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Analysis of Industrial Effluents as They Affect the Quality of Surface Water in Enugu Nigeria

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Abstract- Industrial contamination of water bodies due to discharges of untreated or partially treated effluent is a major problem occurring in many developing countries like Nigeria. 'This study surveys how effluents discharged from Emene industrial area of Enugu in Nigeria have impacted on the receiving Ekulu River. Laboratory analysis of samples were carried out. First sample was collected at the point where the river receives the industrial effluent. The second sample was collected at the upstream point to serve as the control. I3oth samples were analysed at Enugu State water corporation water analysis laboratory. Physiochemical and biological parameters were used in the analysis of the samples. The results were statistically analysed to show that there is significant difference between the point of receiving the effluent in the river and the upstream point. This manifested in the presence of high concentration at the receiving point. of the river of various parameters used in the analysis. The implication of this is the alteration primarily in the physiochemical and biological constitution of the water, which invariably impacted on various areas affecting the flora and fauna as well as human domestic and industrial usages. Appropriate treatment of the effluent before discharging among other measures have been recommended.

Indexed Terms- Impact, Effluent, Water, Quality, Enugu.

I. INTRODUCTION

In developing countries one of the most critical problems is improper management of vast number of Wastes generated by various anthropogenic activities. Water bodies especially fresh water reservoirs are the most affected. This has often rendered these natural resources unsuitable for both primary and secondary usages (Fakayode, S.O. 2005). Industrial effluent contamination of natural water bodies has emerged as a major challenge in developing and densely populated countries like Nigeria. Estuaries and inland water bodies, which are major souccs of drinking water in Nigeria arc often contaminated by the activities of the adjoining populations and industrial establishments (Sangodoyin, AY 1995).

Effluent from industries have a great deal of influence of the pollution of water bodies, as river systems are the primary means for disposal of wastes. These effluents can alter the physical, chemical and biological nature of the receiving water body (Sangodoyin, A.Y. 1991). Increased industrial activities have led to pollution stress on surface water (Ajayi S.O. and Osibanji, O. 1981). The resultant effects of this on public health and the environment are usually in great magnitude (Osibanjo, O. et al 2011).

With competing demands on limited water resources, industrial pollution remains one of the major problems 'facing Nigerian cities. However, effluent discharge practices in Nigeria are yet too crude and the society is in danger, especially in the industrialized part of the cities. In Enugu, Nigeria, the story is not different. The Federal Environmental Protection Agency (FEPA) established to cheek these environmental abuses has had little or no impact on pollution control in our environment (Ezeronye, O.U and Amogu, N 1998).

This study therefore undertakes the impacts Emene industrial effluents have exerted on the quality of segment of Ekulu River in Enugu, Nigeria.

II. LITERATURE REVIEW

Assessing the nature of effluents, Kosaric (1992) opined that waste waters are generated by many industries as a consequence of their operation and processing. The classified waste effluents generated by selected industries as; oxygen consuming wastes generated by breweries, dairies, distillers, packaging houses etc. high suspended solids from coal washeries, iron and steel industries etc. high dissolved solids from chemical plants, tanneries, water softening, oily and grease from laundries, metal finishing, oil fields, coloured from pulp and paper mills, textile dye houses, palm oil mills etc high alkaline from chemical plants, tanneries, textile finishing etc. and high temperature from bottle washing plants, power plant etc. Agedengbe et al (2003) noted that an important pollution index of industrial waste waters is the oxygen function measured in terms of chemical oxygen demand and biological oxygen demand while the 'nutrients status of waste water are measured in terms of nitrogen and phosphorous. However, Ezenobi et al (2004) added that P11, temperature and total suspended solids are other important quality parameters. The effluent total hardness concentrations of a chemical- biological treatment plant were found greater then the influents (Ogunfokowokan, 1 998). The results are presented in terms of the relative flux as a function of time related to hydrodynamic conditions and pollution characteristics of water waste.

Tracing the source of industrial effluent through soap and detergent industry, El-Cohary et al (1987) observed that characterization of the composite waste water from both soap and food processing plants indicated that waste was highly contaminated with organic compounds as indicated by COD and BOD values. In a study to assess the seasonal variation in bacterial heavy metal biosorption in a receiving river as affected by industrial effluents, Kanu et al (2006) observed an overall seasonal variation of heavy metals such as lead and zinc in the rainy season as compared to other metals for dry season. The concentrations of heavy metals were also generally low in some sample and no similar trends were observed in the control samples. Except for iron and zinc, the concentrations of the heavy metals were relatively low. Moreover, effluent from the soap manufacturing plant contained significant concentrations of oil and grease amounting to 563 mg.

According to Calarnari (1985), process water in paper and board mills contain a lot of sugars and lignocelluloses, which support the growth of bacteria, mold and some yeast. Effluents from fertilizer plants contain a high concentration of potentially toxic wastes rich in ammonia and phosphorous which support the growth of algae, yeast and *cyanobacteria*. *Celluloytic* bacteria such as *Klebsiclla pneumonia* and *enterobacter* have been isolated from spent water from the paper arid pulp industries. The occurrence of these microbs in the effluent lead to excessive oxygen demand loading, and also disturb the ecological equilibrium of the receiving waters with much lose of aquatic life.

Waste water from brewery industry originates from liquors pressed from grains and yeast recovery, and have the characteristic odour of fermented malt and slightly acidic. (Kanu et al, 2006). Ekhaise and Anyasi (2005) were of the opinion that introduction of waste water high in organic matter and essential nutrients bring about changes in the microflora. They reported high courts of bacterial population in lkpoba River in Benin City of Nigeria receiving a brewery industrial effluent.

Similar results were reported by Kanu and Others in 2006 of the effect of brewery discharge into Eziama River Aba, Nigeria.

Onwuka et al (2004) studied eighty eight samples of the ground water near industrial effluent discharges in Enugu in order to evaluate its portability. The parameters of interest are common waste; derivable chemical constituents such as nitrates. The results showed that eight out of ten samples analysed tested that the bacteriological quality of the ground water showed evidence of sewage and industrial effluent contaminations. The identification of *E. Coli* in the water indicates faecal contamination. Improvement in the management of domestic wastes, such as the use of central sewer was suggested as a means of preserving the aquifer and consequently improving the quality of the ground water.

Ibekwe et al (2004) analysed the waste water in the accumulation pond and final discharge point of Nigerian Bottling company Plc. in Owerri, Nigeria to determine their bacteriological and physio-chemical characteristics. Species of organisms isolated include; staphylococcus, bacillus, lactobacillus, and streptococcus. Others were, *Kiebsiella*, *Escherichia*, *proteus* and *serratia*. Species of lactobacillus and proteus were isolated from the final discharge point only. Bacteria count after 72 hours was higher with a maximum count $6x10^7$ Cfu/ml in the final discharge point. The final discharge contained more dissolved solids which was double than that of the accumulation pond. It was also found that the dissolved oxygen was slightly higher in the final discharge point than accumulation pond. Although, these findings were found to be within the permissible limits of effluent discharge specified by the federal ministry of Environment in Nigeria, the consequent long term bioaccumulation effects on microbial ecosystem were not reported.

The toxicity of benzene, hydroxylbenzene, chlorobenzene, methylbenzene and dimethylbenzene to four chemolithotrophic bacterial (Nitrosornonas Nitrobacteria, thiobacillus and leptothrix) Isolated from the New Calabar water were investigated by Odokurna and Oliwe (2003). The static method of acute toxicity assessment was employed. Mortality within a period of five hours exposure to toxicant was the index of assessment. Toxicity of chemicals to the bacteria decreased in the following order. Phenol > xylem > benzene > chlorobenzene > toluene > xylem for Nitrobactcr, phenol > chlorobenzene > benzene was for leptothrix. The toxicity of the chemicals to the test organisms decreased in the. order, phenol > chlorobenzene > benzene > xylene > toluene. Sensitivity of the bacteria to the chemicals decreased in the order; Nitrosornonas > leptothrix >Thiobacillus > Nitrobacteria. The toxicity generally decreased with increased methyl substitution in the case of Nitrobacter and Thiobacillus but increased with increased methyl substitution in the case of Nitrosornonas and leptothrix. Hydroxyi and halogenated substituted derivatives were more toxic than methyl substituted derivatives. These results indicate that wastes containing hysroxyl and chiorosustituted derivatives of benzene may pose greater toxicity problem to microbiota than wastes containing methyl substituted derivatives. The nitrification stage of the nitrogen cycle will also be greatly impaired in the presence of these groups of chemicals in a river.

Davis and Reilly (1980) asserted that palm oil mill effluent is an important source of inland water pollution when released without treatment into local rivers or lakes. Noting that palm oil mill effluent is generated from three major sources sterilizer condensate, hydrocyclone waste and separator sludge, Ma (2000) added that it contains various suspended components including all walls, organelles, short fibres, as spectrum of carbohydrates ranging from hernicelluloses to simple Sugars, a range of nitrogenous compounds from proteins to amino acids, free organic acid and an assembly of minor organic and mineral constituents. Accepting the fact that palm oil mill waste water treatment system is one of the major sources of green house gasses due to their biogas emission, Wu et at (2009) were of the view that palm oil mill effluent has generally been treated by anaerobic digestion, resulting in difficulty in perceiving the magnitude of pollution being caused to the receiving waters by such discharges.

Assessing the danger in the use of water bodies as sink for industrial effluent Anetor et al (2003), emphasized that population explosion, hazardous rapid urbanization, industrial and technological expansion, energy utilization and wastes generation from domestic and industrial sources have rendered many water resources unwholesome and hazardous to man and other living resources. Some heavy metals contained in effluents have been found to be carcinogenic while other chemicals equally present are poisonous depending on the dose and duration of exposure. Undoubted, waste water from industries and residential areas discharged into another environment without suitable treatment could disturb the ecological balance of such an environment (Botkin and Kelly 1998). In Nigeria, cities like Kaduna, Lagos and Aba depend very much on their rivers. However, the rush by African countries to industrialize has resulted in discharge of partially treated or raw wastes into the surrounding bodies of water (Nwachukwu et al 1989). Water pollution may derive natural processes such as weathering and soil erosion. in the vast majority of cases, however, impairment of water quality is either directly or indirectly the result of human activities (Dix, 1981) Sturnm and Morgan (1981) identified point and non-point sources of water contamination.

Point sources arc discrete and readily identifiable and as a result they are relatively easy to monitor and regulate. Most sewage from urban areas and industrial waste waters arc discharged from point sources. Non point sources, on the other hand are distributed in a different manner.

Davis and Walker (1986) were of the opinion that when a biodegradable organic waste is discharged into an aquatic ecosystem such as stream, estuary or lake, oxygen dissolved in the water is consumed due to the respiration of micro organisms that oxidize the organic matter. The more the biodegradable a waste is, the more rapid is the rate of its oxidation and the corresponding consumption of oxygen. Because of this relationship and its significance to water quality, the organic content of waste waters is usually measured in terms of the amount of oxygen consumed during its oxidation. In an aquatic ecosystem, a greater number of species of organisms are supported when the dissolved oxygen concentration is high. Meetens et al (1995) observed that oxygen depletion due to waste discharge has the effect of increasing the numbers of decomposer organisms at the expense of others. When oxygen demand of a waste is so high as to eliminate all or most of the dissolute oxygen from a stretch of a water body, organic matter degradation occurs through the activities of anaerobic organisms, which do not require oxygen.

According to Perry et al, (2007), nitrogen or phosphorus or both may cause aquatic biological productivity to increase, resulting in low dissolved oxygen and eutrophication of lakes, rivers, estuaries and marine waters.. Mott and Associates (2001), stressed that many serious human diseases are caused by water borne pathogens. In developed countries, the spread of water borne disease has been largely arrested through the introduction of water and sewage facilities and through hygiene. But in many developing countries, such diseases are still major causes of death especially among the young ones (Lamb, 1985).

III. MATERIAL AND METHODS

The study involved the laboratory analysis of effluent at the point of being discharged into the Ekulu River. This was taken where the waste water was-wcl1 mixed in the river. Also, sample was taken at the upper part of the stream (control point). This was taken at the middle part of the river since it is shallow sandy water. The samples were collected in the morning and evening to know the variation in the contamination and to take the average of the parameters. Sampling bottles were sterilized in order to activate the micro organisms with the use of surgical glove so as not to add to the bacteria in the water. Sterilized cup was used to collect the samples into sterilized bottles. The samples were covered immediately in order to avoid contamination through air. The samples were placed in cooler to prevent increase in bacterial load and also to avoid depletion of the contamination due to oxidation and direct sunlight. Ten sample bottles were used for the analysis. Two bottles each were used for the physical, chemical and biological analysis. Another four bottles were used for the laboratory analysis of the control point and point of discharge in the receiving stream; this was to aid the accuracy of the result and to avoid contamination of the samples during analysis of the samples by the chemical used in analysis.

Speetrophotorneter (DR. 20600 model) and glass comparators were used to determine colour. PH was determined using lovibond instruments and electronic meters. Mercury- in glass thermometer was used to determine temperature. Mettler Toledo MC 2006 conductivity meter was used to measure electrical conductivity.

Turbidity levels were measured in Nephelometric units (NTU) using HACH 2100A turbidity meter. Alkalinity was determined by Titrarnetric method (using titration).Transmission spectrometer was used to determine sulphate. Titration of the samples with silver nitrate determined chloride. For nitrate, 1ml of sodium arsenic was added to the sample, shaken thoroughly, 5m1 was separated from the Mixture in a test tube and l0mls of bruane sulphate added, then 10mis of conc. Sulphuric acid was added and the remaining solution mixed and allowed to develop for about l hr; the absorbance was then read with the aid of spectronic 20. To determine iron, a percentage of water was pipette in a test tube, 5mills of sodium acetate buffer was added, 5mls of 0.023% of phenolphthalein was added, it was allowed to develop for about 30 minutes, then with the aid of spectropholorneter absorbance was read. Copper was determined with the aid of spectrophotometer. In the determination of lead, 5drops of 10% potassium cyanide was added to a measure of 10mls water, eventually spectrophotometer was used to measure absorbance. Biochemical Oxygen Demand was determined by conventional methods according to association of Official Analytical Chemists (AOAC) 2002. In chemical Oxygen Demand determination, potassium dichromate was used in the test and oxygen used in oxidizing the water was determined.

The following parameters were used in the laboratory analysis of the samples; general appearance, colour, odour, turbidity, temperature, PH, total dissolved solid, total suspended solid, total solid, dissolved oxygen, COD, BOD, conductivity, iron, lead, copper, zinc, coliform, E. coli and total plate.

Comparative analysis was carried out to determine whether there arc variations between the point of discharge result and the up stream point (Control point) result using the t test statistics.

IV. DATA PRESENTATION AND ANALYSIS

Samples of the effluent point of discharge into the receiving river and the upstream point were taken to the laboratory.. The analysis turned out the following result in the table;

Laboratory analysis of the samples.

S/no	Parameter	Units	Waste Water Result	Point of discharge Result	Upstream point Result
1	General Appearance	-	Brown	Light brown	Light
2	Colour	Unit	120	58	15
3	Odour	-	Little	Little	Nil
4	Turbidity	NTC	510	72	18
5	Temperature	ºC	29	26	25
6	PH	-	8.6	6.9	6.7
7	Total Dissolved solid	Mg/L	653	82.6	12.2
8	Total suspended solid	Mg/L	82.3	10.1	16.3
9	Total solid	Mg/L	735.5	92.7	18.7
10	Dissolved oxygen	Mg/L	3.3	2.6	1.5
11	COD	Mb/L	41.8	25.1	20.4
12	BOD	PS/cm	45.1	10.3	90
13	Conductivity	Mg/L	956.78	121	18
14	Sulphate	Mg/L	201	36.3	5.8
15	Nitrate	Mg/L	12	3.3	1.2
16	Phosphorous	Mg/L	1.3	0.8	0.3
17	Chlorides	Mg/L	500	72	0.72
18	Alkalinity	Mg/L	461	22	8.7
19	Iron	Mg/L	0.02	0.01	0.015
20	Lead	Mg/L	0.0026	Nil	Nil
21	Copper	Cfu/ML	0.00 1	Nil	Nil
22	Zinc	Cfu/ML	0.003	Nil	Nil
23	Coliforrn	Cfu/ML	67	36	15
24	e-coli	Mg/L	+ve	+ve	Nil
25	Total plate	Mg/L	102	52	20

V. COMPARATIVE ANALYSIS

- Hypotheses

Ho = μ_1 = μ_2 (No significant difference by the physiochemical characteristics at selected point in the upstream point and the discharge point)

III = $\mu_1 = \mu_2$ (There is significant difference)

Critical Region: Reject Ho if/t Cal> It tab, otherwise accept.

Using t =

$$t = \frac{X1-X2}{Sp\sqrt{\frac{1}{n1} + \frac{1}{n2}}}$$

T calculated = 2.975

From t Distribution Table,

t 0.975, 46 2.0 14

Decision; Since t cal > t tab ie 20975 > 2.014, then H_0 is rejected and H_1 accepted. This means that there is significant difference between the point of discharge and the upstream (control point result.

VI. RESULTS AND IMPLICATIONS

There is wide difference between the parameters of receiving point of discharge and upstream point. The upstream gave a clue of the river parameters and served as control for the point of discharge. The difference in concentration of the waste water and the raw river water were much. Also the rate of dilution by the river is high to bring down the concentration of the waste water. The waste water was believed to have been treated to a certain level before discharge. This makes the mixing point to be very low in regard to the waste water data collected.

The impacts of the industrial effluents on the receiving Ekulu River were manifested in various areas;

At the point of discharge of the effluent into the river, the water has odour, unlike the condition at the upstream which has no odour. This invariably makes it unfit for human consumption and other domestic purposes.

High level of turbidity (72) was observed at the point of discharge into the river while upstream point (18) is lower. High turbidity can significantly reduce the aesthetic quality of lakes, streams, having the harmful impact on recreation and tourism. It can increase the cost of water treatment for drinking and food processing. It can harm fish and other aquatic lives by reducing food supplies, degrading spawning beds and affecting gill functioning. Besides, high turbidity diffuses sunlight and slows photosynthesis. Plants begin to die, reducing the amount of dissolved oxygen and increasing the acidity. Both of these effects harm aquatic animals. Smith and Davies (2001), observed that if light level gets too low, photosynthesis may stop altogether and algae will die. Moreover, high turbidity raises water temperature as the suspended particles absorb the sun's heat. Warmer water holds less oxygen, thus increasing the effect of reduced photosynthesis. In addition, some aquatic animals may not adjust well to the warmer water, particularly during the eggs and larval stages. Furthermore, high turbid water can clog the gills of fishes, stunt their growth and decrease their resistance to diseases. Also the organic materials that may cause turbidity can also serve as breeding grounds for pathogenic bacteria. Turbid water can clog industrial machines and interfere with making food and beverages.

The point of discharge of effluents into the river contains total dissolved solid in the neighborhood of 82.6 mg/L, in higher proportion to that of the upstream point which has 12.2 mg/l. Water with high dissolved solids generally arc of inferior palatability and may induce unfavourable physiological reaction in the consumer

The point of discharge contained 10.1/mg/l total suspended solid as against the 6.3 mg/l at the upstrearn. High rate of suspended solids in the surface water can clog fish gills, either killing them or reducing their growth rate. They also reduce light penetration, and the ability of algae to produce food and oxygen. Again, when the water flow slows down as when it enters a reservoir, the suspended sediments settle out and drop to the bottom. This makes the water become clear, but as he sediment settles, it may smother the bottom dwelling organism, cover, breading areas and smother eggs. Meanwhile, indirectly, the suspended solids affect other parameters such as temperature and dissolved oxygen; because of greater heat absorbency of the particular matter, the surface water becomes warm, and this tends to stabilize the stratification (layering) in stream pools, embayment and reservoir. This, in turn interfere with mixing, decreasing the dispersion of oxygen and nutrients to deep layers. Suspended solids also interfere with effective drinking water treatment. 1-ugh sediment loads interfere with coagulation, filtration and disinfection of turbid water. They also cause problems for industrial users, interfer with recreational use and aesthetic enjoyment of water.

Poor visibility can be dangerous for swimming and diving. Sediment deposition nay eventually close up channels or fill up the water body converting it into a wetland. High rate of total dissolved solids may cause the water to be corrosive, salty or brackish taste, resulting in scale formation and decreased efficiency of hot water heaters. They may equally contain elevated levels of ions that arc above the primary and secondary drinking standards such as an elevated level of nitrate, arsenic, aluminum, copper lead etc. high total dissolved solids also affect the quality of the water, interfering with washing clothes and corroding plumbing fixtures.

The nitrate level at the point of discharge (3.3mg/L) is very high. Already, water with nitrate levels exceeding 1.0mg/l is not recommended to be given to babies under three months of age as it brings about methemoglobinema disease.

The phosphorous content at the point of discharge (0.8mg/L) is not favourable, as compared with the O.3mg/L observed at the upstream point. Instances where phosphate is a growth limiting nutrient, the discharge of raw or untreated industrial waste into a water body may stimulate growth of photosynthetic aquatic micro organisms in nuisance quantities.

While E, Coli is absent in the upstream point of the river, it is present at the point of effluent discharge into the river. It has been affirmed that *E Coli* present in water bodies can bring about diarrhea, urinary tract infections, respiratory illness, pneumonia and the likes.

The sulphate content is very high at the point of discharge of effluents into the river (36.3 mg/L) as against the 5.8 mg/F at the upstream point. Although sulphates are normally considered a serious problem in most water supplies, they can nevertheless be troublesome if sulphate reducing bacteria arc present. These bacteria are capable of reducing the sulphate radical to hydrogen sulphide with the accompanying rotten egg odour.

The chloride level at the point of discharge into the river is very much higher (72rng/L) than what was obtained at the upstream point (0.72). Chloride in water may have no adverse physiological effects but a sudden increase above their back ground level (as in the case in question) may indicate pollution.

VII. RECOMMENDATIONS

The result obtained from the analysis show that the effluent being discharged from Emene industrial area into the Ekulu River has considerable negative impacts on the water quality of the receiving river.

It is therefore recommended that careless disposal of effluents in the area should be discouraged. There is need for each industry in the area to install a waste treatment plant with a view to properly treat wastes before discharging them into the surrounding river. Even where such facility is available, it is recommended that there be competent personnels that will effectively and efficiently handle the treatment processes, making sure that the waste water discharge is in line with the discharge guidelines.

The introduction of cost-effective cleaner production technology should be enforced. Industries should be encouraged to evolve site waste separation and reduction as well as recycling their waste water for use in some areas in order to reduce cost of fresh water.

Federal Environmental protection agency (Agency responsible for Monitoring Environmental Quality in Nigeria) should rise to its responsibility by imposing levies or prosecuting owners of industries that discharge their untreated or partially treated wastes into the surrounding water. Such industries should also be made to take remediation measures to ameliorate the situation.

CONCLUSION

The study has shown that the effluents from Emene industrial area of Enugu have much of negative impacts on the water quality of the receiving Ekulu River. This is depicted by the fact that the results obtained from the analysis of the physiochernical and biological parameters of samples from the receiving part of the river did not compare unfavorably with the upstream point. There is general increase in concentration of the parameters analysed at the point of discharge in the stream as opposed to the upstream (control) point.

Thus, the continuous discharge of untreated or partially treated effluents into the river may result in severe accumulation of the contaminants which may be toxic to different organism in that environment. This invariably may not he palatable and therefore should not be encouraged.

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