ISSN 2049-8373
JOURNAL OF ENVIRONMENT

Research Paper

Impact of Aluminium Company Wastewater on Water Quality along the Drainage

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Abstract

An assessment of the impact of wastewater discharged from Aluminium Company into an open drainage was carried out, as a result of the linkage of the drains to nearby water body used for cultivation. Wastewater samples were collected two points before discharged point (BDP), point of discharge (POD) and three points after discharged point (ADP) during the months of February and March, 2011. Physicochemical parameters and metals (Al, Cr, Cu, Ni, Pb and Zn) were analysed in the wastewater. Physicochemical parameters were analysed using the APHA standard methods while metals were determined by atomic absorption spectrophotometer. pH values of the BDP, POD and ADP were found to be in the range of 5.00-6.20; 6.35-6.70 and 4.80-5.9 respectively. pH results of the various sampling points were above the permissible level of FMENV guideline regulation; this shows the effects of other activities apart from this aluminium wastewater. The BOD and COD results at various points were not within the regulatory limit. The metal mainly Cr, Cu, Ni and Pb are all within the limit of discharge while Al and Zn with mean values of BDP, POD and ADP were 47.2±2.0 and 2.67±0.06; 51.5±0.3 and 2.81±0.04; and 44.1±5.9 and 2.58±0.05 are not within the stipulated FMENV guideline regulation. Test (p=0.05) showed significant difference between BDP and ADP in some water quality parameters analysed. It is expedient to treat the wastewater prior to discharge into open drains.

Keywords: *Wastewater, Aluminium Company, Water Quality, Drainage, Physicochemical Parameters*

1. Introduction

Water is one of the most important chemical substances for the maintenance of life. It constitutes about 70% of the earth surface. Water is one of the most important elements on earth. Every living being needs water for its survival. Without water, plants, animals, microbes-everything will perish (Babu et al, 2000). Water is indispensable for man's activities hence many ancient cities and towns were built around water bodies (Ukpong, 2008). Water is also a vital resource for agriculture, manufacturing, transportation and many other human activities. Despite its importance, water is the most poorly managed resource in the world (Fakayode, 2005). "Wastewater," also known as "sewage," originates from household wastes, human and animal wastes, industrial wastewaters, storm runoff, and groundwater infiltration (Choudhary & Parmar, 2013). Wastewater, basically, is the flow of used water from a community. The nature of wastewater includes physical, chemical, and biological characteristics which depend on the water usage in the community, the industrial and commercial contributions, weather and infiltration/inflow. The introduction of industries on one hand manufactures useful products but at the same time generates waste products in the form of solid, liquid or gas that leads to the creation of hazards, pollution and losses of energy. Most of the solid wastes and wastewaters are discharged into the soil and water bodies and thus ultimately pose a serious threat to human and routine functioning of ecosystem. The discharge of industrial effluents, municipal sewage, farm and urban wastes carried by drains and canals to rivers worsen and broadens water pollution. High levels of pollutants in river water causes an increase in Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Dissolv-

ed Solids (TDS), Total Suspended Solids (TSS), toxic metals such as Cd, Cr, Ni and Pb and faecal coliform and hence make such water unsuitable for drinking, irrigation and aquatic life (Tariq et al, 2006).

Ground and surface waters can be contaminated by several sources such as indiscriminate discharge of untreated Industrial effluents (Sundari & Kanakarani, 2001). In farming areas, the routine application of agricultural fertilizers is the major source (Emongor et al, 2005). In urban areas, the careless disposal of industrial effluents and other wastes may contribute greatly to the poor quality of the water (Chindah et al, 2004; Ugochukwu, 2004 and Emongor et al, 2005). In most developing countries like Nigeria, most industries dispose their effluents without treatment. Lagos, which is the industrial centre of Nigeria; industrial effluents are discharged directly into the drainage systems without treatment by many industries. The drainage systems are channelled into canals, which empty their contents into the rivers and lagoons. The implication of this is the pollution of surface water with consequent effects on human health. Effluents from industries had been known to contaminate water, soil and air with associated heavy disease burden and eventual shorter life expectancy in developing countries (WHO, 2003). These industrial effluents have a hazardous effect on water quality, habitat quality and complex effects on flowing waters (Ethan et al, 2003). Industrial wastes and emission contain toxic and hazardous substances, most of which are detrimental to human health (Jimena et al, 2008; Rajaram & Ashutost, 2008 and Ogunfowokan et al, 2005). Determination of the nature and source of chemical species in the industrial environment are of primary importance in the study of trace element pollution (Ogunfowokan & Fakankun, 1998).

A study on water quality of Ogun River (Nigeria), which receive industrial effluent from Lagos and Abeokuta, was conducted, says that the level of turbidity, oil and grease, faecal coliform and iron were very high in all the sampling sites (Jaji et al, 2007). Fakayode (2005) studied the impact of industrial effluent on water quality of a river in Nigeria and showed that the chemical parameters studied were above the allowable limits and also tended to accumulate downstre-am. The characteristics of selected effluents from industri-es in Ikeja, Nigeria, were analyzed and it was reported that the concentration of pollutants in the effluent-ts discharge is on the high side, exceeding the maximum recommended limits (Sangadoyin, 1995). High blood lead level was reported among Nigerians due to exposure to the environmental pollutant which can get into the human body through various sources (Orisikwe, 2009). The incidence of dialysis encephalopathy with the presence of Aluminium in the public water supply was reported by Packham (1990). According to him, the risk of Alzheimer's disease was 1.5 times higher in districts where the mean aluminium concentration exceeded 0.11 mg/L than in district where the concentration were less than 0.01 mg/L. In this study, the physicochemical properties of Aluminium industrial effluents and wastewater from the drainage where this effluent is discharged were analyzed. The levels of parameters such as pH, hardness, dissolved solids, total solids, phosphate, nitrate, sulphate, chloride, dissolved oxygen, BOD and COD and heavy metals (Al, Cr, Cu, Ni, Pb and Zn) were determined to serve as pollution indicator. There is little information on the level of aluminium element in the wastewater from Aluminium industries. Hence, the research is aim at determining the impact of Aluminium industrial effluent on the wastewater drainage.

2. Materials and Methods

The samples of effluent from Aluminium industry, 2 points before the effluent discharged point (BDP1 and BDP2 ; 50 metres apart) and 3 points after the discharged point (ADP 1, ADP2 and ADP3; 50 metres apart) were collected from drainage that receives effluent from Aluminium industry located in Ikeja industrial estate Lagos, Nigeria. Samples for physicochemical parameters and heavy metal determination were collected into 1.5 Litres and 75 ml respectively, cleaned, dry, polyethylene bottles which have been previously washed with 20% nitric acid and subsequently with distilled water. Samples for heavy metal were presserved with 5 ml concentrated Nitric acid on site. Samples were refrigerated at 4 ^{o}C, prior analysis. Wastewater samples collected along the drainage before the discharge of the effluent which served as control.

pH was measured using a Model 3020 pH meter while alkalinity, hardness, total dissolved solids, total solids, phosphate, nitrate, sulphate, chloride, dissolved oxygen, Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) were determined using standard method described by American Public Health Association (APHA -AWWA-WPCF, 1999). Heavy metals were deter-mined with atomic 210 VGP Flame Atomic Absorption Spectrophotometer after digestion with aqua regia.

3. Results and Discussion

The mean results of the various sampling locations are presented in Tables 1 (a & b) while Table 2 shows the mean results of the overall points BDP and ADP with the POD. Figure 1 shows the various contributions of the metals to the sampling locations.

The pH of the BDP, POD and ADP ranges from 5.5 to 6.2, 6.4 to 6.7 and 4.8 to 5.9 respectively. The pH range is not within the FEPA (6.0-9.0), lower pH values would increase the acidity of the receiving stream, a situation that is deleterious to aquatic live and even humans when sea foods such as oyster shell, fish and water snails from such streams are consumed (Chukwu, 2005).

Table 1a. Average of Physicochemical Characteristics* and Heavy Metal of Sampling Locations

Site Code		pH	Alkalinity	TDS	TS	TH	Phosphate	Sulphate	Nitrate	Chloride
BDP1	Mean	5.63±0.48	37.6±0.3	9.8 ± 0.1	148±6	35±25	0.09±0.01	3 ±0	2.64±0.05	43.3±0.5
	Range	5.0-6.0	37.5-38.0	9.7 – 9.8	142-152	22.0-22.5	0.08-0.09	3.0-3.0	2.6-2.7	43-44
BDP 2	Mean	5.98±0.33	40.8±0.5	10.3±0.5	153±2	25±0.4	0.10±0.01	4±0	2.74±0.05	41.5±0.6
	Range	5.5-6.2	40.0-41.0	9.5-10.6	150-154	24.5-25.5	0.10-0.11	4.0-4.0	2.7-2.8	41-42
POD	Mean	6.48±0.16	40.9±0.6	13.0±0.0	191±11	29±0.5	0.04±0.01	6±0	2.89±0.01	50.3±0.5
	Range	6.4-6.7	40.0-41.5	13.0-13.1	175-198	28.0-29.0	0.04-0.05	5.4-5.9	2.8-2.9	50-51
ADP 1	Mean	5.7±0.1	38.0±0.02	8.4±0.2	169±5	23.4±0.5	0.03±0.01	3.6±0.2	2.73±0.05	42.3±0.49
	Range	5.6-5.9	38.0-38.1	8.1-8.5	161-172	23.0-24.0	0.03-0.04	3.4-3.9	2.7-2.8	42-43
ADP 2	Mean	5.19±0.03	33.8±0.50	7.3±0.1	160±4	21.3±0.5	0.03±0.01	3.01±0.01	2.53±0.05	40±0
	Range	5.1-5.2	33.0-34.0	7.3-7.5	155-163	21.0-22.0	0.03-0.04	3.0-3.01	2.5-2.6	40-40
ADP 3	Mean	4.86±0.09	31.0±0.8	7.1±0.0	152±6	19.8±0.2	0.02±0.01	2.1±0.3	2.24±0.1	38±0.5
	Range	4.8-5.0	30.0-31.0	7.1-7.2	145-159	19.5-20.0	0.02 -0.03	2.0-2.5	2.1-2.3	38-39

**All units in mg/L except pH with no unit*

Table 1b. Average of Physicochemical Characteristics* and Heavy Metal of Sampling Locations

Site Code		DO	BOD	COD	Al	Cr	Cu	Ni	Pb	Zn
BDP 1	Mean	4.44±0.01	289±6	350±0	45.3 ± 0.2	0.05±0.00	0.04±0.00	0.04±0.01	0.04±0.00	2.63±0.05
	Range	4.4-4.5	280-295	350-350	45.0-45.5	0.05-0.05	0.03-0.04	0.04-0.05	0.04-0.04	2.6-2.7
BDP 2	Mean	4.56±0.06	326±5	442±2	49.1±0.3	0.06±0.00	0.04±0.00	0.08±0.00	0.04±0.00	2.72±0.01
	Range	4.5-4.7	325-330	440-445	49.0-49.5	0.06-0.06	0.04-0.04	0.08-0.09	0.04-0.04	2.71-2.73
POD	Mean	4.84±0.04	381±9	510±7	51.5±0.3	0.07±0.00	0.05±0.00	0.09±0.01	0.05±0.01	2.81±0.04
	Range	4.8 -4.9	370-390	500-515	51.0-51.7	0.06-0.07	0.05-0.05	0.08-0.09	0.04-0.06	2.75-2.85
ADP 1	Mean	4.34±0.04	358±5	491±1	49.1±0.1	0.06±0.00	0.04±0.00	0.07±0.01	0.04±0.00	2.63±0.02
	Range	4.0-4.4	350-361	490-492	49.0-49.3	0.06-0.07	0.04-0.04	0.06-0.08	0.04-0.04	2.60-2.65
ADP 2	Mean	4.20±0.04	324±7	476±5	42.4±0.1	0.06±0.01	0.04±0.00	0.06±0.00	0.04±0.00	2.59±0.02
	Range	4.2-4.3	325-330	475-480	42.3-42.5	0.05-0.06	0.04-0.04	0.06-0.06	0.04-0.04	2.55-2.60
ADP 3	Mean	3.90±0.03	284±11	451±2	40.8±8.6	0.04±0.0	0.04±0.00	0.04±0.00	0.04±0.00	2.52±0.02
	Range	3.9-3.9	275-300	450-453	35.2-39.0	0.04-0.04	0.04-0.05	0.03-0.04	0.03-0.04	2.50-2.55

**All units in mg/L except pH with no unit*

Higher pH values also could encourage some sea weeds such as water hyacinth to grow and multiply on the surface water. This is at present a serious concern to the Lagos state government as most streams/rivers in Lagos have been overtaken by water hyacinth. This has posed a serious threat to navigational and fishing activities. pH has profound effects on water quality i.e. it affects the metals solubility, the alkalinity and hardness of the water. Aquatic organisms are also affected by pH because most of their metabolic activities are pH dependent (Chen & Lin, 1995 and Wang et al, 2002). The levels of alkalinity BDP ranges from 37.5 to 41.0 mg $CaCO_3$/L, with an average level of 37.6±0.3 mg $CaCO_3$/L, ADP alkalinity level ranges from 30.0 to 38.1 mg $CaCO_3$/L with an average level of 31.0± 0.8 while POD ranges from 40.0 to 41.5 with an average level of 40.9±0.6 mg $CaCO_3$/L. There is no significant difference between the levels of alkalinity of BDP and ADP.

TDS level in the BDP, POD and ADP ranges from 9.5 to 10.6 mg/L; 13.0 to 13.01 mg/L and 7.1 to 8.5 mg/L respectively. The level of TDS is lower than the regulatory limit. T-test at 95% limit shows a significant difference between BDP and ADP, this implies that the effluent from POD has an effect on the waste water along the drainage.

Table 2. Average Physicochemical Characteristics* and Heavy Metal of Sampling Locations Compared with Standards

Parameter		BDP	POD	ADP	FEPA, 1999	WB, 1995
pH	Mean	5.63±0.48	6.48±0.16	4.86±0.09	NA	NA
	Range	5.0-6.2	6.4-6.7	4.8-5.9	6.0-9.0	6.0-9.0
Alkalinity	Mean	37.6±0.3	40.9±0.6	31.0±0.8	NA	NA
	Range	37.5-41.0	40.0-41.5	30.0-38.1	NA	NA
TDS	Mean	9.8 ± 0.1	13.0±0.0	7.1±0.0	2000	NA
	Range	9.5-10.6	13.0-13.1	7.1-8.5	NA	NA
TS	Mean	148±6	191±11	152±6	NA	NA
	Range	142-154	175-198	145-172	NA	NA
TH	Mean	35±25	29±0.5	19.8±0.2	NA	NA
	Range	22.0 – 25.5	28.0-29.0	19.5-24.0	NA	NA
Phosphate	Mean	0.09±0.01	0.04±0.01	0.02±0.01	5	NA
	Range	0.08-0.11	0.04-0.05	0.02-0.04	NA	NA
Sulphate	Mean	3±0	6±0	2.1±0.3	500	NA
	Range	3.0-4.0	5.4-5.9	2.0-3.9	NA	NA
Nitrate	Mean	2.64±0.05	2.89±0.01	2.24±0.1	20	NA
	Range	2.6-2.8	2.8-2.9	2.1-2.8	NA	NA
Chloride	Mean	43.3±0.5	50.3±0.5	38±0.5	600	NA
	Range	41.0-44.0	50-51	38.0-43.0	NA	NA
DO	Mean	4.44±0.01	4.84±0.04	3.90±0.03	NA	NA
	Range	4.4-4.7	4.8-4.9	3.9-4.4	NA	NA
BOD	Mean	289±6	381±9	284±11	30	50
	Range	280-330	370-390	275-361	NA	NA
COD	Mean	350±0	510±7	451±2	80	250
	Range	350-445	500-515	450-492	NA	NA
Al	Mean	45.3±0.2	51.5±0.3	40.8±8.6	NA	NA
	Range	45.0-49.5	51.0-51.7	35.2-49.3	NA	NA
Cr	Mean	0.05±0.00	0.07±0.00	0.04±0.0	<1.0	0.1
	Range	0.05-0.06	0.06-0.07	0.04-0.07	NA	NA
Cu	Mean	0.04±0.00	0.05±0.00	0.04±0.00	<1.0	0.5
	Range	0.03-0.04	0.05-0.05	0.04-0.05	NA	NA
Ni	Mean	0.04±0.01	0.09±0.01	0.04±0.00	<1.0	0.5
	Range	0.04-0.09	0.08-0.09	0.03-0.08	NA	NA
Pb	Mean	0.04±0.00	0.05±0.01	0.04±0.00	<1.0	0.1
	Range	0.04-0.04	0.04-0.06	0.03-0.04	NA	NA
Zn	Mean	2.71 ± 0.01	2.81±0.04	2.51±0.05	<1.0	0.5
	Range	2.60-2.73	2.75-2.85	2.50-2.65	NA	NA

**All units in mg/L except pH with no unit; NA= Not Available*

The levels of TS ranges from 142 to 154 mg/L with an average of 151 ±5 mg/L for BDP, ADP ranges from 145 to 172 mg/L with an average of 160±8 mg/L while POD values ranges from 176 to 198 mg/L with an average value of 191 ±11 mg/L. The level of TS at the BDP is lower compared with the ADP value; the higher value for ADP could be attributed to the effluent from the Aluminium Company which is agreement with earlier report (Ethan et al, 2003

and Ogunfowokan et al, 2005).

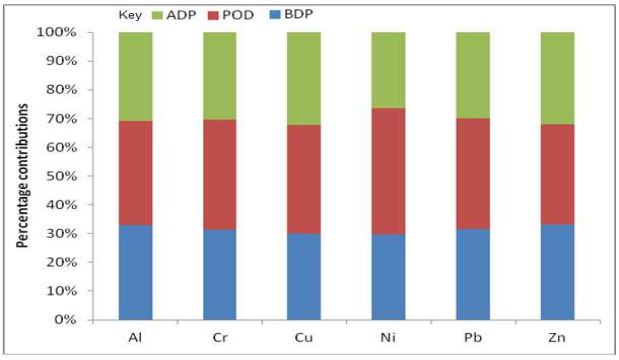

Figure 1. Percentage Contributions of Metals to the Various Sampling Points

The average level of TH i.e. 29 ±0.5 mg/L in the POD was higher compared to the BDP i.e. 24 ±1 mg/L and ADP i.e. 21 ±2 mg/L. T-test at 95% limit shows no significant difference between BDP and ADP.

The average level of phosphate i.e. 0.09 ±0.01 mg/L in the BDP was higher compared to the ADP i.e. 0.03 ±0.1 mg/L and POD i.e. 0.04 ±0.01 mg/L. The high level of phosphate at BDP was as a result of domestic waste water from residential houses around the area which likely make use of detergents for washing. Sulphate levels at BDP ranged from 3.0 to 4.0 mg/L with an average level of 3.5 ±0.5 mg/L, ADP ranged from 2.0 to 3.9 with an average level of 2.9 ±0.2 mg/L while POD values ranged from 5.4 to 5.9 with an average value of 5.6 ±0.2 mg/L.

Nitrate level in the BDP, POD and ADP ranged from 2.6 to 2.8; 2.8 to 2.9 and 2.1 to 2.8 mg/L respectively. The level of nitrate is lower than the regulatory limit. T-test at 95 % limit shows no significant difference between BDP and ADP, this implies that the effluent from POD has no effect on the waste water along the drainage.

The average level of chloride in the POD was 50.3 ±0.5 mg/L while BDP and ADP average values are 42 ±1 and 40 ±2 mg/L respectively. The level of chloride is lower than the regulatory limit. T-test at 95% limit shows no significant difference between BDP and ADP, this implies that the effluent from POD has no effect on the wastewater along the drainage but accumulation of the chloride level with time will have effect on the aquatic life in the stream where the drainage empties into.

DO level of the POD was 4.84 ±0.04 mg/L while BDP has DO value of 4.5 ±0.01 mg/L and ADP has DO value of 4.1 ±0.2 mg/L. DO is very crucial for the survival of aquatic organisms and is also used to evaluate the degree of freshness of a river. BOD and COD level of the BDP and ADP were 308 ±21 and 398 ±49; 322 ±32 and 473 ±18 mg/L respectively. The BOD and COD level of the POD was 381 ±9 and 510 ±7 mg/L respectively. The values are all higher than the regulatory limit of FEPA.

Table 3 shows the Pearson correlation coefficient results of physicochemical characteristics of sampling locations. There is strong positive correlation at p=0.05 between NO_3^{-1} and TDS (0.999); DO and TDS (0.997); TH and SO_4^{-2} (0.997); BOD and TS (0.999). This shows that any condition that affects one will affect the other. The levels of heavy metals at the sampling points BDP, ADP and in the

Table 3. Pearson Correlation Coefficient of Physicochemical Characteristics of Sampling Locations

	pH	Alkalinity	TDS	TS	TH	PO_4^{3-}	SO_4^{2-}	NO_3^-	Chloride	DO	BOD	COD
pH	1.000											
Alkalinity	0.944	1.000										
TDS	1.000**	0.943	1.000									
TS	0.766	0.513	0.770	1.000								
TH	0.985	0.874	0.986	0.865	1.000							
PO_4^{3-}	0.138	0.455	0.132	-0.531	-0.034	1.000						
SO_4^{2-}	0.969	0.834	0.970	0.901	0.997*	-0.112	1.000					
NO_3^-	0.999*	0.957	0.999*	0.739	0.977	0.179	0.958	1.000				
Chloride	0.968	0.831	0.969	0.904	0.997	-0.117	1.000**	0.956	1.000			
DO	0.998*	0.965	0.997*	0.721	0.971	0.204	0.950	1.000*	0.948	1.000		
BOD	0.797	0.554	0.800	0.999*	0.889	-0.489	0.921	0.771	0.924	0.754	1.000	
COD	0.376	0.050	0.381	0.883	0.529	-0.866	0.593	0.337	0.598	0.312	0.859	1.000

** Significant at the 0.05 level; ** Significant at the 0.01 level*

Effluent (POD) are presented in Table 1 (a & b) while Figure 1 shows the percentage contribution of each metal. Al, Cr, and Cu were of average levels of 51.5 ±0.3, 0.07 ±0.00 and 0.05 ±0.00 mg/L, respectively, in the effluent (POD), while the average levels of Ni, Pb and Zn in the effluents were 0.09 ±0.01, 0.05 ±0.01, 2.81 ±0.04 mg/L, respectively. The average levels of Al , Cr , Cu , Ni, Pb and Zn BDP were 47.2 ±2.0, 0.05 ±0.00, 0.04 ±0.00, 0.06 ±0.02, 0.04 ±0.00 and 2.7 ±0.01 mg/L, respectively, while their corresponding average levels ADP were 44.1 ±5.9, 0.05 ±0.01, 0.04 ±0.00, 0.06 ±0.01, 0.04 ±0.00, 2.58 ±0.05 mg/L, respectively. To ascertain the source of the metal elevation in the samples, which is to determine whether they have been introduced by the activities of the Aluminium Company or other activities than Aluminium Company? This was deducted from the measured concentration and the resulting values converted into the percenttage contributions, that for the selected metals, Al, Cr and Ni have over 45% of the wastewater along the drainage contributed by the wastewater generated by the Aluminium Company while Cu ,Pb and Zn have over 45% contributed by other activities (Figure 1).

4. Conclusion

The study aimed at determining the physicochemical properties of aluminium industrial effluents and wastewater from the drainage where this effluent is discharged through. The results of the study revealed that the effluent qualities of aluminium industry adversely affected and impaired the water along the discharge channel. The groundwater system may be impacted negatively if the heavy metals succeed in percolating into the groundwater system. The levels of some parameters at after discharged point were not significantly elevated than the corresponding levels before discharged point. The quality of the industrial effluent was poor and did not meet the minimum requirement to be discharged into surface water.

Acknowledgement

The authors appreciate the supports of Dr Olowu, R.A. and Mr Adeagbo, A.O.

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