IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)
e-ISSN: 2319-2402,p- ISSN: 2319-2399.Volume 8, Issue 11 Ver. I (Nov. 2014), PP 22-27
www.iosrjournals.org

Impact of Industrial Effluents Discharge on the Quality of Nwiyi River Enugu South Eastern Nigeria

[1]OGWO, P.A. and [2]OGU, O. G.
[1] *Department of Environmental Management &Toxicology, Michael Okpara University of Agriculture, Umudike.*
[2]*Department of Environmental Resource Management, Abia State University Uturu, Nigeria.*

Abstract: *A study was conducted to assess the impact of industrial effluents on Nwiyi River Enugu, Nigeria. Four sampling points were established 100m apart from AMA Breweries, and samples were collected on 2 hourly bases over a period of 24 hours. The samples were then analyzed for pH, EC, TSS, TDS, hardness, alkalinity, acidity, nitrate, phosphate, chloride, sulphate, DO, BOD , COD, turbidity, oil and gas, phenol compounds, Mg, Ca, AS, Al, Zn, Fe, Pb, Cu, Ni, Mn, Cr, Cd, cyanide, total plate count, and total coliform using standard methods. Results obtained were analyzed statistically using mean and compared with national and international regulatory agencies guidelines. Results show that EC, turbidity, phosphate, Fe, COD, BOD, alkalinity, total plate count, total coliform were significantly above FEPA/WHO permissible limits in water, while TDS, TSS and pH were within the limits but have the potentials to exceed the limits if the trend continues without checkmating. However, there were no traces of phenol compounds, oil and gas, As, Al, Cr, Cd, cyanide, Pb and Ni. The DO was reduced due to high BOD and COD contained in the water. The study revealed that the quality of Nwiyi River is poor and pollutants of organic, inorganic and fecal origin are entering into the river due to industrial effluent discharge. It was recommended that regulatory agencies should mandate industries to install efficient waste and wastewater treatment plants so that waste and wastewater emanating from their operations could be properly treated before being discharged into Nwiyi River.*
Key words: *Industrial effluents, Nwiyi River, water pollution, Enugu Nigeria.*

I. Introduction

Development process, industrialization, anthropogenic activities and population explosion have affected environmental quality in many ways, with attendant negative impacts on the environment and human health. Waste generated and disposed off to the environment without proper monitoring and management become public nuisance overtime. With technological development in manufacturing industries, chemicals have become important substances for human development. Industrialization is a major activity promoted by the Nigerian government as a developing nation in her development strategies to make meaningful and significant contributions to the enhancement of human welfare. Industrial operation, normally involve the conversion of raw materials and resources into finished and /or semi-finished products, with attendant residues in the form of energy and matter. If the residues are not utilized, they become wastes, and if discharged into the biosphere without proper treatment, can become pollutants. The degree to which the pollutants affect the physical environment depends on their quantitative and qualitative characteristics as well as the receiving media. This is so because some pollutants are readily biodegradable, while others persist for a long time and may not even decompose. Also, some pollutants have low toxicity, whereas others are highly toxic and / or carcinogenic even in trace quantities.

Water is an essential natural resource for agriculture, manufacturing, transportation and many other anthropogenic activities. It is essential for all forms of life and makes up 50-97% of the weight of plants and animals and about 70% human body (Buchholz, 1998). The WHO estimates that more than 20% of the world population has no access to safe drinking water and that more than 40% of all population lack adequate sanitation (Oastridge *et al*, 1999). Poor water quality is still a significant problem in many parts of the world. It can often limit the use of the vital resource and in more extreme cases can harm human and other life forms (Forum *et al*, 2001). Water can be polluted by substances that dissolve in it or by solid particulates and insoluble liquid droplets that become suspended in it (Plant *et al*, 2001). Besides drinking, water is also used for fish and aquaculture, irrigation, hydropower generation and many more.

Pollution of water bodies is increasing steadily due to rapid population growth, industrial proliferation, urbanization, increasing living standard and wide sphere human activities. The rapid urbanization has caused population explosion in urban centers and the generation of wastes both liquid and solid has grown to commendable proportions. The pace of development of waste disposal schemes could not match the rapid rate of urbanization in these urban centers during the last few decades. As a result, the wastes not properly disposed reaches the water sources and therefore our water sources like rivers, lakes and reservoirs that are in close

proximity of these urban centers are highly polluted. The problem of water pollution is being experienced by both developed and developing Countries. The most common types of polluting substances include pathogenic organisms, oxygen demanding organic substances, plant nutrients that stimulate algae blooms, inorganic and organic toxic substances (Cornish *et al,* 1999).

Wastewater from industries and sewage spillages from burst pipes in urban areas in Nigeria are released into water bodies. With the prevailing hard economic situation in the Country, most of the effluents are released into the water environment untreated or partially treated. Most Industrialists in Nigeria have adopted the use of substandard treatment methods that partially treat and in most cases forgo the effluent treatment process in their bid to minimize cost and maximize profit. The major problem of Nwiyi River is the pollution from nearby industries. Several industries are located in close proximity to the river and some of them do not have well-established sewage treatment facilities, therefore effluents from these industries are directly discharged in the river exclusively without adequate treatment which results in nutrient enrichment, the accumulation of toxic compounds in biomass and sediments, loss of dissolved oxygen in water, high biological oxygen demand (BOD) and Chemical oxygen demand (COD) and other nuisances. Another problem of Nwiyi River is the inflow of sewage from the adjoining areas where a number of households lack proper infrastructures like sewage network. As a result, the sewage generated from these areas is directly discharged in the river without treatment. Inflow of silt from the catchment due to intensive agricultural activities is another source of contamination in Nwiyi river. People who live in the vicinity of Nwiyi river depend solely on this river as a source of water for domestic use. The major challenge therefore is how to strike a balance between industrialization, economic development and environmental sustainability, so that why we strive to attain an industrialized and developed nation, the quality of our environment will not be jeopardized. This can be done by examining the operations and activities of our industries to know the degree of their resultant impacts on the environment and establish whether they can be assessed before they occur. The objective of the study was therefore to evaluate the impacts of industrial effluents discharge on the quality of receiving river and as well suggest possible mitigation measures for the attenuation of any possible negative impact. This was done using AMA Breweries and Nwiyi River at Ninth Mile Enugu, Nigeria as a case study.

II. Materials And Methods

The Study Area

Enugu lies between latitude $5^0 55^1 7^{11}$N and longitude $6^0 55^1 7^{11}$E. The area is bounded in the north by Benue state, in the west by Ebonyi state, in the south by Abia state and Anambra state in the east. Enugu is situated on much of the highlands of the Awgu, Udi and Nsukka hills and the rolling lowlands of the Ebonyi River Basin to the east and Oji River and Ajali basin to the west. The hydrology of Enugu is governed by the Oji River. The area falls within the tropical wet and dry climatic zone, with annual temperature range of 23.57^0C and 28.5^0C, mean annual and seasonal rainfall of about 1500mm. The soil type is generally the red, loose ferrallitic sandy soils.

Enugu has a rapid population growth, estimated to be 3.8 million according to the 2006 National Census. The population density is about 273 persons per square kilometer. Single family houses usually bungalows and storey buildings and apartment houses predominates Enugu urban. Many slums exist in peri-urban areas in Enugu with residents mostly poor dwellers, and they lack adequate and safe water supply, sanitation and environmental play spaces. Although there are a lot of manufacturing industries within and around Enugu, the predominant occupation of the people is farming.

Sanitation and Water Supply

Due to population explosion and urbanization, water supply to Enugu urban had not met the demand for water and has been increasing tremendously. Moreover, considerable parts of this limited quantity of water is polluted by sewage, municipal wastes, industrial effluents and open defecation which is predominant in peri-urban areas/slums because of poor sanitation facilities, and a wide array of other pollutants. The menace of water borne diseases and epidermis still threatens the well-being of the population. Thus, the quality as well as the quantity of clean urban water supply is of vital significance for the welfare of the inhabitants of Enugu state. About 1500mm of rainfall is received in the state, and there are no systems of rain water harvesting, so 98% of the rain water is lost as flood and runoff water. Only about 2% of the rain water is fetched for domestic use. The flood and runoff water carry oxygen-demanding wastes, disease causing wastes, human and animal excreta, non biodegradable plastic films and other pollutants to the urban surface water and streams. The nutrient rich water stimulates the growth of algae and other aquatic weeds in the receiving water body. The water bodies loose all their dissolved oxygen in the long run due to natural biological process of eutrophication and end up as dead, smelly pools of water. The major problem of Nwiyi River is the pollution from nearby industries. Several industries are located in close proximity to the river and some of them do not have well-established sewage treatment facilities, therefore effluents from these industries are directly discharged in the river exclusively

without adequate treatment which results in nutrient enrichment, the accumulation of toxic compounds in biomass and sediments, loss of dissolved oxygen in water, high biological oxygen demand (BOD) and Chemical oxygen demand (COD) and other nuisances. Another problem of Nwiyi River is the inflow of sewage from the adjoining areas where a number of households lack proper infrastructures like sewage network. As a result, the sewages generated from these areas are directly discharged in the river without treatment. Inflow of silt from the catchment due to intensive agricultural activities is another source of contamination in Nwiyi river. People who live in the vicinity of Nwiyi river depend solely on this river as a source of water for domestic use.

Sampling and Chemical Analysis

Four sampling points were established at the river for the study; the effluent discharge point, 100m upstream, 100m middle stream from discharge point and 100m downstream from the middle stream. Individual samples were collected from sampling point at 2 hours basis over a period of 24 hours. 12 separate 2-hourly samples using volumes proportional to the flow rate were composited to obtain four separate samples; one for each sampling point. Analysis was carried out on the composite samples for physical, chemical, organic, heavy and traces metals, and bacteriological characteristics.

Physical Characteristics

The physical characteristics analyzed included; appearance, colour, pH, temperature, odour, Electrical Conductivity (EC), Total Suspended Solids (TSS), Total Dissolved Solids (TDS), Total Hardness and Turbidity. pH and temperature were analyzed in-situ with pH/temperature meter. Colour was determined by stirring the composite samples until sediments suspend freely, and then was determined with calibrated colour disc. TDS, TSS, EC and turbidity were determined in-situ using Jenway M470 portable Conductivity/TDS meter.

Chemical and Organic Characteristics, heavy metals

The chemical and organic characteristics included; alkalinity, acidity, nitrate, chloride, sulphate, phosphate, DO, BOD, COD, phenol compounds, oil and grease, As, Al, Zn, Fe, Pb, Cu, Ni, Mn, Cr, Cd, Mg, Ca and Cyanide. DO was analyzed using Wrinklers method with azide modification following the description given in APHA. BOD was analyzed by subtracting the value of final concentration of DO (after 5 days of incubation at 20^0C) from the initial concentration of DO. COD was measured by dichromate reflux method because it has advantage over oxidants owing to its oxidizing power, its applicability to a wide variety of samples. Nitrate, phosphate and sulphate were analyzed spectrophotometrically. Chloride was analyzed titremetrically. Oil and grease, phenol compounds, alkalinity, acidity and cyanide were measured by methods adapted from standard methods for the examination of water and wastewater (APHA, 1992). An Atomic Absorption Spectrophotometer (Boston, MA 02118-2512, USA) was used for the determination of heavy metals and some trace metals including; Cd, Cr, Mn, Ni, Cu, Pb, Fe, Zn, Al, As, Ca and Mg.

Bacteriological Characteristics

Bacteriological characteristics analyzed include; total plate count, total coliform and E coli. Total plate count was estimated according to the heterotrophic plate count method suggested by the American Public Health Association. Total coliform and E coli analysis was done using the Most Probable Number (MPN) procedure. The technique involved three successive steps: presumptive test, confirmed test and complete test which detects the coliform bacteria as indicator of fecal contamination (APHA, 1998). Results obtained were analyzed statistically and compared with WHO and Nigeria Federal Ministry of Environment maximum permissible limits for domestic and recreational purposes to establish whether there are significant pollution impacts from industrial effluent discharge into Nwiyi River.

III. Results And Discussion

Results

Table 1: Physico-chemical and organic characteristics of Nwiyi River

Parameters	P1	P2	P3	P4	Mean
pH	6.4	8.4	7.6	7.6	7.5
colour	-	25	20	15	15
EC (mg/l)	420	760	130	90	350
Turbidity (NTU)	770	900	890	590	787.5
TSS (mg/l)	660	14	12	12	174.5
TDS (mg/l)	240	250	70	40	200
Hardness (mg/l)	655	71.6	42.1	21.8	197.63
Alkalinity (mg/l)	120	860	140	100	305
Acidity (mg/l)	30.0	-	5.0	4.0	9.75
Nitrate (mg/l)	55.0	10.2	6.10	6.80	19.53
Phosphate (mg/l)	2.10	1.06	1.20	1.40	1.44
Chloride (mg/l)	80.1	23.4	16.4	23.4	35.83

Sulphate (mg/l)	22.4	40.0	20.0	16.0	24.6
DO (mg/l)	2.4	3.4	2.8	3.8	3.10
BOD (mg/l)	36	81	25	20	41.75
COD (mg/l)	250	48.5	88	60	111.63
Phenolics (mg/l)	NO	NO	NO	NO	-
Oil and grease (mg/l)	NO	NO	NO	NO	-

Table 2: Heavy metals, trace metals and bacteriological characteristic of Nwiyi river

Parameters	P1	P1	P3	P4	Mean
As (mg/l)	NO	NO	NO	NO	-
Al (mg/l)	NO	NO	NO	NO	-
Zn (mg/l)	0.04	0.10	0.10	0.02	0.07
Fe (mg/l)	160	0.20	0.10	0.15	40.11
Pb (mg/l)	NO	NO	NO	NO	-
Cu (mg/l)	0.06	0.08	0.05	0.05	0.06
Ni (mg/l)	NO	NO	NO	NO	-
Mn (mg/l)	0.05	0.05	0.05	0.03	0.045
Cr (mg/l)	NO	NO	NO	NO	-
Cd (mg/l)	NO	NO	NO	NO	-
Mg (mg/l)	40	9.50	1.90	1.90	13.33
Ca (mg/l)	2000	13.50	13.50	5.70	58.18
Total plate count (cfu/100ml)	1420	-	1688	2800	1447
Total coliform	220	-	208	810	309.5

(cfu/100ml)

Ps'= sampling points

IV. Discussion

Physical Properties

The pH of Nwiyi river ranged from 6.4 at P1 to 8.4 at P2, while 7.6 was recorded for both P3 and P4. The mean pH of the river was calculated as 7.6. Generally, pH values indicate the alkalinity of the river. APHA (1999), Culley *et al* (1973); Gersberg *et al* (1983) and Greenway *et al* (1999) related high pH with photosynthetic activities. The high rate of photosynthesis can be related to the high concentration of the plant nutrients, which is an indicator of pollution in the aquatic systems. In Nigeria, the Federal Ministry of Environment effluent limit for pH in water for domestic use is 6.0-9.0, while the WHO maximum permissible limit for pH in drinking water is 6.5-8.5 (FEPA, 1991; WHO, 1993). Based on the guidelines, the mean pH of Nwiyi river is within the permissible limit. This result agrees with those obtained by Vandana *et al* (2009). The EC varied from 90mg/l in P4 to 760mg/l at P2; 130mg/l and 420mg/l were recorded at P3 and P1 respectively with a mean value of 350mg/l. The EC values obtained in this study were significantly above the FEPA permissible limit of 20mg/l for EC in domestic water supply. The high concentration of EC in Nwiyi river is of concern as it renders the water unfit for domestic use. EC is a function of the type and quality of dissolved substances in water. Results indicated that as the concentrations of dissolved ions increase, the EC of water increase. The increase in EC level may be due to effluents resulting from various wastes from Ama breweries coupled with other industries that discharge effluents into the river. The value of turbidity ranged from 49NTU at P4 to 190NTU at P2; with 89NTU and 77NTU recorded at P3 and P1 respectively. Turbidity values recorded at the sampling points were significantly higher than the WHO permissible limit of 0-5NTU for domestic use. Turbidity in drinking water is caused by particulate matter that may be present from water sources as a result of inadequate filtration. These particulates can protect micro-organisms from the effects of disinfection and can stimulate bacteria growth (Hunter *et al*, 2009). The high level of turbidity obtained in this study may be attributed to surface runoff along with silt and organic debris resulting from heavy rains. The turbid state of Nwiyi river is of great concern because it allows for microbial contamination which can cause significant damage to humans and animals. TSS was recorded as 14mg/l, 660mg/l, 12mg/l, 12mg/l and 174.5 at P2, P1, P3, P4 and mean value respectively. The maximum value of TSS was recorded at the P1 (upstream from Ama breweries); this could be due to discharge from other industries upstream of AMA breweries. The values for TDS recorded in this study were 450mg/l, 240mg/l 70mg/l and 40mg/l at P2, P1, P3 and P4 respectively. Based on WHO and FEPA maximum permissible limit of 500mg/l and 2000mg/l respectively for TSS and TDS and a limit of 1000mg/l for TDS, the concentrations of TSS and TDS in Nwiyi river are within the permissible limits and therefore pose no adverse effects when used for domestic and recreational purposes. Poor waste disposal and collection efficiency in Enugu urban coupled with industrial effluent discharge gave rise to huge amounts of organic and inorganic substances into aquatic systems (Bashir *et al*, 2004), which in turn increases turbidity, TSS and TDS in the river. The values of total hardness were recorded as 71.6mg/l, 655mg/l, 21.8mg/l and 41.3mg/l at P2, P1, P3 and P4 respectively. Maximum total hardness of 655mg/l was recorded at P2 which could be due to effluents from industries that discharge upstream of AMA breweries. Results showed that the hardness was within the WHO allowable limit for hardness in drinking water. However, this result was

significantly higher than those obtained by Ahaneku *et al* (2014). These significant variations could be due to the concentration of Ca, Mg and Fe ions observed in the study.

The alkalinity of the water was recorded as 860mg/l, 120mg/l, 140mg/l and 100mg/l at P2, P1, P3 and P4 respectively. Similarly, acidity was recorded as 30mg/l, 0mg/l, 4mg/l and 5mg/l at P1, P2, P3 and P4 respectively. The results were within the range of those obtained by Phiri *et al* (2005). The nitrate was recorded as 10.2mg/l, 55mg/l, 6.1mg/l, and 6.8mg/l and19.53mg/l at P2, P1, P3, P4 and mean respectively. In Nigeria, the maximum permissible limit for nitrate in drinking water is 20mg/l. The mean of results obtained was within the limit but can significantly exceed the limit if the trend continues. According to Johns *et al* (1973); Lewis *et al* (1980) and WHO (1993), high levels of nitrate-nitrogen are directly associated with cancer and methaemoglobinaemia or blue baby syndrome; an acute condition which is most frequently found among bottle-fed infants of less than three months of age. Cave *et al* (1999) has also confirmed that nitrate can be used as a crude indicator of fecal pollution where micro-biological data are not available. Phosphate was recorded as 1.06mg/l, 2.1mg/l, 1.2mg/l and 1.4mg/l at P2, P1, P3 and P4 respectively. The FEPA allowable limit for phosphate as P in water system that will reduce the likelihood of algae growth is < 5mg/l, while WHO maximum permissible limit is 0.5mg/l. The results show that the concentration of phosphate was significantly above the WHO standard. Considering the levels of phosphate reported in this study, eutrophication may be a problem especially during treatment as filter clogging may occur (Murray *et al,* 2000). In addition, the growth of blue-green algae could release toxic substances (cyanotoxins) into the water system (Holdsworth, 1991). However, levels of phosphate as low as 0.035mg/l has been reported to cause eutrophication-related problems in temperate zones (Rast *et al,* 1996). The high levels of phosphate reported in this study may be due to industrial effluents coupled with releases from wastes of diverse compositions into the river. Chloride was recorded as 23.4mg/l, 80.1mg/l, 16.4mg/l and 23.4mg/l at P2, P1, P3 and P4 respectively. Sulphate was recorded as 40.0mg/l, 22.4mg/l, 16mg/l and 20mg/l respectively at P2, P1, P3 and P4. The FEPA allowable limits for both chloride and sulphate in drinking water is 250mg/l. Results obtained for both chloride and sulphate were within the permissible limit. At the moment, the levels of chloride and sulphate are normal for domestic use. The concentrations of chloride and sulphate were reported to be higher than the concentrations of phosphate and nitrate, this may be related to the nature of the river which may be rock and suspected to contain some chloride mineral salts.

The DO was reported as 3.4mg/l, 2.4mg/l, 2.8mg/l and 3.8mg/l at P2, P1, P3 and P4 respectively. The DO recorded in this study was within the minimum limit of not < 2mg/l as stipulated by FEPA. Result show an inverse relationship between DO and BOD, as BOD was recorded as 86mg/l, 36mg/l, 25mg/l and 20mg/l at P2, P1, P3 and P4 respectively. According to FEPA, the maximum permissible limit for BOD in water is 15mg/l. Results obtained in this study for BOD were significantly higher than the limit. The COD was 48.5mg/l, 250mg/l, 88mg/l, 60mg/l and 111.63mg/l at P2, P1, P3, P4 and mean respectively. The mean value of COD was significantly above the 80mg/l FEPA permissible limit for COD in drinking water. Both BOD and COD depict the pollution of the river due to pollutants of organic origin. The water level of the river recedes during the summer season thereby decreasing the volume of water and increasing the concentration of organic matter and thus the concentrations of BOD and COD.

Phenol compounds, As, Al, oil and grease, Ni, Cr, Cd, Pb, cyanide and , were analyzed in this study, but were not observed at any concentration. Nevertheless, their no concentrations might not necessary reflected that the river is pollution free. The biota lives in and around the river might have accumulated metals from time to time. However, Zn was recorded as 0.1mg/l, 0.04mg/l, 0.1mg/l and 0.02mg/l at P2, P1, P3 and P4 respectively. The results obtained for Zn in this study was within maximum permissible limit of 1mg/l according to Nigeria FEPA. Fe was reported as 0.2mg/l, 160mg/l, 0.1mg/l and 0.15mg/l at P2, P1, P3 and P4 respectively. According to FEPA, the allowable limit for Fe in drinking water is 20mg/l. The mean of the values was recorded as 40.11mg/l, which was significantly above the permissible limit. Cu was recorded as 0.08mg/l, 0.06mg/l, 0.05mg/l and 0.05mg/l at P2, P1, P3 and P4 respectively. This result was within the allowable limit of 1mg/l for Cu. Mn was reported as 0.05mg/l at P1, P2 and P3, while 0.03mg/l was recorded at P4. This was also within the FEPA permissible limit of 5mg/l for Mn in water. 9.5mg/l, 40mg/l, 1.9mg/l and 1.9mg/l were recorded at P2, P1, P3 and P4 for Mg respectively. This result was within FEPA permissible limit of 200mg/l. Ca was recorded as 13.5mg/l at P2 and P3, while 200mg/l and 5.7mg/l at P1 and P4 respectively. Ca recorded was within FEPA allowable limit of 200mg/l.

Bacteriological Parameters.

Total plate count was recorded as 1420cfu/100ml, 1688cfu/100ml and 2800cfu/100ml at P1, P3 and P4 respectively. Total coliform was reported as 220cfu/100ml, 208cfu/100ml and 810cfu/100ml at P1, P3 and P4 respectively. Results show that both total plate count and fecal coliform were present in the water and above the 0cfu/100ml permissible limit.

V. Conclusion

The study was conducted to analyzed the impact of industrial effluents on Nwiyi river to determine their conformity with standards set by national and international regulatory agencies (FEPA and WHO). The study revealed that the water quality is poor and pollutants of organic, inorganic and fecal origin are entering into the river thereby deteriorating its quality. The results suggest that the effluents being discharged into the river have considerable negative effects on the quality of the river and as such, the water is not fit for human use. Since the violation of effluent standards is significant enough to be of concern to environmental protection agencies and public health, careless disposal of wastes and effluents into the river should be discouraged. Industries operating within the vicinity of the river should install a functional and efficient effluent treatment plant so that wastes and wastewater resulting from their operations are treated properly before being discharged into Nwiyi river.

References

[1]. APHA (1992). Standard methods for the Examination of Water and Wastewater; 16th edition. American Public Health Association. American Water Works Association and water Pollution Control Federation, Washington DC.

[2]. APHA, (1998). Standard Methods for Examination of Water and Wastewater. American Public Health Association, Washington DC.

[3]. APHA (1999). Standard Methods for Analysis of water and wastewater, 19th edition.

[4]. Ahaneku, I.E. and Adeoye, P.A. (2014). Impact of Pit Latrine on groundwater quality of Foko Slum Ibadan Southwestern, Nigeria. British Journal of Applied science and technology, 4(3):440-449.

[5]. Bashir, H. and Kawo, A.H. (2004). Environmental Pollution: A case study of wastewater Effluent parameters of some Industries in Kano, Nigeria. Biological and Environmental Sciences Journal for the tropics 1(1).

[6]. Buchholz, R.A. (1998). Principles of Environmental Management. The Greening of Business, 2nd Prentice-Hall, London, Uk.

[7]. Cave, B. and Kolsky, P. (1999). Well study: Groundwater, latrines and health. Task No 163. Task management and quality Assurance. London School of Hygiene and tropicalMedicine,UK,Loughborough,Univ,Ukavailable:http://www.lboro.ac.uk/well/1999.

[8]. Cornish, G. and Mensahh, A. (1999). Water Quality and peri-urban irrigation report OD/TN95HR Wallingford, Wallingford, UK.

[9]. Culley, Jr., D.D. and Epps, A.E. (1973). Use of Duckweed for Wastewater Treatment and Animal Feed. Journal of Water Pollution Control Fed. 45:337-347.

[10]. FEPA (1991). National Guidelines and Standards for Industrial Effluents, Gaseous Emissions and Hazardous Wastes Management in Nigeria. Government Notice.

[11]. Forum, U. and Entwicklung, C. (2001). Policy Paper for the Bonn International Conference on Freshwater. World Water Conference 4th Dec; Bonn.

[12]. Gersberg, R.M., Elkins, B.V. and Goldman, C.R. (1983). Nitrogen Removal in Artificial Wetlands. Water Research 20:363-367.

[13]. Greenway, M., Woolley, A., Tanner, C.D., Raisin, G. Ho, G. and Mitsch, W.J. (1999).Special Issues: Constructed and Natural Wetlands for Pollution Control.Ecological Engineering, 12:39-55.

[14]. Holdsworth, R. (1991). New Health Consideration in Water Treatment, Avebury Technical, Aldershot. IRDC, Rural Water Supply in China. Journal Int. Research. Dert. Center (IRDC), pp 1-11, Canada.

[15]. Hunter, P.R., Zmirou-Navier, D. and Harteman, P. (2009). Estimating the Impact on Health of Poor Reliability of Drinking Water Interventions in Developing Countries. Science of the Total Environment, 407(8):2621-2624.

[16]. Johns, M.W. and Lawrence, C.R. (1973). Nitrate-rich Groundwater in Australia: A Possible Cause of Methaemoglobinaemia in Infants. The Medical Journal of Australia, 2:925-975.

[17]. Lewis, J.W., Foster, S.D. and Draser, B.S. (1980). The Risk of Groundwater Pollution by On-site Sanitation in Developing Countries, a Literature Review. International Reference Center for Wastes Disposal (IRCWD) Report No 01/82, Duebendorf, Switzerland.

[18]. Murray, K., Du Preez, M. and Van Ginkel, C. (2000). National Eutrophication Monitoring Programme Implementation Manual Draft. Water Research Commission, Pretoria.

[19]. Oastridge, J.W. and Trent, R. (1999). Why is Freshwater an Issue for Business? Background Paper. Can 176-oa.tr. United Nations-CDS, p 9.

[20]. Phiri, O.,Mumba, P., Moyo, B.H.Z. and Kadewa, W.(2005). Assessment of the Impact of Industrial Effluent on the quality of receiving rivers in urban areas of Malawi. International Journal of Environmental Science and Technology, 2(3): 237-244.

[21]. Plant, J.S., David, S., Barry, F. and Lorraine, W. (2001). Environmental Geochemistry at the Global Scale. Journal of Science Direct, 16:1291-1308.

[22]. Rast, W. and Thornton, J.A. (1996). Trends in Eutrophication Research and Control. Hydrological Process, 10:295.

[23]. Vandana, M., Iqbal, S.A., Sobrata, P. and Neelofar, I. (2009). Environmental Impact Assessment of Industrial Effluents on Water Quality of Betwa River Discharged from Mandideep Industrial Area in Madhya Pradesh. Current World Environment, 4(2):327-334.

[24]. WHO (1993). Revision of WHO Guidelines for Drinking Water Quality, Bilthoua, s Netherlands