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Pollution Chemistry of the River Niger and Its Tributaries: Characteristics of Industrial Waste Effluents

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Our studies on the pollution chemistry of the lower reaches of the River Niger a distance of 41 km and its tributaries showed the extent to which the river is being polluted by human activities (agriculture, urbanization and industrialization) through the major tributaries which discharge their waters into the Niger after passing through villages, agricultural plains, and cities.

A number of industries are located near the tributaries and discharge their waste effluents into them directly or through man-made channels. Indirectly during the rainly seasons, industrial wastes ultimately find their way into the River Niger and its tributaries during heavy flooding (Figure 1).

Pollution surveillance is an important program if mankind will be able to enjoy the fruits of his technological advancement because waste products of our industries, if not properly handled, constitute great health hazards. This study attempts to establish the nature and level of non-metallic pollutants which could be traced directly or indirectly to come from the industries situated near these tributaries, and those other industries whose waste effluents eventually get into the Niger. Waste effluents from the following: (Table 1) breweries, paint industries, soft drink factories, a vegetable oil industry and a cotton mill, were analysed for important water quality parameters.

MATERIALS AND METHODS

Samples of effluents were collected between June and December 1989 during production. In each case total effluent over a period of one hour was mixed thoroughly in the effluent system and representative samples were taken for analysis. The analytical samples were collected in clean sterilized polyethylene bottles and preserved at 4°C in the laboratory (APHA-AWWA WPCF 1980: Lawal and Singh 1981).

pH was determined with a Beckman direct reading pH meter, Model 23A (Central Scientific Co. Chicago, U.S.A.). The meter was

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Table 1: Industries near the River Niger and its tributaries showing their products and volume of effluents per day.

Industry	Products	Volume of Effluents per day, (L)
Diamond Breweries (Nig) Ltd., 9th Mile, Enugu	Monarch Lager, Diamalt	180,000
Olympic Breweries (Nig) Ltd., Abagana	Canon Lager	120,000
Premier Breweries (Nig) Ltd., Onitsha	Premier, Master Lager	200,000
Nigerian Bottling Company, Onitsha	Coke, Sprite, Fanta etc. Soft drinks and Carbonated water	190,000
Nigerian Bottling Company, 9th Mile Ngwo (Enugu)	Soft drinks and Carbonated water	180,000
Olympic Bottling Company (Nig) Ltd., Abagana	Gina Soft Drinks and carbonated water	90,000
Rexonoh Bottling Company (Nig) Ltd., 9th Mile, Enugu	Reno Soft Drinks and carbonated water	80,000
Devoe Damex (Nig) Ltd., Oji River	Damex Paints emulsions & varnishes	1,000
Masterpiece Chemicals Company (Nig) Ltd., Oji River	Galaxy Paints, emulsions and varnishes, sale of chemicals	900
Anambra Vegetable Oil Products (Nig) Ltd., Nachi	Cooking oils	150,000
Nigerian Cotton Mill, Onitsha	Textiles and Yarns	250,000

standardized using an acetate buffer at pH 4.0 and a phosphate buffer at pH 9.2 respectively. Alkalinity was determined by titration with a 0.01N H_2SO_4 using phenolphthalein and a mixed indicator of bromocresol green - methyl red. Acidity was also determined by titration. Total solid was obtained by drying known

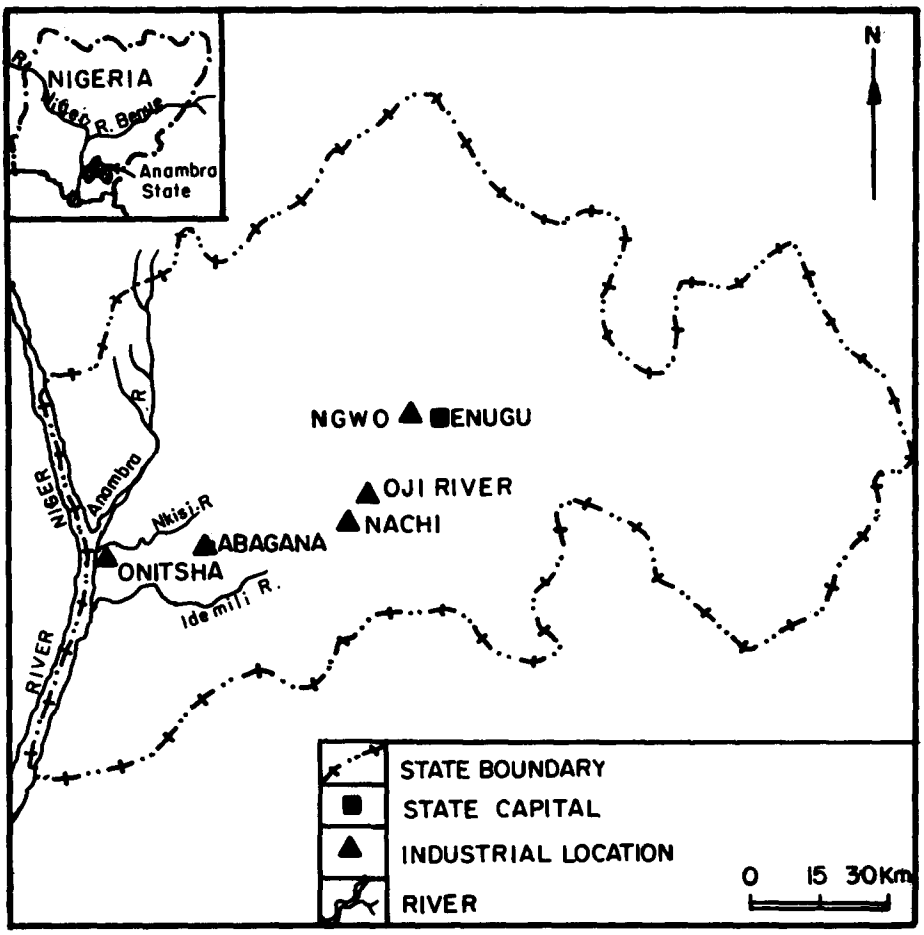

Figure 1: Map of Anambra State showing the River Niger and the industries in the Niger Basin.

volume of effluent at 105 ± 5°C (Hanson 1973). Suspended solids were determined by filtering a known volume of effluent through a glass-fibre membrane filter (0.20 micron). Dissolved solids were calculated from the difference between total solids and suspended solids. Filtered effluents were used to determine total phosphorous by the molybdate blue method and the absorbance measured at 880nm with a Pye Unicam SP 8000 U.V spectrophotometer. Nitrate was determined by the phenoldisulfonic acid method and the absorbance measured at 410nm using the same spectrophotometer (Theroux et al 1943). Dissolved oxygen (DO) and biochemical oxygen demand (BOD) were determined using the azide modification of the Winkler's method on a diluted portion of the filtered sample (Hanson 1973). Chemical oxygen demand (COD) was obtained by the dichromate method (Hanson 1973), while oil and grease were determined by extracting a known volume of effluent with petroleum ether (40-60°C). The extract was evaporated to dryness at 105°C and the residue weighed.

RESULTS AND DISCUSSION

The results are summarized in Table 2.

The PH of effluents from the Beer breweries ranged from 6.34 to 8.00, while the effluents from the soft drink factories varied from 9.28 to 10.10. The effluents from the soft drink factories were more alkaline than the beer breweries. The paint industries were generally neutral, slightly above PH 7.00. Effluent from the vegetable oil factory was definitely acidic as a result of the free fatty acids (ffa) liberated during auto-oxidation.

The PH of the Niger and its tributaries sampled at Onitsha after the entry of the effluents remained fairly constant at the value of 6.3 to 7.3 throughout the year indicating that the PH of the industrial effluents had little effect on the water quality of the rivers.

Sources of water for these industries were derived either from private wells or the municipal supplies when available. These waters were usually treated with excess hypochlorite to sterilize them. The Olympic Breweries added calcium chloride to its brew water to harden it and lower its PH. The high values of chloride (Diamond breweries 165.05mg/dm^3, Olympic breweries 162.60mg/dm^3) attributed to this fact. There are two kinds of solids, namely suspended solids and dissolved solids. For beer breweries, the amount of suspended solids and dissolved solids in the discharge were very close, but much higher than the values obtained from soft drink industries in which the suspended solids were less than dissolved solid in the paint and vegetable oil industries.

The 5 - day biochemical oxygen demand (BOD_5) values, which is an index of gross pollution, appear higher in discharge from beer breweries than in soft drink industries possibly because of greater anaerobic activities involved in beer brewing. The vegetable oil industry and the textile industry showed similar high values when compared to paint industry discharge.

All discharges from the industries studied were high in COD and showed no trend. However, soft drink discharges were lower than discharges from beer breweries, paint or textile industries. The value of 19013.33 obtained from the discharge of the vegetable oil industry is an indication of the stability of vegetable oil to complete oxidation.

Total phosphate also appeared generally high, showing no observable trend. Consequently, it is expected that algae can thrive in the effluents, particularly from the beer breweries and textile mill (Sawyer 1952).

Organic oxidisable nitrogen serves as food for some specific bacteria, and as such enhances biochemical oxygen demand. The vegetable and soft drink industries had higher nitrogen values

Table 2: Characteristics of some industrial effluents in the lower Niger and Anambra Basins

Parameter / Industry	pH	Total Alk. mg/dm	Acidity mg/dm^3	Chloride mg/dm^3	Suspended solids mg/dm^3	Dissolved solids mg/dm^3	Total Solids mg/dm^3
Breweries							
Diamond Breweries (Nig) Ltd., Ngwo	7.6	52.9	115.20	165.0	1769.9	1776.5	546.4
Olympic Breweries (Nig) Ltd., Abagana	8.0	62.3	124.88	162.6	1583.5	1522.1	3105.6
Premier Breweries (Nig) Ltd., Onitsha	6.8	980.0	-	-	-	-	800.0
Soft Drinks							
Bottling Companies:							
Nigerian Bot.Co.Ngwo	9.3	158.1	NIL	105.0	214.6	971.9	1186.5
Nig.Bot.Co., Onitsha	10.3	147.0	-	-	-	-	170.0
Rexonoh Bot.Co.Ngwo	9.5	167.7	NIL	81.0	364.0	535.5	900.0
Olympic Bot. Co Abagana	6.3	7.6	10.6	120.2	35.9	431.9	782.8
Paint Industries:							
Devoe Damex (Nig) Ltd., Oji River	7.3	182.9	52.70	107.7	678.7	525.0	1203.7
Masterpiece (Nig) Ltd., Oji River	7.6	186.8	72.10	112.4	2558.0	308.0	2866.0
Textile Company:							
General Cotton Mill, Onitsha	10.0	1600.0	-	-	-	-	4000.0
Vegetable Oil Co:							
Anambra Vegetable Oil Products (AVOP) (Nig) Ltd., Nachi	4.8	129.7	122.5	145.8	2096.0	519.0	2615.0

Khan, H U (1982).

Table 2: Continues

	BOD_5 mg/dm^3	COD, mg/dm^3	Total Phosphorous mg/dm^3	Nitrate mg/dm^3	Nitrate Nitrogen mg/dm^3	Total Nitrogen mg/dm^3	Oil & Grease mg/dm^3
Breweries							
Diamond Breweries (Nig) Ltd., Ngwo	405.8	5848.7	15.4	33.2	7.9	-	-
Olympic Breweries (Nig) Ltd., Abagana	232.2	1047.1	17.5	19.6	4.4	-	-
Premier Breweries (Nig) Ltd., Onitsha	850.0	1867.0	11.7	-	-	17.2	-
Soft Drinks							
Bottling Companies:							
Nigerian Bot.Co.Ngwo	375.3	1366.4	7.3	41.9	9.5	-	-
Nig.Bot.Co., Onitsha	115.0	261.0	2.9	-	-	5.4	-
Rexonoh Bot.Co.Ngwo	177.5	406.1	5.8	108.3	24.5	-	-
Olympic Bot. Co. Abagana	89.9	344.8	3.2	162.8	36.8	-	-
Paint Industries:							
Devoe Damex (NIg) Ltd., Oji River	97.6	5321.3	10.5	70.8	16.0	-	161.4
Masterpiece (Nig) Ltd., Oji River	59.4	2255.9	1.8	88.6	20.0	-	102.2
Textile Company:							
General Cotton Mill, Onitsha	400.0	807.0	27.6	-	-	29.7	-
Vegetable Oil Co:							
Anambra Vegetable Oil Products (AVOP) (Nig) Ltd., Nachi	416.5	190133	8.6	132.2	29.9	-	1019.2

Khan, H U (1982).

than either the beer or paint industries.

Oil and grease values were measured for the vegetable and paint industries only. The values were understandably high especially for the vegetable oil industry. These results showed that the effluents were grossly polluted and should be treated before discharge. However, the volume of discharge from these industries compared to the volume of water into which they discharge often given wrong impression of the increasing level of pollution. Attempts must therefore be made to limit the pollutants by suitable control measures.

As shown in Table 1, the amount of waste water discharged into the rivers by the Diamond breweries for example, is about 180.00 litres per day. Yet this is but a nominal fraction of the total effluents from all sources within the study area. This volume of waste effluents not withstanding, the volume and the flow rate of the rivers into which they discharge minimize their consequencies.

As would be expected, the chemical oxygen demand was always higher than the biochemical oxygen demand, otherwise, there was no correlation between the two (Singh and Pickup 1975). In general, the nature and volume of the pollution load was a function of the type of industry. For example, waste water discharged from the vegetable oil industry had characteristically high levels of oil and grease, chemical oxygen demand and total solids, but low pH; the soft drink bottling factories were associated with high pH but lower solid content whereas the textile industry effluent had a high alkalinity as well as high total solid. Chloride concentration was highest in the brewery effluents as a result of not only using hypochlorite in the treatment of their well waters but also using calcium chloride in their manufacturing process.

The nature and volume of pollution load was also a function of the batch manufacturing process. Hence the pollution load was bound to be more alkaline, for example, if in the beer breweries, the bottle washing section was more active at the time of investigation than any other section, just like COD and BOD_5 were bound to be higher with brew and fermentation discharges.

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