Environmental impact assessment of two polluting sources on stream in Nigeria

Christopher O. Akinbile[1,2*], Wasiu O. Olugbojo[1] and Obafemi O. Olubanjo[1]

(1. *Department of Agricultural and Environmental Engineering, Federal University of Technology, Akure, Nigeria*;

2. *Department of Biological and Agricultural Engineering, Universiti Putra Malaysia (UPM), Malaysia*)

Abstract: The environmental impact of locating two polluting sources of landfill (refuse dump) and petrochemicals on Alaba stream in Akure, Nigeria was assessed. Twenty physio-chemical parameters were analyzed for wet and dry seasons respectively with three sampling points within 5m intervals from one another of the two polluting sources on the stream. The parameters include: colour, odour, taste, pH, temperature, turbidity, alkalinity, conductivity, dissolved oxygen (DO), biochemical oxygen demand (BOD5) and total solids (TS). Others were chloride (CL-), total dissolved solids (TDS), total suspended solids (TSS), lead (Pb), nitrate (NO3), sulphate (SO4-2), oil and grease, Escherichia coli (E-coli) and faecal coliform. Some parameters were determined in-situ while others were determined using APHA (2005) standard procedures and results obtained were subjected to statistical analysis. All the samples investigated contained a considerable degree of pollution which asserted the pollution of the stream. The results for dry and wet seasons indicated that the conductivity, 353.33±15.0 and 256.67±26.58, Alkalinity, 52.83±16.0 and 90.90±20.98, DO, 0.33±0.08 and 0.48±0.01mg/l, Turbidity, 57.22±7.15 and 8.10±1.70, BOD, 0.20±0.10 and 0.22±0.11, TDS, 0.18±0.16 and 0.46±0.42. E-coli had values 55.37±7.45 and 8.99±3.23, faecal coliform, 241.50±11.64 and 129.83±35.06 and Pb, 13.72±7.68 and 11.88±5.20 respectively. Others were sulphate, 1298.33±422.52 and 1273.33±423.77, nitrate, 6.40±0.96, chloride, 0.33±0.12. Most of the values (with the exception of pH and alkalinity) were above the maximum permissible levels of FAO, WHO and NSDWQ standards and parameters such as pH, turbidity, DO, BOD, Pb, E-coli and faecal coliform decreased as the distance from the polluting sources increased.

Statistical analyses showed significant differences at specific confidence levels while treatment of Alaba stream is required to achieve minimum acceptable level for domestic uses, public awareness on the dangers inherent in polluting the stream should be carried out.

Keywords: Pollution; physico-chemical parameters; microbiological Parameters; petrochemical; landfill; stream; Akure

Citation: Akinbile, C. O., W. O. Olugbojo, and O. O. Olubanjo. 2015. Environmental impact assessment of two polluting sources on stream in Nigeria. Agric Eng Int: CIGR Journal, 17(3): 21-32.

1 Introduction

There are numerous scientific and economic facts that, water shortage or its pollution can cause severe decrease in productivity and deaths of living species (Garba et al., 2008). Reports by Food and Agricultural Organisation (FAO) revealed that in African countries, particularly in Nigeria, water related diseases had been interfering with basic human development (FAO, 2007). Sanitary land filling remains one of the major methods for municipal and industrial solid waste disposal (Mohajeri et al., 2010). Up to 95% of total municipal solid waste (MSW) collected worldwide are disposed using the landfills. However, sanitary landfill generates large quantity of heavily polluted leachate, which induced highly potential hazard for the public, flora, fauna health and ecosystems (Aziz et al., 2004).

In Nigeria today, research indicate that the majority of the common fresh water sources are polluted, resulting to serious outbreak of diseases. A study by Umeh et al., (2004) showed that 48% of the people in Katsina-Ala Local Government area of Benue state are affected by urinary *schistosomiasis*, due to the increase in water

Received date: 2015-01-20 **Accepted date:** 2015-08-02

***Corresponding author: Christopher O. Akinbile,** Department of Agricultural & Environmental Engineering, Federal University of Technology, Akure, Nigeria. Email: coakinbile@futa.edu.ng

pollution index. Some previous investigations indicate that 19% of the whole Nigerian population is affected, with some communities having up to 50% incidence. This has raised serious concerns to World Health Organisation (WHO) in an attempt to improve cultural and socio-economic standards of people in the tropical region (Umeh *et al.*, 2004).

Groundwater contamination could be traced to a variety of activities. While contamination sources such as septic systems are found everywhere, others are regional, eg saline intrusion. The unsanitary mode of disposal of wastes, such as defecation in streams and the dumping of refuse in pits, rivers and drainage channels as seen in most Nigerian urban settlements, could be expected to affect surface and groundwater quality (Sangodoyin, 1991). The bacterial qualities of groundwater, pipe borne water and other natural water supplies in Nigeria have been reported to be unsatisfactory, with coliform counts far exceeding the level recommendation by W.H.O (Edema et al., 2001). The objective therefore was to assess the environmental impact of two polluting sources on *Alaba* River from the standpoint of access to potability and sanitation in Akure, Nigeria.

2 Study area and methodology

2.1 Description of the study area

The stream was so named (*Alaba*) because it is channeled naturally across *Alaba* village, close to the south gate of the Federal University of Technology, Akure (FUTA), Ondo State. Akure, the capital city of Ondo State of Nigeria is located between latitude 9°17′N and longitude 5°18′E which has a tropical humid climate with two distinct seasons, a relatively dry season from November to March and a wet/rainy season from April to October. The average annual rainfall ranged between 1,405 mm and 2,400 mm of which the rainy season accounts for 90% while the month of April marks the beginning of rainfall (Akinbile 2006). The towns sharing borders with Akure are, Ikere in the north, Ondo in the south, Owo in the east and Igbara-oke in the west with sandy-loam as the predominant soil type. *Alaba* stream flows through the settlements around FUTA south gate, the area that is characterized by private accommodations for students most of whom lacked University residence and significant number of shopping malls and lock-up shops. Similarly, apart from shopping malls, gas stations especially one is located very close to the stream to serve the area for those that might need kerosene for domestic purposes and gasoline for their generators and cars. Due to these infrastructures, the population in *Alaba* settlement is huge and as a result of lack of proper waste disposal facility, significant proportion of wastes generated are dumped into the stream and at ungodly hours mostly at night to avoid being caught by law enforcement agencies which suggests that the inhabitants knew that their practice of waste disposal is unlawful.

2.2 Sampling and analysis

Water samples were collected from two polluting sources located on *Alaba* stream (refuse dumpsite and petrochemical sources along the course of the river) at 5 m, 10 m and 15 m distances respectively. The samples were collected during the dry season (March) and wet season (July) all in 2013 and were collected using sterilized bottles and stored in refrigeration at 4℃ in accordance with standard procedures as stated by APHA (2005). They were transferred to the laboratory for physical, chemical and bacteriological tests. Three samples were collected from each polluting sources at 5 m intervals. The qualitative analyses were carried out at FUTA Central laboratory. The physical parameters tested include: odour, taste, colour, turbidity and temperature. Chemical parameters analyzed were Electrical Conductivity (EC), Alkalinity, pH, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Sulphate (SO_4^{2-}), Chloride (Cl^-), Nitrate (NO_3^-), Lead (Pb), Oil and grease, while the bacteriological assay water tests included; *Escherichia coli* (E-coli) and Faecal coliform counts. The color of water was measured by adding 50ml of the samples in test tubes and compared with 50ml of distilled; the colour difference was observed and recorded. Odour of the samples was dictated by the use of the examiner's sense of smell. Temperature, turbidity, PH and EC values were measured *in-situ* by thermometer, turbidimeter, pH meter (Mettler Toledo, Schwerzenbach, Switzerland) and conductivity meter respectively. The samples analyzed at the University central laboratory also include; TDS, TSS, BOD, alkalinity, NO_3, NO_2, SO_4^{2-}, Cl^-, oil and grease using standard methods for the examination of water (APHA 2005). The concentration of heavy metal (Pb) was determined with flame atomic absorption spectrophotometer. Also, bacteriological assay was used for the determination of faecal coliform bacteria and *Escherichia coli* while microbial analysis was carried out in the laboratory using APHA, 2005 standards. All the results were compared with the World Health Organization (WHO 2004), Food and Agricultural organization (FAO 2004) and the Nigerian Standard for Drinking Water Quality (NSDWQ 2007) values. The results were subjected to statistical analyses using simple ANOVA technique and SPSS at specific levels of significance.

3 Results and Discussions

The results of physical analysis of the samples collected during the dry season are presented in Table 1 while that of the wet season are shown in Table 2. Temperature ranged from 25 ℃ -34℃ in dry season and 23 ℃ - 28 ℃ in wet season with the mean values of 29.83 ℃ ±3.19 ℃ and 25.67 ℃ ±1.75 ℃ (Table 3 and Table 4). These values were higher when compared with the WHO, FAO and NSDWQ standard values of 25℃. Akinbile (2006) reported that noticeable high temperature confirmed the presence of some biological species and their rates of activity in such samples. Temperature had an effect on most chemical reactions that occur in natural systems and the amount of DO gases in it. Most of the samples were coloured which also indicated the presence of pollutants in the form of suspended solids which was also responsible for the high turbidity values recorded in both seasons. Turbidity values ranged from 50.30 to 67.40 NTU (Table 5) and from 5.60 to 10.50 NTU (Table 6) for dry and wet seasons respectively and with the mean values of 57.22±7.15 NTU (Table 3) and 8.10±1.70 NTU (Table 4). These were higher than five nephelometric units (NTU) maximum permissible in water (USEPA, 2002). However, turbidity values were much higher in dry season when compared with wet season; this might perhaps be due to the increase in the volume of water flow during the wet season which was also responsible for the dilution hence the reduction in measured values. High turbidity is often associated with higher levels of particle suspension and disease causing microorganism such as bacteria and other parasites. In water bodies such as lakes, rivers and streams, high turbidity levels can reduce the amount of light reaching lower depths, which can inhibit growth of submerged aquatic plants and consequently affect species which are dependent on them, such as fish and shellfish. High turbidity levels can also affect the ability of fish gills to absorb dissolved oxygen (EPA, 2005; Schwartz et al., 2000) Colour, taste and odour were properties that are subjectively determined. The presence of colour was an indication of pollution and confirmed the presence of dissolved and suspended particles, waste disposal into the stream and infiltration (Ogedengbe and Akinbile 2004; Mohamed et al., 2009). Dissolved impurities present in the samples may be either from natural sources or from the discharge of noxious substances like excreta, oil, bathwater into the water course by man (Shaw, 1994).

Table 1 Physical characteristics of the samples analyzed in dry season

S/N	Samples	Temperature (°C)	Turbidity (NTU)	Colour	Taste	Odour
1	W1	34.0	67.40	Straw brown	Nil	Offensive
2	W2	31.0	64.53	Dark brown	Tasty	Offensive
3	W3	29.0	55.75	Straw colour	Tasty	Inoffensive
4	W4	32.0	32.34	Yellowish	Nil	Offensive
5	W5	28.0	30.60	Yellowish	Nil	Offensive
6	W6	25.0	28.30	Colourless	Tasty	Inoffensive

Note: WI-W3= water samples from refuse dump source.
W4-W6= water samples from petrochemical source.

Table 2 Physical characteristics of the samples analyzed in wet season

S/N	Samples	Temperature (℃)	Turbidity (NTU)	Colour	Taste	Odour
1	W1	28.0	10.50	Straw brown	Nil	Offensive
2	W2	26.0	8.40	Straw brown	Tasty	Offensive
3	W3	25.0	7.40	Colourless	Nil	Offensive
4	W4	27.0	9.30	Yellowish	Nil	Offensive
5	W5	25.0	7.40	Colourless	Nil	Offensive
6	W6	23.0	5.60	Colourless	Tasty	Inoffensive

Note: WI-W3= water samples from refuse dump source.
W4-W6= water samples from petrochemical source.

Table 3 Comparison of dry season data analyzed with water standards

Parameters	Mean ±SD	WHO	FAO	NSDWQ
pH	6.3 ±0.14	6.0-68.5	6.5-8.5	6.5-8.5
Temperature	29.8 ±3.18	25 ℃	25°C	25 ℃
Turbidity	57.27 ±7.15.0	0.5-5	5.0	5.0
Alkalinity	52.83 ±16.0	100	200	-
EC (µs/cm)	353.33 ±15.0	300	3.0	1000 µs/cm
DO	0.33 ±0.07	0.3	2.0	-
BOD	0.20 ±0.10	5.0	10	-
TS	0.42 ±0.22	500	2000	-
TDS	0.18.±0.16	0.5	2.0	500
TSS	0.26 ±0.20	500	40	-
Pb	13.72 ±7.68	10	0.05	0.01
CL^{-1}	0.33 ±0.12	250	100	250
NO_3	6.40 ±0.96	5.0	30	50
SO_4	1298.33 ±22.52	150	20	100
Oil and grease	12.02 ±2.86	10-20	10	-
E-coli	55.37 ±7.45	0	0	0
Feacal coli	241.50 ±11.64	0	0	0

Table 4 Comparison of wet season data analyzed with water standards

Parameters	Mean ±SD	WHO	FAO	NSDWQ
pH	6.65 ±0.58	6.0-68.5	6.5-8.5	6.5-8.5
Temperature	25.67 ±1.75	25℃	25	25℃
Turbidity	8.10 ±1.70	0.5-5	5.0	5.0
Alkalinity	90.90 ±20.98	100	200	-
EC (µs/cm)	256.67 ±26.58	300	3.0	1000 µs/cm
DO	0.48 ±0.14	0.3	2.0	-
BOD	0.22 ±0.11	5.0	10	-
TS	2.62 ±2.94	500	2000	-
TDS	0.46.±0.42	0.5	2.0	500
TSS	2.64 ±2.91	500	40	-
Pb	11.88 ±5.99	10	0.05	0.01
CL^{-1}	0.33 ±0.12	250	100	250
NO_3	6.38 ±0.94	5.0	30	50
SO_4	1273.33 ±22.77	150	20	100
Oil and grease	5.33 ±2.02	10-20	10	-
E-coli	8.99 ±3.23	0	0	0
Feacal coli	129.83 ±35.06	0	0	0

Table 5 The chemical and bacteriological characteristics of the samples connected in dry season.

				Refuse dump			Petrochemical		
Parameters	WHO	FAO	NSDW	5M	10M	15M	5M	10M	15M
Temp(℃)	25	25	25	34	31	29	32	28	25
pH	6.0-8.5	6.5-8.5	6.5-8.5	6.2	6.1	6.3	6.5	6.3	6.4
Turbidity	0.5-5	5.0	5.0	67.40	64.53	55.75	50.75	54.60	50.30
Alkalinity	100	200	-	50	70	27	50	50	70
EC(µs/cm)	300	3.0	1000	260	300	410	270	280	600
DO	0.3	2.0	-	0.25	0.27	0.31	0.37	0.34	0.45
BOD_5	5.0	10	-	0.36	0.26	0.14	0.24	0.08	0.12
CL^{-1}	200	2000	-	0.2	0.5	0.4	0.4	0.2	0.3
NO_3	5.0	2.0	500	6.5	8.2	6.4	5.8	5.5	6.0
Pb(µg/m1)	0.3	40	-	22.2	23.1	15.4	8.5	5.6	7.5
SO_4	150	0.05	0.01	1350	2130	1110	1060	1100	1040
TS	500	100	250	0.53	0.75	0.21	0.57	0.25	0.24
TDS	0.5	30	50	0.394	0.123	0.259	0.279	0.001	0.007
TSS	10	20	100	0.14	0.63	0.05	0.29	0.25	0.23
Oil &Grease	10-20	10	-	15.8	13.5	7.8	12.3	13.3	9.5
E coli	0	0	0	67.23	58.23	48.45	58.52	52.33	47.51
Faecal coli	0	0	0	260	245	237	246	235	226

Note: pH is dimensionless unless otherwise stated all units are in mg/L Turbidity=NTU

Table 6 The chemical and bacteriological characteristics of the samples connected in wet season.

				Refuse dump			Petrochemical		
Parameters	WHO	FAO	NSDW	5M	10M	15M	5M	10M	15M
Temp(℃)	25	25	25	28	26	25	27	25	23
Ph	6.0-8.5	6.5-8.5	6.5-8.5	6.5	6.9	7.2	6.8	7.3	6.0
Turbidity	0.5-5	5.0	5.0	10.5	8.4	7.4	9.3	7.4	5.6
Alkalinity	100	200	-	120	70	90	110	80	70
EC (µs/cm)	300	3.0	1000	250	240	290	230	240	290
DO	0.3	2.0	-	0.48	0.47	0.49	0.46	0.48	0.50
BOD_5	5.0	10	-	0.26	0.02	0.18	0.32	0.31	0.24
CL^{-1}	200	2000	-	0.2	0.6	0.4	0.4	0.3	0.3
NO_3	5.0	2.0	500	6.4	8.1	6.8	5.7	5.5	6.1
Pb(mg/m1)	0.3	40	-	15.2	21.1	12.4	6.5	11.6	4.5
SO_4	150	0.05	0.01	1050	2045	1500	1000	1005	956
TS	500	100	250	6.211	5.342	4.176	0.019	0.002	0.024
TDS	0.5	30	50	0.004	0.005	0.075	0.071	0.101	0.019
TSS	10	20	100	6.207	5.347	4.101	0.052	0.099	0.005
Oil& Grease	10-20	10	-	8.7	6.5	3.8	5.3	3.2	4.5
E coli	0	0	0	12.30	8.45	5.03	13.35	8.20	6.60
Faecal coli	0	0	0	120	110	106	125	118	112

Note: pH is dimensionless unless otherwise stated all units are in mg/L Turbidity=NTU

Electrical conductivity (EC) values ranged from 260-600 µs/cm during dry season (Table 5) and 230-290 µs/cm during wet season (Table 6) while their mean values were 353.33±15.0 µs/cm and 256.67±26.58 µs/cm for both dry and wet seasons respectively (Tables 3 and 4). The values were more prominent in wet season than in dry season which was due to increased presence of pollutants with less volume of flow when compared with wet season samples. Olaoye and Onilude (2009) asserted that the presence of EC values in water showed the presence of conductive ions in solution.

Alkalinity values ranged from 27-70 mg/L (Table 5) in dry season and 70-120 mg/L (Table 6) in wet season with the mean value of 52.83±16.0 mg/L (Table 3) and 90.90±20.98 mg/L (Table 4) in both dry and wet seasons respectively. Though the values were below the permissible levels of 100 and 200 mg/L in the WHO and FAO standards respectively during dry season, a slight increase in the values were recorded during wet season. Kaushal, *et al.*, (2013) remarked that there could be long-term changes in the alkalinity of rivers and streams in response to human disturbances such as in wastes dump into such rivers. Taking the measurements of alkalinity is very important in determining a stream's ability to neutralize acidic pollution from rainfall or wastewater and it is one of the best measures of the sensitivity of the stream to acid inputs.

The pH values ranged from 6.1 to 6.3 (Table 5) in dry season and 6.0 to 7.3 (Table 6) in wet season with a mean value of 6.3±0.14 (Table 3) and 6.5±0.58 (Table 4). This is an indication that the stream was acidic and indicated the presence of heavy metals such as lead from damaged battery cells and improperly disposed used cans of aerosols and other disinfectants deposited into the stream as waste. While the values rose above the permissible limits during wet season, falls below the range of maximum desirable for municipal uses which were between 6.5 and 8.5 in dry season. The tolerable pH limits for fish and other aquatic animals is 9.0 above which the BOD and DO would be reduced thereby endangering the aquatic lives. The pH findings from this study agreed with the values obtained by (Longe and Balogun 2010, Akinbile 2006; Ikem et al., 2002).

Dissolved oxygen (DO) values ranged between 0.24 and 0.45 mg/L (Table 5) in dry season and 0.46 and 0.50 mg/L (Table 6) in the wet season with mean value of 0.33±0.08 mg/L (Table 3) and 0.48±0.01 mg/L (Table 4) respectively. The values were above 0.3 mg/L recommended by the WHO. Low levels of DO in the river was an indication of oxygen depletion which is justified by the presence of pollutants that use up oxygen in water and reduced photoperiod and photosynthesis activities of aquatic plants. Similar observations were recorded by (Abowei, 2010) in his study. DO is an important factor used for water quality control and similar values were reported by Igbinosa and Okoh (2009) and Jaji et al., (2007). Higher amount of DO may be due to higher water dilution and its reduction depended on the biodegraded quantity of organic and inorganic materials within the dilution capacity which agreed with the findings of Ogedengbe and Akinbile (2004).

The values of BOD_5 for the samples ranged between 0.08 and 0.36 mg/L and 0.02 and 0.32 mg/L in both dry and wet seasons respectively while mean values were 0.02±0.10 mg/L and 0.02±0.32 mg/L respectively (Tables 3 and 4). The observed lowest value might be due to pollutants' infiltration into the stream from the various polluting sources on the stream and private residences which might also result in the death of aquatic lives occasioned by the oxygen depletion at that point. This was similar to the findings of Jaji et al., (2000) and Mohajeri et al. (2010).

The values of total solid (TS), total suspended solid (TSS) and total dissolved solid (TDS) during the dry and wet seasons are as shown in Tables 5 and 6 which ranged between 0.21 and 0.75 mg/L, 0.05 and 0.63 mg/L and 0.001 and 0.394 mg/L for dry season and ranged between 0.002 and 6.21 mg/L, 0.005 and 6.21 mg/L and 0.004 and 0.10 mg/L in wet season. Their mean values were 0.42±0.22 mg/L, 0.26±0.20 mg/L and 0.18±0.16 mg/L for dry season and 2.61±2.63 mg/L, 2.64±2.91 mg/L, 0.46±0.42 mg/L for wet season respectively (Tables 3 and 4). The values of TS, TSS and TDS obtained during the dry and wet seasons were all below the FAO, WHO and NSDWQ water standards (WHO, 2004 and FAO, 2004).Despite the fact that they were lower than the WHO, FAO and NSDWQ values, considerable degree of pollution was detected in all the samples analyzed which makes the river unfit and unsafe for some domestic use (EPA, 2002). Olaoye and Onilude (2009) reported that the effect of presence of total suspended solids was the turbidity due to silt and organic matter and the water high in suspended solid which may be aesthetically unsatisfactory for bathing. TDS in water has been associated with natural sources, sewage urban runoff, and industrial waste water (EPA, 2002).

The values obtained for sulphate were very high and ranged between 1100 and 2130 mg/L and 956 and 2045 mg/L (Table 5 and Table 6) in both dry and wet seasons while mean values of the element were 1298.33±22.52 mg/L and 1273.33±23.77 mg/L in dry and wet seasons respectively (Table 3 and Table 4). These figures are rather high when compared with the WHO, FAO and NSDWQ Standards which were (150, 20, 100) mg/L respectively. The possible source of sulphate came from oil pollution and other discharges into the water bodies. Chloride ranged from 0.20 to 0.50 mg/L for both seasons with the mean value of 0.33±0.12 mg/L (Table 5 and Table 6). Even though it is below the WHO, FAO and NSDWQ levels, its presence indicated pollution requiring treatment before use. This agreed with the findings of Igbinosa and Okoh (2009). Chlorides were found in brackish water bodies contaminated by sea water or in groundwater aquifers with high salt water content. The presence of chlorides in the stream is an indication of sewage pollution from other chloride compounds (Shaw, 1994). Nitrate values for the samples all ranged from 5.50 to 8.20 mg/L with the mean value of 6.40 ±0.96 mg/L (Table 5 and Table 6) for both the dry and wet seasons the value being the same. The value is above the permissible level of 5.0 mg/L by the WHO but well below the values of FAO and NSDWQ which were 30mg/L and 50mg/L respectively. This showed appreciable presence of pollutants in all the water samples and agreed with the observations made by Chauhan and Rai (2010). Water containing nitrates contaminants proved harmful especially to infants causing *methaemoglobinaemia* otherwise called infantile cyanosisor *blue baby syndrome* if consumed (Akinbile, 2006). It is a serious blood condition in which the nitrates are absorbed into the blood stream and converting oxygen carrying hemoglobin into methaemoglobin.

High values of oil and grease were indicative of contributions from the manufacturing industrial effluent discharge and oil leakages. This may be due to location of a filling station and mechanic workshop nearby and the usage of *Alaba* stream as a cheap source for automobile washing services. It ranged between 7.80-15.5 mg/L and 3.20-8.70 mg/L in both dry and wet seasons (Table 5 and Table 6) while the mean values are 12.02±2.86 mg/L and 5.33±2.02 mg/L (Table 3 and Table 4) respectively. It was observed that the values were above FAO standard of 10 mg/L in dry season while they were below the standard in wet season, seepage may be responsible for this changes. In case of heavy pollution, prevention of natural aeration of the stream leading to death of aquatic life is a normal occurrence.

The results of water sampled revealed high values of faecal contamination ranging from 2.26×10^2 - 2.60×10^2 cfu/ml and 1.09×10^2- 2.0×10^2 cfu/ml while that of *Escherichia coli* values also ranged from 4.7×10^1-6.7×10^1 cfu/ml and 6.7×10^1- 1.3×10^1 cfu/ml. These values are far above '1 per 100ml' approved by the WHO guidelines of drinking water quality. *Escherichia coli (E-coli)* and faecal coliform bacteria contents were high and greater than one in all the samples analyzed being an indication of faecal pollution of human wastes and this confirmed bacteriological pollution, not limited to human sources and coming perhaps from the remains of dead animals, refuse dump, open defecation, surface runoff, pasture and other land areas where animal wastes were deposited. The WHO and NSDWQ standards were 1 in 100 ml but all the samples analyzed showed values greater than 1/100 ml. A thorough treatment of water from the stream would be required before it can be consumed domestically. Additional sources include seepage or discharge from septic tanks, sewage treatment facilities and natural soil /plant bacteria (EPA, 2002) and as a result groundwater could also be contaminated due to animal wastes, sewage, refuse dump and various human activities around the stream (Shaw, 1994). The high amount of faecal coliform indicates pollution from human faeces. According to Adekunle et al., (2007), 'coliform populations gave an indication of presence of pathogenic organisms usually present in the faeces of humans and animals'. The existence of human waste in water could lead to water borne diseases such as: diarrhea, typhoid and hepatitis. Also the presence of *Escherichia coli (E-coli)* bacteria in water could lead to urinary tract infections: meningitis, diarrhea, acute renal failure and haemogtic anemia (Adekunle et al., 2007; Rangwala et al., 2007).

Significance of correlation coefficients

The significance of the observed correlation co-efficients showed in Table 7 and Table 8 revealed that out of the total 140 correlations found between two parameters, 10 were found to be significant at the 0.01 level and 24 were found to be significant at the 0.05 level in dry season while 9 and 16 were found to be significant at the 0.01 level and 0.05 level in wet season respectively and the rest were interwoven between negative and positive correlations. Strong correlations were found between pH and turbidity, temperature and DO, temperature, *Escherichia coli* (E-coli) and feacal coliform: Between BOD and faecal coliform, between TDS and faecal coliform, between TSS and *Escherichia coli* (E-coli), between TSS and oil and grease, between temperature and alkalinity, between TDS and SO_4 to mention but few.

Table 7 Correlation coefficient of physiochemical variables in dry season from the study data

	PH	Temp	Turbidity	Alkalinity	ED	DO	BOD	CL^{-1}	NO_3	Pb	SO_4	TS	TDS	TSS	Oil&G	E coli	Faecal coli
pH	1	-0.310	- 0.883**	- 0.177	- 0.299	0.772*	- 0.377	-0.426	-0.067	-0.425	-0.809*	-0.117	-0.783*	-0.820*	- 0.416	-0.365	-0.389
Temp		1	0.670	- 0.212	- 0.821*	- 0.785	0.884**	0.715	0.843*	0.107	0.642	0.069	0.315	0.362	0.655	0.916**	0.978**
Turbidity			1	0.73	- 0.506	- 0.909**	0.736*	0.584	0.469	0.262	0.913**	-0.020	0.677	0.710	0.629	0.728	0.758*
Alkalinity				1	0.242	0.276	0.117	0.429	-0.502	0.727	0.040	0.117	0.366	0.467	0.334	0.099	-0.147
ED					1	0.723	-0.514	-0.578	-0.480	-0.227	0-.334	0.042	-0.139	-0.318	-0.738*	-0.734*	-0.763*
DO						1	- 0.659	-0.525	-0.604	-0.134	-0.831*	-0.044	-0.551	-0.588	-0.554	-0.697	-0.808*
BOD							1	0.776*	0.780*	0.197	0.764*	0.094	0.477	0.470	0.623	0.921**	0.922**
CL^{-1}								1	0.363	0.743*	0.638	0.476	0.698	0.779*	0.636	0.739*	0.676
NO_3									1	-0.339	0.558	0.032	0.115	0.014	0.234	0.682	0.831*
Pb										1	0.293	0.562	0.693	0.821*	0.387	0.198	0.061
SO_4											1	0.320	0.835*	0.764*	0.351	0.606	0.689
TS												1	0.656	0.541	-0.343	-0.153	-0.071
TDS													1	0.953**	0.185	0.290	0.314
TSS														1	0.414	0.393	0.363
Oil&Grease															1	0.855*	0.718
E coli																1	0.960**
Feacal coli																	1

**. Correlation is significant at the 0.01 level (1-tailed).

*. Correlation is significant at the 0.05 level (1-tailed).

Table 8 Correlation coefficient of physiochemical variables in wet season from the study data

	PH	Temp	Turbidity	Alkalinity	ED	DO	BOD	CL^{-1}	NO_3	Pb	SO_4	TS	TDS	TSS	Oil&G	E coli	Faecal cl
pH	1	-0.040	-0.057	-0.265	0.000	0.074	-0.305	0.317	0.410	0.321	0.592	-0.029	0.182	0.415	-0.324	-0.495	-0.471
Temp		1	0.999**	0.817*	-0.673	-0.727	0.075	0.523	-0.171	0.531	0.441	-0.031	0.203	0.006	0.729*	.0809*	0.572
Turbidity			1	0.822*	-0.653	-0.697	0.075	0.542	-0.210	0.549	0.442	-0.058	0.207	-0.006	0.760*	.0810*	0.569
Alkalinity				1	-0.323	-0.405	0.506	0.258	0.011	0.260	-0.067	-0.315	-0.279	-0.456	0.544	.0746*	0.649
ED					1	0.904**	-0.120	0.023	-0.100	0.009	-0.322	-0.021	-0.102	0.003	-0.315	-0.763*	-0.711
DO						1	0.000	-0.056	-0.116	-0.065	-0.300	-0.350	-0.207	-0.155	-0.302	-0.740*	-0.601
BOD							1	-0.620	0.531	-0.618	-.0734*	-0.704	-9.50E**	-9.70E**	-0.223	0.399	0.707
CL^{-1}								1	-0.583	1.000**	.0815*	0.192	0.727	0.590	0.701	0.025	-0.345
NO_3									1	-0.581	-0.363	-0.161	-0.661	-0.351	-0.785*	-0.151	0.157
Pb										1	0.822*	0.186	0.727	0.589	0.704	0.034	-0.336
SO_4											1	0.290	0.814*	0.768*	0.465	-0.017	-0.315
TS												1	0.656	0.775*	-0.038	-0.163	-0.406
TDS													1	0.920**	0.489	-0.103	-0.474
TSS														1	0.135	-0.361	-0.659
Oil&Grease															1	0.618	0.289
E coli																1	0.906**
Feacal coli																	1

**. Correlation is significant at the 0.01 level (1-tailed)
*. Correlation is significant at the 0.05 level (1-tailed).

In dry season, there were strong positive correlations significant at 0.01significant level between turbidity and BOD (R=0.736), turbidity and faecal coliform (R=0.758), turbidity and alkalinity** (R=0.822), turbidity and oil and grease (R=0.729), turbidity and E-coli (R=0.810) and Akinbile *et al.*, (2012) asserted that leachate contained suspended solid matter consisting of particles of many different sizes which were relatively small solid particles that caused the leachate to appear turbid. Higher rate of turbidity in stream water constitute dissolution of polluting materials. Positive correlations significant were also observed between BOD and Cl (R=0.776), BOD_5 and NO_3 (R=0.780), BOD_5 and SO_4 (R=0.764), Cl and Pb (R=0.743), *E-coli* and Cl (R=0.739), NO_3 and faecal coliform (R=0.831), Pb and TSS (R=0.821), SO_4 and TDS (R=0.835), pH and DO (R=0.772), SO_4 and TSS (R=0.764) and oil and grease and E- coli (R=0.855) while in wet season positive correlation significant at 0.001were found between temperature and alkalinity (R=0.817), temperature and oil and grease (R=0.729), temperature and E-coli (0.809) Also in dry season there were strong positive correlation significant at 0.05 significant level between temperature and BOD_5 (R=0.9778), temperature and E-coli (R=0.16), temperature and faecal coliform

(R=0.978) and according to Akinbile et al., (2012), increase in water temperature increased the rate of photosynthesis by algae and other plants life in the water. The bacteria required oxygen for the process so the BOD_5 was high at this location. Therefore, increased water temperatures will speed up bacterial decomposition and result in higher BOD_5 levels. When BOD_5 levels were high, dissolved oxygen (DO) levels decreased because the oxygen that was available in the water was being taken up by the bacteria'.

Also positive correlations significant at 0.01 were observed between alkalinity and *E-coli* (R=0.763), Cl and SO_4 (R=0.815), Pb and SO_4 (0.822), SO_4 and TDS (R=0.814), SO_4 and TSS (R=0.768), TS and TSS (R=0.775). All these indicated that an increase in one of the parameters favored increase in another due to the inter-relative significance in-between them.

Consequently, strong negative correlation significant at 0.05 in dry season were found between pH and turbidity (R= -0.883) (decrease in value of pH will consequently cause a decline in turbidity value at 0.05 significant level) and between temperature and BOD_5 (R= -0.909) while in wet season EC and *E-coli* (R= -0.763), DO and *E-coli* (R= -0.740) and NO_3 and oil and grease (R= -0.785) were also significant at 0.05 level.

Also in dry season there were strong positive correlation significant at 0.05 significant level between temperature and BOD_5 (R=0.9778), temperature and *E-coli* (R=0.16), temperature and faecal coliform (R=0.978), TDS and TSS (R=0.953), *E-coli* and faecal coliform (R=0.960) also in wet season positive correlations significant at 0.05 level were found between temperature and turbidity (R=0.999), EC and DO (R=0.904), BOD_5 and TDS (R=9.501), BOD_5 and TDS (R=9.709), Cl and Pb (R=1.00) and *E-coli* and faecal coliform (R=0.906).

The trend was an indication that the pollutants presence in the test parameters was strongly interrelated and interdependence on one another with the co variability values observed. For instance, DO dependence on faecal coliform, NO_3, oil and grease and Cl indicated that the effect of oxygen depletion will be significantly felt on all the aforementioned parameters considerably. This would also be true with all other parameters of high correlation values in all other constituents analyzed in the study. In all the parameters tested using t-test correlation analysis, there were significant differences in all the parameters considered at 95% confidence interval also confirming the presence of pollutants at irregular concentrations in all the water samples.

4 Conclusions and recommendations

The study identified the main causes of pollution of *Alaba* stream to be indiscriminate dumping of refuse into the stream, channeling of raw sewage into the river, open defecation along the banks, discharge of untreated effluents into the river, oil seepage and general non-challant attitude of the *Alaba* inhabitants. It was also established from the study that *Alaba* stream was highly polluted, going by the results of the physical, chemical and bacteriological tests carried out on the stream when compared with the WHO, FAO and NSDWQ water standards. Most of the parameters were above the maximum permissible levels required for pollution; therefore it could not be used for domestic purposes unless it is properly treated. If the trend of pollution is left unchecked, the stream would continue to constitute environmental nuisance and the extinction of aquatic lives in it would be sooner than later. A holistic approach is recommended in order to address the pollution of the stream as the challenges are multidimensional and interventions must be considered on long-term, mid-term and short-term basis. Local authorities should provide a technically-sound and environmentally-benign management strategies for pollution control. Enforcing strict compliance to environmental laws much be vigorously pursued and increase awareness on dangers inherent in pollution of streams should be emphasized.

Acknowledgements

The authors are grateful to The World Academy of Science (TWAS) for providing three months Visiting Scholar fellowship for Dr. Christopher Oluwakunmi AKINBILE (FR Number: 3240275076) and the *Universiti Putra Malaysia* (UPM) that enabled him utilize the fellowship.

References

Abowei, J. F. N. 2010. Salinity, dissolved oxygen, pH and surface water temperature conditions in Ngoro River, Niger Delta, Nigeria. *Advanced Journal of Food Science and Technology* 2 (1): 36 – 40.

Adekunle, I. M., M. T. Adetunji, A. M. Gbadebo, O. B. Banjoko. 2007. Assessment of Groundwater Quality in a typical rural settlement in Southwest Nigeria, *International Journal of Environmental Research and Public Health,* 4 (4): 307-318.

Akinbile C.O. 2006. Hawked water quality and its health implications in Akure, Nigeria. *Botswana Journal of Technology*, 15 (2): 70–75.

Akinbile, C.O, M.S. Yusoff, A. Zuki. 2012. Landfill leachate treatment using sub surface flow constructed wetland by *Cyperus haspan, Waste Management*, 32: 1387-1393.

APHA. 2005. Standard methods for the examination of water and waste water, twenty first ed., American Public Health Association, Washington, DC.

Aziz, H.A., M.S. Yusoff, M.N. Adlan, N.H. Adnan, S. Alias. 2004. Physico-chemical removal of iron from semi-aerobic landfill leachate by limestone filters. *Waste Management,* 24 (4), 353–358.

Chauhan J., J.P.N. Rai. 2010. Monitoring of impact of Ferti-irrigation by post-methanated distillery effluent on groundwater quality. *Clean – Soil, Air, Water*, 630–638.

Edema, M.O., A. M. Omemu, and O. M. Fapetu. 2001. Microbiological and Physicochemical analysis of different sources of drinking water. *Nigerian Journal of Microbiology* 15 (2): 57-61.

EPA. 2005. "Protecting Water Quality from Agricultural Runoff." Fact Sheet No. EPA-841-F-05-001

EPA. 2002. Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms. Document No. EPA-821-R-02-012. October 2002.

FAO. 2007. Food and Agricultural Organisation. Coping with water scarcity, World Water Day, 22nd March, 2007. Available on 127 017 2010 from: http://www.fao.org/nr/water7docs/wwd07brochure.pdf [Assessed on 21 June 2012]

Garba, Z.N., C.E. Gimba, S. A. Hamza, and A. Galadima. 2008. Tetrimetric determination of arsenic in well water from Getso and Kutama, Gwarzo Local Government Area, Kano state, Nigeria *Chemicals' Journal*, 5(4): 78-80

Igbinosa E.O., A.I. Okoh. 2009. Impact of discharge wastewater effluents on the physico-chemical qualities of a receiving watershed in a typical rural community. *International Journal of Environmental Science and Technology,* 6 (4): 1735–1742.

Ikem A., O. Osibanjo, M.K.C. Sridhar, A. Sobande. 2002. Evaluation of groundwater quality characteristics near two waste sites in Ibadan and Lagos, Nigeria. *Water, Air, and Soil Pollution,* 140: 307–333.

Jaji, M. O., O. Bamgbose, O. O. Odukoya, and T. A. Arowolo. 2007. Water quality assessment of Ogun River, south west Nigeria. *Environmental Monitoring and Assessment* 133: 473–482

Kaushal, S.S., G.E. Likens, R. Utz, M.L. Pace, M. Grese, and M. Yepsen. 2013. Increased river alkalinization in the Eastern U.S. *Environmental Science and Technology,* DOI: 10.1021/es401046s

Longe E.O. and M.R. Balogun 2010. Groundwater quality assessment near a municipal landfill, Lagos, Nigeria. *Research Journal of Applied Sciences, Engineering and Technology*, 2 (1): 39–44.

Mohajeri, S., H.A. Aziz, M. H. Isa, M. J.K. Bashir, L. Mohajeri, M.N. Adlan. 2010. Influence of Fenton reagent oxidation on mineralization and decolorization of municipal landfill leachate. *Journal of Environmental Science and Health* 45: 692–698.

Mohamed A.F., W. Z. W. Yaacob, M. R. Taha, A.R. Samsudin. 2009. Groundwater and soil vulnerability in the Langat Basin Malaysia. *European Journal of Scientific Research*, 27: 628–635

NSDQW 2007. Nigerian Standard for Drinking Water Quality. Nigerian Industrial Standard NIS 554, Standard Organization of Nigeria, Lagos.

Ogedengbe, K., C.O. Akinbile. 2004. Impact of industrial pollutants on quality of ground and surface waters at Oluyole Industrial Estate, Ibadan, Nigeria. *Nigerian Journal of Technological Development* 4 (2): 139–144

Olaoye, O.A., A. A. Onulide. 2009. Assessment of microbial quality of sachet-packaged drinking water in western Nigeria and its public health significance. *Public Health,* 123 (3): 729- 734.

Rangwala, S. C., K. S. Rangwala, P. S. Rangwala, 2007. Water supply and sanitary engineering: eEngineering, (22nd ed.), Anand, Charotar Publishing.

Sangodoyin A.Y. 1991. Ground and surface water pollution by open refuse dump in Ibadan, Nigeria. *Discovery and innovation*, 3 (3): 37-43.

Shaw, E.M. 1994. Hydrology in Practice (3rd ed.), London, Chapman and Hall.

Schwartz, J., R. Levin, R. Goldstein. 2000. Drinking Water Turbidity and gastrointestinal illness in the elderly of Philadelphia. *Epidemiology and community health.*54: 45-51

Umeh, J.C., O. Amali, E. U. Umeh. 2004. The socio-economic effects of tropical diseases in Nigeria. *Economics and Human Biology*, 2: 245-263.

USEPA. 2002.U nited States Environment Protection Agency, Safe Drinking Water Act Amendment http:// www.epa.gov/safe water /mcl. html [Assessed on 30 September 2011]

WHO. 2004. Guidelines for Drinking Water Quality. Vol. 1, Recommendation. 3rd Ed. WHO, Geneva.