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Microbial and physico-chemical analyses of five major dump sites and nearby water sources

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Abstract
An investigation was carried out on microbial and physico-chemical analysis of soil (heap sites) near water sources in Oka river water, Ikare and Iwaro stream water, Akungba and Ayegunle well water in Akoko area of Ondo state, Nigeria. The isolated and identified bacteria from the samples include *Escherichia coli*, *Bacillus* sp, *Staphylococcus aureus*, *Streptococcus* sp, *Klebsiella* sp, *Micrococcus* sp, and *Enterobacter* sp, while fungi include *Rhizopus species*, *Aspergillus niger*, *Rhizopus oryzae*, *Candida albicans*, *Candida sp*, *Aspergillus fumigatus* and *Gonytrichum macrocladum.* The physico-chemical analysis showed that Ikare soil samples had the highest pH (6.75) and highest potassium (175 ppm). Samples from Oka-Akoko had the highest organic matter (2.56%) and total nitrogen (0.30 ppm), while the highest phosphorus (6.45 ppm) was obtained from Akungba. The lowest pH (5.25) and total nitrogen (0.16 ppm) were observed from Akungba's soil samples. The water samples from Oka-Akoko had the highest pH (7.66) and dissolved oxygen (45 ppm), while Iwaro samples had total hardness (149 ppm) and nitrate (0.05 ppm). Water samples from Ikare were observed to have the highest temperature (28.3 ^{0}C), while the lowest pH (7.09) and total hardness of (48.21 ppm) was observed in Akungba's samples and lowest nitrate (0.01 ppm) and temperature (26 ^{0}C) from Oka-Akoko. All the water samples were positive for *Escherichia coli* which indicate fecal pollution of water, thereby suggesting that water from these sources were not suitable for drinking, as well as for domestic purposes. This study is important for broader understanding of soil quality and appropriate management system that will maximize plant productivity, as well as water quality which is essential to the health of the communities.
Key words: Akoko river, stream, well, dump sites, pollution

Introduction

Heap sites are areas or land sites where material wastes from several sources are deposited, while refuse dumps are the municipal solid wastes and industrial wastes including the liquid effluents containing heavy metals (Olanrewaju, 2002). In Nigeria, the urban and rural landscapes are littered with garbage, plastics, bottles, disposable cups, discarded tyres and even human and live-stock faeces. The wastes constitute a habitat for vector and other nuisance organisms capable of transmitting or causing diseases like typhoid fever, infantile diarrhoea and cholera in humans and animals (Siboe *et al*., 1996). Wastes have been classified into broad categories according to its origin and risk to human and environmental health, they include household waste, municipal waste, commercial, hazardous (toxic) and non-hazardous industrial wastes, construction and demolition waste, health care wastes, human and animal wastes and incinerator wastes (Tchobanoglous *et al*., 1993). The waste has been claimed to constitute a threat to soil quality, health, water and the entire ecosystem.

The majority of the rural populace in developing countries does not have access to potable water, they therefore depend on well, stream and river water for domestic use. The bacterial qualities of some natural water supplies in Nigeria have been reported to be unsatisfactory, with the coliform counts far exceeding the level recommended by the World Health Organization (Edema *et al*., 2001). The quality of water is of vital concern for mankind, since it is directly linked to human welfare. The concentration of many naturally occurring, regulated chemicals and substances like calcium, sodium, iron, manganese is often the key factor in determining the natural component of water and a contaminant (EPA, 2005). Coliform bacteria are a commonly used bacteria indicator of water pollution, although not an actual cause of disease.

The habit of continuous discharge of wastes waste into streams and rivers without treatment motivated the Federal government of Nigeria to promulgate Decree Number 58 that established the Federal Environmental Protection Agency (FEPA) on 30 December 1988, which was aimed at achieving secured quality environment for all Nigerians (FEPA, 1989). The objective of this study was to examine the microbial and physico-chemical properties of five samples of water and heap sites in Ondo state. This is with a view to providing the community with potable water that is free from disease-producing microorganisms and chemical substances that are dangerous to human health.

Materials and methods

Sample collection

Five samples of soil (refuse dump), and five samples of water from Stream, well and river was collected from Ikare, Oka, Akungba, Iwaro and Ayegunle in Akoko area of Ondo State, Nigeria. Samples were collected into sterile bottles, carefully labeled and transported to the laboratory for microbiological and physico-chemical analysis.

Media preparation
The media used was prepared according to the manufacturer's instructions. Sabouraud Dextrose Agar (SDA) was used for fungal isolation (Guinea *et al.,* 2005), while Nutrient Agar (NA) was for bacterial isolation from both water and soil heap samples.

Preparation of soil and water samples
Methods of Eaton *et al.,* 1995 was used. The inoculum was prepared by dispensing either 1g of soil sample or 1 ml water sample into 10 ml of distilled water in a test tube, mixed thoroughly as stock cultures. Ten test tubes were later set up with each containing 9 ml of distilled water. Serial dilution of each sample was carried out using a sterile pipette to accurately transfer 1 ml of the sample mixture into 9 ml of distilled water to give 10 dilutions. One millilitre of 10^{-2}, 10^{-3}, 10^{-5} dilution was discharged into the centre of the Petri dish, molten SDA, cooled at 45^0C was poured into each Petri dish. It was carefully mixed thereafter with the inoculum by tilting the plates front and back, clockwise and anticlockwise. The plates were allowed to cool and set before incubating at 25^0C for 72 h according to Fawole and Oso, 1995.

Identification of fungal isolates
The identification of fungal isolates was based on macroscopic and microscopic examination of the cultures. Macroscopic growth pattern of the fungi and their colour on the plates were observed. Slides were observed under the microscope at ×100 magnifications.

Total viable counts for both soil (heap sites) and water sample
The total viable count was done on each of the soil and water sample by counting the total number of colonies grown on the plates after incubation at 25^oC for 72 h.

Preservation and storage of isolates
After obtaining the pure cultures of different isolates, it was necessary to preserve them for further use. Slants were prepared by preparing a double strength SDA medium in a McCartney bottle to about half of the bottle, which was then placed in a slanted portion and allowed to set. A flamed inoculating needle was used to transfer a loopful of the organisms to the slants aseptically. The slants were kept and preserved (Simione and Brown, 1991).

Biochemical tests and identification of bacterial isolates
Identification of the bacteria Isolates
The cellular morphology and biochemical characteristics of the microbial isolates were used for the identification of the isolates according to Garrity and Holt, 2001. Cultural characteristics like shape, colour, elevation, surface, edge as well as microscopic features were used for identification. The Bergey's Manual of determinative bacteriology by Buchanan and Gibbons, 1974 was used to compare the characteristics with the results obtained.

Gram' Staining
A wet mount of each isolate was prepared, stained with crystal violet for 60 seconds, iodine was then added for 60 seconds, the wet mount was subsequently flooded with 95% ethanol for 30 seconds, washed and safranin was added to counter stain for 1 min. It was rinsed with water, air dried and examined under the light microscope using x100 oil immersion objective lens. Gram positive organisms appeared purple while Gram negative organisms appeared red (Olutiola *et al.*, 1991).

Catalase test
The test demonstrates the presence of catalase enzyme characterized with the release of oxygen from hydrogen peroxide H_2O_2. A drop of 3% H_20_2 solution was added to the microscope slide and a loopful of the organism was made to touch the drop of H_20_2. Catalase production gave prompt effervescence of oxygen, while absence of effervescence showed negative reaction (Sohani and Sanjeeda, 2012).

Starch hydrolysis
The medium containing starch was used by adding 2% starch to Nutrient Agar (NA) and MRS agar with respect to the number of bacteria and lactic acid bacteria to be cultured. Starch agar plates were inoculated by single streak across the surface with pure isolates. The inoculated plates were incubated at 37^0C for 24 h. Iodine reagent was then used to flood the growth. Presence of clear halos surrounding colonies was positive for their ability to

digest the starch, indicating the presence of alpha-amylase, while absence indicates negative reaction (Olutiola *et al.*, 1991).

Turbidity, motility, indole and orthinine

Methods of Sohani and Sanjeeda, 2012 was used. The test tubes were inoculated with test organisms aseptically and were incubated at 37℃ for 3-5 days. For motility test, turbidity from the surface, moving downward indicates that the organism was motile, while for Orthinine test, a change in color from purple to yellow indicates production of orthinine and indole.

Fermentation of Sugars (Glucose, Lactose, Sucrose, Fructose and Mannitol)

Different sugar broths were prepared and dyed with phenol red, 9 ml each was pipetted into test tubes containing a Durham tube each in an inverted position. The broths were sterilized in an autoclave at 121^0C for 15 min and allowed to cool to a temperature of about 45^0C. After cooling, broths were aseptically inoculated with a loopful of the colonies of 24 h old culture of the isolates and incubated at 37^0C for 168 h (7 days). Acid production was observed by a change in color from red to yellow, and gas production by the collection of gas at the top of the Durham tubes (Aneja, 2003).

Physico-Chemical properties

The following analyses were carried out on water samples: $P^{H,}$ Conductivity (Ns/cm^3), Temperature (^oC), Turbidity (NTU), Dissolved oxygen (ppm), Sodium (ppm), Calcium (ppm), Potassium (ppm) and magnesium (ppm, Calcium hardness ($Caco_3$), Total hardness, Carbonate, Bicarbonate, Hydroxide, Total alkalinity, ($caco_{3),}$ Carbonate, alkalinity, Chloride (ppm), Phosphate(ppm), Nitrate (ppm), Sulphate (ppm), Chromium (ppm), Iron (ppm), Lead (ppm), Manganese (ppm), Zinc (ppm), Copper (ppm), Cadmium (ppm), while $P^{H,}$ Conductivity (Ns/cm^3), Organic matter (%), Total Nitrogen (ppm), Phosphorus (ppm), Potassium (ppm), Sodium (ppm) and Electrical conductivity (dsm^{-1}) were carried out on soil samples.

The pH readings and Temperature were carried out as described by Udo and Ogunwale (1986) and Ajayi and Adejumo (2011). The conductivity measurements were made by a standard conductivity meter model 4010, JENWAY, UK. In both cases, 20 g of soil samples were weighed and suspended in 50ml of distilled water and stirred before introducing the probe. Turbidity was done using Nephelometric measurement. Exchangeable cations (sodium, calcium, potassium and magnesium using the methods of Alexander and Clark (1965) as adapted by Udo and Ogunwale (1986). To obtain soil extract, 1 g of ground soil sample was added to 10 ml 1 N ammonium acetate, shaken for 30 minutes and filtered. The filtrate was used for the determination of the concentrations (ppm) of sodium (Na^+) and potassium (K^+) by flame photometry, calcium (Ca^{++}) and magnesium (Mg^{++}) by means of a Perkin Elmer Atomic Absorption spectrophotometer (Isaac and Kerber, 1977). The determination of total nitrogen was done using the total (kjedahl) nitrogen method, while those of phosphorus was done spectrophotometrically, using the molybdovanadate method according to AOAC methods of analysis. Phosphate was determined spectrophotometrically using the persulphate digestion method (APHA, 1992), while nitrate was determined spectrophotometrically using the phenol disulphonic acid method (Taras, 1950). Total Organic Matter Contents was determined using the methods of Walkley and Black (1934). The analysis of soil samples for all the metals was done using Atomic Absorption Spectrophotometer (AAS) (Unican 939/959 model using the method described by AOAC (2005). In each case, soil samples were subjected to pretreatment which include air-drying, sieving and acid digestion before analysis. The results are expressed in mg/kg, as well as in g/100g (%). Micro nutrients (Heavy metals: lead, copper, iron, chromium, manganese, cadmium, zinc) of the soil was determined using the Atomic Absorption Spectrophotometer. The Electrical Conductivity of the soil sample was determined by dipping the electrode of the conductivity meter into the sample, and the readings were noted for stable value shown as mS/cm.

Results

Water Samples

Different species of bacteria were obtained on Nutrient Agar. These included, *Escherichia coli, Bacillus species, Micrococcus species, Enterobacter species, Klebsiella species* while on SDA, several fungi including *Rhizopus species, Aspergillus niger, Rhizopus oryzea* and *Gonytrichum macrocladum* were obtained (Tables 1 and 2).

The physico-chemical parameters of water sources includes, pH values ranged from 7.09 to 7.66 as shown in Table 3. Conductivity and Temperatures were between 19.3 to 45.7 Ns/cm^3 and 26.0 to 28.5 0^oC respectively. Turbidity was between 0.002 to 0.082 NTU, Calcium was between 11.22 to 50.90 ppm, Calcium hardness was between 28 to 149, Total hardness was between 118.21 to 257.10 ppm, Magnesium was between 1.22 to 48.36 ppm, Bicarbonate was between 183 to 359.9 ppm, Total alkalinity was between 183 to 359.9 ppm, Chloride was between 120.53 to 237.52 ppm, Phosphate was between 59-0.97 ppm, sulphate was between 0.18 to 0.35 ppm, Nitrate was between 0.01 to 0.05 ppm, Potassium was between 2.1 to 52 ppm, Sodium was between

6.8 to 66 ppm, Iron was between 0.36 to 0.51 ppm, carbonate alkalinity, Carbonate, Hydroxide, Chromium, Lead, Manganese, Zinc, Copper and Cadmium were below the detection level.

Soil Samples from heap Sites

The bacteria obtained on Nutrient Agar from soil heaps include *Bacillus species, Escherichia coli, Staphylococcus species, Streptococcus species* and *Micrococcus species* while on SDA, several fungi species include, *Aspergillus niger, Candida species* and *Rhizopus species* were obtained (Tables 4 and 5).

The physico-chemical parameters of soil sample include, pH values which ranged from 5.24 to 6.75, Conductivity was between 39.75 to 72.0 NS/cm^3, Organic matter was between 0.58 to 2.56 %, Total nitrogen was between 0.16 to 0.30 ppm, Phosphorus was between 13 to 175 ppm, Sodium was between 100 to 192 ppm, Electrical conductivity was between 4.25 to 6.95 dsm^{-1}, Exchangeable acidity was between 3.70 to 6.23 meq/100 g, and Calcium was between 106 to 360 ppm in Table 6.

A total of seven bacteria were obtained from both water and soil samples, out of which five bacteria, *Escherichia coli, Bacillus sp, Micrococcus sp, Enterobacter sp* and *Klebsiella sp* were present in water samples, while *E. coli, Bacillus sp, Micrococcus sp, Staphylococcus sp* and *Streptococcus sp* were obtained from soil samples. Nine fungal species were also obtained for both water and soil samples out of which five fungi, *Rhizopus sp, Aspergillus niger, Rhizopus oryzae, Gonytrichum macrocladum* and *Aspergillus sp* were present in water sample, while *Aspergillus sp, Candida sp, Rhizopus oryzae, Candida albicans, Aspergillus fumigatus* and *Rhizopus stolonifer* were obtained from soil samples.

The physico-chemical analysis showed that Ikare soil samples had the highest pH 6.75 and potassium 175 ppm, Oka-Akoko had the highest organic matter 2.56%, total nitrogen 0.30 ppm, while Akungba had the highest phosphorus 6.45 ppm. The lowest pH 5.25 and total nitrogen 0.16 ppm were obtained for Akungba while for water samples, Oka- Akoko had the highest pH 7.66 and dissolved oxygen 45 ppm, Iwaro had total hardness 149 ppm and nitrate 0.05 ppm, Ikare had the highest temperature (28.3^{0}C) while Akungba had lowest pH 7.09 and total hardness 48.21 ppm, while Oka-Akoko had the lowest nitrate (0.01 ppm) and temperature (26 ^{0}C).

Discussion

Underground water is generally believed to be the purest source of water (Gordan and John, 1996; Prescott *et al*, 2002) as a result of the purification properties of the soil. Water sources can be contaminated due to improper construction, shallowness, animal wastes, proximity to toilet facilities, sewage, refuse dump sites, and various human activities (Bitton, 1994). The bacteria isolated from all the samples include *Escherichia coli, Bacillus sp, Staphylococcus aureus, Streptococcus sp, Micrococcus sp,* and *Enterobacter sp.* which are of public health significance. *S. aureus* is known to produce enterotoxin (Bennet and Lancette, 1992), *Micrococcus sp* belongs to the intestinal flora, but also widely distributed in soil and water (Schlegel, 2002). *Enterobacter sp* isolated from water samples are examples of non fecal coliforms, and can be found in vegetation and soil (Schlegel, 2002). The fungal species isolated were *Rhizopus species, Aspergillus niger, Rhizopus oryzae, Candida albicans, Aspergillus fumigatus* and *Gonytrichum macrocladum.* These organisms are saprophytes.

The pH of all the water and soil samples were in agreement with pH assigned by EPA as the standard pH of samples which ranged from 6.5 to 8.5 (EPA, 2002). The high turbidity observed with the surface waters is often associated with higher levels of disease causing

Table 1. Biochemical characteristics of water and soil isolates

S/No	Gram reaction	Arrangement	Shape	Spore staining	Catalase	Starch hydrolysis	Motility	Indole	Onithine	Glucose	Lactose	Sucrose	Manitol	Fructose	Organism
1.	-	Cluster	Short	-	+	-	+	-	+	+	-	-	AG	AG	*Escherichia coli*
2.	+	Cluster	Long	-	+	+	+	_	+	+	+	+	AG	A	*Bacillus* sp
3.	-	Cluster	Short	-	+	+	-	-	+	+	+	+	A	A	*Klebsiella* sp
4.	+	Cluster	Short	-	+	+	+	+	-	+	+	+	AG	A	*Enterobacter* sp
5.	+	Cluster	Short	-	-	+	-	-	+	+	-	-	A	A	*Micrococcus* sp
6.	+	Chain	Cocci	-	+	+	-	-	+	+	+	+	AG	AG	*Streptococcus* sp
7.	+	Cluster	Cocci	-	+	-	-	-	-	+	-	+	AG	AG	*Staphylococcus* sp

KEYS
AG = Production of gas and acid, + = Positive test, - = Negative test

Table 2. Identification of fungal isolates of water and soil samples

S/No	Shape	Appearance	Elevation	Surface	Hyphae	Septa	Spore	Spread features	Organism
1.	Circular	Black	Raised	Smooth	Unbranched	Septate	Conidia	Phialides produce chains of mostlyround sometimes rough conidia	*Aspergillus niger*
2.	Circular	Fluffy and woolly whitish colonies turning dark greenish	Raised	Smooth	Branched	Septate	Large conidia	Conidia are roughed single celled and clustered together at the end of each conidiophores	*Aspergillus fumigatus*
3.	Circular	Black	Raised	Smooth	Unbranched	Septate	Conidia	Phialides produce chains of mostlyround sometimes rough conidia	*Aspergillus sp*
4.	circular	Colonies very fast growing and usually grey brown	Oval	Rough	Branched	Aseptate	Group of Sporangiophores arising from rhizoids	Whoris Sporangiophores produced terminally sporangia black and sub globose to oval	*Rhizopus stolonifer*
5.	Circular	Cotton candy like whitish colonies which later turns pale or dark brown grey	Raised	Rough	Branched	Aseptate	Sporangiophore pale to dark brown	Sporangiophores arising directly from stolons or aerial hypae producing rhizoids	*Rhizopus oryzae*
6.	Circular	Cotton candy like whitish colonies which later turns pale or dark brown grey	Raised	Rough	Branched	Aseptate	Sporangiophore pale to dark brown	Sporangiophores arising directly from stolons or aerial hypae producing rhizoids	*Rhizopus sp*
7.	Circular	Creamy white	Raised	Smooth	Branched	Septate	Conidiophores is long and green	One to many celled round and mycelia forms was produce	*Candida albicans*
8.	Circular	Creamy white	Raised	Smooth	Branched	Septate	Conidiophores is long and green	One to many celled round and mycelia forms was produce	*Candida* sp
9.	Circular	It changes the colour of the agar to yellow	Raised		Branched	Septate	Conidiophores arising from a septate mycelium	Conidiophores bearing whorls of phialides on short basal cells of the colour hyphae	*Gonytrichum macrocladum*

Table 3. Physico-Chemical Properties of Water Sources

S/N	Parameters	Oka-Akoko River water	Ikare Stream water	Ayegunle Well water	Akungba Well water	Iwaro Stream water	WHO Standards	FMENV Standard (2003)
1	P^H	7.66	7.42	7.42	7.09	7.32	6.5-8.5	6.5-8.5
2	Conductivity (Ns/cm^3)	45.7	33.6	32.4	19.3	28.9	1000	100
3	Temperature (^oC)	26.0	28.3	27.5	26.5	27.0	5-50	20-30
4	Turbidity (NTU)	0.063	0.184	0.002	0.082	0.032	–	50
5	Dissolved oxygen (ppm)	45	44	42	38	36	1000	50
6	Calcium (ppm)	32.06	27.66	50.90	11.22	59.72	–	65
7	Calcium hardness ($Caco_3$)	80	69	127	28	149	75	500
8	Total hardness (ppm)	113.28	120.72	203.21	48.21	257.10	1400	500
9	Magnesium (ppm)	1.22	24.06	25.31	8.99	48.36	30	50
10	Carbonate (ppm)	BD	BD	BD	BD	BD	–	-
11	Bicarbonate (ppm)	305	244	183	128.1	359.9	–	-
12	Hydroxide (ppm)	BD	BD	BD	BD	BD	–	-
13	Total alkalinity ($caco_{3)}$ (ppm)	305	244	183	128.1	359.9	_	-
14	Carbonate alkalinity (ppm)	BD	BD	BD	BD	BD	–	-
15	Chloride (ppm)	145.35	180.80	166.62	120.53	237.52	250	250

Table 4. Physico-Chemical Properties of Water Sources contd.

S/N	Parameters	Oka-Akoko River water	Ikare Stream water	Ayegunle Well water	Akungba Well water	Iwaro Stream water	WHO Standards	FMEWV Standard, 2003
16	Phosphate (ppm)	0.97	0.86	0.84	0.59	0.96	–	5
17	Sulphate (ppm)	0.24	0.18	0.21	0.18	0.35	250	240
18	Nitrate (ppm)	0.01	0.04	0.03	0.05	0.05	50	50
19	Potassium (ppm)	2.1	5.9	25.000	2.9	52	400	-
20	Sodium (ppm)	6.8	24	38.00	7.6	66	200	-
21	Chromium (ppm)	BD	BD	BD	BD	BD	–	-
22	Iron (ppm)	0.48	0.50	0.48	0.36	0.51	0.1	1.0
23	Lead (ppm)	BD	BD	BD	BD	BD	–	0.05
24	Manganese (ppm)	BD	BD	BD	BD	BD	0.05	0.4
25	Zinc (ppm)	BD	BD	BD	BD	BD	5	5
26	Copper (ppm)	BD	BD	BD	BD	BD	–	0.3
27	Cadmium (ppm)	BD	BD	BD	BD	BD	–	0.05

Key:

- BD – Below detection level
- ppm – parts per million

Table 5. Identification of fungal isolates from Soil samples (heap sites)

Shape	Appearanc	Elevation	Surface	Hyphae	Septa	Spore	Spread	Fungi
Circular	Creamy white	Raised	Smooth	Branched	Septate	Conidiophores is long and green	One to many celled round and mycelia forms was produce	*Candida* sp
Circular	Creamy white	Raised	Smooth	Branched	Septate	Conidiophores is long and green	One to many celled round and mycelia forms was produce	*Candida albicans*
circular	Colonies very fast growing and usually grey brown	Oval	Rough	Branched	Aseptate	Group of Sporangiophores arising from rhizoids	Whoris Sporangiophores produced terminally sporangia black and sub globose to oval	*Rhizopus stolonifer*
Circular	Fluffy and woolly whitish colonies turning dark greenish	Raised	Smooth	Branched	Septate	Large conidia	Conidia are roughed single celled and clustered together at the end of each conidiophores	*Aspergillus fumigatus*

Table 6. Physico-chemical properties of heap sites (soil)

S/N	Parameters	Oka- Akoko	Ikare	Ayegunle	Akungba	Iwaro	WHO Standard
1	P^H	6.55	6.75	6.50	5.25	5.79	7-8.5
2	Conductivity (Ns/cm^3)	39.75	72.0	64.45	45.80	44.43	nil
3	Organic matter (%)	2.56	1.57	0.72	0.58	0.95	50-100
4	Total nitrogen (ppm)	0.30	0.21	0.16	0.16	0.26	-
5	Phosphorus (ppm)	2.45	2.50	1.80	6.45	4.58	-
6	Potassium (ppm)	25	175	4.3	13	49	-
7	Sodium (ppm)	136	100	100	112	192	nil
8	Electrical conductivity (dsm^{-1})	5.20	6.78	6.95	4.25	4.47	0.5
9	Exchangeable acid (meq/100g)	5.55	3.70	4.55	6.23	4.45	-
10	Calcium (ppm)	360	3.28	106	220	4.92	-

Key:

- ppm – parts per million

Table 7. Occurrence of bacteria in water and soil samples

Location	*Escherichia coli*	*Bacillus sp*	*Micrococcus sp*	*Enterobacter sp*	*Klebsiella sp*	*Staphylococcus sp*	*Streptococcus sp*
Oka-Akoko	W+, S+	W+, S+					
Ikare	W+				W+	S+	
Ayegunle	W+	W+					S+
Akungba	W+	S+		W+		S+	
Iwaro	W+	W+	W+, S+				

KEYS

- \+ - Present
- \- - Absent
- S - Soil
- W - Water

Table 8. Occurrence of fungi in water and soil samples

Location	*Rhizopus sp*	*Aspergillus niger*	*Rhizopus oryzae*	*Gonytrichum macrocladum*	*Aspergillus sp*	*Candida sp*	*Candid albicans*	*Aspergillus fumigatus*	*Rhizopus stolonifer*
Oka-Akoko	W+	W+, S+				S+			
Ikare		S+			W+				
Ayegunle		W+	W+, S+			S+			
Akungba		W+, S+					S+		S+
Iwaro	S+			W+	W+	S+		S+	W+

KEYS
- \+ Present
- \- Absent
- S Soil
- W Water

microorganism such as bacteria and other parasites. This is in agreement with EPA standards on turbidity. Water sources may get contaminated from soil runoff, which thereby increase its turbidity, which is a measure of cloudiness of water (EPA, 2002; Schwartz *et al*., 2000). Fewer number of disease causing microorganisms may be an indication of lower turbidity value experienced with water samples (EPA, 2002).

The total hardness of samples is in agreement with the Environmental Protection Agency standard of 500 ppm. Total alkalinity in water has been associated with natural sources, sewage urban runoff, industrial waste water and chemicals used in the water treatment process, though of aesthetic rather than health hazards (EPA, 2002; Ballester and Sunyer, 2000). The Magnesium content obtained from Iwaro stream water (48.36 ppm) was higher than the recommended 30 ppm by WHO, 2004. Also, the Iron contents obtained from all the water sources were in agreement with EPA standard of 0.3 ppm (EPA, 2002), but higher than the recommended 0.1 ppm limit by WHO, 2004.

The results on bacteria showed that *Escherichia coli* were more abundant in all the water samples than *Bacillus sp, Micrococcus sp, Enterobacter sp* and *Klebsiella sp*, while for soil samples (heap sites) *Micrococcus sp* and *Bacillus sp* were more abundant than *Escherichia coli, Staphylococcus aureus* and *Streptococcus sp* (Table 7). Fungal results showed that *Aspergillus niger* were more abundant in water sources than *Rhizopus oryzae* and *Gonytrichum macrocladum*, while for soil samples *A. niger* and *Candida sp* were more abundant than *R. oryzae, C. albicans, A. fumigatus* and *Rhizopus sp* (Table 8).

Conclusion

The microbial and physico-chemical analysis of water and soil samples are important for detecting the presence of microorganisms that might constitute health hazards. This can serve as a guide to monitor and protect our environment in relation to soil and water sources within our vicinity. The levels of pH in water and soil samples indicate slight to moderate alkaline nature. Higher values of Total hardness indicate the presence of soluble salts in waters due to which the palatability decreases and hence these waters may cause gastrointestinal irritation. A higher value of Total Hardness and Calcium concentrations imparts encrustation in water supply structure and can cause adverse effects on domestic use. The higher values of Total Alkalinity change the taste of these waters and hence the waters become unpleasant for consumption. Chloride levels in water are unsuitable for consumption. Sulphate levels were within the permissible limit indicating the non-discharge of industrial waste waters into the ground water sources. The presence of phosphate levels may be due to the discharge of agricultural runoff from the nearby agricultural active zones. The presence of bacterial species including *Escherichia coli, Klebsiella sp, Staphylococcus sp, Bacillus sp, Micrococcus sp, Streptococcus sp, Enterobacter sp* and fungal species such as *Rhizopus species, Aspergillus niger, Rhizopus oryzae, Candida albicans, Aspergillus fumigatus* and *Gonytrichum macrocladum* may cause severe health hazards like stomach cramps, diarrhea, vomiting, fever, urinary tract infection, pneumonia, hepatic infections, bacteremia, skin and soft tissue and opportunistic infections on burns, wounds and also blood related infections. Based on the physico-chemical and bacteriological contamination status of the water and soil samples, it is concluded that these waters are not suitable for human consumption. Effective and frequent monitoring of water quality is suggested to safeguard the health of the public residing in the surroundings of the dump sites. These water bodies should be treated to avoid water quality being further deteriorated.

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