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Impact of Aluminium Extrusion Effluent on MBAA River in Inyishi Ikeduru Imo State

Akhionbare Stella Maris O, Umunakwe John Boscos, Adindu Tochukwu M.

***Abstract*— The study Impact of Aluminum Extrusion Effluent on the Mbaa River Inyishi Ikeduru Imo State. Was carried out in order to ascertain the current quality status of the river. Effluent samples from an Aluminum Extrusion company as well as water and sediment samples from the river were collected in March and June 2017 at four sampling point. Subsequently the Physicochemical quality of the river was studied by analyzing river water and sediment. The effluent discharged into Mbaa River in March showed that pH (8.84),Water Temperature (29.00),Biological Oxygen Demand (BOD) (6.50mg/l),Sulphate(13.40mg/l),Nitrate(4.50mg/l),Zinc(3.876mg /l), Iron(0.780mg/l) and Chromium (0.15mg/l), levels all fell below maximum limits allowable by NESREA and hence meets working targets of the quality of effluents dischargeable into surface water. The waste water has a Total dissolved solids (TDS) (14,008.8mg/l), Total suspended solid (TSS) (7,003.00 mg/l), Chloride (2,081.00 mg/l), Aluminium (12.52 mg/l) and Nickel (8.650mg/l) which fell above NESREA limits , similar trend on limit was also observed in June with pH (5.27),Water Temperature (27.30),Biologica Oxygen Demand (BOD)(5.20mg/l),Sulphate(130.30mg/l),Nitrate(0.113mg/l),Zinc (0.703mg/l), Iron (0.157mg/l) and Chromium (0.131mg/l). The result on effect of discharged wastewater during the study period into Mbaa River showed that the effluent increased the water pH from 5.40 -7.20 (6.27 + 0.27), Turbidity ranged from 2.40 - 6.70 (4.84 + 0.58) NTU, Temperature ranged from 26.30 – 28.90 (27.76 + 0.33)OC, Cl ranged from 9.35 – 12. 05 (10. 36 + 0. 44) mg/l, BOD5 ranged from 2.10 – 2.50 (2. 29 + 0.48) mg/l, Ni ranged from 0.67 – 1.02 (0.85 + 0. 05) mg/l etc. Was compared with the standards set by NESREA both for the effluent and water samples, also the sediment samples for pH ranged from 4.24 – 6.01 (5.00 + 0.22), Ni ranged 0.45 – 27. 01 (12.2 + 4.19) mg/kg and Al ranged from 2.08 – 14.84 (7.48 + 1.48) mg/kg etc. All parameters were higher in sediments than in water samples for all stations. Thus variance of Descriptive statistics, special and temporal variation, the one way ANOVA test and student t-test was used. It was also observed from the trend analysis that the river capacity to assimilate effluent and be self-purified was not exceeded by the volume of the effluent discharged into it from the factory as its quality was nearly restored within the 1100m distance at Sample 3 and 4. It is recommended that since it takes about 1100m for the river to self-purify, the factory should provide an aerated lagoon/ stabilization pond to enable some biodegradation of the effluent prior to discharge, in order to shorten the distance before self-purification. It was also found out that careless disposal of the effluent should be discouraged and the need for each extruding industry to install a waste treatment plant with a view to treating waste before discharge into the stream is recommended.**

Akhionbare Stella Maris O, Department of Environmental Technology, Federal University of Technology of Owerri, Imo State Nigeria
Umunakwe John Boscos, Department of Environmental Technology, Federal University of Technology of Owerri, Imo State Nigeria
Adindu Tochukwu M. Department of Environmental Technology, Federal University of Technology of Owerri, Imo State Nigeria

***Index Terms*— aluminium, analyzing, effluent, extrusion, impact ,physicochemical, stabilization, wastewater.**

I. Introduction

Man depends upon water for life, and also man's concern with water quality differs from place to place and often depends upon his social and economic status (Akhionbare, 2009). The major causes of water contamination are by far man's activities, and in this case, contamination occurs rapidly and dramatically. In an attempt to meet man's needs, he engages in different activities, extracting environmental resources and releasing the waste products to the physical environment (Wokocha and Emodu, 2011). The impact of industrial toxins and hazardous wastes on aquatic life, including micro-organisms cannot be over-emphasized. Consequently, upon the industrial revolution, many production and manufacturing companies have, due to improper waste management techniques, added toxic and hazardous wastes, including synthetic compounds into water bodies (Obire *et al.*, 2007). Some of these environmental wastes or pollutants affect air, water and soil quality and these invariably affect man in so many other ways including health. Industrial wastes consist of liquid, solid and gaseous pollutants, which have effect on the element of the environment, altering its natural compositions and rendering it unsafe for human dependence (Wokocha and Emodu, 2011). Ground- and surface-waters can be contaminated by several sources. Human and animal wastes as well as organic chemicals, pesticides and petroleum products find their ways into surface and underground water supply through seepage, accidental and deliberate discharges into the water thereby affecting its quality and beneficial uses (US EPA, 2000; Akhionbare 2015). Effluent in the artificial sense is generally considered to be water pollutant, such as the outflow from a sewage treatment facility or the wastewater discharge from industrial facilities. Effluent means water sullied or contaminated by any matter in solution or suspension resulting from domestic, industrial or other activities (USEPA, 2000). Contaminants present in effluent discharge includes petroleum products, herbicides, pesticides, fertilizers, heavy metals, detergents, raw sewage, hot water from cooling plants, bacteria and various disease causing protozoans (Akhionbare,2015). The presence of these wastes in the environment causes extensive damage to the water quality and the ecology of the environment, especially when microbial degradation activities fail to remove these pollutants enough to prevent environmental pollution (Obire *et al*, 2003). These contaminants are assimilated into living plants and animals, moving quickly into food chain and affecting the health of animals and humans. Water pollution is therefore one of the greatest environmental problems in developing countries, including Nigeria. Rivers are by far the cheapest form of water supply compared to other sources likes groundwater and seawater desalination. According to Amadi *et al*. (1997), meeting water quality criteria for streams and rivers is required to protect drinking water resources, encourage recreational activities and to provide a good environment for fish and wildlife. Therefore, water quality evaluation and management is of ecotoxicological importance. Changes in water chemistry of rivers are mainly anthropogenic via domestic, industrial and agricultural discharges which may in turn result to degradation of the aquatic ecosystem (Ajao and Anurigwo, 2002). For example, the continuous migration of people to the urban centers has aggravated the pollution status of the Mbaa River in Imo State, southeastern Nigeria through the discharge of effluents from domestic, industrial (particularly that from an aluminium extrusion industry nearby) and agricultural point and diffused sources flanking both sides of the river. In terms of quality, surface water is vulnerable to pollution from untreated industrial effluents and pesticides, as well as oil and lube spillages from the operations of mechanic and vehicular activities. Water quality also depends on effluent types and discharge quantities from different types of domestic, agricultural and industrial, as well as seasonal allochthonous inflows from runoffs.

Following these uncontrolled man-made and technological advancement activities, most sources of water sources no longer meet the quality standard for human consumption, other domestic uses, and aquatic lives. When water body is loaded with waste materials or heat, its natural ability for self-purification is disturbed. These changes may be sufficient to render the water unsafe for domestic, industrial, recreational and other users. Good quality water is that which is pure and safe to use and has is good for beneficial uses (Akhionbare, *et al*, 2010).

The problem of water pollution in the global context has been suggested to be a leading worldwide cause of deaths and diseases by Pink (2006), and that it accounts for the death of more than 14,000 people daily. In a recent national report on water quality in the United States of America, 45% of assessed stream miles, 47% of assessed lake acres, and 32% of assessed bay and estuarine square miles were classified as polluted (US EPA, 2007).

Inyishi in Ikeduru Local Government Area is a suburb of Owerri, a southeastern city of Nigeria. The area is reckoned in terms of commerce and industry and as a suburb of metropolitan Owerri, has experienced tremendous growth in the industrial sector, even as most of the industries are located proximal to rivers and streams. One of these industries is the Aluminium Extrusion Industry (ALEX). The company manufactures aluminuim roofing sheets, Profiles and other related metaliferous products. As a most convenient and available option, this company discharges its effluents from the production lines into the nearby Mbaa River. This discharge adds to the other sources coming from municipal and domestic origins from the teeming inhabitants of the area. This class of pollutants that could be introduced into the river by residents of the area therefore could include domestic wastes (from households), inorganic and organic chemicals, as well as oil and gas chemicals (e.g oil, gasoline, cleaning solvents, detergents, etc). These pollutants could impair the water quality, and its use for fishing, irrigation practices, recreation, swimming, boating, transportation, and the health of the entire biodiversity. Though these commercial and industrial inputs into the river have been ongoing for several years now, few researches have been carried out to ascertain the current physico-chemical and microbiological status of the repository Mbaa River. The current research therefore was an attempt to fill this gap in knowledge.

Aluminium Extrusion as a Source of Pollution

Commercial Aluminium extrusion is generally a hot metal forming operation and the basic process consist of forcing a preheated chamber through a die opening and constant use of water for its chilling or cooling process (http://www.hxalu.com/c/nigeria).

Proportionally it releases high qualities of Dross and Ingot. Aluminium extrusion process is generally of four major sections: billet casting, extension press, anodizing or powder coating section and finishing or dispatching section (Fig 2.1) The major process in the anodizing section involves the use of large amount of water, chemical additive from which any type of aluminium coated material could be produced.

The liquid effluent at no estimated period is usually discharged into nearby streams, resulting to discharge of various pollutants. The biological, physical and chemical qualities of water in the effluent require treatment process to prevent the waste from polluting the environment.

Though the major problem in the anodizing section is the primary or pretreatment process which removes all materials that can be easily collected from the raw waste water before it, damages or clog the pump line of the primary treatment clarifiers, objects commonly removed during pretreatment include wires, stables, plastic ball and strings from the waste tank.

The Influent from the tank passes through an automated mechanically raked pipe, which is typically paced according to the accumulation on a flow rate into a waste water tank which makes use of an oxidation process to further mix the waste water with a solution of micro- organisms for a long period of time. This operation is the secondary treatment process which results to an aerated process of about 30hours at a time to ensure results.

Electroplating process is usually considered as the integral part of Aluminum forming whenever the treatment process is performed. Best standards are available for effluent maximum load on various discharges (NESERA, 2009).

Aluminium forming is the deformation of aluminum into specific shapes by hot or cold process and the end product is to produce profile, roofing sheets etc.

The basic wastewater management system process is mostly comprised of removing phosphates and nitrate from the water supply substance like activated carbon and sand are among the most commonly used materials that assist in the process .This operation is the last treatment step of the tertiary treatment process.

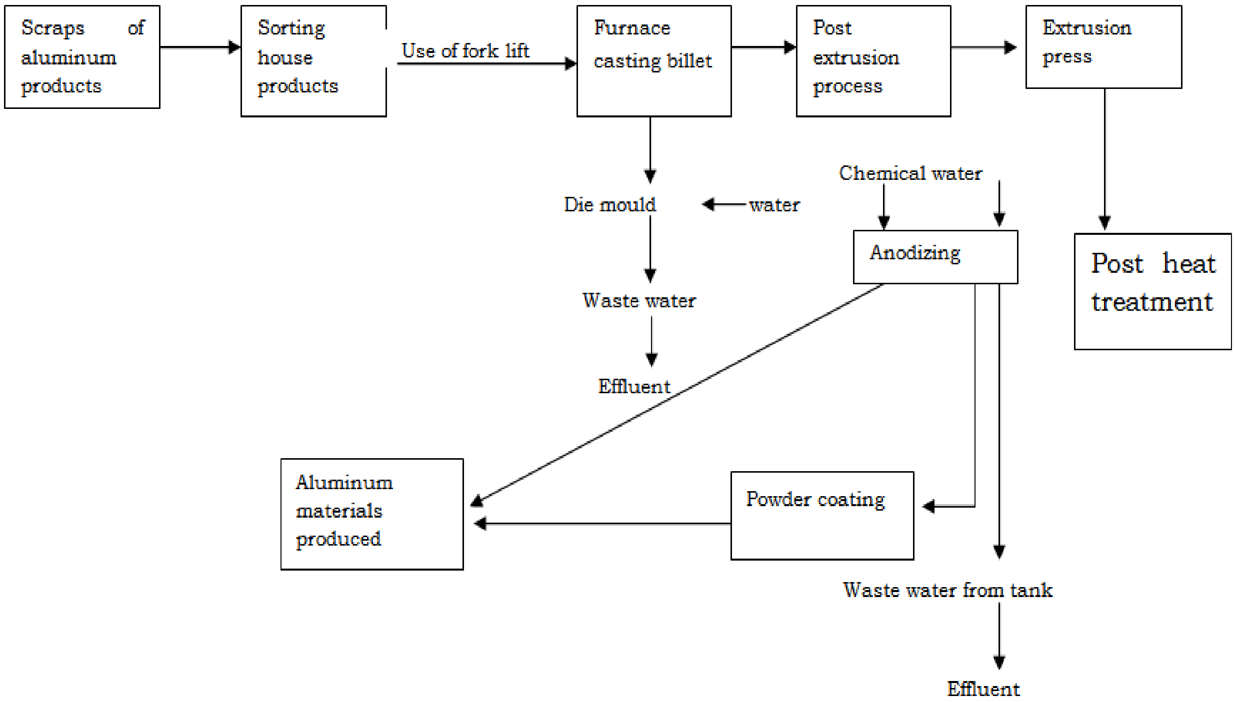

Fig 1 Flow Diagram for Aluminuim Extrusion Process (Adindu Tochukwu,2018).

This also involves the use of selected disinfectant to exterminate or at least inactivate the pathogens. Chemical disinfection agent includes chlorine, ozone, ultraviolet radiation, chlorine dioxide and bromine. Metals such as copper, chromium, lead and zinc have been commonly found and are discharged not only to waste water but also to waste sludge. The waste water when discharged untreated will persists for a long period. Therefore any river close to aluminum industry cannot be spared from pollution due to the discharge of this waste

Characteristics of Aluminium Effluent

Aluminium is reactive metal and is hard to extract from its ore (Aluminium oxide Al_2O_3). Studies show that the soluble form of aluminium causes harmful effects in working environment where it can be found, such as mines and factories (Abbate *et al.,* 2003). In the environment aluminium accumulates in plant and causes health problem for animals that consumes the plants. The concentration of aluminium appears to be highest in acidified rivers at which the number of fish and amphibians are in decline due to reaction of effluent with proteins in the gills of fish, the embryos of frogs and birds (Adakole 2000). High concentrations of effluent may also be found in acidified soil which can damage the roots of trees. Pollutants from aluminium extrusion can be divided into three categories effluent to water, emission to air, and solid waste

Effluent to water

Aluminium finishing process is the most difficult chemical process, these gives rise to pollutants which are discharged to water called effluents. When assessing these pollutants produced during surface treatment, four key parameters among others are monitored:- pH, Total Suspended Solids (TSS), Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD).

In order to have treated water from the aluminium effluent, the waste water has to undergo a process known as chemical characterization process. Various studies show that the aluminium hydroxide thus formed; flocculates and coagulates the suspended solids and thereby assimilate into waste water (Carmona *et al.*, 2003). The destabilized particles are believed to be responsible for the aggregation and precipitation of the suspended particles and for the adsorption which is subsequently removed by sedimentation and flotation (Bayramoglu *et al* 2004), effluent can be treated by using activated sludge and/or anaerobic process to control BOD and COD.

However, the toxicity of heavy metal and organic compounds in effluents and sludge is a matter of debate within the industry. Extensive research on every aspect of aluminium exposure should not be taken as safe.

Emission to air

Direct emission from the process of aluminium extrusion itself are minimal and considered to be relatively insignificant, although little research has been done into this field. These gaseous and particulate emissions to air that are produced primarily come from the surface treatment sludge and fuel combustion during the casting process. Typical emission includes Sulphur dioxide (SO_2), Nitrogen dioxide (NO_x), Carbon monoxide (CO) and Carbon dioxide (CO_2).

There is the need for a continuous use of air quality standard to protect health. This includes protecting the ecosystem such as plants and animals, from harm as well as protecting against decreased visibility and damage to crops, vegetation and buildings (US EPA, 2000).

Effluent Disposal

After treatment, waste water must either be reused or disposed off to the environment. In these processes, the waste water disposal is discharged and diluted into stream, river, lake or oceans. The cake sludge is discarded into a sludge yard and is further disposed into a landfill. In other to avoid an adverse environmental impact on the quality of the treated and disposed effluent, it must be consistent to local water quality objectives which rigorous analysis must be performed in many cases. Modern or best available technology must be applied to be able to know the impact of the proposed discharge.

Analysis of the Effluent

Waste water contains different chemical bath from the anodizing bath such as the chromic bath, De-smoothing bath, electroplating or anodizing bath, caustic soda bath etc. which contain different chemical substances from the bath, these can be used to characterize their discharge on physical and chemical characteristic (Atinson *et al.,* 2000).

Management of Aluminium Extrusion Effluent.

Treatment of waste water from anodizing section is carried out through the following processes.

- Grit removal
- The polymer additive combined with the aluminum hydroxide and congeals which create wooly mass from the caustic bath is been skimmed away through a rising bath water, to a maximum. Possibly a double bath rising process is adopted. The flocculating agent found in the rising bath is recycled to the effluent section for treatment.
- Primary clarification of the combined waste water from the acid and basic bath or alkaline bath before and after recovery process is essential at which circular clarifier is used.
- Heavy aluminium sludge is dried up to 75 percent solid on a sludge drying bed or lagoons depending on the EPA guidelines on the disposal of hazardous waste is taken to a general municipal landfill.
- Effluent from primary clarifier can be removed from sludge and sent off for use in the manufacturing of bricks and clays, cosmetics and paper products. If often prove unfeasible, the anodizing sludge is often taken for disposal to a resource conservation and recovery act landfill at which the collected leach is processed and treated.

Non-Management of Aluminium Extrusion Effluent

Heavy metals are toxic and can accumulate in a system without being noticed (Akhionbare, 2009). Heavy metals introduced into the river can cause harm to aquatic life even at low concentrations. Sources of heavy metals include Industrial activities (mining, oil exploration activities, manufacturing and agricultural practices) domestics and commercial practices that generate wastes and natural factors. Metal content in river vary between water column and bed sediment depending on concentration from processes operating within the catchment. They exhibit toxicity in the aquatic environment and can hence adversely affect the food chain. Rapid urbanization and Industrialization has led to an increase disposal of heavy metal, radio nucleotide into the environment (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4600254/) which in plating solution it may contain heavy metals such as Ni, Cu, Zn, Al, Cr, and Pd. These waste water are hazardous to the environment, generated from electroplating industrial effluent, cool burning industries, refining and steel producing industries. This may alter water and sediments setting of the river. Thus of recent some innovative solution to waste management have been introduced to reduce the disposal of waste water from anodizing bath which is termed hazardous due to the toxicity level that is associated with degraded heavy metals and physicochemical parameter in water.

II. MATERIALS AND METHODS

Ikeduru local Government is one of the 27 LGAs of Imo state of Nigeria with a population of 199,316 according to the 2006 National Population Census; with an annual growth rate of 9%. The study area Inyishi in Ikeduru Local Government Area (LGA) of Imo State. The company Aluminium Extrusion Industry PLC, popularly called ALEX, is situated about 4km along the Atta Amaimo Road in Inyishi Village which is 100m away from Mbaa river (Fig. 3.1). The company was established in 1978 is engaged in the manufacturing of aluminium billet which is processed into aluminum roofing sheets and profiles.

The geographical setting of the area lies between latitudes 05.59740^{o}and 05.59624 ^{o}N, and longitudes 007.16605^{o} and 007.16565^{o} E at a mean elevation of 54m.The Iyi-Afo Inyishi (Mbaa River) is a major fresh water wich runs into Onu-Iyide River in Umu-Oziri Village, Ikeduru local government area of Imo State,Nigeria. The rivers are characterized by dry valleys which are usually covered by flood waters in period of high rainfall. The aquifers are recharged by means of flood water infiltration during the rainy season.

The geological setting and human activities (Industrial input, fishing, farming and recreation) around and within the Mbaa River are major factors that modify the chemistry of the river ecosystem (McMurry and Fay 2004). Other sources of potential water contamination may result from erosion water run-off, farming activities such as washing of some farm produce in the rivers (example bread-fruit, cassava) and washing of motor vehicles along the river banks etc.

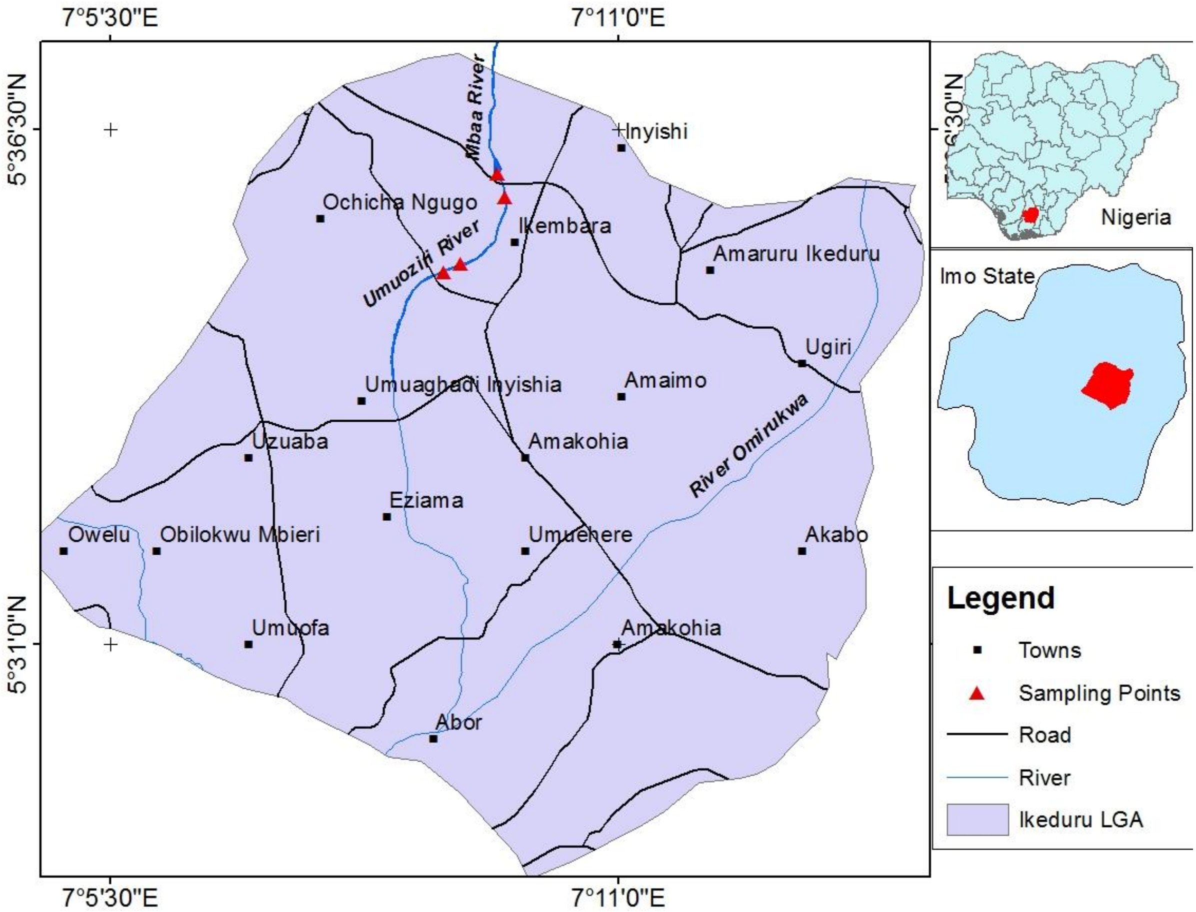

Fig: 2. Map of Imo state in Nigeria showing the Mbaa River in Inyishi.

Sampling points

The Industrial Effluent sample was collected from the factory after treatment, before it is discharged through a pipe from the factory into the river.

Four sampling points were established to cover possible impacted and un-impacted areas along the river course based on an earlier field reconnaissance tour. The points were characterized as follows;

S1. This is location sited upstream about 100 meters from the point of discharge of the aluminium effluent S2. This is immediately after the discharge or fallout point where the effluent is channeled into the water. S3. The location sited about 500 meters downstream from the point of discharge of aluminium extrusion effluent (Fig 3.1) in Umu-oziri. S4: The location sited about 1100meters downstream from the point of discharge of aluminium extrusion effluent (Fig 3.1) in Umu-oziri .

Sample collection

A grab sampling method was used in collection of samples and this was done twice in March and June, 2017. 2 liter polyethylene container that was thoroughly cleaned was used. For water sample collection for BOD determination the samples were collected with 150ml bottle. River sediment was collected at the various sampling points using Eckmann grab sampler and also sample for heavy metals were collected with 250ml bottle and fixed with concentrated trioxonitrate acid.

All collected samples were packed in an Ice-chest and immediately transported to the laboratory for analysis.

III. RESULTS

The results of the analysis of samples of Aluminium Extrusion Effluent and the receiving Mbaa River samples and sediments drawn from March and June , 2017 are presented in Table 4.1,4.2,4.4,and 4.5 respectively.

Physico-chemical Quality of water column

The levels of the physico-chemical parameter of water samples presented in Table 4.1 and Table 4.2 of the parameters measured showed that Chemical Oxygen Demand (COD) had a comparatively wide range (26.18 mg/l). pH, turbidity, water temperature and Electrical Conductivity (EC) varied from 5.40-7.20 (6.27 $\pm$ 0.27), 2.40-6.70 (4.84 $\pm$ 0.58) NTU, 26.30 – 28.90 (27.76 $\pm$ 0.33) ^{O}C and 10.48 -11.92 (11.15 $\pm$ 0.19)µS/cm respectively.

Total Dissolved Solids (TDS), Total Suspended Solids (TDS) and Total hardness varied from 5.30-5.80 (5.53 $\pm$ 0.05), 10.60-14.30 (12.19 $\pm$ 0.45) and 3.70-10.70 (8.88 $\pm$ 0.80) mg/l respectively. Chloride, sulphate, Nitrate and Biological Oxygen Demand (BOD) varied from 9.35 – 12.05 (10.36 $\pm$ 0.44), 0.23 – 1.86 (0.74 $\pm$ 0.19), 1.29 – 3.14 (1.94 $\pm$0.20) and 2.10 – 2.50 (2.29 $\pm$ 0.48) mg/l respectively. The heavy metals (Cr, Ni, Zn Fe and Al) varied from 0.00-0.04 (0.01 $\pm$ 0.01), 0.67-1.02 (0.85 $\pm$ 0.05), 0.01-0.59 (0.33 $\pm$ 0.09), 0.27 – 3.49 (1.54 $\pm$0.38) and 0.02 – 1.27 (0.70 $\pm$ 0.16) respectively. Water was also cloudy in appearance at all four stations in June contrary to the situation in March 2017 which was clear in appearance at all the station.

Table 1: Physico-chemical Quality of Effluent and water samples for March , 2017.

S/N	PARAMETERS	WS1	WS2	WS 3	WS 4	Effluent
1	pH	5.69	5.40	5.52	5.66	8.84
2	Turbidity (NTU)	600	6.20	5.60	6.70	8.50
3	Temperature (^{O}C)	28.60	27.50	28.90	28.50	29.0
4	Conductivity (µS/cm)	11.76	11.92	11.06	11.00	14,008.0
5	TDS (mg/l)	5.60	5.80	5.50	5.50	7,003.00
6	TSS (mg/l)	11.50	12.00	10.80	14.30	17.10
7	Total Hardness (mg/l)	9.70	10.60	9.60	10.00	324.80
8	Chloride mg/l	9.36	9.40	9.40	9.35	2,081.00
9	COD (mg/l)	15.50	15.20	13.80	13.60	1,034.60
10	BOD_5 (mg/l)	2.20	2.20	2.40	2.30	6.50
11	Sulphate (mg/l)	0.23	0.32	0.40	0.38	13.40
12	Nitrate (mg/l)	2.34	1.64	3.14	1.94	4.50
13	Chromium, (mg/l)	0.014	0.039	0.010	0.027	0.15
14	Nickel, (mg/l)	0.746	0.887	0.707	0.665	8.650
15	Zinc, (mg/l)	0.120	0.065	0.012	0.186	3.876
16	Iron, (mg/l)	3.486	1.936	0.772	0.865	0.780
17	Aluminum, (mg/l)	0.835	0.984	0.706	0.701	12.520

WS1= Water Sample 1 WS2= Water Sample 2 WS3= Water Sample 3 WS3= Water Sample 4

Table 2 : Physico-chemical Quality of Effluent and water samples for June ,2017

S/N	PARAMETERS	WS 1	WS2	WS3	WS 4	Effluent
1	pH	7.20	6.94	6.96	6.79	5.27
2	Turbidity (NTU)	4.9	4.4	2.4	2.5	11.1
3	Temperature (^{o}C)	26.3	27.8	27.9	26.6	27.3
4	Conductivity (µS/cm)	10.48	10.84	10.62	11.50	3,940
5	TDS (mg/l)	5.50	5.40	5.30	5.60	1,970
6	TSS (mg/l)	12.60	13.54	12.20	10.60	19.20
7	Total Hardness (mg/l)	9.60	8.20	10.70	8.60	190.80
8	Chloride mg/l	12.05	11.34	12.05	9.93	105.08
9	COD (mg/l)	36.50	12.05	17.10	10.32	197.36
10	BOD_5(mg/l)	2.50	2.40	2.20	2.10	5.20
11	Sulphate (mg/l)	1.864	0.985	0.808	0.894	130.30
12	Nitrate (mg/l)	1.566	1.835	1.736	1.288	0.113
13	Chromium, (mg/l)	0.0005	0.0006	0.0004	0.0007	0.131
14	Nickel, (mg/l)	0.798	0.991	1.020	0.951	6.667
15	Zinc, (mg/l)	0.538	0.587	0.581	0.550	0.703
16	Iron, (mg/l)	0.673	2.272	2.071	0.267	0.157
17	Aluminum, (mg/l)	0.978	1.267	0.070	0.020	12.871

WS1= Water Sample 1 WS2= Water Sample 2 WS3= Water Sample 3
WS3= Water Sample 4

Table 3 Descriptive statistics of the physico-chemical parameters of Mbaa River, 2017.

Parameters	Minimum	Maximum	Range	Mean	SE	NESREA 2009
pH	5.40	7.20	1.80	6.27	0.27	6-9
Turbidity (NTU)	2.40	6.70	4.30	4.84	0.54	5.0
Temperature (^{O}C)	26.30	28.90	2.60	27.76	0.33	40.0
EC (uS/cm)	10.48	11.92	1.44	11.15	0.19	Ns
TDS (mg/l)	5.30	5.80	0.50	5.53	0.05	500
TSS (mg/l)	10.60	14.30	3.70	12.19	0.45	25
T. Hardness (mg/l)	3.70	10.70	7.0	8.88	0.80	Ns
CC (mg/l)	9.35	12.05	2.70	10.36	0.44	1.00
COD (mg/l)	10.32	36.50	26.18	16.76	2.92	60
BOD (mg/l)	2.10	2.50	0.40	2.29	0.48	30
SO^{2-}_4 (mg/l)	0.23	1.86	1.63	0.74	0.19	500
NO_3 (mg/l)	1.29	3.14	1.85	1.94	0.20	20
Cr (mg/l)	0.00	0.04	0.04	0.01	0.01	1.00
Ni (mg/l)	0.67	1.02	0.36	0.85	0.05	1.00
Zn (mg/l)	0.01	0.59	0.58	0.33	0.09	5.00
Fe (mg/l)	0.27	3.49	3.22	1.54	0.38	10.0
Al (mg/l)	0.02	1.27	1.25	0.70	0.16	0.5

Ns = Not Stated, SE= Significant Error of Mean, NESREA= National Environmental Standards and Regulations Enforcement Agency, EC= Electrical Conductivity, TDS= Total Dissolved Solids, TSS= Total Suspended Solids, T. Hardness= Total Hardness, COD= Chemical Oxygen Demand, BOD= Biological Oxygen Demand

Physico-Chemical Quality of Sediment of Mbaa River.

The concentrations of the physicochemical Values measured during the study period are presented in Table 4.4 and Table 4.5. pH varied from 4.24-6.01 (5.00 ± 0.22), Heavy metals (Cr, Ni, Zn, Fe and Al) ranged as follows 0.01 – 8.03 (4.19 ± 1.45) , 0.45-27.01 (12.2 ± 4.19), 0.89-8.50 (4.25 ± 1.22) , 5.19-9.79 (6.96 ± 0.48) and 2.08 – 14.84 (7.48 ± 1.48) mg/kg respectively. The values were higher in sediments than in water samples for all stations.

Physico-Chemical Quality of the wastewater (Effluent) from ALEX

The concentrations of the physicochemical quality of the effluent of the industry measured during the study period are presented in Table 4.1 and Table 4.2. The pH value across the study period ranged between 8.85 and 5.27 while the water temperature varied from 27.30 and 29.00, Turbidity of the effluent was in the range of 8.50 and 11.1 NTU, Electro conductivity (EC) of the effluent was in a range 14,008.0 and 3,940 uS/cm, Total Dissolve solids varied from 7,003.00 and 1,970. Total suspended solids and Hardness varied from 17.10 to 19.20 and 324.80 to 190.80mg/l respectively. The concentration of the other physicochemical parameters are as follows; Chloride (2,081.00, 105.08mg/l);Chemical Oxygen Demand (1,034.60, 197.36mg/l); Biological Oxygen Demand (6.50, 5.20mg/l); Sulphate (13.40, 130.30mg/l); Nitrate (4.50,0.113mg/l) and the concentration of the heavy metal ranged from Chromium (0.15, 0.131mg/l); Nickel (8.650, 6.667mg/l); Zinc (3.876, 0.703mg/l) Iron(0.780, 0.157mg/l and Aluminuim (12.520, 12.871mg/l).The values for June and March 2017 gave rise to true colour and an apparent colour to the river respectively.

Table 4: Physico-chemical Quality of Sediments of Mbaa River in March , 2017.

S/N	PARAMETERS	SD1	SD2	SD3	SD4
1	pH	5.70	4.77	4.25	4.24
2	Chromium, (mg/kg)	8.02	8.02	8.01	8.03
3	Nickel, (mg/kg)	27.01	22.90	22.76	19.80
4	Zinc, (mg/kg)	7.88	8.50	5.55	7.50
5	Iron, (mg/kg)	6.70	6.80	7.82	9.79
6	Aluminum,(mg/kg)	10.87	14.84	7.45	8.50

SD 1= Sediment 1 SD2= Sediment 2 SD3= Sediment 3 SD 4= Sediment 4

Table 5 : Physico-chemical Quality of Sediment s of Mbaa River in June, 2017 .

S/N	PARAMETERS	SD1	SD2	SD3	SD4
1	**pH**	**6.01**	**5.03**	**4.88**	**5.12**
2	Chromium, (mg/kg)	0.401	0.046	0.759	0.254
3	Nickel, (mg/kg)	2.764	0.683	1.313	0.451
4	Zinc, (mg/kg)	1.674	0.890	1.027	0.935
5	Iron, (mg/kg)	6.366	5.190	6.876	6.108
6	Aluminum, (mg/kg)	5.674	4.021	3.980	2.086

SD 1= Sediment 1 SD2= Sediment 2 SD3= Sediment 3 SD 4= Sediment 4

Table 6 Descriptive Statistics Of the Physico-Chemical Quality on Sediments of the Mbaa River , 2017 .

Parameters	Minimum	Maximum	Range	Mean	SE
pH	4.24	6.01	1.77	5.00	0.22
Cr (mg/kg)	0.01	8.03	7.98	4.19	1.45
Ni (mg/kg)	0.45	27.01	26.56	12.2	4.19
Zn (mg/kg)	0.89	8.50	7.61	4.25	1.22
Fe (mg/kg)	5.19	9.79	4.60	6.96	0.48
Al (mg/kg)	2.08	14.84	12.76	7.18	1.48

SE= Significant Error of Mean

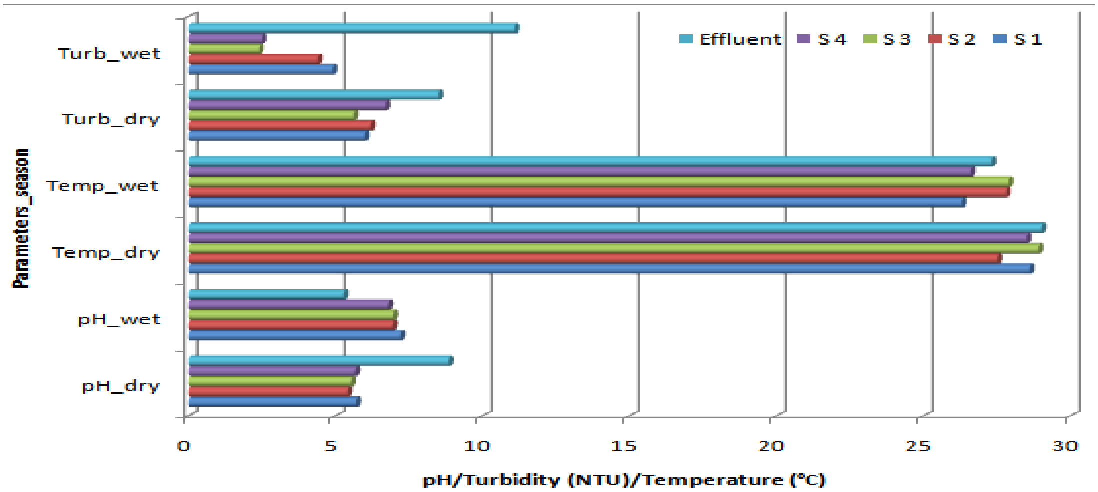

Fig. 3 Spatio-temporal variations in pH, temperature and turbidity of water and effluent samples
March = Dry June = Wet SD 1= Sediment 1 SD2= Sediment 2 SD3= Sediment 3 SD 4= Sediment 4

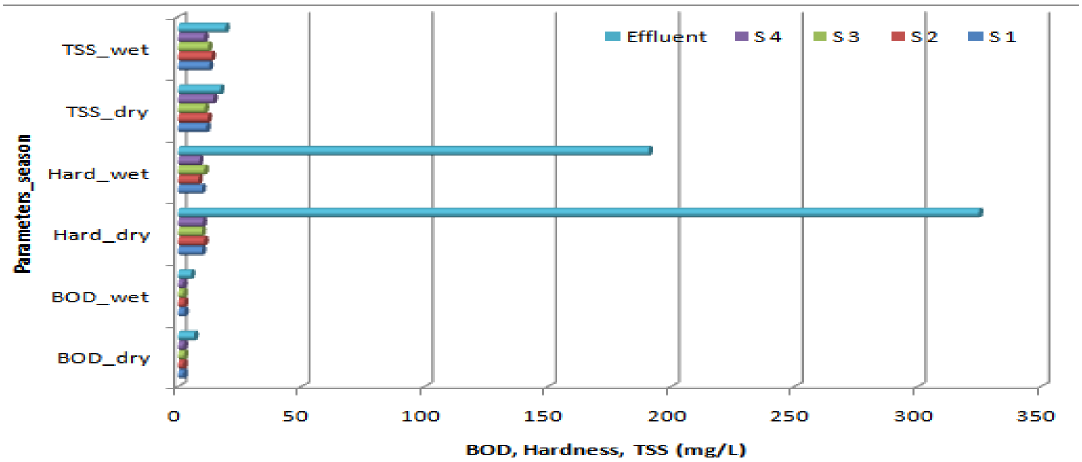

Fig. 4 Spatio-temporal variations in Biological Oxygen Demand, Total Hardness and Total Suspended Solids of water and effluent samples
March = Dry June = Wet SD 1= Sediment 1 SD2= Sediment 2 SD3= Sediment 3 SD 4= Sediment 4

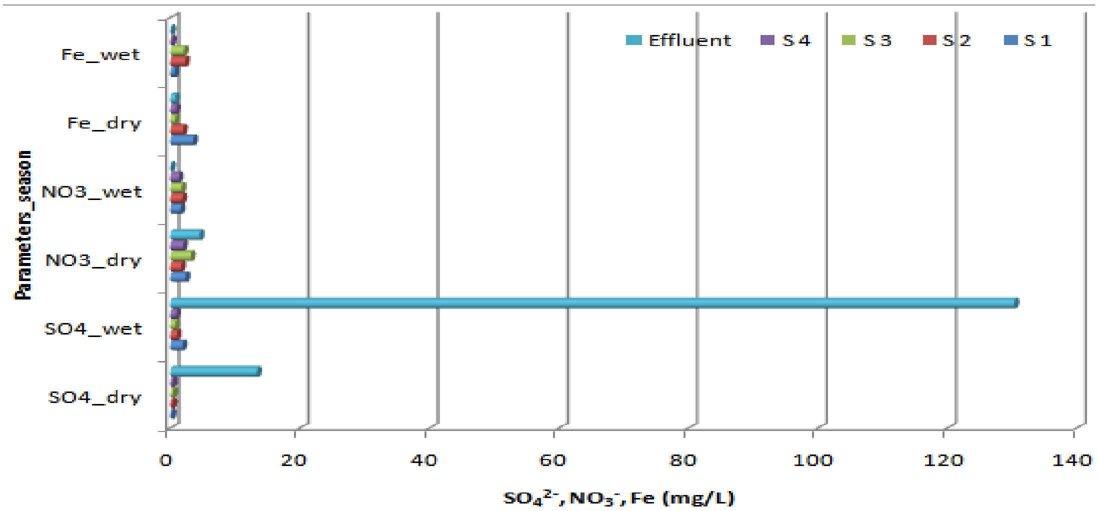

Fig. 5 Spatio-temporal variations in Sulphate, Nitrate and Iron concentrations in water and effluent samples March = Dry June = Wet SD 1= Sediment 1 SD2= Sediment 2 SD3= Sediment 3 SD 4= Sediment 4

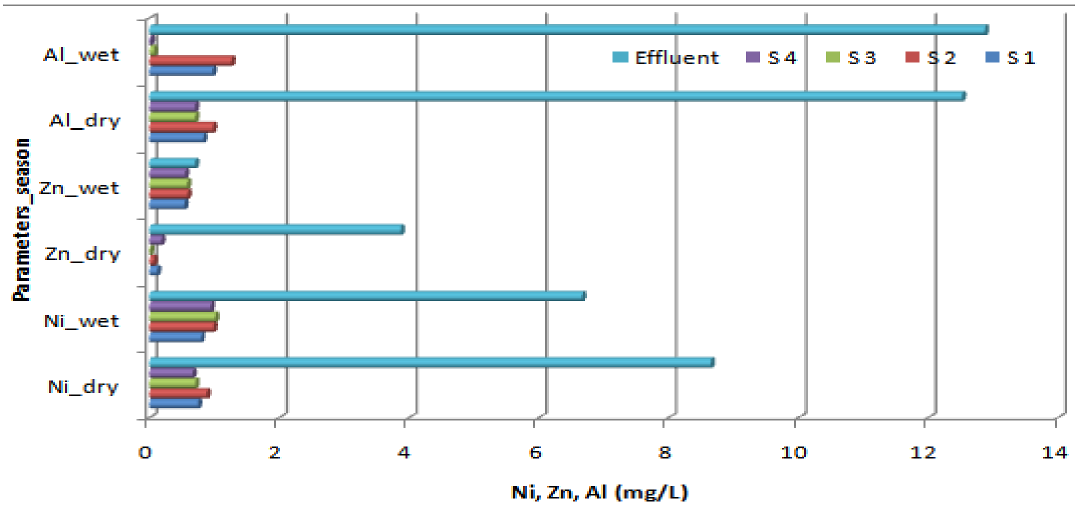

Fig. 6 Spatio-temporal variations in Ni, Al and Zn ion concentrations in water and effluent samples March = Dry June = Wet SD 1= Sediment 1 SD2= Sediment 2 SD3= Sediment 3 SD 4= Sediment 4

IV. DISCUSSION

Quality of the Effluent

4.1 Shows the quality of the waste water effluent from Aluminium Extrusion industry at Inyishi Ikeduru Prior to discharge into the Mbaa River. A comparison of its quality with the National Environmental Standards and Regulations Enforcement Agency 2009 guidelines for maximum concentration allowed for effluent discharge into inland water for manufacturing or Electroplating industries shows that the quality of the effluent falls within limit. The pH, Chloride, Nitrate, Sulphate, Biochemical Oxygen Demand (BOD), Total Dissolved Solids (TDS), Cr, Ni, Zn and Fe all fell below the maximum levels allowable by NESERA. Al (1.27mg/kg) was higher than the limit of 0.5mg/kg and the colour of the wastewater which has turbidity of 6.70NTU falls above limit of 5.0NTU prescribed by NESERA for effluent dischargeable into water bodies. This was a cause for worry and because it has the ability to change the taste of the water in period of higher discharge and low water volume (especially during dry season).

The results indicate that the wastewater from Aluminium Extrusion Industry do not meet all physicochemical parameter guidelines for the quality of effluent discharge into surface water bodies.

\Effect of waste water on the Quality of the River

Figure 4.1 shows a comparison of the physico-chemical quality of effluent and River in March and June 2017. The effect was higher in March than in June for pH and water temperature while for S1, the turbidity and water temperature was higher in March than in June, also for S2 the pH and water temperature was higher in June than in March, while for S3 and S4 Sampling station pH was higher in June than in March.

It is possible that the effect of effluent discharge for June on Heavy Meta levels for Ni, Zn and Al was higher in S1and S2 which shows that assimilation of Heavy Metals was more during dry season than rainy season.

Effect of waste water on the Quality of River Sediment

The concentration of heavy metals was much higher in sediments than in the water for both March and June sampling periods. This is a common fact as sediments acts as sink and reservoir for heavy metals in a river system (Akhionbare, 2007 and Akhionbare, 2009). The liquid effluent input increased the pH values for the river sediment but decreased the value of Cr, Ni and Fe down the sampling station.(from SD1 to SD4) both in March and June as a result to the decaying domestic and industrial waste littered at the upstream area contributing to the basic nature of the water (Ekeh and Sikoki 2003). Al and Ni increased from the effluent discharge these imply that the main source is from the waste water discharged. Al and Ni is a component of some alloy and also evident within the watershed at the receiving effluent station. Therefore Period of increased in concentration of the heavy metals in sediment correspond with periods of increase in water samples. These was also present for period of lower pH values for water on dry season at the sampling locations (Fig 4.1). The inverse relationship between pH and heavy metal concentration in media are known at higher pH values, most metals precipitate out of the media (Akhionbare, 2009). The one way Analysis of variance (ANOVA) test reveals that the concentrations of pH and Zn (Sig = 0.000 each), SO^{2-}_4 (sig = 0.017), Cr (Sig = 0.016) and Ni (Sig = 0.034) differed significantly during the study period between March and June (Appendix 1). However, the levels of Water Temperature, Electrical conductivity, Total dissolved solids, total suspended solid, total hardness, COD, BOD_5, Fe and Aluminum were significantly different at p = 0.05. The high significant correlation values between the concentration suggest that the association of these parameter originates from a common source (untreated waste and sewage) which is evident within the study area as the company do not have sewage dump site nor the dweller have a car wash site therefore discharging or washing into the river is the only option.

Comparison in Levels of Parameters in Water column and Sediments

The student's t-test of significance values reveals that the pooled value of the Physico-chemical parameters varied significantly between WS2 and WS4 sampling locations (Sig = 0.034). However between water columns and sediment matrices, all of pH (sig = 0.01), Cr (sig = 0.023), Ni (sig = 0.031), Zn (sig = 0.020), Fe (sig = 0.000) and Al (sig = 0.003) varied significantly at $p < 0.05$ (Appendix 3). These indicate that waste water effluent has not overwhelmed the self purification ability of the river water.

V. Conclusion

It was observed that the water had high point source of pollution which are responsible for the pollution of Mbaa River and also attributed possible due to the physiographic nature of the stream. The result of the analysis for most parameters did not show the expected trends in water quality from upstream to downstream sites on the river along the four sampling sites. It is expected that the concentration of most parameters downstream should be high than upstream which is not the case of this study. This clearly confirms that the main source of contamination on Mbaa River is a point source pollution. Nevertheless non-point source such as the diffuse pollution from agriculture, washing of cars, domestic activities etc. added to the contamination of the river curse and posses severe health risk to several nearby communities who rely on the river primarily as their source of domestic water.

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