BASELINE ASSESSMENT OF METAL CONCENTRATIONS AND PHYSICO-CHEMICAL PARAMETERS OF SURFACE WATER SAMPLES FROM IDU INDUSTRIAL ZONE, ABUJA FCT-NIGERIA

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ABSTRACT

The concentration of Calcium (Ca), Magnesium (Mg), Copper (Cu), Lead (Pb), Iron (Fe), Cadmium (Cd), Nickel (Ni), Chromium (Cr) and Manganese (Mn) were determine in the surface water samples from Idu Industrial Zone of the Federal Capital Territory (FCT), Nigeria during the dry season in March, 2010. In assessing the baseline data, surface water samples result were compared with WHO/FEPA Standard. The metal concentrations (mg/l) in surface water samples were found in the range: Ca (0.63-7.50), Mg (0.12-0.35), Cu (0.03-1.45), Pb (0.0-1.03), Fe (3.65-5.85), Cd (0.63-0.94), Ni (0.17-1.17), Cr (0. 08-0.50) and Mn (0.20-1.78). The concentration of Pb, Cd, Fe, Mn, Cr and Ni in surface water were found to be higher than WHO/FEPA limits, while Ca, Mg and Cu were found within WHO/FEPA limit. Consequently surface water quality of Idu Area were found in the range: pH (5.13-6.95), Temp^{0}C (19.5-32.5), EC(µS/cm) (240-340), TDS(mg/l) (130-350), TSS(mg/l) (0.4-5.6), DO (mg/l) (1.5-4.0), Total Phosphorus (mg/l) (0.019-0.5), Total Alkalinity (mg Ca CO_3/l) (18.0-59.55), Total Hardness (mg Ca CO_3/l) (25.0-69.0), Chloride(mg/l) (0.0-0.09), Oil/Grease (mg/l) (0.01-1.41), COD (mg/l) (2.9-15.2), BOD(mg/l) (6.2-15.2) and Nitrate(mg/l) (0.6-4.6). The findings would be expected to serve as baseline study for the FCT Industrial Area and offer a useful tool in monitoring the impact on the environment as the new FCT grows in Industrial activities over the years.

Keywords: Baseline Data, Environmental Pollution, Federal Capital Territory (FCT), Industrial Area, Metal Concentration, Physico- Chemical and Surface Water.

INTRODUCTION

Environmental pollution is the basis for predicting and monitoring the sustainability effects of any planned City like Abuja. Efficient environmental pollution is one of the pressing problems facing modern society. Viable solutions to this problem must include methods of preventing further contamination and effective monitoring of pollutants in the environment.

Abuja the Capital city of Nigeria is known for being the best purpose-built city in Africa hence requires environmental baseline assessment for the proposed industrial development. The establishment of the baseline data will assist the Regulatory Authorities in future environmental compliance monitoring and policy making as it relates to Idu Industrial Zone.

The collection of baseline environmental data helps to identify the current state of the environment, its control; effective environmental management of industrial zone and its environs is the key to successful implementation of the master plan and the orderly development of a "City-beautiful" envisaged by the master plan itself. This cannot be achieved successfully without a reliable and up to date environmental baseline data (Wikipedia Encyclopedia, 2009).

It is obvious that Idu satellite settlements (the main industrial zone) of the Federal Capital Territory (FCT) shall be known for heavy concentration of industries in the near future. The industrial plants use raw materials that are usually processed in order to obtain useful components for industrial applications. The industries will in turn release wastes as sludge during processing which eventually are released into the environment. In most cases the effluents are usually treated before the release while in a few cases they are released in untreated forms thereby becoming hazardous to the environment.

To protect the environment from the adverse effects of pollution, many nations worldwide have enacted legislations to regulate various types of pollution as well as to mitigate the adverse effects of pollution. In 1987, the Nigerian Government promulgated the Harmful Wastes Decree which provides the legal framework for the effective control of the disposal of toxic and hazardous waste into any environment within the confines of Nigeria.

There are several ways through which metals get into the soil, but of great concern are the man-induced emissions into the soil which have been reported by Wild (1996) as; "emission from industry and from domestic waste disposal are the biggest of the anthropogenic source". Emissions from industries and domestic sources finally get into public sewage system, which water ultimately discharges into rivers that are usually utilized in various ways including irrigation and house hood activities. Industrial discharge has been reported as a major contributor in water pollution worldwide (Akan *et al*., 2007).

Ifedi and Fedelia (2008) reported that there are little or no data at all on the industrial emissions in most developing countries including Nigeria. This paper is aimed at establishing a baseline data of some metal concentrations and of physico- chemical parameters of water samples for Idu Industrial Zone of the Federal Capital Territory (FCT) prior to industrial development.

EXPERIMENTAL LOCATION

The Federal Capital Territory (FCT) Abuja is located between latitudes $8^0 25^{\prime}$and $9^0 25^{\prime}$ north of the equator and longitudes $6^0 45^{\prime}$ and $7^0 45^{\prime}$ east of Greenwich meridian. It occupies an area of approximately 8,000km^2 and it is bounded by Kaduna State to the North, Nasarawa State to the East, Kogi State to the Southwest and Niger State to the West (Wikipedia Encyclopedia, 2009).

SAMPLE COLLECTION

Samples for laboratory analysis were collected in 2-Litre pre-cleaned polyethylene containers at a depth of 20cm and were immediately taken to the laboratory after collection for analysis. The samples were refrigerated at 4^0C (Ademoroti, 1996, APHA, 1992). The analysis of samples was based on the standard procedures recommended for water and waste water (APHA, 1992). Atomic Absorption Spectrometry double beam AAS (Shimadzu AA 650 model) was used for Metal concentrations of the water samples at National Animal Production Institute, NAPI Zaria

The pH was determined in-situ using pH meter previously calibrated with buffer solution. Electrical Conductivity, DO, TDS, and Temperature were determined in-situ using a Multi-parameter water quality monitor (Hanna Instrument C99 and 200 series Multi-parameter Bench Photometers), having a light Source of Tungsten lamp with narrow band interference filter at 525 nm). Silver Nitrate Method was used for the chloride determination (Ademoroti, 1996, APHA, 1992 and WHO, 1982), Nitrate and Phosphourus were measured using Hanna Instrument C99 and 200 series Multi-parameter Bench Photometers. Oil and Grease was determined by Partition – Gravimetric method (Ademoroti, 1996 and APHA, 1992). Total Alkalinity and Hardness by were determined by Titration method.

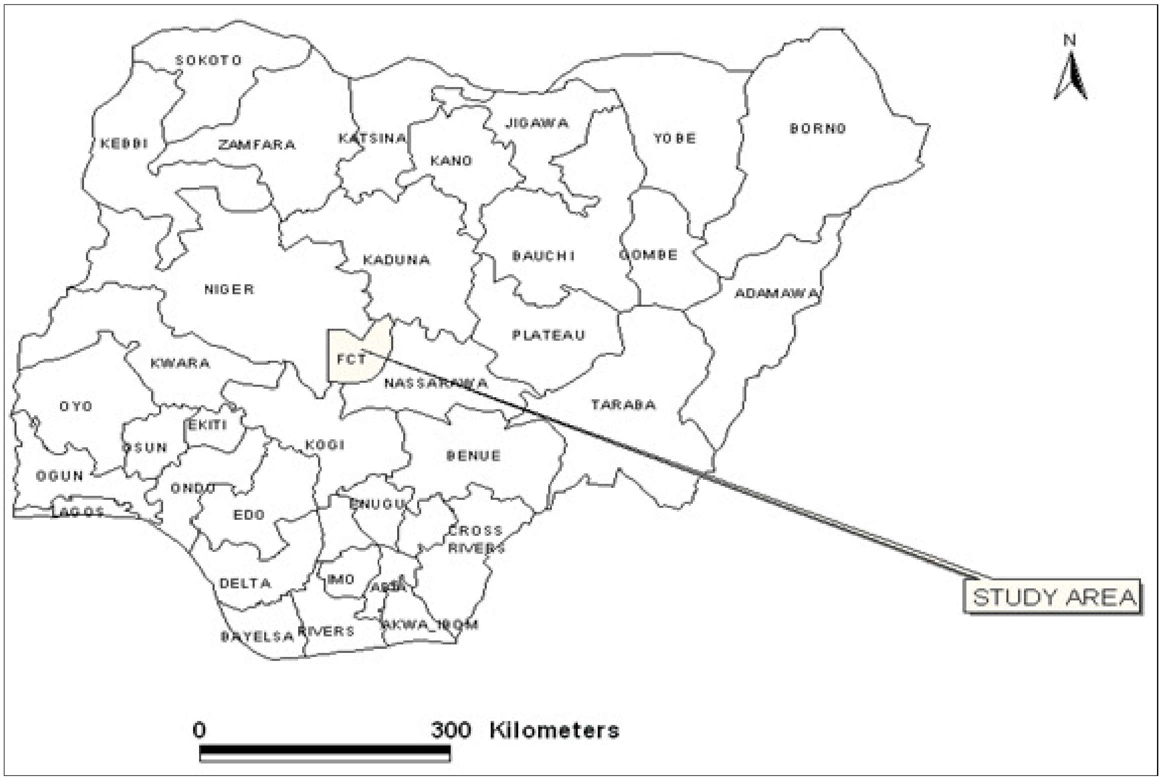

Figure 2a. Map of Nigeria showing Federal Capital Territory (FCT)

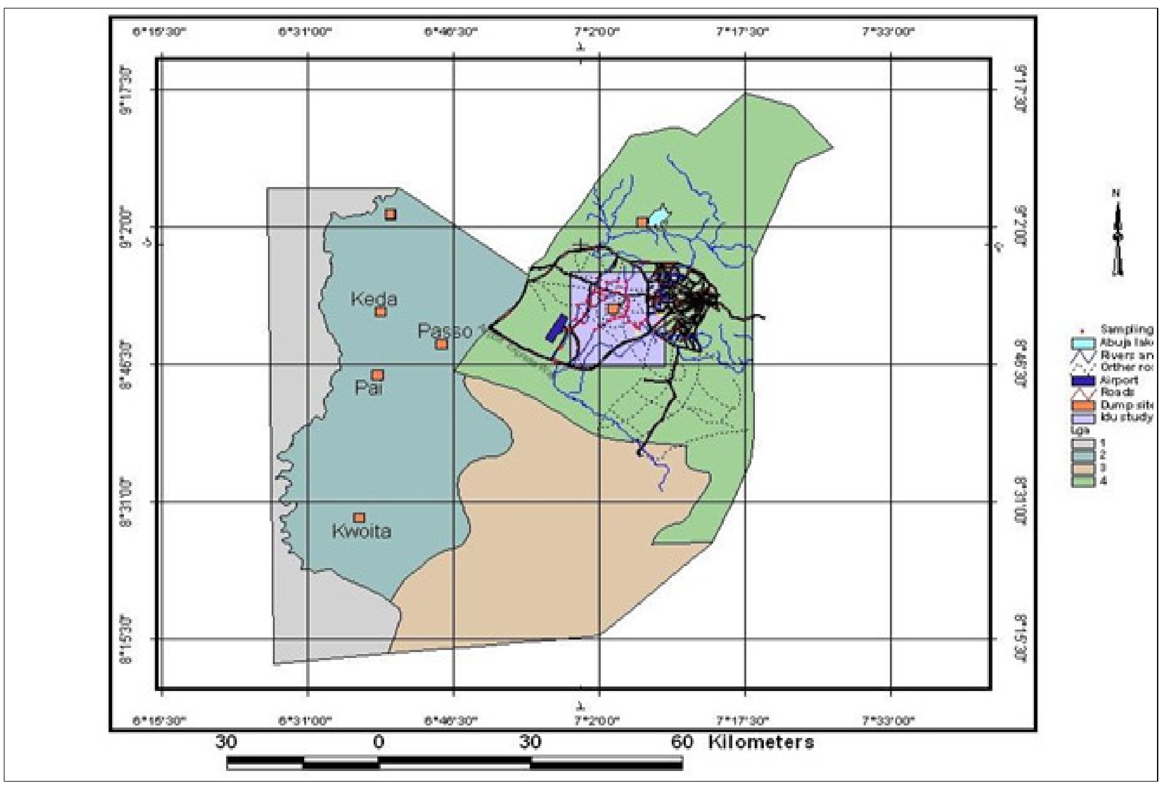

Figure 2b. Map of Federal Capital Territory and its environs showing Sampling Area: The sampling sites is enclosed in a square

In the determination of the parameters, the instrument were properly checked and calibrated before and after use. All methods of analysis were consistent with APHA, 1992; DPR, 2002; FEPA, 1991; FMENV, 2001 and Ademoroti, 1996 standard procedures. Two composite control water samples were collected at about 1km away from the Industrial Zone.

Key: River Sampling Locations

Sampling Location On River	Abbreviation	Sampling Location On River	Abbreviation
River Point At Gosa Bore Hole	RGBH-1	River Point At Wupe	RW-19
River Point At Gosa Village	RGV-2	River Point At Wupe Plant	RWP-20
River Point At Gosa Lea	RGLEA-3	River Point At Wupe Juction	RWJ-21
River Point At Kunyami Village	RKV-4	River Point At Wupe River	RWR-22
River Point At Dump Site	RDS-5	River Point At Wupe River One	RWRO-23
River Point At Dangbar Village	RDV-6	River Point At Wupe River Two	RWRT-24
River Point At Fcc Proposed Dumsite	RFPDS-7	River Point At Wupe River Three	RWR3-25
River Point At Dump Site Two	RDST-8	River Point At Wupe River Four	RWRF-26
River Point At Dump Site Pedestrian Bridge	RDSPB-9	River Point At Wupe River Five	RWR5-27
River Point At Idu Village Bridge	RIVB-10	River Point At Wupe Sewer Row One	RWSRO-28
River Point At Idu Express (Control)	RIEC-11	River Point At Wupe Sewer Row One	RWSRO-29
River Point At Idu Express Bridge	RIEB-12	River Point At Wupe Sewer Row Two	RWSRT-30
River Point At Nig. Turkish Nile University	RNTNU-13	River Point At Wupe Sewer Row Three	RWSRT-31
River Point At Nig. Turkish Nile University Two	RNTNUT-14	River Point At Wupe Sewer Row Four	RWSRF-32
River Point At Nig. Turkish Nile University Three	RNTNU3-15	River Point At Wupe Sewer Row Five	RWR5-33
River Point At Nig. Turkish Nile University Four	RNTNUF-16	River Pai	RP-34
River Point At Nig. Turkish Nile University Five	RNTNU5-17	River Point At Pai Two	RPT-35
River Point At Nig. Turkish Nile University Six	RNTNUS-18		

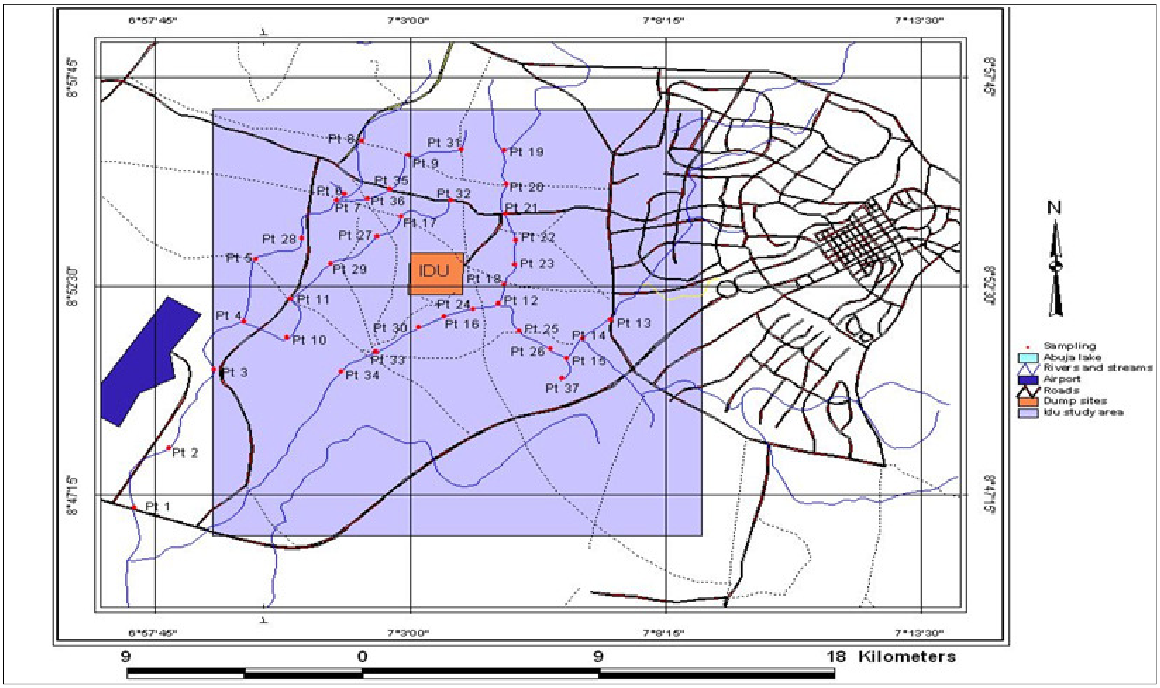

Figure 2c. Map of Federal Capital Territory Showing the Sampling Points

Water Samples Treatment

The water sample was digested by transferring $100cm^3$ portions into a beaker followed by the addition of $5cm^3$ conc. HNO_3. The beaker containing the acid mixture was placed on a hot plate for 3 hours at 110 ± 0.5^0C. The mixture was heated vigorously until the volume reduced to $20cm^3$; the sample was allowed to cool and another $5cm^3$ conc. HNO_3 was added. The beaker was covered with watch glass and returned to the hot plate. The heating was continued and small portion of HNO_3 was added until the solution appeared light colour and clear. The beaker and the watch glass were washed with water and the sample was filtered. The volume was adjusted to $100cm^3$ with water (APHA, 1992). Triplicate digestion of each sample together with blank was carried out. The digest were transferred into well-stopped rubber containers and kept for the analysis using double beam AAS (Shimadzu AA 650 model) method (APHA, 1992). However, spiked and unspiked samples were digested and analyzed as described above.

RESULTS

The result on the physico-chemical Characteristics of surface water quality of Idu Industrial Area collected from 35 sites is summarized and presented in (Tables 1) while the metal concentrations of surface water of Idu Industrial Area, is presented in (Table 2).

DISCUSSION

The result shows that water samples were generally slightly acidic or acidic in some areas. The pH range varied from 4.63 to 6.45 for the season with mean±s.d of 5.929±0.558 for the season. The surface water samples exhibited a significant positive correlation Temperature ($p<0.01$) and negative correlation with Electrical Conductivity ($P<0.05$). The high pH values reading may be attributed to the re-location of FCT dump site from Mpapa and Azhata to Goza within the Idu Industrial area. The values were lower when compared with SPDC EIA report range of (6.1 – 7.8). These values were also different from what was reported for lake Oguta with low/acidic pH values less than 5.0 (Nwadiaro and Odigi, 1991). The values obtained were below FEPA limit and may be attributed also to the flushing of various swamps of acidic nature due to the decay of organic matter into the river (Reinier *et al.,* 1985). In 1985, Reinier *et al* obtained pH values of 4.9 at Ogbolokposo and 7.4 for Crawford Creek. Most values were found to be higher than the tolerable limits of pH value 6.5 stipulated by FEPA for drinking water in dry seasons.

The Temperature of the surface water in the study area ranged between 19.5^{0}C to 32.5^{0}C while the mean±s.d of 23.708±2.480 was obtained for the season. Pearson correlation revealed a weak significant positive correlation with pH and a weak negative correlation with Total Hardness ($p<0.01$). However the temperature levels of Idu River were within the (WHO) range of 10^{0}C - 50^{0}C and (FEPA) value of ≤40^{o}C.

The electrical conductivity of the surface water ranged from 240 µScm^{-1} to 340 µScm^{-1} during the dry season. This values were above the range of values (65.1 µScm^{-1} to 168 µScm^{-1}) obtained by Fugro (2004) from Wupa river in the FCT. Further analysis revealed a strong significant positive correlation with TDS ($p<0.01$; Appendix 1) and a weak but significant positive correlation with TSS ($p<0.05$).

This can be attributed to increased total dissolved solids as we go downstream since a rapid method of obtaining an estimate of the dissolved solid in a water sample is by measurement of its electrical conductivity. The results obtain is within WHO and FEPA limits. The WHO value is 810,000 µScm^{-1} while the FEPA value is 1,500 µScm^{-1}.

The Total alkalinity (expressed as HCO_3) range from 18.0 mg/l $CaCO_3$ to 59.55 mg/l $CaCO_3$ with mean value of 30.924±9.217 mg/l $CaCO_3$ for the season with a weak negative significant correlation with Temperature ($p<0.01$). It also exhibited a little but significant correlation with Total Hardness, COD and nitrate appendix 1. The FEPA permissible level in marine systems is given as 35-200mg/l. This can be attributed to the presence of any dissolved substance, usually weak anions that can accept and neutralize protons (SPDC, 2002).

The dissolved oxygen (DO) content of the surface water range from 1.5mg/l to 4.0mg/l during dry season. The mean±s.d concentrations was found to be 2.874±0.598mg/l with CV% of 20.83 during the dry season. However, pH, Temperature, Total Hardness, Oil & Grease, COD and BOD were found to exhibit a little negative correlation while EC, TDS, TSS, Total Phosphous, Total alkalinity, Chloride and Nitrate demonstrated a little significant positive correlation with surface water DO (Table 3.0).

The low value of DO in the dry season may be due to fact that it is a period of oxygen utilization due to intense plant growth and decay. According to SPDC, 2002, river average of 4.5mg /l satisfies the minimum oxygen requirement for aquatic life as long as oxygen consumers such as organic material which degraded aerobically are not present. The study river indicated river average that is 0.3mg/l less than the minimum oxygen requirement for aquatic life.

The COD values range from 2.9mg/l to 17.5mg/l with overall mean±s.d value of 11.243±3.114 mg/l for dry season samples. The COD values were, however, within the range of 50-500mg/l and 80mg/l stipulated by WHO and FEPA respectively. Pearson Correlation coefficient analysis revealed a weak significant correlation with Nitrate and BOD ($p<0.01$).

The oil and grease content of the river ranged between 0.01 mg/l to 1.41mg/l for the dry season. The recorded values may be due to accidental spills during loading to some dispersion from oil spills in nearby petrol stations located within the construction yard at the study site into the river.

The overall mean± s.d value of 0.376±0.062mg/l during the season was insignificant compared to the stipulated value of 10mg/l by FEPA. Statistical analysis revealed a weak positive correlation with Total Hardness ($p<0.05$). EC, pH, TSS, DO, COD, BOD and Nitrate showed little negative correlation with Oil and Grease.

The phosphorus content of the river during the period of this study ranged from 0.019mg/l to 0.5mg/l for the dry season. The large Agricultural Farm lands near the river where the highest value was recorded may have contributed, hence their run offs will be heavily laden with nutrients. Statistical analysis revealed a little positive correlation with Temperature, EC, pH, TDS, TSS, DO and Total Hardness while little negative correlation were observed with Total alkalinity, Chloride and BOD. The values obtained were below FEPA limit of 5.0mg/l.

The Chloride levels of the river ranged 0.0mg/l to 0.099mg/l with mean value of 0.186±0.32mg/l during dry season. Reinier *at al.,* (1985) obtained 13, 288mg/l as average for Warri river. The results obtained are below the regulatory limits of 250mg/l stipulated by WHO and FEPA for Chloride in rivers. Correlation Coefficient analysis confirmed a weak positive relationship with pH ($p<0.05$).

The BOD values of the study site ranges from 6.20 mg/l to 15.20 mg/l during the dry season. The overall mean±s.d values obtained for dry season was 9.51±2.88mg/l. There was a weak significant negative correlation observed with TSS ($P<0.05$) and also a weak significant positive correlation observed with COD ($p<0.01$). The values were within FEPA regulatory limit of 30.0mg/l.

The study area recorded values between 25 mg/l$CaCO_3$ to 69 mg/l $CaCO_3$ for dry season. The overall mean±s.d values obtained for dry season was 38.77±10.896 and are below FEPA regulatory limit of 200 mg/l$CaCO_3$. Pearson Correlation Coefficient exhibited weak and significant positive correlation with Oil & Grease ($p<0.05$) and a significant negative correlation with EC and Nitrate ($p<0.05$ and $P<0.01$) respectively.

The Nitrate levels at the study site were found within the range of 0.6-4.6mg/l for dry season water samples. The mean±s.d value recorded 4.97±1.249mg/l. It also showed a weak positive correlation with COD ($p< 0.01$) and a weak negative correlation with Total Phosphorus and Total Hardness ($p<0.01$). The coefficient of variation was 29.73 for dry season. These values were within FEPA limit of 20mg/l.

Total Dissolved Solid (TDS) of the study area were found to range between 130mg/l to 350mg/l for the season. The mean±s.d was 156.0±49.062mg/l for the season and were within FEPA limit of 500mg/l. The coefficient of variation was 31.449 for dry season. Pearson Correlation Coefficient analysis exhibited a strong significant correlation with EC ($p<0.01$; Appendix 1) and a weak positive correlation with TSS ($p<0.01$). It also showed a weak negative correlation with pH ($p<0.05$).

Total Suspended Solid (TSS) of the study area was found to range between 0.00mg/l to 5.6mg/l for dry season. The mean±s.d value was 0.697±1.47mg/l during dry season and was within FEPA limit of 30mg/l. The CV% of 95.28 was recorded and a weak significant positive correlation was observed with EC ($p<0.05$) and TDS ($p<0.01$). A weak significant correlation was also observed with BOD ($p<0.05$).

Surface Water from Idu Industrial Area, FCT

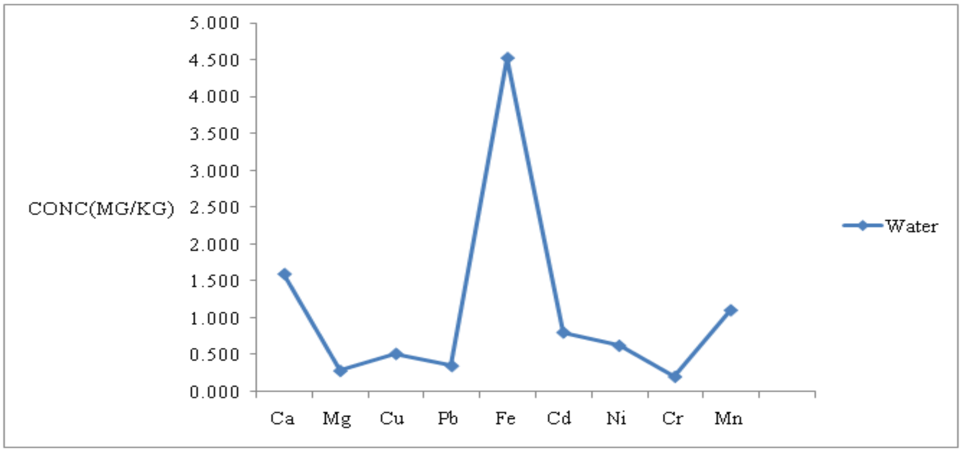

Figure 3. Mean Dry Seasonal Variation In Metal Concentrations Of Surface Water And Sediment In Idu Industrial Area, Fct

Metal Concentration in Surface Water

The result on the mean±sd Metal Concentrations (mg/kg) in Surface Water quality of the study area is presented in (Table 2.0) for the dry season sampling. All metals analyzed in this study were detected in water samples of Idu Industrial Zone except Pb that were below detection limit at 13 locations during the dry season of the study media (water). The values obtained from Idu River are higher when compared to those obtained by Ahonkhai and Chukwuogo (1996).

The metal concentrations of surface water for Ca and Mg were below WHO limits for both dry and wet season samples. The correlation matrix revealed a weak significant positive relationship with Cr ($p<0.05$; Table: 2). Further statistics analysis of Mg revealed a strong significant positive correlation with Fe ($p<0.01$; Table: 2). Cd, Ni, Cr and Mn were above FEPA and WHO limit while Fe was above FEPA limit and within WHO limit. This may be attributed to presence of dump site at the study site and the flushing of various swamps of acidic nature due to the decay of organic matter into the river (Reinier *et al.,* 1985). Iron was the most abundant heavy metal at the study area. The correlation matrix revealed a strong negative correlation with Mg ($p<0.01$). Cu was below WHO limit for the season and above FEPA limit except at two locations during the dry season. It indicated a weak negative significant correlation with Mn ($p<0.01$).

CONCLUSION

This study showed that the surface water, Sediment and the Soil quality of Idu Industrial Zone of the FCT has not been impacted environmentally and the results obtained can be used as baseline data with which future Industrial activities could be monitored.

This study also showed that there is need to carry out more studies on other physical, chemical and biological parameters that this study did not cover.

RECOMMENDATION

In the light of the above, it is recommended that, the regulatory authorities concern should as a matter urgency intensify effort in data gather to bridge the gap that exist in this regard. Furthermore, effective monitoring of the Industrial Zone should not be compromised to avoid the Industries developing from discharging untreated effluent into the FCT environment.

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Table 1. Mean and Range of Physico-Chemical Characteristics of Surface Water sample from Idu Industrial Area, FCT

S/N	PH	TEMP(0C)	EC(µS/cm)	TDS(mg/l)	TSS(mg/l)	DO(mg/l)	Total Phosphorus (mg/l)	TOTAL ALKALINITY (mg Ca CO3/l)	TOTAL HARDNESS (mg Ca CO3/l)	CHLORIDE (mg/l)	OIL/GREASE (mg/l)	COD (mg/l)	BOD (mg/)	NITRATE (mg/l)
Range	5.13-6.95	19.5-32.5	240-340	130-350	0.4-5.6	1.5-4.0	0.019-0.5	18-59.55	25-69	0.0-0.099	0.01-1.41	2.9-15.2	6.2-15.2	0.6-4.6
Mean ±sd	5.93± 0.56	23.70±2 .48	266.86 ±23.48	156.00 ±49.06	2.03 ±1.47	2.87 ±0.59	0.20 ±0.12	30.92 ±9.22	39.77 ±10.89	0.19 ±0.32	0.38 ±0.36	11.24 ±3.11	9.51 ±2.87	4.97 ±1.24
CV,%	9.41	9.75	8801.0	31.45	95.28	20.83	60.66	29.80	27.40	172.48	98.17	27.70	30.27	29.73
FEPA Limit	6.5-8.5	≤40	1500	500	30	7.5	5	–	200	250	10	80	30	20

Table 2. Range and Mean Seasonal Variation in Metal Concentrations of Surface Water of Idu Industrial Area, FCT

Parameters	Ca	Mg	Cu	Pb	Fe	Cd	Ni	Cr	Mn
Mean ±sd	1.596±1.68	0.285±0.04	0.516±0.42	0.352±0.29	4.521±0.58	0.805±0.10	0.626±0.32	0.205±0.09	1.106±0.45
Range	0.63-7.50	0.12-0.35	0.03-1.45	0.0-1.03	3.65-5.85	0.63-0.94	0.17-1.17	0.08-0.50	0.20-1.78

Table 3. Pearson Correlation Coefficient for Dry Season Metal Concentrations (mg/kg) in Surface Water from Idu Industrial Area, FCT

	Ca	Mg	Cu	Pb	Fe	Cd	Ni	Cr	Mn
Ca	1.00								
Mg	0.001	1.00							
Cu	-0.089	0.004	1.00						
Pb	-0.069	-0.161	0.111	1.00					
Fe	-0.035	-0.703**	0.058	-0.050	1.00				
Cd	-0.200	-0.197	0.096	0.312	0.123	1.00			
Ni	0.027	0.362*	0.238	0.315	-0.326	-0.457**	1.00		
Cr	0.405*	0.050	0.177	-0.396*	0.124	-0.339*	0.226	1.00	
Mn	0.119	-0.184	-0.628**	0.023	0.074	0.337*	-0.562**	-0.248	1.00

Table 4. Pearson Correlation Coefficient for Dry Season Physico-Chemical Characteristics of Surface Water from Idu Industrial Area, FCT

	PH	TEMP	EC	TDS	TSS	DO	TOTAL PHOS	TOTAL ALKALI	TOTAL HARD	CHLORID E	OIL GREASE	COD	BOD	NITRATE
pH	1 .00													
TEMP	.434**	1 .00												
EC	-.364*	.015	1.00											
TDS	-.352*	.062	.857**	1.00										
TSS	.031	-.178	.417*	.480**	1.00									
DO	-.053	-.084	.046	.101	117	1.00								
TOTAL PHOS	.099	.043	.161	.039	.174	.031	1.00							
TOTAL ALKALI	.002	-447**	-.23	-.090	.074	.110	-.079	1.00						
TOTAL HARD	.242	.219	-.397*	-.256	-.018	-.178	.242	-.125	1.00					
CHLORIDE	-.344*	-.300	.168	-.080	.034	.100	-.266	.014	-.251	1.00				
OIL & GREASE	-.173	-.011	-.286	-.074	-.109	-.119	.003	.030	.410*	-.041	1.00			
COD	.044	-.102	.166	-.045	-.102	-.162	.037	-.201	-.186	.195	-.276	1.00		
BOD	-.186	-.272	.052	-.165	-.342	-.095	-.017	.034	-.326	.146	-.166	.463*	1.00	
NITRATE	-.196	-.139	.212	.292	-.057	.179	-.431**	-.192	-.580**	.292	.187	.506**	.140	1.00