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HUMAN HEALTH AND ENVIRONMENTAL RISK ASSESSMENT OF THE ALAKIA INDUSTRIAL DISTRICT OF IBADAN, SOUTH WEST NIGERIA

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ABSTRACT

A scientific survey was conducted in February 2002 in three communities (Majawe, Osun-Abolowojaiye and Papa Adogba) communities of Alakia Industrial district of Ibadan to determine the extent of the damages caused by the negative impact of the industrial effluent discharges into the Elesin stream and emissions of gaseous pollutants into the atmosphere within the three communities. A socio-economic survey was also carried out to establish the impact(s) on human and livestock populations of the study area. A sample of non-affected areas served as control for comparison. The degree of pollution was established by the determination of the concentrations of the metals including Pb, Ca, N, K, Cd, Fe, Zn, Ca, Cr, Mn, Na, Mg, a specific non metal phosphorus as well as chlorides (Cl^-) and Nitrates ($N0_3^-$). The study established the presence of metals in concentrations higher than the recommended limits in effluent discharges in all the samples in the study area and a clear link between the effluent discharges and pollution with its severe damages in the area.

INTRODUCTION

Eighty percent of the industries in Nigeria discharge solid waste, liquid effluents and gaseous emissions directly into the environment without any treatment. A survey of 200 randomly chosen industries in Nigeria indicated that only 18% perform even rudimentary recycling prior to waste disposal (FEPA, 1998). The scenario points to a growing problem of industrial pollution that threatens the health of the ecosystem and humans.

The location of industries like the pharmaceutical companies and the breweries indirectly undermines human health by introducing poisons such as metals at higher than safe limits into industrial effluents with adverse consequences on the ecosystem. For example, literature indicts ammonia, a major constituent of spent brewery water as causing substantial damage if not properly controlled (Ajayi and Osibanjo, 1981; Osibanjo, 1996). Similarly, the presence of heavy metals at higher than safe limits poses serious health problems (Towill, 1978). The first thing we noticed about the Elesin stream that runs a perpetual stench and the permanent brown (dirty) colour of the water starting from the point where the industrial effluents joined the stream (point A in Figure 1). Also, a walk through the streets of the three communities revealed some peculiar stains on corrugated iron roofing sheets and other metallic gadgets such as wire nettings of windows. The stench spanned the stream as far as can be traced.

In addition to this, the people showed the levels of flooding reportedly resulting from massive effluent discharge especially at night. They believed that the peeling paints on the walls of their houses, the cracks on walls and the punctures on their roofs were probably due to corrosive substances present in the effluent.

The Study Area

Ibadan is one of the largest cities in Nigeria and Africa. The Alakia area of the city, comprising of three fast growing communities of Papa Adogba, Majawe and Oshun Abolowojaiye are located on the outskirts of the metropolis between latitude $7^{0}20^{1}$-$7^{0}25^{1}$N and longitude $4^{0}00^{1}$-$4^{0}10^{1}$E. The sample points are shown in figure 1. Some industries including Premier Agro oils Nigeria Limited, Sword Sweet Limited, Ashmina Pharmaceutical Company Limited and Nigerian Breweries Plc, are located within these communities. They discharge effluents into Elesin stream, which runs through the entire length of the area.

Vegetation

The vegetation includes shrubs, scanty trees, grasses, and weed. Scattered palm trees are found growing naturally.

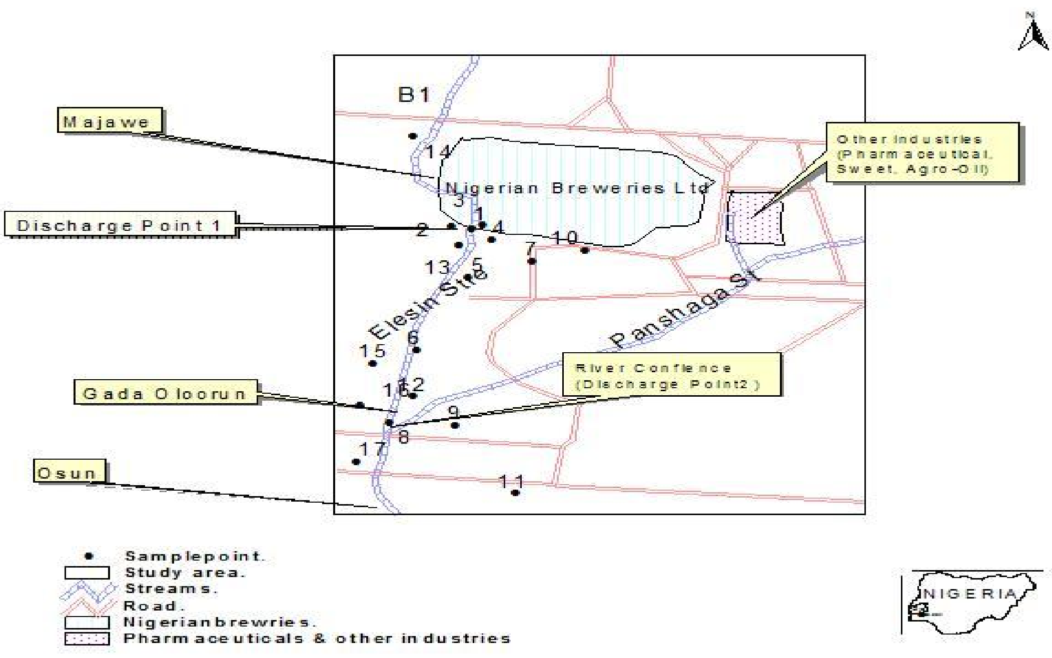

Figure 1: Study Area showing sample points

Some of the palm trees are dead. About 5% of the area under investigation is cultivated. The cultivated area falls mainly on the extreme end of Papa Adogba (figure 1). Majawe and Osun communities are not cultivated. Cocoyam, plantain, banana, maize and vegetable crops such as lettuce, *amaranthus, celosia* (sokoyokoto) are cultivated. From observation, the banana fruits appeared tiny and not filled out. The land at Majawe and Osun communities was not cultivated due to low productivity of crops. Farmers therefore abandon farming in the areas. The death of the aquatic organism in the river near the brewery was traced to the effects of the untreated effluent from the industries.

METHODOLOGY

Three communities namely Majawe, Osun Abolojaiye and Papa Adogba of Alakia in Ibadan were visited in February, 2002. The objective of the visit was to make a preliminary assessment of the extent of possible damage the breweries and other industries discharge existing in the above communities might have caused on the people and the environment.

Study location layout

Figure 1 illustrates the site of industries in relation with the ecology and the sample points. The Brewery industry treatment plant is located at the lower end of the shaded area at point "A". The effluents from the treatment plant are discharged through two channels constructed to pass under the factory fence leading to a nearby Elesin stream. The water from the upstream (B1) appeared colorless, while water discharged from "A" had cream color. The upper stream flows slowly, but from the point of effluent discharge to the downstream, the water flow rapidly indicating constant discharge from the factory. The extent of assessment was about 2 km from point "A" along the downstream area.

Socio-economic situation

In the socio-economic survey conducted in February 2002, focus group discussions were held with each community at which men and women inhabitants expressed their opinions and gave historical information on their villages, the changes they noticed over time, especially before and after the industries were established. The discussions provided useful ideas on which were based questionnaires that were later administered to selected individuals in each community and adjacent villages as control. In the same month, an enumeration was conducted covering 50 persons each in Majawe and Osun Abolowojaye, 80 in Papa Adogba and 100 as control from several communities outside the area drained by Elesin and Panshaga streams. The results presented below show the frequencies and estimates made by the respondents. A second stage of the investigations was carried out to obtain details of losses of crops, livestock and other properties that were not covered in the quantity survey. This involved every household in the three villages.

In this exercise, we carefully interrogated the householders and prevented exaggerations even though we could not, in most cases, observe the dead animals. The empty cages that once housed chickens provided visible evidence while the absence of roaming or scavenging goats or sheep told a confirmatory story of losses or inability to sustain their production.

Soil Sampling

Eight soil composite samples were taken in two depth ranges of 0-20 and 20-40 cm, and at random at 3 and 100 m to discharge point "A" at Majawe and from several points 5 m on either side of the stream bank on the land of Osun and Papa Adogba communities. Soil samples were also taken at the up stream at Isebo community to serve as control. The chemical constituents including heavy metal contents of the soil samples were analyzed following the standard methods (APHA, 1989; Jain and Bhatia, 1987; Suess, 1982).

Plant Sampling

Nine plant samples of some of the existing foods, fruit and vegetable crops cultivated on the inland valleys were taken for laboratory analysis and analyzed for heavy metal contents and some nutrients.

Water Sampling

Water samples from the Elesin stream were taken upstream, marked "B1" in Figure 1. Samples were also taken at point "A" where the effluent discharge from the breweries joined the body of the stream. Well water (drinkable and non drinkable) located at about 10 and 50 m away from the polluted stream in the downstream direction was also sampled. Sampling was equally made at the point of discharge directly from the factory, 5 m, away from the discharge point and at two points each in the Osun and Papa Adogba communities. The sample locations are numbered 1-17 in Figure 1. Most of the wells dug close to the stream were abandoned due to bad odour, taste and harmful effect of the well water. The odour of the polluted water was highly unpleasant and obnoxious.

RESULTS AND DISCUSSION

Socio-economic survey

The results of the survey of samples of individuals in the three communities and the control are presented in Tables 1 to 13.

Table 1 shows the structure of families in the study area indicating that on the average there are about 16 persons in each household in Majawe and Papa Adogba while there were 15 persons in Osun and 13 in the control. These family compositions averaged 5 male adults, 4 female adults, 2 male and 3 females aged 7 to 14 and one each male and female of less than 7 years of age in Majawe. The pattern in Papa Adogba reveals approximately 4 males and female adults each, 3 males and 2 females of age 7 to 14 while children aged less than 6 averaged one and a half or 3 in two families. For Osun there were on the average, 3½ male and female adults, 3 male and 2 females aged 7 to 14 and 1½ male plus one female of less than 7 years. The control communities showed 3-4 males as adults, 3 females as adults while there was 2 each male and female aged 7 to 14 and one each of ages 0 to 6.

The implication of these patterns is that many houses include several tenants such that there may be two or three men and their wives living in the same house as well as children. In Ibadan, the house owners often sub -let portions of their houses.

Table 2 sought to identify the key sources of potable water in view of the critical role of water in the lives of the people. All communities except Osun identified wells as the principal source of potable water. The range of questionnaire responses was from 33% for Osun to 94 % for the control. Thus, when unsure of Water Corporation Supply, most inhabitants dig wells to source water for domestic use. The next most important source of water for the affected communities is processed water (purchased) delivered by tankers plus the new pure water packs being sold by entrepreneurs in Ibadan. Further investigations showed that the tanker delivery of water was a recent measure taken by the communities to reduce the health hazards of using polluted water. Bundles of receipts were shown to the investigators who were told that the communities were purchasing water collectively. There is distinctively less purchase of water in the control communities where wells are not contaminated.

The lowest average of ₦71.0, ($1.00 = N80.00) was recorded as amount spent per week on water in the control communities while Osun had ₦393.84, Papa ₦547.14 and Majawe ₦599.45. The range of reported expenses is scaring, from ₦30.00 to ₦3,000.00 per week. We gathered that the principal sources of water for the various uses in the villages were Osun and Elesin and Akinfenwa streams. Until pollution stopped them, the villagers collected water freely from these streams. The Akinfenwa stream continues to serve the purpose for the control areas.

As shown in Table 3, the uses of streams ranged from washing plates (2%), drinking (16%), bathing (20%), washing clothes (26%) to cooking (28%) in Majawe. Fewer respondents reported that they used stream water for these purposes in Papa while they were much higher in Osun as 28% said they drank, 39% used the water to cook, 49% used it for bathing and 55% washed clothes with it. There were 2% who reported irrigating crops (vegetables) with the water. However, there is a sharp contrast in the control communities where only 1% recorded the use of stream water for any of these purposes.

In Table 4, the non-usable sources were reported with higher percentages for well water. The reasons given were pollution bad smell or taste. Again such reasons were not applicable in the control areas. Thus it is clear that the effects of effluent discharged from the brewery denied the villagers of clean water for domestic uses and forced them to spend extra money to purchase water per family as presented in Table 5. In Majawe, the respondents reported an average of ₦129.80, varying from ₦10.00 to ₦300.00 while the respondents in Papa gave ₦88.07 ranging from ₦21.00 to ₦357.00 and in Osun, ₦83.24 varying from ₦21.00 to 240.00. There was no report of expenditures from the control communities. Such expenses did not have to be incurred if the water in the stream and especially the wells were clean and usable.

Table 6 captures the sanitary habits of the people of the community. The most commonly used mode of disposing faecal materials is pit latrine for both adults and children. There were about 30 percent using water closet. It is to be noted that where fewer people (8.2%) employed water closet in Osun, much higher percentage (77.6%) used pit latrine. The 15% of respondents at Papa and 14% of respondents at Osun who defecates in bushes leave much to be desired. Their habits could be responsible for some of the identified health problems presented in Table 7.

The sampled members of the communities were asked to indicate the most frequent infections and diseases noticed in their families. Their responses and those of the control communities are presented in Table 7. The results need to be closely studied, as those who suffer cannot easily describe some of the effects of heavy metal contamination.

The table shows that worms, dysentery, diarrhea cholera and typhoid which were common could be the result of poor sanitary habits of the people while rashes, skin infections, hepatitis are probable outcomes of polluted water and air. Malaria is carried by mosquitoes and its incidence can be higher where stagnant water is available for mosquito breeding. As shown in chemical analysis report, eye problems could be linked to heavy metal poisoning. There were only 4% of respondents in Majawe and 8.2% of respondents in Osun reporting eye problems. Although the cause of death can only be definitely established through post mortem examination, the frequency 14.3% in Osun and 4% in Majawe suggest a need for closer look. If the pressure of higher than standard levels of certain heavy metals (cadmium, chromium, lead), in water, soil or plant tissues could result in kidney damage, liver damage and brain damage, then a case can be made for their effect in causing more deaths than normal in the communities. Brain damage can cause many defects, among which are eye problems. There were several blind or semi-blind persons who traced their misfortunes to the pollution in the area.

In Table 8, the respondents provided their opinions on suspected causes of the diseases shown in Table 7. Water pollution, with between 58 and 88 percent frequencies was the most commonly cited. This is closely followed by air pollution. But in either case, the control communities did not indict these sources.

The respondents were sincere enough to mention dirty environment while the control communities felt that mosquito bites and malaria as well as unsafe sources of water were responsible. There were those who claimed that they had no idea which is an honest statement. Unfortunately, such people may inadvertently, cause harm to themselves by their habits.

In Table 9, is illustrated the loss of useful working time arising from various illnesses that the people suffered. The average number of weeks that the illnesses lasted was lowest in Osun with 6.2, while it was 7.6 in Papa Adogba and the control communities. The highest was Majawe with 8.9 weeks. The reported range was from one to 104 weeks.

On the other hand, the average expenditures were lowest in the control communities with ₦5,136.36 ranging from ₦1000.00 to ₦30, 000.00. In Majawe the expenses averaged ₦7,522.62 and ranged from ₦400.00 to ₦70,000.00. The highest average expenditure was ₦24,172.20 ranging from ₦175.00 to ₦200,000.00. These expenditures depended not only on the duration of illness but on the nature, complication and required curative processes.

Apart from the period of sickness, recovering invalids often lack the capacity to work. This is the reason why we sought to know how much work time they lost on the average. Table 10 shows that respondents in the control group lost 4 weeks while Papa Adogba group lost 6 weeks. Those in Majawe reported an average of 14 weeks while the people of Osun indicated an average of 39 weeks. This relatively higher average loss could be as a result of few large losses of up to 260 weeks. The ranges were 1 to 12 weeks in the control, 1 to 104 weeks in Majawe and Papa and one to 260 weeks at Osun. Such losses of useful working time tend to reduce the earning capacity of the people concerned tending to make them poorer.

The damages suffered with respect to the house roofs, wells as well as various livestock were indicated in Table 11. This shows the frequency of respondents who reported losses while only 6 percent of the control group of communities reported crumbling roofs, 37.5 percent in Papa, 52 percent in Majawe and 91.8 percent in Osun reported the damage to their roofs.

In the case of wells, no problems were noted in the control communities, whereas, 15, 38 and 41% respondents in Papa, Majawe and Osun communities stated that their wells were useless. Lost farm crops ranged from frequency of 1% in the control to 6.3% at Papa, 14% at Majawe to 35% at Osun village. A keen observer would notice that the Elesin stream banks were not actively cultivated for high valued irrigated vegetables that usually command good prices in the dry season in Ibadan. This neglect is attributable to the pollution occasioned by the effluent discharged unto the stream by the neighbouring industries.

The number of respondents who complained of loss of goats, sheep and chickens ranged from 10% in Papa Adogba to 61% in Osun Abolowojaye. Such complaint in the control communities was from only 5.6 percent.

The community respondents were asked to state whether they had been forced to re-roof their houses and if so what were the circumstances. The responses are collated in Table 12 where 45% Osun, 52% Majawe and 65% Papa Adogba confirmed re-roofing their houses. Only 8 percent of the control communities said they re-roofed. On the contrary 46% in Majawe, 20 percent at Papa, 4 percent in Osun and 66% of the control said they did not have to re-roof houses. The reasons given for re-roofing were mainly damage and leakages. In the control, a few said their roofs were blown off. The period during which these re-roofing activities took place was between 1990 and 1998.

A rough estimate of average and range of expenditures on the re-roofing was sought. The least recorded average was N5,566.60 among the control groups while the average in Papa area was N17,431.91. There was an average of N21,082.14 in Majawe while the highest average was N25,814.77 at Osun Abolowojaye. These expenses varied from as low as N500.00 in Osun to as high as N150, 000.00 in the same community.

As a final general observation, the respondents were asked to give general comments about the environmental situation. The responses were mixed but they reflect the preoccupations of the various groups. Water and air pollution worried the people of the three affected communities most while only 9 percent of the control mentioned water pollution. About 20 percent of the respondents at Majawe and 26 percent in Osun suggested proper disposal of wastes. Pipebone water was requested as a means of reducing the impact of the polluted water on the health of the people. Curiously some respondents in the affected communities felt that the environment was fair if the effluent discharge was removed. A consequence of the negative impact of the pollution is the reported desertion of the villages by some people. Some of such people with whom we made contact said they left on medical advice.

Summary of socio-economic findings:
Our socio-economic survey confirmed that there were no major differences in family

structures of the various communities though the people in the control areas appear to have two persons fewer per household than the affected communities.

The main sources of potable water were wells which when polluted forced the people to purchase water in tankers or pure water packs for direct drinking. There was a clear difference between the quantities of water purchase among the affected communities when compared with the control group who, because of functioning wells, did not have to spend so much on water.

Before the advent of severe pollution, the inhabitants used the streams, Osun, Elesin as their main sources of water for domestic use. But at this point in time, such uses have been curtailed and even irrigation of vegetable crops in dry season farming is rarely practiced. The effluents from the brewery and other industries in the neighborhoods with its permanent occur, its unpleasant colour and the confirmed poisonous contents has thus denied the people of free natural water for their daily domestic uses.

The people of the three communities reported average daily expenses on water ranging from N83.24 to N129.80.

The sanitary habits of the community reflected that they used pit latrines most frequently while a relatively small percentage used the modern water closet system. Indeed, even if they could afford the use, lack of pipe borne water would deter its use as is the situation in most high density areas of Ibadan city. The most frequent infections and diseases among the families included round worms, dysentery, cholera, typhoid and diarrhea which could result from poor sanitary habits while rashes, skin infections, hepatitis are probable outcomes of polluted air and water. Malaria would be common where pools of stagnant water allow mosquitoes to breed. Heavy metal contaminants are, however, indicted for kidney, liver and brain damage that could lead to eye problems or death. Many deaths were reported in the area.

The loss of useful working time is an important opportunity cost of illness. This was recorded for the villages and found to be much higher than the case of control communities. Attempts were also made to calculate average expenditures on illness and these ranged from N5,136.36 in the control area to N24,172.20 in Papa Adogba. In all cases, the affected communities spent more than the control groups.

Roof top crumbling was a common feature of the effect of air pollution in the communities. While only 6 percent of the control reported such damage, the affected communities had frequencies ranging from 37 percent to 92 percent. This is another glaring evidence of impact of pollution on the people and their environment.

Among the control communities, nobody complained of abandoned, useless wells whereas up to 35 percent of the people in the affected areas had to abandon their wells, especially those close to the course of the polluted stream.

Far more people in the affected communities complained of loss of goats, sheep and chickens than those of the control areas. In Osun village, 45 percent of our sample reported that they had no re-roof their houses while 52 percent were similarly compelled in Majawe and 56% at Papa Adogba. Such re-roofing was reported to cost an average of N17,431.91 at Papa, N21,082.14 in Majawe and N25,814.77 at Osun villages, respectively.

Chemical analysis of water, soil and plants water

Table 14 shows the results of the chemical analysis of water samples in the affected communities. The pH was acidic (5.35-6.65) which does not fall within the permissible range of between 6.5 and 8.5 (WHO, 2004) and those of control sample (Table 4). The samples showed pH>6.5 with exception of that from Papa Adogba well (pH 6.65) which contained very high Na (315mgL^{-1}). At the effluent discharge point, the pH was 5.6 and 300 m away from the discharge point, pH was 5.35. The well water had a pH ranging from 6 to 6.65 while that of stream water ranged from 5.60 to 5.80. In all cases, the stream water had a pH>6 (Table 14).

Heavy metals such as Pb, Cr, Cu, Ni and Mn were relatively higher in most of the water samples than WHO standards and those of control sample (Table 4). Iron concentrations on the other hand, were high and those of Cd were above the permissible level of 0.01 mgL^{-1} of WHO. The high metal content (Table 1) observed was due to low pH values recorded for the samples. This is because acidic medium indicated by low pH generally leads to the release of metals, which are otherwise immobile. Most of the well water samples contained metal in concentrations lower than the stream water. This is expected because the higher the pH values, the lower the release of metals.

The Isebo upper stream served as the control or reference point. The stream samples here contained higher concentrations of Cd, Cr, Cu, and Ni than samples of water from Elesin stream taken from the downstream area. About 10 m upstream, before the Elesin stream water mixes with the discharge from the breweries, effluents and all the heavy metal concentrations except for Fe and Mn were higher than the values at discharge point “A”.

Table 1: Family Structure in the sampled Villages

Traits	Majawe (M)	Papa Adogba (P)	Osun (O)	Control (C)
Adult Male	4.76	3.84	3.57	3.55
Adult Female	3.96	3.89	3.43	3.39
Children 7-14 Male	2.36	2.91	3.02	1.85
Children(7-14) Female	2.92	2.69	2.41	2.09
Children (0-6) Male	1.14	1.59	1.24	1.04
Children(0-6) Female	1.14	1.59	1.24	1.04
Total Per Household	16.28	16.39	15.14	13.06

Table 2a: Sources of Potable Water in the surveyed area (%)

Traits	Majawe (M)	Papa Adogba (P)	Osun (O)	Control (C)
Water Tap	2.0	2.5	-	12.2
Stream / Brook	12.0	-	20.4	-
Rain harvest	24.0	10.0	20.4	5.5
Well	84.0	70.0	32.7	94.4
Tanker (Water) Corporation	50.0	40.0	79.6	-
Pure Water Packs	8.0	33.75	10.2	6.6
Expenses Range	30-3000	N35-3200	N150-16	20-100

Table 2b: Streams forming Sources of Water in the area (%)

Areas	Majawe (M)	Papa Adogba (P)	Osun (O)	Control (C)
Osun	20	80	60	-
Elesin	12	3/3.75	30.6 15	-
Akinfenwa	-	-	-	1.0

Table 3: Uses of Water from the Stream

Traits	Majawe (M)	Papa Adogba (P)	Osun (O)	Control (C)
Cooking	28.0	3.75	38.8	1.0
Washing Clothes	26.0	3.75	55.1	1.0
Swimming	0.0	0.0	0.0	1.0
Drinking	16.0	3.75	28.6	0.0
Bathing	20.0	1.25	48.9	1.0
Fishing	0.0	0.0	0.0	1.0
Irrigation	0.0	0.0	2.0	1.0
Others-washing Plates	2.0	0.0	0.0	0

Table 4: The sources that are no longer usable

Traits	M	P	O	C
Well	44.0	83.3	75.5	--
Stream/Brook	38.0	52.5	77.6	--
Reasons				
Pollution	38.0	56.3	57.1	--
Bad Smell	14.0	6.3	12.2	--
No idea	10.0	2.5	6.1	--
Bad Taste	--	10.0	6.1	--
Bleaches Clothes	--	1.2	--	--

Table 5: Average Daily cost of obtaining safe drinking water

Traits	M	P	O	C
Daily Expenditure	₦129.8	₦88.07	₦83.24	Nil
Range	₦10-00	₦21-357	₦21-240	Nil

Table 6: Sanitary habits/facilities for defecating in the communities

ADULTS	M	P	O	C
Backyard (Bush)	--	15.0	14.2	6.0
Pit Latrine	60.0	47.5	77.6	58.0
Water Closet	30.0	32.5	8.2	46.0
Potty	0.0	0.0	0.0	0.0
CHILDREN				
In house	2	0.0	0.0	0.0
Pit Latrine	60.0	49.3	73.5	61.0
Back of house (Bush)	2.0	14.6	16.1	1.0
Water Closet	30.0	34.6	8.2	39.0
Potty	4.0	6.6	8.2	--

Majawe (M) Papa Adogba (P) Osun (O) Control (C)

Table 7: Infections and their frequencies in the families (%)

Traits	M	P	O	C
Worms (Ascaris etc)	48.0	55.0	56.1	7.0
Bilharziasis & Blood in Urine	10.0	17.5	12.2	0.0
Cholera	26.0	33.0	46.9	0.0
Dysentery	46.0	30.0	38.8	2.2
Diarrhoea	52.0	53.8	51.0	4.4
Onchocerciasis	10.0	13.8	10.2	0.0
Typhoid	38.0	53.8	48.9	4.4
Rashes*	56.0	52.5	53.1	7.0
Ring Worm	34.0	46.3	46.9	5.0
Skin Infection*	72.0	75.0	46.9	11.0
Guinea Worm	4.0	5.0	14.3	0.0
Hepatitis*	14.0	28.8	22.4	2.0
Malaria	14.0	50.0	20.4	0.0
Cough	22.0	18.8	14.3	4.4
Swollen Legs	0.0	0.0	6.1	0.0
Eye Problem*	4.0	0.0	8.2	0.0
Death	4.0	0.0	14.3	0.0

Table 8: Suspected Causes of Identified Diseases

Traits	M	P	O	C
Water Pollution	60.0	57.5	87.7	--
Air Pollution	42.0	20.0		--
Dirty environment	6.0	6.3	0.0	1.0
Unsafe sources of water	2.0	0.0	0.0	10.0
No idea	6.0	13.8	0.0	1.0
Mosquito bites	0.0	13.8	0.0	13.0

Table 9: Duration of Disease / Expenditure on Cure

Traits	M	P	O	C
Average duration (weeks) Range	8.9 1-104	7.6 1-78	6.2 1-32	7.6 1-52
Average Expenses Range	₦400-70.000 ₦400-70.000	₦24,173.2 ₦175-200.000	₦11,344.18 ₦500-60.000	5136.36 1000-30.000

Majawe (M) Papa Adogba (P) Osun (O) Control (C)

Table 10: Lost Working Opportunity Due to the ill health

Traits	M	P	O	C
Lost weeks (Ave)	14.06	6.1	38.8	4.0
Range	1-104	1-104	1-260	1-12

Table 11: Recorded Material Damages suffered in the communities

Traits	M	P	O	C
Crumbling roofing sheets	52.0	37.5	91.8	6.0
Contaminated well	38.0	15.0	40.8	0.0
Farm crop lost	14.0	6.3	34.7	1.0
Animals (Goats)	56.0	27.5	57.1	5.6
Animals (Sheep)	26.0	10.0	38.8	5.6
Animals (Chicken)	56.0	28.7	61.2	2.2
Animals (Ducks)	14.0	7.5	18.4	0.0
Animals (Rabbits)	2.0	5.0	2.0	0.0
Fish	--	--	--	1.0

Table 12: Record of Re-roofing of houses and the reasons

Traits	M	P	O	C
Compelled to re-roof	52	65	45	8
No re-roofing	46	20	4	66
Damaged & Leaking roof	58	61	88	3
Period of re-roofing	1994-1998	1990-1999	1992-1998	1992-1998
Average cost	₦21,082.14	₦17,431.91	₦25,814.77	₦5566.60
Range	₦1000 to 72000	N3000 to 85,500	₦500 to ₦150,000	₦700 to 12,000

Majawe (M) Papa Adogba (P) Osun (O) Control (C)

Table 13: General comments on the environmental situation

	M	P	O	C
Water pollution is serious	18	38	144	9
Air pollution is serious	36	39	27	--
Ensure proper waste disposal	20	--	26	2
Brewery prevents clean environment	--	20	--	--
They should provide pipe-borne water	8	6	6	6
Treat brewery effluents	--	--	--	--
Environment is fair except for the effluent discharge	28	6	6	--
Take care of the bad dusty road	--	--	--	5
People disserting village	--	5	8	--

Majawe (M) Papa Adogba (P) Osun (O) Control (C)

This is indicative of possible pollution from the brewery effluent.

It is important to note that continuous intake of this water may be harmful to humans. The well water at Papa Adogba contained higher concentration of some heavy metals like Cd, Ni and also Na (315 ppm). It is therefore, not desirable for drinking or to be used for cooking or in food processing. Presence of Mn in the samples is a direct result of its accumulation in plant as recorded by a concentration of 5.14 ppm at the discharge point.

Soil

The average pH of the soil samples was close to 5, ranging from 4.75 to 5.35 indicating strong acid medium (Table 2 and Fig. 2). The soil at 3 and 100 m from the point of effluent discharge downstream contained high concentrations of heavy metals such as Pb (10.65 mgl^{-1}) Cr (12.37mgl^{-1}), Cu (13.8mgl^{-1}) and Ni (5.5mgl^{-1}) as compared with the reference soil (Isebo sample) with Pb (4.02 mg L^{-1}), Cr (6.25 mg L^{-1}), Cu (3.10 mg L^{-1}) and Ni (3.85 mg L^{-1}). This behavior confirms the high mobility of heavy metal cations under acid conditions. The heavy metal profile further downstream of effluent discharge point (e.g., Gada Oloorun, about 150 m from effluent discharge point) was still lower with the following Figures: Pb (303 mg L^{-1}), Cr (3.10 mg L^{-1}) and Ni (2.25 mg L^{-1}).

Plant

Figure 3 shows the concentration of macro- and micronutrients including heavy metals in plant tissues of various crops. Pb, Cu, Cr and Ni were not detected in the plant/root tissue partly due to selective absorption of the heavy metals. The concentrations of Zn, Fe and Cu ranged from moderate to high in the tissue while potassium was moderate . The highest level of Mn was detected in cocoyam grown close to the effluent discharge point. It was followed by that grown on the vegetable farm. The lettuce contained the highest level of Cu and Fe, the accumulation of which can be toxic to man and animals. Figures 3, 4 and 5 showed the distribution of metals, % total metal and cations in the plants.

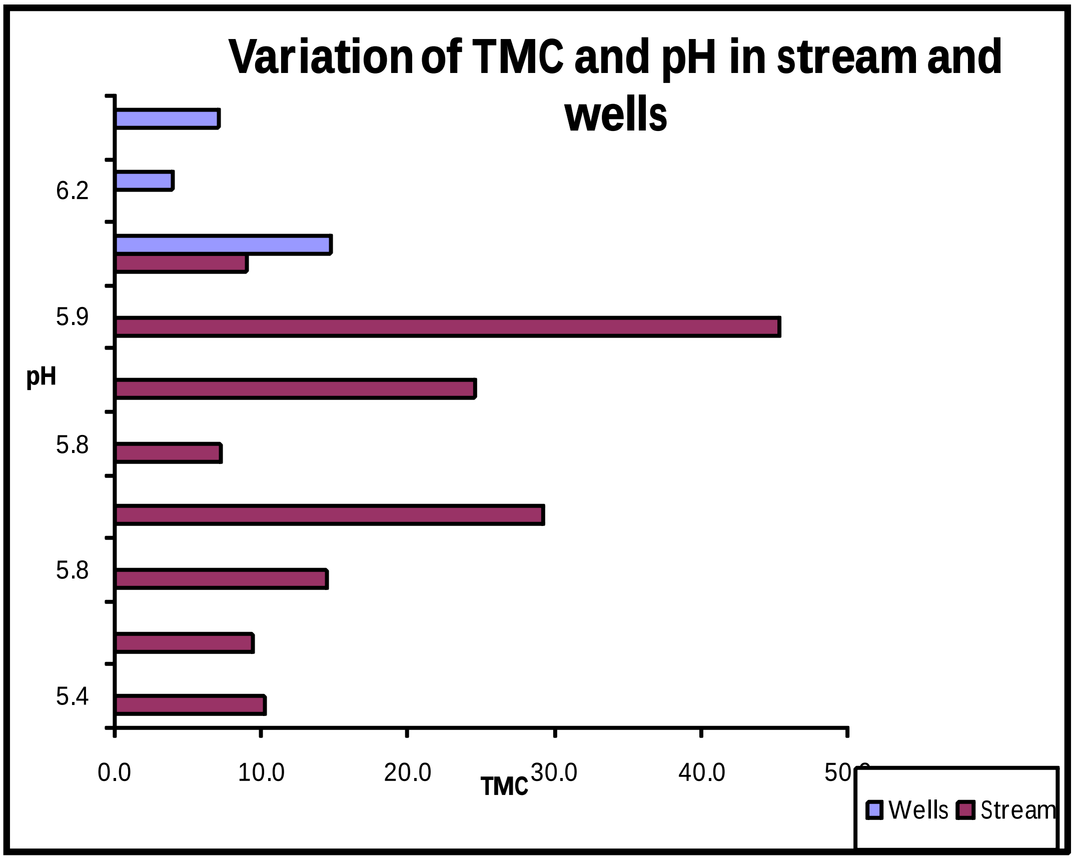

Fig. 2: The variation of Total Metal Concentration (TMC) and pH in Elesin stream and surrounding wells

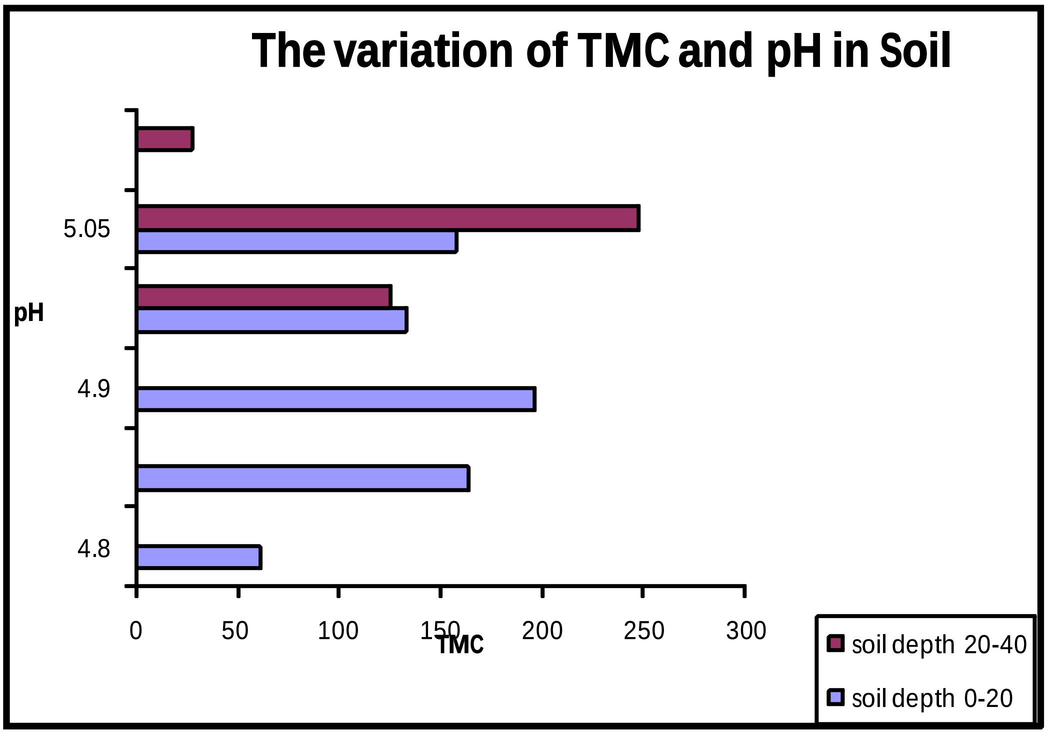

Fig. 3: The variation of TMC and pH in soil

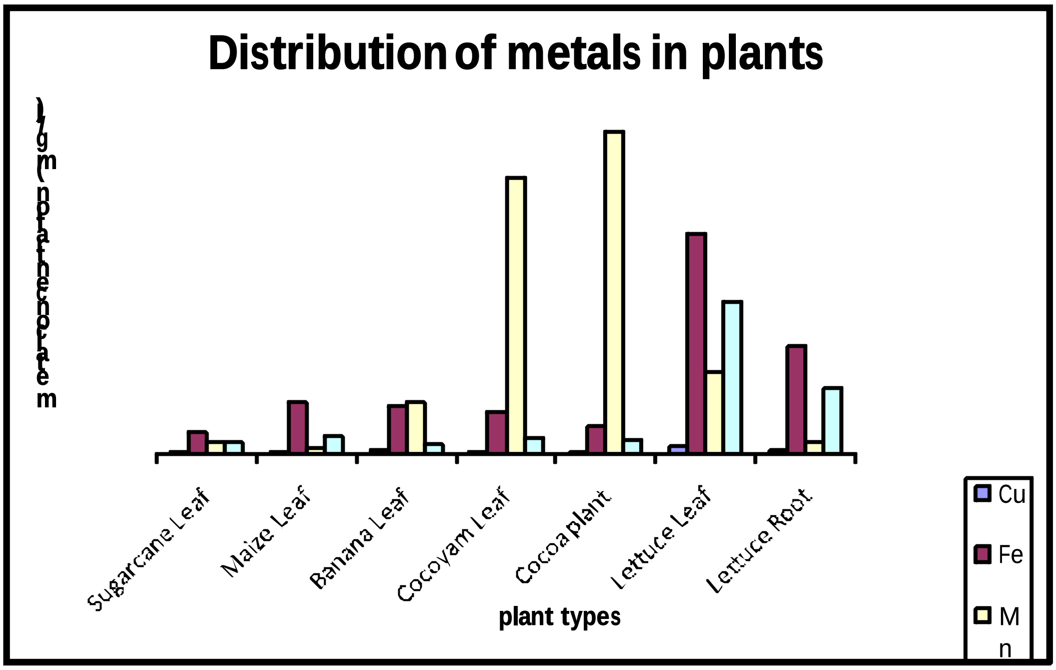

Fig. 4: Distribution of heavy metals in plants

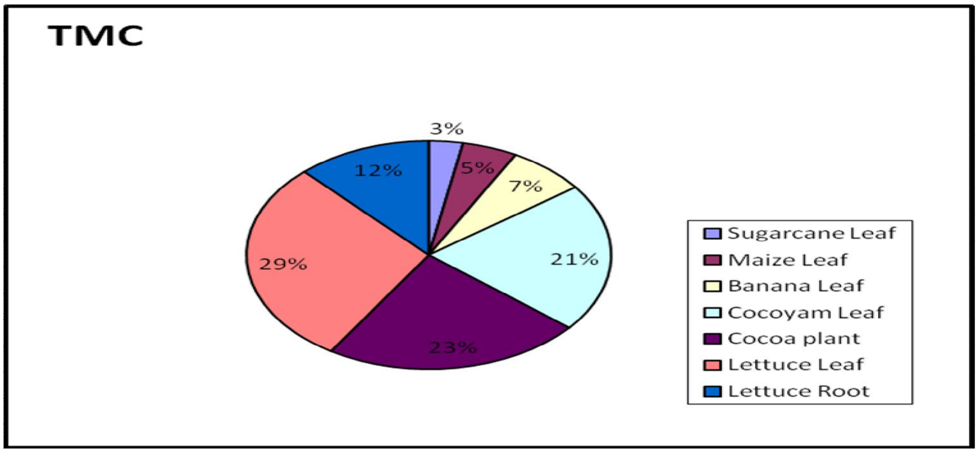

Figure 5: Percentage of TMC in plants

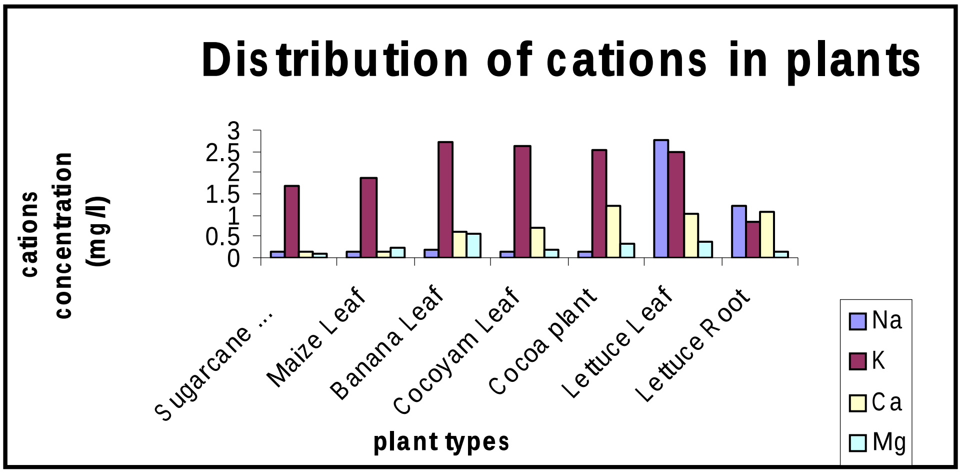

Figure 6: Distribution of Cations in Plants

CONCLUSION

Contamination of the well by Fe, Cd, Cr, Ni and Cu was evident based on current international World Health Organization (WHO) guidelines. According to the WHO (2004) guidelines, Fe, Cd, Cr, Ni and Cu should not exceed 6.30, 0.01, 0.01, 0.05 and 0.05 mg L^{-1}, respectively in drinking water. The permissible pH level is 6.5. Average figures obtained from the chemical analysis of both stream and well water samples gve the following values: Fe (11.92 mg L^{-1}), Cd (0.04 mg L^{-1}), Cr (0.21 mg L^{-1}) Ni (0.30 mg L^{-1}) and Cu (0.2 mg L^{-1}). The average pH was 5.9. The pH level of the water samples was below permissible levels of 6.5. Elesin stream and the surrounding ground water were acidic. pH were 5.9 on an average. This enhances leaching of heavy metals and corrosive tendencies of the water bodies.

The high levels of heavy metals in the soil indicate contamination from air and effluent from the factory, some of which are washed by rain and leached through the soil to contaminate well-water. The composition of air effluent was not determined at the time of experiment. The high rate of corrosion of roof tops leads one to postulate that the obnoxious gas emission was acidic. Similarly, the composition of water (waste) from the brewery was not equally determined because of the difficulty in obtaining the permission of the authority of the factory. Though, some of the plants sampled do not reflect high content of Pb, Ni and Cr in the leaf, more than half of the sampled plants contained total metal content of more than 10 %.

Levels of Pb, Ni, Cd, Cr, Fe, and Cu found in stream and well-water that were polluted were 3 – 5- folds higher than that of the reference samples. Further scientific investigation is, however, necessary to confirm that the effluent and gas from the industries mentioned before are highly toxic and corrosive respectively. Our study revealed a direct link between the industrial effluent waste and pollution with its severe damages in the Majawe, Osun-Abolowojaiye and Papa Adogba Communities.

It is suggested that urgent measures should be taken to arrest the pollution and clean up the area.

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Appendix 1: Chemical analysis of water samples in the surveyed area (ppm)

Description	pH	Pb	Cd	Cr	Cu	Fe	Mn	Ni	Zn	Na	K	Ca	Mg	P	Cl		No_3
WHO (2004)	6.5 – 8.5	0.01	0.01	0.10	0.05	0.30	0.10	0.05	1.00					50	10		
Discharge pt.1 (Factory Exit)		5.80	0.00	0.030	0.22	0.10	6.19	0.00	0.32	0.36	50.25	6.12	10.00	3.86	4.43	N.D	2.26
Osun 200 m From discharge pt	5.35	0.00	0.036	0.27	0.13	8.32	0.05	0.33	1.14	47.25	6.80	15.00	5.43	2.23	121.6	2.39	
Majawe UpStream Near fence	5.75	0.00	0.024	0.12	0.04	8.53	5.14	0.27	0.30	13.50	8.16	24.40	13.58	1.10	8.68	2.57	
Well PapaAdogba	6.65	0.01	0.055	0.23	0.06	5.50	0.02	0.41	0.86	315.0	1.70	14.00	25.36	0.57	147.6	2.04	
Stream 3 m from Discharge point	5.75	0.00	0.046	0.45	0.76	24.1	0.21	0.40	3.30	54.00	8.16	7.80	5.68	9.42	N.D	3.32	
Papa Veg. Farm Stream sample	5.90	0.00	0.044	0.26	0.16	16.1	0.14	0.34	7.48	52.75	7.14	11.20	6.26	2.23	N.D	12.62	
Gada Oloorun Stream sample		5.90	0.17	0.037	0.2	0.58	41.2	0.32	0.39	2.50	42.00	7.14	6.60	5.66	0.57	17.37	10.68
MajawaAkin.Well	6.00	0.00	0.035	0.13	0.04	5.01	0.00	0.26	9.30	10.50	6.80	11.50	2.90	1.65	-	-	
Well at Celestial Church compound		6.20	0.00	0.013	0.12	0.02	2.33	0.00	0.12	1.34	9.00	1.70	21.80	3.84	0.00	-	-
Drinking well at Celestial Church		6.00	0.00	0.041	0.15	0.05	6.90	0.00	0.27	1.64	22.50	6.80	15.40	8.06	0.00	-	-
Discharge pt. 2		5.50	0.10	0.031	0.25	0.26	6.93	0.05	0.24	1.50	58.50	7.48	2.60	1.60	0.85	-	-

N.D. = Not detectable

Appendix 2: Extractable ions in the soil

No. Description		pH	Pb	Cd	Cr	Cu	Fe	Mn	Ni	Zn	Av.P	Na	K	Mg	Ca
						ppm							meg/100g		
1 Gada Oloorun 0-20	4.75	4.25	0.17	4.82	5.00	21.95	2.40	2.65	19.50	66.8	2.07	0.17	0.79	2.23	
2 Gada Oloorun 20-40 5.35	3.00	0.17	3.10	2.50	9.40	1.50	2.25	5.90	64.2	2.10	0.23	1.27	9.47		
3 A 0-20 100m-Dis	5.15	10.65	0.29	12.37	13.80	38.00	1.70	5.05	51.00	109.1	2.10	0.29	0.85	1.86	
4 B 20-40 100m	5.05	7.87	0.23	10.22	9.30	41.00	2.00	4.05	51.00	103.8	2.10	0.35	1.04	2.27	
5 0.20 Papa Adogba	4.75	6.50	0.28	7.85	10.65	80.00	6.40	4.45	48.00	70.4	2.32	0.39	1.02	2.26	
6 A 0 –20 p 3m-Dis	4.90	10.65	0.23	9.40	12.15	89.50	5.00	3.65	65.50	95.0	2.39	0.37	0.31	1.57	
7 Isebo 0-20		5.30	4.62	0.29	6.25	3.10	127.0	9.50	3.85	3.70	86.3	2.20	0.51	1.71	3.45
8 Isebo 20-40		5.05	1.80	0.15	6.20	2.30	198.0	34.40	2.15	2.55	52.8	1.98	0.48	1.08	2.14

NB: Very high level of Na saturation, 35-40% Na saturation.

Appendix 3: Chemical analysis of some plant tissues collected from the Communities

No.	Description	Pb	Cd	Cr	Cu	Fe	Mn	Ni	Zn	Na	K	Ca	Mg	P
1	Sugarcane leaf-Gada Oloorun	ND	ND	ND	7.5	110.0	62.5	ND	55.0	0.12	1.67	0.13	0.10	0.25
2	Maize leaf-vegetable farm	"	"	"	10.0	252.2	30.0	"	87.5	0.15	1.87	0.14	0.22	0.31
3	Banana leaf-vegetable farm	"	"	"	12.5	230.0	250.0	"	50.0	0.17	2.72	0.61	0.55	0.25
4	Cocoyam leaf-vegetable farm	"	"	"	7.5	210.0	1350.0	"	77.5	0.15	2.64	0.72	0.18	0.38
5	Cocoa pt. Majawe discharge Pt.	"	"	"	7.5	140.0	1575.0	"	67.5	0.14	2.55	1.21	0.31	0.31
6	Lettuce leaf P.A	"	"	"	35.0	1075.0	405.0	"	745.0	2.78	2.47	1.01	0.38	0.38
7	Lettuce root P.A	"	"	"	17.5	527.5	62.5	"	322.5	1.24	0.85	1.10	0.14	0.25
8	Isebo Upper Stream	"	"	"	7.5	162.5	300.0	"	62.5	0.17	3.40	0.86	0.23	0.31
9	RefPt2	"	"	"	12.5	157.5	250.0	"	72.5	0.15	2.21	0.79	0.42	0.25

Appendix 4: Chemical analysis of Water from other locations distant from the discharge points

S/No.	Pb	Cd	Cr	Cu	Fe	Mn	Ni	Zn	Ca	Mg	Na	K	NO_3	Cl	pH
A/ Level	0.01	0.01	0.10	0.05	0.20	0.10	0.05	1.00					10	50	6.5 - 8.5
1	0.00	0.000	0.02	0.00	62.75	2.59	0.01	2.10	47.50	27.82	51.00	11.40	2.39	ND	4.65
2	0.00	0.000	0.00	0.00	0.00	0.02	0.01	0.00	14.50	6.82	39.75	3.75	3.79	468.99	6.6
3	0.00	0.000	0.00	0.00	0.00	0.36	0.02	0.02	66.00	36.32	64.50	7.50	2.79	165.01	7.2
4	0.00	0.000	0.00	0.00	0.00	0.04	0.00	0.00	2.50	1.32	14.25	3.15	2.04	ND	6.8
5	0.00	0.002	0.00	0.00	0.00	0.02	0.01	0.00	3.00	0.82	24.75	5.55	1.33	ND	6.8

1-- Water from stream Alalubosa village, 50m from Brewery
2-- Well water, from Aroko village, Bakery 2
3-- Well water, from Alalubosa village, 50m to Brewery
4-- Well water, from Adedibu village
5-- Rain Water

** ND – Not detectable.

A/Level = Acceptable Level