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Pollution of the River Niger and Its Main Tributaries

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The River Niger system, with a length of about 4200 kilometers, and a discharge volume of 190 cubic kilometers, per year is the third largest river in Africa, and the largest in West Africa. It serves as an important waterway for the transportation of goods and provides rich agricultural flood basins for the cultivation of food and vegetables. Also it is a major source of animal proteins in form of fishes, snails and other aquatics. Above all the River and its tributaries represent the main source of domestic water supply for the rural communities, and water for irrigation. Therefore there is a need to establish the nature and present levels of pollutants in the river, and the contribution made by the tributaries to the gross pollution level.

A number of studies have been reported. Martins (1982) reported on the geochemistry of the River Niger while Nriagu (1986); Livingstone (1963); and Imevbore (1970) provided some chemical data on the upper reaches around and above its confluence with River Benue at Lokoja. Ajayi and Osibanjo (1981) reported on the chemical properties of some tributaries above the confluence of the Niger and the Benue. So far no work has been reported on the lower reaches of the Niger where contributions of the Benue and other major tributaries are significant, and where there are large settlements on its banks and the banks of the tributaries. This work aims at establishing base-line levels of the various pollutants and their sources.

MATERIALS AND METHODS

Figure 1 shows the study area, the sampling points numbered from 1 to 7 and the major tributaries, namely Anambra, Nkisi, and Idemili rivers. Surface water samples for analysis were collected over a period of twelve calender months, covering the rainy season (April 1988 to October 1988), and the dry season (Nov. 1988 to March 1989). The samples were collected mid-stream at depths of about 20cm by dipping the sample containers into the river from a row boat. Four samples were collected from each sampling

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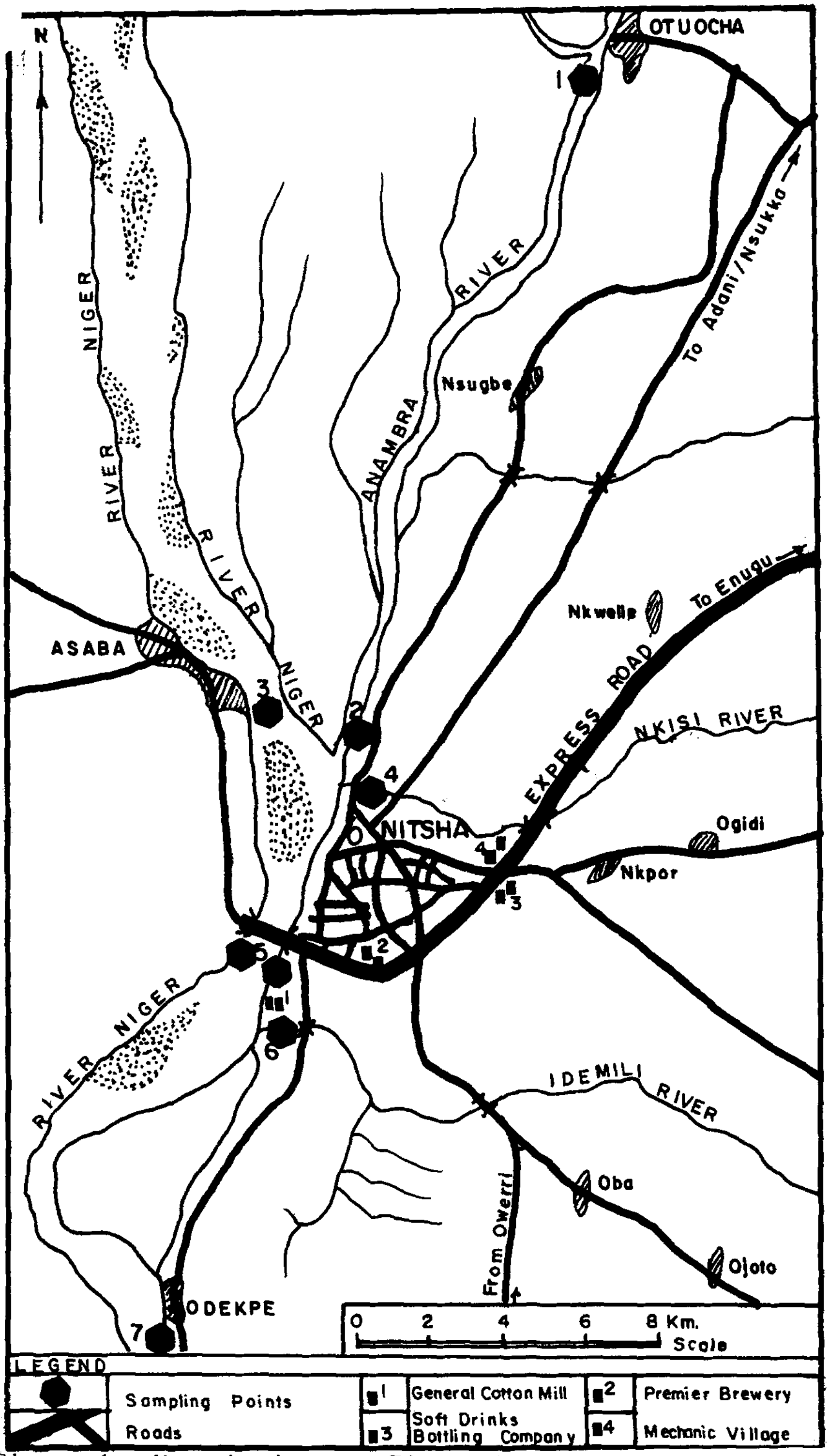

Figure 1: Map showing the River Niger, tributaries and sampling points.

point for the determination of dissolved oxygen (D.O), biochemical oxygen demand (B.O.D), cations and anions and for measurements of pH conductivity, total solids, and acidity. The samples were analysed as described below. Dissolved oxygen and biochemical oxygen demand were determined using the azide modification of the Winkler's method on a dilute sample (Hanson 1973). Chemical oxygen demand was obtained by the dichromate method (Hanson 1973). Total solid was obtained by drying a measured volume of effluent at $105 \pm 5^{o}C$ (Hanson 1973). Suspended solids were determined by filtering a known volume of water through a glass fibre membrane (0.29 micron), drying and weighing. pH was determined with a Bechman direct reading pH meter, model 23 A (Central scientific Company, Chicago), standardised with acetate buffer at pH 4.0 and phosphate buffer at pH 9.2. Alkalinity was determined by titrating with 0.01M H_2SO_4 using phenolphthalein and a mixed indicator of bromocresol green-methyl red. Total acidity was determined by titration with 0.02M NaOH with phenolphalein as indicator. Phosphate was determined using molybdate blue method and absorbance measured at 880nm with a Pye Unican SP 800 U.V spectrophotometer. Nitrate was determined by the phenoldisufonic acid method (Theroux et al 1943). Oil and grease were determined by extracting measured volume of water with petroleum ether (40-60^{o}C) and the residue weighed after drying at 105^{o}C. Silica was determined by colour development using ammonium molybdate and oxalic acid reagents and absorbance measured at 460nm. Ammonia was determined using Nessler reagent and absorbance measured at 525nm. Total hardness was determined by means of EDTA titration using Eriochrome Black T indictor. Calcium hardness was similarly determined using E.D.T.A and murexide; and magnesium by substracting calcium hardness from total hardness.

RESULTS AND DISCUSSION

Table 1 summaries the results of the analyses of the surface waters of the Niger and its tributaries. There is a marked difference in the chemical and physiochemical properties of the rivers during the rainy and the dry seasons. For the Niger, the average water temperatures were generally higher during the rainy season than during the dry season. This is due to surface evaporation requiring heat from the water body. Water conductivities were generally lower during the rainy season than during the dry season. The low values of the conductivities indicate that the rivers do not contain many ions. This is confirmed by the low levels of HCO_3^-, Cl^-, NO_3^-, PO_4^3, Fe^{3+}, Na^+ and Mg^{2+} Sulphate was hardly detected during both seasons; this confirms what Nriagu (1986a) had already reported. While total alkalinity was higher in the rainy season, the total acidity was higher during the dry season. Total solids, and total hardness were higher during the dry season as result of evaporation. However, total hardness was generally less than 40mg/dm^3, as $CaCO_3$ which makes the waters soft and potable (Sawyer and McCarty 1967; Othmer 1970). These levels are below the recommended WHO standard for the quality of raw water for public supply (Cox 1964). Oil and grease values of 3.65mg/dm^3 (dry season), and 8.13mg/dm^3 (rainy season were high compared to the recommended WHO standard of 1.0mg/dm^3 WHO (1971).

Table 1. Baseline characteristics of the river: (Rainy & dry regimes compared)

MEAN VALUES	ANAMBRA #		NKISI *		IDEMILI x		NIGER /	
	R	D	R	D	R	D	R	D
Temperature °C	30.3	27.6	31.1	27.2	31.5	26.5	31.1	29.2
pH	6.8	6.9	6.7	6.6	6.7	6.3	7.3	7.0
Colour, Hazen Unit	15.6	5.3	87.5	40.8	72.5	24.3	29.2	12.3
Conductivity Us/cm	23.6	23.2	50.5	26.0	55.5	35.7	51.5	79.5
Total Hardness mg/dm^3	22.8	18.3	19.8	20.5	27.4	16.1	25.9	32.7
Oil & Grease	17.1	2.2	9.6	2.7	11.0	4.4	8.1	3.7
Total solid mg/dm3	88.9	70.7	223.8	131.0	188.7	97.0	135.7	161.1
Dissolved Oxygen mg/dm^3	6.4	7.3	7.1	6.8	2.3	2.0	7.2	8.5
BOD_5 mg/dm^3	0.4	0.8	2.9	0.1	2.1	1.1	1.8	1.5
COD/mg/dm^3	137.3	52.9	108.5	36.0	142.2	52.8	145.3	107.9
Total alkalinity mg/dm^3	11.6	4.4	14.0	3.7	14.7	5.8	21.4	16.6
Total acidity mg/dm^3	3.2	3.9	2.9	5.7	3.5	9.7	2.6	4.7
Free Carbondioxide mg/dm^3	4.9	3.0	5.5	4.3	8.3	6.8	3.8	3.1
Total carbondioxide mg/dm^3	15.2	6.9	17.8	7.5	19.6	11.4	22.6	17.6
Bicarbonate (HCO_3^- mg/dm^3	14.2	5.4	17.1	4.5	17.9	7.1	26.0	20.2
Chloride as Cl^- mg/dm^3	98.8	57.8	91.1	56.8	65.4	61.2	73.0	62.2
Nitrate as NO_3^- mg/dm^3	26.1	21.9	22.9	31.1	14.1	18.2	25.9	42.2
Phosphate PO_4^{3-} mg/dm^3	3.2	6.2	3.2	7.1	3.0	6.4	3.3	6.0
Sulphate (SO_4^{2-} mg/dm^3	T	R	A	C	E			
Ammonia (NH_3) mg/dm^3	14.0	8.5	10.8	8.5	21.4	9.0	19.3	14.3
Silica, SiO_2 mg/dm^3	0.2	0.3	0.3	0.4	0.3	0.3	0.2	0.3
Sodium mg/dm^3	22.7	19.4	10.9	15.8	21.5	12.9	17.1	15.2

Table 1 Continued

MEAN VALUES	ANAMBRA #		NKISI *		IDEMILI x		NIGER/	
	R	D	R	D	R	D	R	D
Potassium mg/dm^3	4.4	2.2	2.8	1.9	5.5	2.0	4.4	4.7
Calcium mg/dm^3	9.5	1.9	4.5	2.0	8.8	2.6	5.5	3.1
Magnesium mg/dm^3	3.0	1.1	0.7	0.1	2.9	0.4	3.1	3.4
Total Iron mg/dm^3	29.3	18.2	30.7	21.8	30.2	22.0	29.8	18.7

#Average of sampling points 1 and 2; *sampling point 4;
x sampling point 6; / average of sampling points 3, 5 and 7;
R Rainy season; D Dry Season.

The values were higher during the rainy season because of increased shipping activities as well as heavy flooding during the rains, during which surface oil and grease are washed into the rivers. The average pH of 7.0 was within the WHO recommendation of 7.0 to 8.5 for drinking water. The water supports aquatic life and many fishing activities take place in the Niger and its tributaries. The C O D and B O D were elevated during the rainy season as would be expected because of increased microbial activities as well as due to organic pollutants like grease and oil. The dissolved oxygen content was higher during the dry season (8.47mg/dm^3) compared to the rainy season (7.18).

The contributions made to the gross pollution level of the River Niger by the tributaries are obvious (Table 2). The Anambra River, in the course of its journey to the Niger, traversed vast areas of farm land. The Anambra River is relatively unpolluted, although the C O D was around 137.28/dm^3 during the rainy season and 53mg/dm^3 during the dry season. The C O D at the sampling point 1 (122mg/dm^3, for rainy season and 153mg/dm^3 for the dry season) were less than at the point 2 where it entered the Niger. This increase is attributed to organic matters (pesticides, fertilisers, animal wastes, etc) which gradually reach the river before it reaches the Niger. This is also responsible for the elevated values of phosphate and nitrate ions. Total hardness was below 23mg/dm^3 while total dissolved solid was below 27mg/dm^3. This was the level of impurities getting into the Niger at point 2.

The Nkisi and Idemili rivers were relatively more polluted than the Anambra river in terms of their contribution to the pollution of the Niger. The Nkisi river (sampling point 4) enters the River Niger just before the city of Onitsha. Before that, it has experienced human activities in the hinterland, and during the rainy season it is very turbid and brown (87.5 hazen units) due to flooding. The Idemili river on the other hand, took a long detour, entering the Niger near the industrial area of Onitsha. The contributions of Nkisi and Idemili rivers reflect the effects of human settlements and activities. Although the B O D values are

Table 2. Physicochemical characteristics of the rivers at the sampling points

MEAN VALUES		SP 1	SP 2	SP 3	SP 4	SP 5	SP 6	SP 7
Temperature oC	R*	30.0	30.7	30.8	31.1	31.4	31.5	31.0
	D*	27.0	28.2	26.7	27.2	28.5	26.5	30.3
Colour Hazen Units	R	8.5	22.7	26.0	90.0	27.5	80.0	25.7
	D	5.2	5.3	13.7	11.8	24.3	24.3	11.3
Conductivity Us/cm	R	21.5	25.7	51.7	38.8	60.3	46.0	53.0
	D	20.7	25.6	74.0	26.0	101.3	35.7	63.0
Total hardness mg/dm^3	R	27.0	28.6	23.6	19.8	26.2	27.4	27.9
	D	16.1	20.6	32.4	20.5	34.3	16.1	31.3
Oil & Grease mg/dm^3	R	31.6	2.5	4.2	9.6	10.9	11.0	9.3
	D	2.4	2.1	2.5	2.7	5.1	4.4	3.4
Total Solids mg/dm^3	R	63.5	114.3	141.3	223.7	146.1	188.7	199.7
	D	66.0	75.3	187.3	232.3	171.7	9.7	124.3
Dissolved Oxygen mg/dm^3	R	7.1	5.8	7.2	7.1	6.5	2.3	7.9
	D	7.3	7.2	8.4	7.4	8.7	2.0	8.9
BOD5mg/dm^3	R	0.5	0.4	1.4	2.9	1.4	2.1	2.5
	D	0.5	1.1	1.2	0.6	1.5	1.1	1.8
C O D mg/dm^3	R	121.6	153.0	133.4	108.5	163.9	142.3	138.3
	D	41.9	64.0	124.9	28.9	126.9	52.8	129.8
pH	R	6.7	6.9	7.4	6.8	7.3	6.2	7.3
	D	6.8	7.0	7.1	6.7	7.0	6.3	6.9
Total acidity $CaCO_3$ mg/dm^3	R	3.2	3.2	2.0	2.9	2.7	3.5	3.3
	D	4.2	3.5	5.0	5.7	3.8	9.7	5.3
Total alkalinity $CaCO_3$ mg/dm^3	R	9.4	13.8	20.5	14.0	19.9	14.7	32.7
	D	3.3	5.5	17.3	3.7	17.7	5.8	14.7
Free CO_2 mg/dm^3	R	5.1	4.7	3.1	5.5	3.9	8.3	4.4
	D	2.9	3.1	2.6	4.3	3.2	6.9	3.3
Total CO_2 mg/dm^3	R	18.4	16.8	21.0	17.8	21.4	19.6	25.2
	D	5.8	7.9	17.9	7.6	18.8	11.4	16.2
HCO_3^- mg/dm^3	R	11.4	16.9	25.0	17.1	24.3	17.9	28.9
	D	4.1	6.7	21.2	4.5	21.6	7.1	17.9
Chloride mg/dm^3	R	130.9	66.5	70.7	91.1	88.3	65.4	67.1
	D	59.2	56.4	69.3	56.8	60.8	61.2	56.5
K^+ mg/dm^3	R	4.7	4.0	3.7	2.8	4.8	5.5	1.8
	D	1.5	2.8	6.3	1.9	4.4	2.0	3.5
Ca^{++} mg/dm^3	R	5.9	13.0	5.1	4.5	6.0	8.8	5.4
	D	1.5	2.2	7.1	2.0	4.7	2.6	3.1
Mg^{++} mg/dm^3	R	3.1	3.0	2.7	0.7	3.3	2.9	3.4
	D	1.2	1.0	4.8	0.1	3.0	0.4	2.5
Total iron mg/dm^3	R	29.3	29.7	30.7	29.8	30.2	29.8	-
	D	18.3	20.2	21.8	10.7	22.0	20.1	-

R* rainy season; D* dry season

high, the quality of the water is not adversely affected. These two tributaries introduce much solid matter into the Niger. Total solid content of Nkisi river was 223.75mg/dm^3 in the rainy season 188.67 and 97.00mg/dm^3 for the rainy and dry seasons respectively. Sampling point 3 represents the water quality of the Niger before it receives the tributaries and before it passes Onitsha. Sampling point 5 reflects the contributions by the tributaries and urbanisation on water quality. These effects are shown in Table 2. For example, total hardness and C O D were generally increased. All these indicate that the tributaries and human activities are gradually polluting the Niger.

Sampling point 7 shows the effect of self-purification. It is 16 kilometers from Onitsha urban. Water quality at 7 was improved, compared to its quality at 5. Oil and grease levels decreased. Total solids decreased from 145.10mg/dm^3 to 119.67mg/dm^3 (rainy season). Dissolved oxygen (D O) increased from 6.50mg/dm^3 (rainy season to 7.9 (dry season). Although the B O D and C O D have increased they minimally affect water quality. These results indicate that self-purification has gradually taken place.

Judging from the gross pollution parameters, it is clear that the Niger is relatively unpolluted; but it must be stressed that there is a need to monitor the pollution levels continuously because of increasing human activities in and around the Niger. Tributaries and human activities were found to be sources of pollution. The contribution due to urban activities is dominant.

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