard in the 2014.

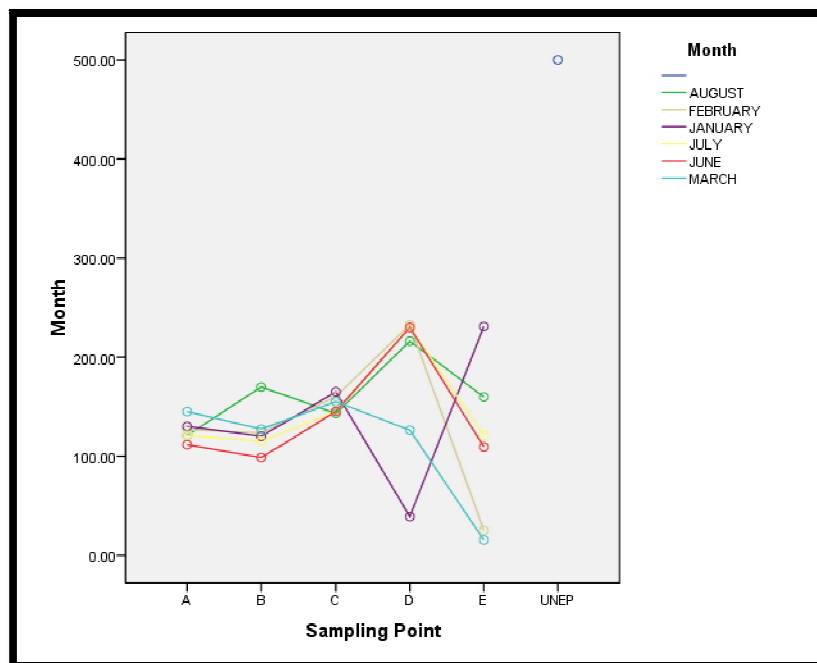


Figure 20: Plot of Mean Variation for Sulphate with UNEP Standard  
Source: Fieldwork 2014

Mean variation for chloride as shown on figure 4.21 reveals that in sample C and D in January, February, March and August, sample D in June, E in August, F in all the six months, E in January, February, June and August were all below the UNEP set limit and are thus in conformity with the UNEP safety standard as at the time of this study (figure 4.21).

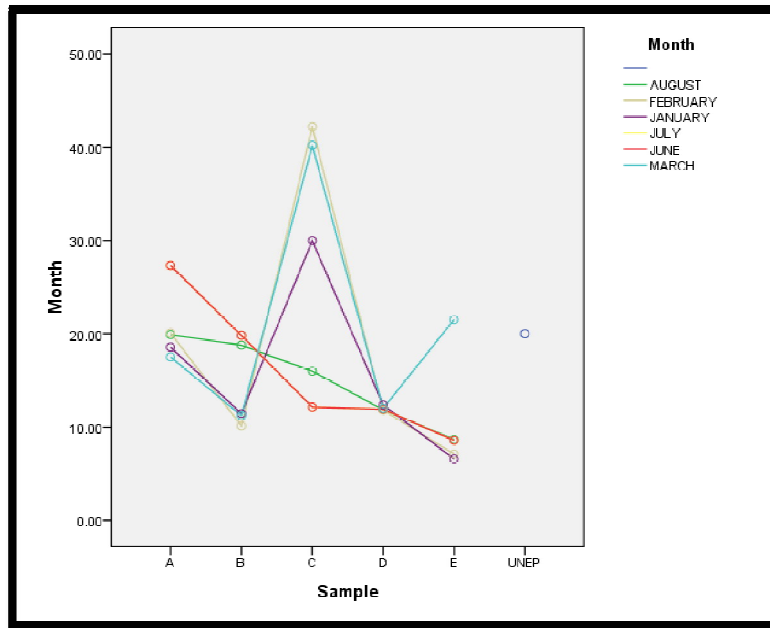


Figure 21: Plot of Mean Variation for Chloride with UNEP Standard  
Source: Fieldwork 2014

The graphical presentation for the mean value of copper also reveals a series of variations. Sample C in January, March and August were below the UNEP admissible limit of 0.01mg/l, same were true for samples D in August, F in all the months, and G in March. Apart from the above samples, the rest sample across the six months of observation were in non-conformity with the UNEP safety standard because they had values which exceeded the UNEP admissible limit (Figure 21).

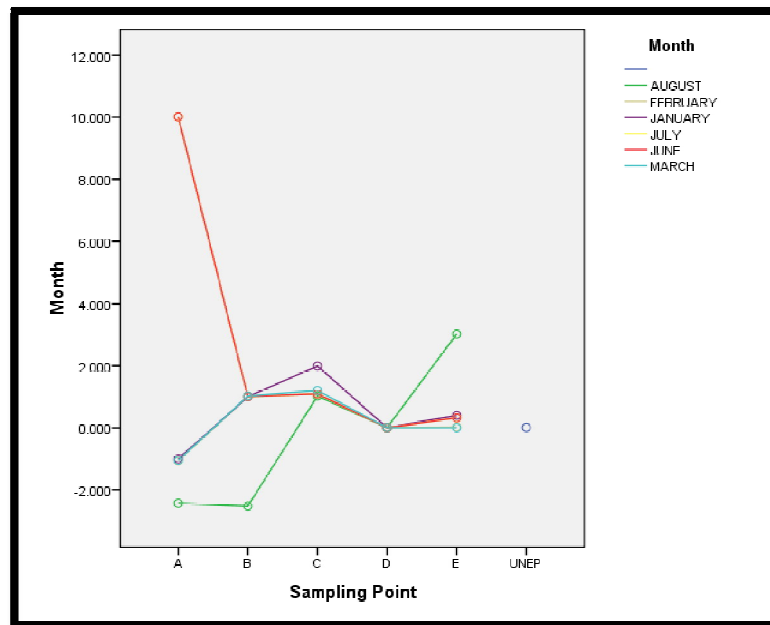


Figure 22: Plot of Mean Variation for Cu with UNEP Standard  
Source: Fieldwork 2014

The graphical representation of the mean variations in Lead (Pb) content within the samples and across the months reveals that all the samples were conventional to the UNEP safety standard limit of 0.2mg/l. The least concentrations of Pb was recorded in samples C and D in the month of August while the highest concentrations were recorded in sample G across the month of January and August (figure 4.23).

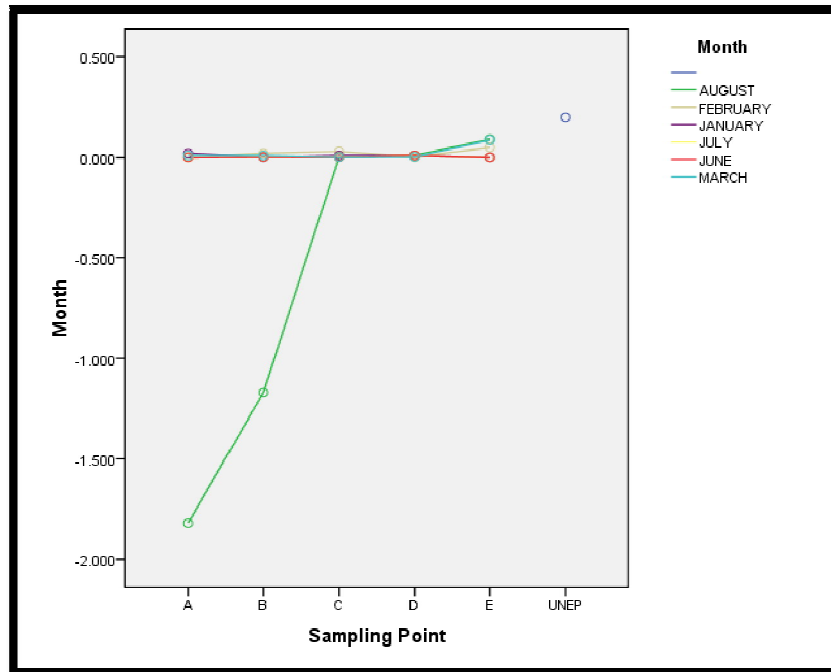


Figure 23: Plot of Mean Variation for Pb with UNEP Standard  
Source: Fieldwork 2014

The graphical presentation for Cadmium (Cd) correspondingly shows very slight disparities across the months and among the sampling points. Apart from samples F in June and G in August which had Cd concentrations that were slightly higher than the UNEP admissible limit, all the other samples from January to August had records of concentrations that were confounded within the UNEP admissible limit of 0.01mg/l.

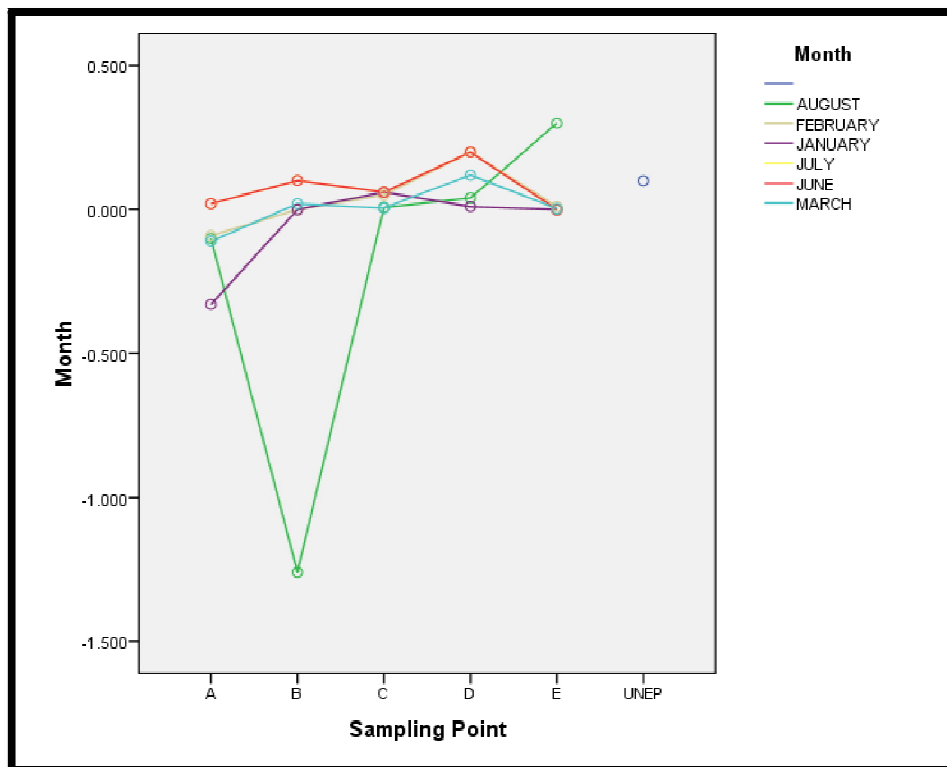


Figure 24: Plot of Mean Variation for Cd with UNEP Standard  
Source: Fieldwork 2014

Similarly, the graphical presentation for Cadmium (Cd) correspondingly shows very slight disparities across the months and among the sampling points except for the month of August within which samples C, D and F recorded values that indicates high disparity from the UNEP safety limit of 0.5mg/l. Apart from the three samples, all the other samples across the months had records of values that were below the UNEP admissible limit and were thus in conformity with the safety standard at the time of this study.

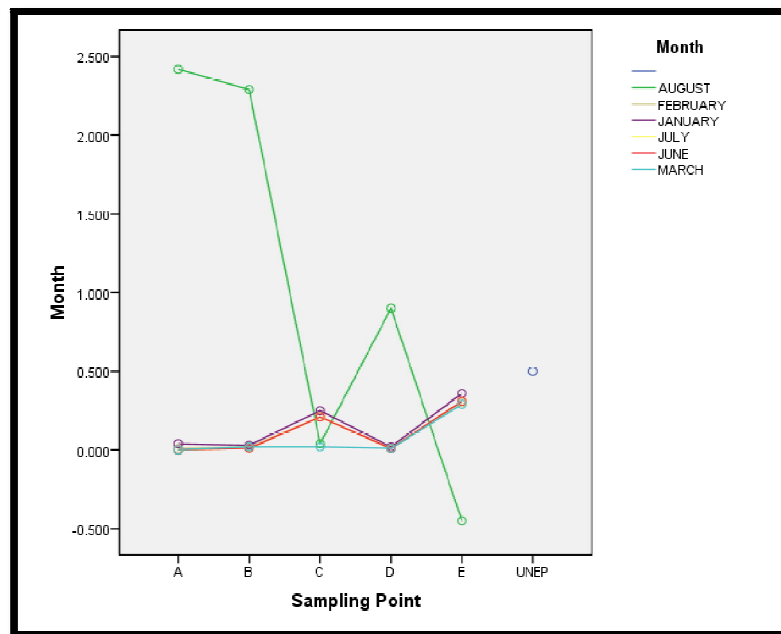


Figure 25: Plot of Mean Variation for Zn with UNEP Standard  
Source: Fieldwork 2014

#### 4. Conclusion

The study uses UNEP safety standard for inland waters and waste waters in order to make the study universal and differ from earlier studies which are mostly based on National standards. The study also answered the questions that were frequently asked when people review literatures of studies carried out on the effect of KRPC effluent on the Romi-Rido environment. One of the questions has been that since most of the studies indicate effectiveness of KRPC effluent treatment then, why then pollution load on Romi river? This research confirms the fact that KRPC effluent treatment attains a moderate universal acceptable limit of compliance to universal safety standards. For this reason, it is suspected that there must be a major source of effluent discharge upstream of Romi river before the refinery facility and from field observations the researcher realized that there are other industries beside KRPC in the Romi-Rodi environment and these other industries carry out activities that can generate the same kind of pollutants assessed in this study. Moreover, the levels of compliance to environmental safety standard of this other industries have not been researched.

This research as an integral part of a course on Environment Resource Planning needs to point out its planning insinuations. Nowadays the role of natural elements in conditioning, though not controlling human activities, is often lost sight of. This study realized that the establishment of the Romi-Rodi industrial site was not based on proper planning. The carrying capacity of the environment was not properly considered and this shows that the Romi-Rodi industrial site was established based on perception of variables which lie in the minds of men rather than proper measurements. Now to counteract this degrading tendency and to rebuild the old determinism on a newer footing, the determinists doctrines in an altered form which approximates very closely to possibilism should be considered, it is the stop and go-determinism propagated by Griffith Taylor, which means one should regulate one's activity as Red light acts for traffic regulations. Therefore, the activities of all the industries in Romi-Rodi environs should be regulated and properly monitored to save the grieving environment.

#### 5. References

- i. Achudume, A.C. (2009), Bull Environ Contam Toxicol: The Effect of Petrochemical Effluent on Water Quality of Ubeji Creek in Niger Delta of Nigeria. Springer Science Business Media. [e-journal] 83:410–415 Available at: [http://www.ccme.ca/assets/pdf/el\\_062](http://www.ccme.ca/assets/pdf/el_062).
- ii. Act 2007, Accessed at [WWW.elri-ng.org/newsandrese2.html](http://WWW.elri-ng.org/newsandrese2.html) Adamu A.J. (2003). The Profiling of Surface Water Pollution in Zaria, An Unpublished M.Sc. Thesis, Ahmadu Bello University, Zaria, Nigeria
- iii. Adamu A.J. (2003). The Profiling of Surface Water Pollution in Zaria, An Unpublished M.Sc. Thesis, Ahmadu Bello University, Zaria.
- iv. Adewoye, R.O. (1998). Environmental Hazard of Energy Production and Use in Nigeria. Central Bank of Nigeria Bulletin vol. 22(4)
- v. Adeyanju, J. A. (1999). Oil Pollution Hazards and the Nigeria Environment. In Akinsoji, I.O, ed. Hazard of Maritime Transport (In press).
- vi. Afebe, O.A. and Oladejo, O.S (2003), Study of Water Quality at Oil Depot in South Western Nigeria, International Journal of Environmental Issue, vol.1, No. (1) Pg.36-48.
- vii. Ahmad, Hadiza A., (2012). Assessment of the Level of Compliance of Kaduna Refinery and Petrochemical Company with Environmental Safety Standard for Effluent Management. An MSc. thesis, University of Abuja, Nigeria.

- viii. Al-Amin, A.M. (2006), Environmental Impact Assessment of Kaduna Refinery on the Rido region of Kaduna metropolis. An unpublished PhD thesis, Ahmadu Bello University, Zaria, Nigeria.
- ix. Alex Ogedenbge (2009). Nigerian Refineries: History, Problems and Possible Solutions (1), available at: [www.mywebsearch.com](http://www.mywebsearch.com)
- x. Botkin, D.B. and Keller, E.A (1998), Environmental Science: Earth as a Living Planet. John Wiley and Sons New York.
- xi. BP Statistical Review of World Energy. June 2013. Page 2. Available at [http://www.bp.com/content/dam/bp/pdf/statistical-review/statistical\\_review\\_of\\_world\\_energy\\_2013.pdf](http://www.bp.com/content/dam/bp/pdf/statistical-review/statistical_review_of_world_energy_2013.pdf).
- xii. Bugaje, A.M., (2006). Industrial Effluents from Kaduna refinery and Petrochemical Company and their Effects on Agricultural Land Use. An unpublished B.Sc project submitted to Usmanu Danfodio University, Sokoto, Nigeria.
- xiii. Bugaje, A.M. (2006). Industrial Effluents from Kaduna refinery and Petrochemical Company and their Effects on Agricultural Land Use. An unpublished B.Sc project submitted to Usmanu Danfodio University, Sokoto, Nigeria.
- xiv. FEPA (Federal Environmental Protection Agency) (1991): National Environmental Protection (Effluent Limitation) Regulations. Federal Environmental Protection Agency, Nigeria.
- xv. Ferguson, J.F., (1990). The Heavy Elements Chemistry: Environmental Impact and Effects. Pergamon Press, Oxford.
- xvi. Izunwanne, J.O. and Obidiaku, M.C (1990). Guiding Against Environmental Hazards on Oil Processing Industry: A Case of KRPC. A Paper Presentation at a Seminar on Environmental Degradation and Pollution Hazard and Control in Nigeria: Kaduna, Nigeria 21<sup>st</sup>-25<sup>d</sup> March 1990.
- xvii. JICA, (2003). <http://www/jica-ri.jica.go.jp/research/environment-develop/>
- xviii. Katung, S.V., (2003). The Impact of Water Quality on the Health of Humans and Animals in Katsina State. Environment and Development Journal 3(2): 82-89
- xix. Kuehn, R.L., Berlin, K.D., Hawkins, W.E. and Ostrander, G.K. (1995), Relationships among Petroleum Refining, Water and Sediment Contamination, and Fish Health. Journal of Toxicology and Environmental Health. 2. (46):101–116. Available at: <http://www.cedare.org/eg/about/about.htm>. Accessed on 3/01/2010.
- xx. Luyben, W.L. (1990). Process Modelling, Simulation, and Control for Chemical Engineers. 2nd ed., 45-48. McGraw Hill, New York, NY, USA.
- xxi. Manual of Analytical Methods (1993). Inorganic Chemistry Unit, Wisconsin State Laboratory of Hygiene, Environmental Sciences Section, Madison, Wis.
- xxii. Musa, S.D and Ahmad, A. (2007). Effects of Kaduna Refinery and Petrochemical Company (KRPC) Effluents on Adjacent Agricultural land; ANG (Association Nigeria of Geographers) Book of Proceedings for the 49<sup>th</sup> Annual Conference. Abuja, Nigeria.
- xxiii. Nigeria Environmental Safety and Regulation Enforcement Agency (NESREA)
- xxiv. Odjugo, P.A.O. and Balogun, T.F., (2006). The Impact of Seasonal Variation and Urbanisation on Rural Water Quality in Delta State, Nigeria. A Paper Presented at the 48<sup>th</sup> Annual Conference of the Association of Nigerian Geographers. Federal University of Technology Yola, Adamawa state, Nigeria.
- xxv. Odjugo, P.A.O and Balogun, T.F. (2006), The Impact of Seasonal Variation and Urbanisation on Rural Water Quality in Delta State, Nigeria. A Paper Presented at the 48<sup>th</sup> Annual Conference of the Association of Nigerian Geographers. Federal University of Technology Yola, Adamawa state, Nigeria.
- xxvi. Olusi, O., (1981). Human Health Hazards Associated with Petroleum Related Pollution in The Petroleum Industry and the Nigerian Environment (Federal Ministry of Housing and Environment, 1981).
- xxvii. Onwumere, B.G. & Oladimeji, A.A. (1990), Accumulation of Metals and Histopathology in Oreochromis niloticus Exposed to Treated NNPC Kaduna (Nigeria) Petroleum Refinery Effluent. – Ecotoxicology and Environmental Safety 19: 123–134.
- xxviii. Osigbernm, D. I., (1998). Environmental Regulation of the Oil and Gas Industry in Nigeria: Lessons from Alberta's Experience. A Published thesis submitted to the Faculty of Graduate Studies and Research Faculty of Law Edmonton. Alberta.
- xxix. Otokunfor T.V. and Obiukwu C., (2005). Impact of Refinery Effluent on the Physicochemical Properties of a Water Body in the Niger Delta. Applied Ecology and Environmental Research 6(3): 49-60. Penkala Bt., Budapest, Hungary <http://www.ecology.uni-corvinus.hu> \_ ISSN 1589 1623\_ 2008.
- xxx. Otokunfor T.V and Obiukwu C. (2005). Impact of Refinery Effluent on the Physicochemical Properties of a Water Body in the Niger Delta Applied Ecology and Environmental Research 6(3): 49-60. Penkala Bt., Budapest, Hungary <http://www.ecology.uni-corvinus.hu> \_ ISSN 1589 1623\_ 2008.