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*Full Length Research Paper*

# Faecal and heavy metal contamination of some freshwaters and their vicinities in Ijebu-north, Southwestern Nigeria

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**Freshwater contamination poses several serious risks to human health. This study was designed to determine the level of faecal and heavy metal contamination in and around some freshwaters in Ijebu North, southwestern Nigeria. Soil samples collected from the vicinities of the freshwater bodies were examined parasitological using test tube floatation method. Soil and water samples were analyzed for Cu, Pb, Cd and Zn. Total viable count and faecal coliform count (FCC) were determined in Omi and Areru streams. *Ascaris lumbricoides* was most frequent around the water bodies. At Konigba pond, Cu, Cd and Zn had mean concentrations 2.10 ± 0.55, 0.50 ± 0.23 and 4.98 ± 2.25 mg/kg, respectively, while at Ajeri pond, Cu, Pb, Cd and Zn had mean concentrations 6.19 ± 1.56, 2.51 ± 1.99, 0.41 ± 0.15 and 58.07 ± 39.29 mg/kg, respectively. In Omi and Areru TCC ranged 5.2 - 15.4 and 4.8 - 12.2 cfu / ml × $10^4$, respectively. The ranges of Cu, Pb, Cd and Zn in Omi were 1.8 - 5.9, 0.12 - 1.18, 0.09 - 0.74, and 11.0 - 23.44 mg/l, respectively, while they were 2.1 - 5.6, 0.09 - 1.36, 0.05 - 0.79 and 11.24 - 17.34 mg/l, respectively in Areru. The study showed the need to provide regular potable water and educate the inhabitants of the study area.**

**Key words:** Freshwater, parasitic helminthes, heavy metals, coliform bacteria, Nigeria.

## INTRODUCTION

On a global scale, contamination of aquatic environments has been regarded as a significant problem with several actual and potential risks to human health. Contamination of water bodies could be through point-source pollution which includes industrial effluents, municipal sewage treatment plants, resource extraction (mining) and combined sewage-storm-water overflows. It also occurs through non-point-source pollution including agricultural runoff (pesticides, fertilizers and pathogens), storm-water and urban runoff, and atmospheric deposition of persistent organic pollutants such as mercury (Nriagu, 1979; Ross, 1994; WHO, 1995; Ritter et al., 2002). Numerous studies have been done on contamination of water bodies in many parts of the world, particularly with a view to reversing the trend and/or the resultant effects on human health (Hill et al., 2005, 2006; Meyer et al., 2005; Mishra et al., 2008; Rai, 2008). However, to the best of knowledge, no information exists in literature on water bodies' contamination from any part of Ijebu North, southwestern Nigeria despite the fact that dumping of refuses from households and mechanic workshops and indiscriminate defaecation near water bodies is common in the area.

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**Abbreviations: TVC,** Total viable count; **FCC,** faecal coliform count; **MPN,** most probable number; **EMB,** eosin methylene blue.

The immediate and future usefulness of water bodies to man cannot be overemphasized. It is therefore imperative to regularly assess the quality vis-à-vis the safety of water bodies which are frequented by humans. In view of the foregoing, this study was designed to determine the level of faecal and heavy metal contamination in some important freshwater bodies in Ijebu North, southwestern Nigeria. In addition, soil samples from the immediate vicinities of the water bodies were examined for parasitic helminth eggs and heavy metals. It is common knowledge that presence of parasitic helminth eggs is indicative of faecal contamination and that at least partly due to surface run-off, such faeces and heavy metals in the vicinities of water bodies may eventually get into the affected water bodies. It is hoped that the findings of this study will stimulate formulation of suitable strategies towards sustainable control/prevention of contamination of water bodies in the study area.

## MATERIALS AND METHODS

### Study area and sites

The study area consisted of Ago-Iwoye and Oru in Ijebu-North Local Government area of Ogun State, southwestern Nigeria. The area lies within latitudes 6° 55´ and 6° 58´ N, longitudes 3° 50´ and 3° 54´ E. Ago-Iwoye is the main seat of the Olabisi Onabanjo University while Oru is a rapidly developing town located about 3.8 km from Ago-Iwoye. The populations of the two towns have been described earlier (Agbolade and Odaibo, 1996; Agbolade et al., 2008a). The freshwater bodies visited in Ago-Iwoye are Omi stream, Ajeri pond, and Konigba pond, while only Areru stream was visited in Oru. The water bodies are important sources of water for laundry and other domestic purposes particularly during prolonged water shortage periods. In addition, Omi stream is important for bathing, swimming and edible water snail collection while Areru stream is also a source of water for manual oil-palm fruit processing, bathing and irrigation on nearby farms. Areru has a refuse dump site at one side of its bank.

### Soil sample collection

Soil samples were collected from each of two accessible sides of each freshwater body along two transects which were 50 m apart. Samples for parasitological examination were collected monthly between August 2007 and February 2008. During each working visit to each of the water bodies, two surface samples were collected along each transect, the first was 3 m (labeled 1A, 1C, 2A and 2C) while the second was 9 m (labeled 1B, 1D, 2B and 2D) away from the bank of each water body. For heavy metal analysis, soil samples were collected at the surface and at 30 cm depth on each transect once for each of Konigba and Ajeri ponds.

### Parasitological examination of soil samples

The test tube floatation method was used. Five grammes of each soil sample were mixed thoroughly with distilled water. The suspension was strained through a net mesh to remove coarse particles. The filtrate was centrifuged for three minutes and the supernatant was decanted. The resultant sediment was further broken-up by shaking and tapping the tube. The sediment was mixed with Zinc Sulphate ($ZnSO_4$) solution (specific gravity of 1.2). A test tube was filled with the mixture, which was then allowed to stand for few minutes with a cover slip on top to collect any floating eggs. The cover slip was then removed and examined under the microscope.

### Heavy metal analysis of soil sample

Two grammes of each soil sample were digested using 2 M $HNO_3$ and then tested for Cu, Pb, Cd and Zn using atomic absorption spectrophotometer (APHA, 1998).

### Bacteriological examination and heavy metal analysis of water samples

Water samples were collected according to the routine method at four different points (25 m apart) along the course of each of Omi and Areru streams once per month in November 2007, January and February 2008. Total viable count (TVC) of each sample was determined using the routine serial dilution method. Faecal coliform count (FCC) of each water sample was determined using the most probable number (MPN) technique (APHA, 1998). This involved the presumptive test using MacConkey broth with Durham tube, confirmatory test using Eosin Methylene Blue (EMB) agar. The tubes and plates were incubated at 37°C for 24 - 48 h. Gas and turbidity in the tubes as well as metallic slum or pink dark centre colonies on EMB agar indicated positive. All isolates that produced gas at 37°C, stained gram negative and were non-spore forming and rod shaped were regarded as faecal coliform. Potato dextrose agar was used to isolate the fungi after incubation for four to seven hours at 28°C. Each of the water samples was analyzed for Cu, Pb, Cd and Zn using atomic absorption spectrophotometer (APHA, 1998).

### Statistical analysis

Mean values and standard deviations were calculated to summarize replicate values of heavy metal concentrations and microbial counts. The chi-square ($\chi^2$) test was used to compare frequencies of occurrence of helminth eggs (Frank and Althoen, 1994).

## RESULTS

The helminthes recorded in the immediate vicinities of the water bodies visited in this study are shown in Table 1. At Omi stream, *Ascaris lumbricoides* had statistically highest frequency of occurrence (100%, 24/24), while *Schistosoma haematobium* and *Trichuris trichiura* had similar frequency (8.3%, 2/24 each) ($\chi^2$ = 144.24, $p < 0.001$). 82.5% (198/240) of the *A. lumbricoides* eggs counted were fertile. The total number of eggs recorded for each of *S. haematobium* and *T. trichiura* was four. At Ajeri pond, *A. lumbricoides* had statistically highest frequency of occurrence (93.8%, 15/16), while each of *S. haematobium* and *Schistosoma mansoni* had a frequency of 6.3% (1/16) ($\chi^2$ = 143.92, $p < 0.001$). 1.1% (4/379) of the *A. lumbricoides* eggs counted was fertile. Only one egg was recorded for each of *S. haematobium* and *S. mansoni*. At Konigba pond, *A. lumbricoides* had statistically highest frequency of occurrence (79.2%, 19/24),

**Table 1.** Helminthes in the vicinities of some water bodies in Ijebu North, southwestern Nigeria.

| Water body | Month/Year | No of eggs per 5 g of soil* | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1A | 1B | 1C | 1D | 2A | 2B | 2C | 2D |
| Omi | Aug 2007 | *As* (1) | *As* (2) | na | na | *As* (7) | *As*(6) | na | Na |
| | Sep 2007 | *As* (5) | *As* (6) | na | na | *As* (10) | *As*(7) | na | Na |
| | Oct 2007 | *As* (8) | *As*(10) | na | na | *As*(16) | *As*(12) | na | Na |
| | Nov 2007 | *As* (10) | *As* (9) *Tt*(12) | na | na | *As*(16) | *As*(9) | na | Na |
| | Dec 2007 | *As* (4) | *As* (6) | na | na | *As*(6) *Sh*(12) | *As*(4) | na | Na |
| | Jan 2008 | *As*(33) | *As*(7) | na | na | *As*(24) *Tt* (2) | *As*(23) *Sh*(2) | na | Na |
| Ajeri | Dec 2007 | *As*(15) | 0 | na | na | *As*(4) | *As*(50) | na | Na |
| | Jan 2008 | *As*(1) | *As*(3) | na | na | *As*(30) | *As*(11) *Sm*(1) | na | Na |
| | Feb 2008 | *As*(41) | *As*(10) | na | na | *As*(13) | *As*(90) | na | Na |
| | Mar 2008 | *As*(30) | *As*(36) *Sh*(1) | na | na | *As*(20) | *As*(25) | na | Na |
| Koni-gba | Dec 2007 | *As*(2) | *As*(25) *Sh*(2) | *As*(3) | *As*(20) | na | na | *As*(1) | 0 |
| | Jan 2008 | 0 | *As*(6) *Sh*(1) | *As*(1) | 0 | na | na | *As*(3) *St*(1) | *As*(3) |
| | Feb 2008 | *As*(20) | *As*(44) | *As*(39) | *As*(50) *Tt*(1) | na | na | *As*(16) | *As*(50) *Sh*(1) |
| | Mar 2008 | *As*(24) *Sh*(1) | *As*(43) | 0 | 0 | na | na | *As*(5) | *As*(30) |
| Areru | Aug 2007 | *As*(6) *Tt* (2) | *As*(14) | *As*(2) *Tt* (5) | na | na | na | *As*(21) *Sh*(3) | *St*(1) |
| | Sep 2007 | *As*(8) | *As*(11) *Ta*(1) | *As*(11) Hk(2) | *As*(6) *Sh*(5) | na | na | *As*(9) | *As*(3) |
| | Oct 2007 | *As*(2) | *As*(16) | *As*(12) | na | na | na | *As*(20) | *As*(1) |
| | Nov 2007 | *As*(11) | *As*(1) | *As*(20) | *As*(25) | na | na | *As*(27) | *As*(7) *St*(2) |
| | Dec 2007 | *As*(23) | 0 | *Tt* (27) | *As*(7) Hk(1) | na | na | *As*(13) | *Sh*(1) |
| | Jan 2008 | *As*(64) | *As*(94) | *As*(65) *St*(5) | *As*(47) | na | na | *As*(78) | *As* (301) |
| | Feb 2008 | *As*(5) | *As*(1) *Sh*(1) | *As*(5) *Sh*(1) | *As*(27) *Sh*(1) | na | na | na | *As*(33) *Sh*(1) |

* As = A .lumbricoides, Tt = T. trichiura, Sh = S. haematobium, Sm = S.mansoni, St = S. stercoralis, Ta = Taenia, Hk = Hookworm, na = Not assessible.

followed by *S. haematobium* (16.7%, 4/24), *Strongyloides stercoralis* (4.2%, 1/24) and *T. trichiura* (4.2%, 1/24) ($\chi^2$ = 148.31, p < 0.001). 11.2% (43/385) of the *A. lumbricoides* eggs counted were fertile. The total number of eggs for *S. haematobium* was five, while each of *T. trichiura* and *S. stercoralis* had one.

At Areru stream, *A lumbricoides* hadstatistically highest frequency of occurrence (92.3%, 36/39), followed by *S. haematobium* (17.9%, 7/39), *T. trichiura* (7.7%, 3/39), *S. stercoralis* (7.7%, 3/39), hookworm (5.1%, 2/39) and *Taenia* (2.6%, 1/39) ($\chi^2$ = 271.41, p < 0.001). The total eggs for *A. lumbricoides*, *T. trichiura*, *S. haematobium*, hookworm, *S. stercoralis* and *Taenia* were 996, 34, 13, 3, 8, and 1, respectively.

**Table 2.** Microbial counts from Omi and Areru streams, Ijebu North, southwestern Nigeria

| Stream | Month/Year | Total viable count (× $10^4$ cfu/ml)* | Total coliform count (× $10^4$ cfu/ ml)* |
|---|---|---|---|
| Omi | Nov. 2007 | 24.7 ± 3.0 | 10.2 ± 5.2 |
| | Jan. 2008 | 18.2 ± 1.6 | 10.3 ± 2.5 |
| | Feb. 2008 | 16.0 ± 2.6 | 7.6 ± 1.9 |
| Areru | Nov. 2007 | 22.8 ± 4.5 | 6.5 ± 1.5 |
| | Jan. 2008 | 13.8 ± 1.9 | 8.5 ± 2.9 |
| | Feb. 2008 | 10.7 ± 1.5 | 8.7 ± 1.8 |

* Values are Mean ± S.D of four replicates.

**Table 3.** Concentrations of heavy metals in Omi and Areru streams, Ijebu North, southwestern Nigeria

| Stream | Month/Year | Concentration (mg / l)* | | | |
|---|---|---|---|---|---|
| | | Cu | Pb | Cd | Zn |
| Omi | Nov. 2007 | 2.60 ± 0.70 | 0.25 ± 0.10 | 0.18 ± 0.09 | 18.20 ± 4.27 |
| | Jan. 2008 | 5.15 ± 0.66 | 0.94 ± 0.18 | 0.58 ± 0.16 | 15.66 ± 3.18 |
| | Feb. 2008 | 4.90 ± 0.53 | 0.64 ± 0.36 | 0.60 ± 0.09 | 12.59 ± 1.39 |
| Areru | Nov. 2007 | 2.65 ± 0.47 | 0.19 ± 0.09 | 0.10 ± 0.04 | 15.91 ± 1.28 |
| | Jan. 2008 | 4.50 ± 0.93 | 1.10 ± 0.23 | 0.53 ± 0.20 | 15.27 ± 2.02 |
| | Feb. 2008 | 3.48 ± 0.56 | 0.85 ± 0.13 | 0.35 ± 0.06 | 13.72 ± 2.09 |

Values are Mean ± S.D of four replicates.

At Konigba pond, Cu, Cd and Zn were detected in 33.3, 58.3 and 100% of the soil samples with concentrations within the ranges of 1.55 - 2.80, 0.30 - 0.95 and 0.45 - 8.45 mg/kg with means of 2.10 ± 0.55, 0.50 ± 0.23 and 4.98 ± 2.25 mg/kg, respectively. Pb was not detected at this pond. At Ajeri pond, Cu, Pb, Cd and Zn were detected in 87.5, 50.0, 87.5 and 100% of the soil samples with concentrations within the ranges of 4.60 - 9.40, 1.45 - 5.50, 0.15 - 0.55 and 2.55 - 114.50 mg/kg with means of 6.19 ± 1.56, 2.51 ± 1.99, 0.41 ± 0.15 and 58.07 ± 39.29 mg/kg, respectively.

The results of the bacteriological analysis of water samples from Omi and Areru streams are shown in Table 2. The ranges of TVC in Omi and Areru were 13.6 - 28.2 and 8.6 - 27.8 × $10^4$ cfu / ml, respectively. The ranges of TCC in Omi and Areru were 5.2 - 15.4 and 4.8 - 12.2 × $10^4$ cfu / ml, respectively. The microbes recorded were *Escherichia coli, Staphylococcus aureus, Bacillus cereus, Bacillus subtilis, Proteus vulgaricus, Proteus morganii*, *Pseudomonas aeruginosa*, *Streptococcus faecium*, *Klebsiella aerogenes*, *Aspergillus fumigatus*, *Aspergillus parasiticus*, *Aspergillus tamarii*, *Fusarium oxysporium*, and *Penicillium oxalicum*. 57.1% (8) of the 14 different microbial species recorded occurred consistently along the water course of both streams throughout the study. These include *E. coli, S. aureus, B. cereus, B. subtilis, P. vulgaricus, P. aeruginosa* and *S. faecium*. *A. fumigatus* was the only consistent fungi isolated. 14.3% (2/14) of the microbial species isolated were associated with Areru only and these were *P. morganii* and *K. aerogenes*. The ranges of Cu, Pb, Cd and Zn in water samples from Omi were1.8 - 5.9, 0.12 - 1.18, 0.09 - 0.74, and 11.0 - 23.44 mg/l, respectively, while they were 2.1 - 5.6, 0.09 - 1.36, 0.05 - 0.79 and 11.24 - 17.34 mg/l, respectively in Areru. Table 3 shows the mean concentrations of the heavy metals in the streams.

## DISCUSSION

The occurrence of eggs of parasitic helminthes in the immediate vicinities of water bodies in this study is indicative of high level of contamination of their surroundings. The practice of indiscriminate defaecation is common around virtually all the water bodies studied. The presence of a refuse dump site at one side of Areru is a source of concern. A previous study showed heavy faecal and parasitic helminthes contamination of dump sites in the study area (Agbolade et al., 2009). Observations also showed that dumping of refuse and/or human faeces into water drainages is a common practice in the study area. The public health significance of this is that nearby water bodies are contaminated with human faeces, particularly in rainy season. Much of the faecal contamination in the water bodies might have been from the immediate vicinities of the water bodies. The observation that substantial percentage of *A. lumbricoides* eggs recorded from the vicinities of three of the water bodies that was fertile is important. Many of such fertile eggs may be blown by wind or flushed by surface runoff into the water bodies. Transmission of *A. lumbricoides* through the water bodies cannot be ruled out. This is because they enjoy regular human contact and, therefore, direct and/or indirect ingestion of the contaminated water seems almost inevitable. The study area has long been known as being endemic for human schistosomiasis, especially the urinary type and the water snail vectors are present (Agbolade et al., 1996; 2004; Okunuga and Agbolade, 1998). Due to frequent contamination of the water bodies, regular supply of the vectors with miracidia from human schistosome eggs seems almost guaranteed.

The microbial analysis of the streams included in this study shows that their TVC exceeded the recommended limit of $1.0 \times 10^2$ cfu / ml (WHO, 1971). The presence of faecal coliforms is an index of bacteriological quality of water. Their presence in the studied streams further lent support to the inference that faecal deposits and waste dumps find their way into them (Hill et al., 2006). It was noticed that the lowest faecal count was observed at sampling point closest to the road. It may be that humans who defaecate directly into the water bodies do so far away from the open, while faecal deposits are carried to other points of the water bodies by runoff (Crowther et al., 2001). Nevertheless, smaller mammals (particularly rodents) might have been coming around the streams to drink water in the course of which they defaecate into them (Belton et al., 1999; Banwo, 2006).

Generally, there is a gradual reduction in the mean TVC in both Omi and Areru streams from November through February. In Omi stream, the mean TCC increased slightly in January, but decreased sharply in February. The period of this study (November - February) coincided with the end of the rainy season. The practice of faeces disposal into drainages seems more prevalent during the rainy season. The belief among the autochthonous population is that the faeces would be washed away by rain water. This probably accounts for the gradual decrease in the mean TVC in both streams and mean TCC in Omi stream. However, in Areru, the mean TCC increased appreciably from in November and reached the peak ($8.70 \times 10^4$ cfu/ml) in February. It is possible that the human defaecation directly into the stream was not reduced as the rains subsided, or animals were responsible for the continued faecal contamination during this period. The gradual increase in mean TCC in Areru might have been due partly to the emergence of *P. morganii* and, more importantly, *K. aerogenes*. These bacterial species seemed to have replaced some fungal species including *A. tamarii, A. parasiticus, P. oxalicum* and *F. oxysporium*. Possibly *P. morganii* and/or *K. aerogenes* are highly repulsive to the growth of those fungal species. This requires further studies.

The results of this study show that, *E. coli, S. aureus, B. cereus, B. subtilis, P. vulgaricus, P. aeruginosa* and *S. faecium* are the predominant bacterial species in the streams. The presence of *E. coli* (a coliform bacteria species) in the streams depicts their being unsafe for human use, particularly for drinking and cooking. The presence of heavy metals in the vicinities and surface water of water bodies in this study is another source of concern. It is known that the occurrence of many heavy metals, such as lead, are often a consequence of anthropogenic and, sometimes, natural processes (WHO, 1995). Refuse dumping directly and/or indirectly into the water bodies are part of the anthropogenic processes which might have contributed to the presence of the metals in and/or around the water bodies. Increased environmental pollution from exhausts of automobiles in the towns is also anthropogenic and this might have contributed to the quantity of Pb available in the water bodies and their surroundings. Gradual release of heavy metals from contaminated surroundings into water bodies cannot be ruled.

Zn and Cu are some of the heavy metals that have been reported to be of useful importance to man and plants (Brady and Weil, 1999; Wardlaw, 2003). However, there concentrations in surface water are often a major factor. For instance, in this study Zn exceeded the maximum tolerable concentration (WHO, 1971; Duruibe et al., 2007). On the other hand, Pb and Cd are toxic even at extremely low levels (WHO, 1971; Wardlaw, 2003) and yet both occurred at unbearably high concentrations in this study.

Unfortunately, apart from the possibility of direct ingestion of heavy metals by humans, studies have shown that some fishes and freshwater snails, including edible ones such as *Lanistes libycus*, innately accumulate heavy metals in their bodies (Adewunmi et al., 1996; Agbolade et al., 2008b; Ekpo et al., 2008). It has earlier been noted that specimens of *L. libycus* from the study area sometimes have *Fusarium sp* attached to their shells (Agbolade et al., 2008b). The combined effect of all these is that humans who frequent the water bodies do so at the detriment of their health.

The findings of this study show that the studied water bodies are unsafe in their present polluted conditions. There is urgent need to ensure adequate and regular provision of safe potable water and refuse management facilities in the study area. Provision and adequate maintenance of household and public toilets by landlords and the government, respectively, in the area is desirable. Adequate education of the inhabitants of the study area on the significance of personal and environmental hygiene particularly with regard to the dangers of indiscriminate refuse and faecal disposal is also urgently needed.

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