Industrial waste pollution in the Kano river basin

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Abstract
Kano river basin, which serves as the main source of water supply to metropolitan Kano, is also used as receiving body for industrial wastes from Sharada and Challawa industrial estates. Of the three major rivers in this basin, the Salanta river was found to receive the highest pollution from the industrial discharges with COD of 8,557.4mg/l, total solids of 16,934.6mg/l, hardness of 1,349.6mg/l CaCO₃, and ammonia of 16,934.6mg/l, hardness of 1,166.9mg/l, total solids of 1,609.9mg/l, ammonia-nitrogen of 5,150.0mg/l. The Challawa river had COD of 598.7mg/l, total solids of 1,458.0mg/l, hardness of 1,332.0mg/l CaCO₃, and ammonia-nitrogen 400mg/l. Both empty into the Kano river where the COD was 1,116.9mg/l, total solids 1,458.0mg/l, hardness 2,506.8mg/l and ammonia-nitrogen 530mg/l. Although these rivers are being used extensively for water supply, irrigation, and fishing, the quality of the water was found to be unsuitable for these purposes. The paper suggests that waste water pre-treatment by all industries, imposition of direct charges on industrial effluents by the regulating agency, as well as continuous monitoring and surveillance are required to ensure the protection of the water resources in the basin.

Introduction
Industrial waste and water resources pollution
The world industrial development is increasingly necessitating focus on the problems of the environment. Water resources is one such environment continually being threatened with devastation by industrial wastes. In third world countries, the industrial pollution problems are comparable to those in the industrialized nations (Hardoy et al., 1992). The Global Environmental Monitoring System (GEMS) of the United Nation Environmental Programme (UNEP) has reported heavy pollution in several rivers in Chile, China, Japan, Mexico, Panama, The Philippines, and Turkey (UNEP, 1991).

In Nigeria, Oluronotola (1990) has reported gross industrial pollution in Ologe Lagoon; Nwaogazie (1990) has recorded textile effluent pollution in Imo and Bonny Rivers in Port Harcourt; and Beecroft et al. (1987) have reported that untreated industrial effluents constitute up to 75 percent of the dry season flow of the River Kaduna. UNDP (1978) and Bichi (1993) have indicated that the dry season flow of River J akar in Kano is almost entirely made up of sewage and industrial waste discharges.

Industrial wastes in the Kano River basin
Kano City is located on the main water shed which separates the two main river basins in the metropolis (Figure 1). The J akara River basin in the North comprises the J akara River and its main tributaries – Gogau, Tukurawa, Govagwarwa, Rafin Mallam, Tsakama, Cijaki, and Getsi. The J akara River basin lies to the south of the water divide. The basin is being drained by Rivers Kano, and Challawa, and their tributaries – Watari, Y’arkuto, Tatsawarki, and Salanta. The main industrial areas of Kano – Bompai, Sharada, and Challawa – are located within these two river basins.

In the Kano river basin, Rivers Salanta and Tatsawarki remove the waste waters from the entire Southern part of Kano (Figure 2). In addition, all the waste waters from the Sharada and Challawa industrial estates are drained by this basin. According to the Ministry of Trade and Industry (1990), Challawa and Sharada industrial estates comprised of 14 tanneries, 11 textiles, and over 20 food processing industries. In addition, there are 30 aluminium, metal and wood processing factories; 25 plastics, rubber and tyre factories; and over 15 chemicals and cosmetic products industries. Most of these industries do not have adequate waste treatment facilities.

The basin, besides being used for extensive irrigation of rice, wheat, and vegetables, is the main source of water for metropolitan Kano, serving a population of 2.8 million people.

The Challawa water works, which has three treatment plants, derives its raw water from this basin. The 10M lpd plant uses surface water from River Challawa; the 120M lpd second plant uses surface water from Kano River; and the 90M lpd third plant utilizes ground water from the Kano river bed. The Tamburawa treatment plant with a capacity of 30M lpd is supplied from tube wells drilled into the Kano river bed just after the Challawa-Salanta confluence (Figure 2). The 30M lpd Wudil plant is also supplied from tube wells drilled into the Kano river bed at Wudil.

The increasing discharge of industrial wastes in this river basin is posing serious danger to the water resources and the health of the people in the area.

Methodology
The sampling program spanned for a period of nine months (January-September 1995), covering the two main seasons – dry and wet – in Kano. Five sampling locations were...
selected, two on River Salanta at railway bridge (SH1) and at Kumbotso-Tamburawa road bridge (SH2); one on River Challawa at Challawa intake works (CR); and two points on River Kano – at Challawa water works intake (KR1) and at Kano-Zaria road bridge (KR2) (Figure 2). For each sampling point, three samples were collected during the dry season, being the critical period with no significant dilution of the wastes, and two samples were collected in the rainy season.

The colour, odour, temperature, PH, conductivity; suspended, settleable, dissolved, and total solids; acidity, alkalinity, hardness, calcium, magnesium, chlorides, ammonia-nitrogen, and chemical oxygen demand (COD) of each sample were determined. In addition, chromium and sulphide of some tannery wastes were also determined.

The method used for the laboratory analysis are those contained in the Standard Methods for the Examination of Water and Waste Water (APHA et al., 1985). In each analysis, two tests were carried out on the sample and the average value taken as the parameter value for the sample.

Discussion of results

The results of the laboratory analysis are summarised in Table I – indicating the average values of the various parameters over the sampling period. These results are discussed according to the three main rivers in the basin.

River Salanta

There were two sampling points on this river. At the railway bridge (SH1) the waste water comprised of mainly tannery wastes from Sharada. The waste water was dark blue in colour with an offending pungent smell. It was characteristically alkaline with an average pH of 9.02. The COD showed high variability reflecting the time of discharge of tannery effluents and dyeing brothes. The waste water had scum with very high solids content. This was particularly responsible for the high solids (16,934.6mg/l) and COD (8,557.4mg/l) of the river at this point. The hardness (1,349.6mg/l CaCO₃) and ammonia-nitrogen (5,150.0mg/l) were quite a lot higher than the recommended values of 90mg/l CaCO₃ and
2.0mg/l respectively, set for irrigation waters (Aikman, 1983). The sulphide content (130.5mg/l S⁻) and chromium (0.09mg/l Cr²⁺) were particularly high, confirming the character of tannery effluents.

Downstream of this sampling point, at the Kumbotso-Tamburawa road bridge, is the second sampling point (SH3). At this point, the waste water comprised of the flows from sampling point SH1, and a number of other smaller drains from the industrial and the neighbouring residential areas. Also, river Tatsawarki, which drains a greater part of the South-eastern Kano metropolis, joins the flow of Salanta river before this point. The effect of dilution has therefore greatly reduced the conductivity (208.9 umho/cm), alkalinity (2,295.9mg/l CaCO₃), magnesium (130.4mg/l), chlorides (462.2mg/l), COD (1,224.1mg/l), and ammonia-nitrogen (1,1980.0mg/l) contents of the water compared with the previous values of 454.3 umho/cm, 5,123.0mg/l CaCO₃, 150.3mg/l Mg²⁺, 724.7mg/l Cl⁻, 8,557.4mg/l O₂, and 5,150.0mg/l respectively at sampling point SH1 upstream.

The pH is also lowered from 9.0 to 8.3. However, the acidity (175.6 mg/l CaCO₃), hardness (1,946.0mg/l CaCO₃), and calcium (1,409.3mg/l Ca²⁺) contents show increasing values at this point compared with 131.8mg/l CaCO₃, 1,349.6mg/l CaCO₃ and 730.1mg/l Ca²⁺ respectively at the upstream point (SH1). This could be due to the discharge of effluents from other industries with high concentration of these pollutants.

The values of these parameters are quite excessive of the maximum allowable limits for domestic water (WHO, 1971) and irrigation waters (Aikman, 1983; Ranganathan, 1982). At the point where this river discharges into the Kano river, the difference in water quality is quite clear in terms of the appearance of the water in the dark Salanta River and in the clearer Kano River which is composed of mainly releases from Tiga dam reservoir in the dry season.

River Challawa
This river has very low flows during the dry season. The Challawa Gorge dam currently

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Figure 2
Industrial areas within the Kano river basin
nearing completion is to sustain the river flow all year round. The water is alkaline with a pH of 8.3. The average values for hardness (1,332.0mg/l), calcium (446.6mg/l), magnesium (161.2mg/l), and ammonia-nitrogen (400 mg/l) are higher than the maximum allowable values of 500mg/l (hardness), 200mg/l (calcium), 150mg/l (magnesium) and 0.5mg/l (NH$_3$-N) for domestic waters (FEP A, 1991). The values for chlorides (151.8mg/l), hardness (1,332.0mg/l), and ammonia nitrogen (400mg/l) are also in excess of the maximum allowable limits of 70mg/l, 90mg/l, and 2.0mg/l respectively set for irrigation waters (Aikman, 1983; Ranganathan, 1982).

This sampling point is, however, upstream of the effluent discharge point from the Challawa industrial estate into the river. The effluents discharged down stream of this point contribute to the pollutional load at sampling point KR2 on the Kano River.

River Kano

Two sampling points were located on this river. Sampling point KR1 was upstream of the effluent discharge point into the river and therefore composed essentially of the water releases from Tiga dam. Sampling point KR2 receives the waste discharges from both Challawa and Sharada industrial estates as well as domestic wastes from the southeastern part of Kano through Rivers Tatsawarki and Salanta. The concentrations of NH$_3$-N, COD, calcium, magnesium, conductivity, and hardness were 123.0mg/l, 223.3mg/l, 1056.3mg/l (Ca$^{2+}$), 159.7mg/l (mg$^{2+}$), 340 umho/cm, and 1,713.4mg/l CaCO$_3$ respectively at sampling point KR1. At sampling point KR2 downstream, these values were 530mg/l, 1,166.9mg/l, 1,224.7mg/l Ca$^{2+}$, 263.0mg/l (mg$^{2+}$), 446.4umho/cm, and 2,506.8mg/l CaCO$_3$ respectively. This indicates higher pollution at KR2 due to discharges of more domestic and industrial wastes through Rivers Challawa and Salanta to this point. The chloride content averaged 236.8mg/l and 193.4mg/l respectively at sampling points KR1 and KR2.

Table I

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<tr>
<th>Parameter</th>
<th>KR1</th>
<th>KR2</th>
<th>CR</th>
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Conclusion and recommendations

The Kano river basin, which serves as a source of water supply to the 2.8 million population in Kano, and irrigation in the Kano River project phases I, II, and III, is receiving considerable pollution from the Sharada and Challawa industrial estates. River Salanta receives the highest pollution (8.557.4mg/l (COD), 16,934.6mg/l (total solids), 454.3umho/cm (conductivity)), from the industrial wastes. The Challawa River, with low flows in the dry season had 598.7mg/l COD, 1,609.9mg/l total solids and 207.5 umho/cm conductivity. Both discharge in to the Kano River in which the COD was 1,166.9mg/l, total solids 1,458.0mg/l,
conductivity 446.4mg/l and hardness 2,506.8mg/l, just down stream of the discharge point. Although the river is used for water supply, recreation, irrigation and fishing, the quality of the water was found to be unsuitable for these uses.

In order to arrest further deterioration in the quality of water in this basin, towards the improvement of its usefulness, the first major step is the compulsory pre-treatment of all industrial and domestic wastes, to acceptable standards, before final disposal into receiving water courses. To ensure this, FEP A should impose direct charges on industrial effluents as an incentive for polluting industries to reduce waste loads. There is also the need to establish a monitoring and evaluation unit to ensure continuous surveillance of the waters in the basin.

References
APHA, AWWA, and WPCF (1985), Standard Methods for Examination of Water and Waste Water (18th edition), American Public Health Association (APHA), American Water Works Association (AWWA) and Water Pollution Control Federation (WPCF), New York, NY.
Hardoy, J.E., Mitlin, D. and Satterthwaite (1992), Environmental Problems in Third World Cities, Earth Scan, London.
UNDP (1978), Kano Sewerage and Drainage Project, Master Plan Report; United Nations Development Programme (UNDP) Project NIR/75/102, Annex A.