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# Mineral composition of soil, plants, water and total bacteria of samples from Arinta water falls in Ipole-Iloro, Nigeria

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**ABSTRACT**

The soil, plants (*Pnematopteris afra* and *Macaranga stauatii*), water along the channel of Arinta Water Falls in Ipole-Iloro, Nigeria, were evaluated for their mineral composition as well as the total bacteria count of the water samples. Sites of sample collection were six ($M_1$-$M_6$) and a distance of 0-477cm in the channel. In the soil, Pb, Ca, Cr, Cd and Co were not detected in any site whereas Cu was detected in two sites and Mn in only one site; Na, K, Zn, Fe and Mg were detected in all the sites but levels of Zn, Cu and Mn were low. In the plant *P. afra,* Na, K, Zn, Ca, Fe and Mg were highly concentrated in the leaves, stem and roots with levels in stem > leaf in Na, K and Mg. Similar trend was observed in *M. stauatii* but the levels being more consistently concentrated in stem > leaf > root in Na, K, Ca, Fe and Mg. The metal bioconcentration factors were all intensive for the two plants. The following physico-chemical water parameters were within the WHO guidelines for potable water: pH, alkalinity, hardness, conductivity, sulphate, nitrate, chloride, total solid, suspended solid and dissolved solid whereas turbidity and phosphate were antagonistic. For the minerals: Na, K, Zn, Fe, Pb, Cu and Mn were mostly within the WHO guidelines unlike Ca and Mg. After 24 hours incubation, the total bacteria count was less than 100 in all the samples and Gram staining results were all negative. The water could be regarded as potable after little treatment and also good for domestic use.

**Key words:** Arinta Water Falls, mineral composition, soil, plants, water, water bacteria load.

## INTRODUCTION

The town Ipole-Iloro Ekiti, Ekiti State, Nigeria is situated between lofty, steep-sided and heavily wooded, north-south trending hills about 113 km east of Ilesa, and about 11km South-east of Efon Alaye. The Ipole-Iloro Water Falls (Arinta Water Falls) is located about 3 km west of Ipole-Iloro town. The Water Falls originated near the top of the stone. The drainage area of the fall is small. It courses rapidly down the stone with a velocity of over 2 metre per second in a southward direction of about 50 metres. The stream actively transport bottom sands downstream and effectively deprives them of mud-sized particles[1]. The Arinta Water Falls serves as number two tourist centre in Ekiti State.

Natural water supply is very plenty in Ekiti State, which has several water schemes [Ero dam, Little Osse (Egbe) dam, Itapaji dam, Ado waterworks, Ikere artesian borehole and mini water schemes at Efon, Okemesi, Igbara-Odo and Ido-Ajinare] but none is working effectively owing to lack of electricity, obsolete equipment or inadequate water pipelines. Therefore access to potable water is poor and this is the major cause of water-borne disease in Ekiti State of Nigeria. Access to potable water will improve health thereby reducing child and adult mortality and health care costs[2].

The 1991 National Census puts the population of Ekiti State at 1,647, 822[3]. At present, potable water is only available to 32% of the population and actual water production is 20,000M[3]. Arinta Water Falls forms a stream which the people of Ipole-Iloro use both as potable water and for domestic uses.

In this study, samples of soil sediments, water and plants were taken along the stream of the Water Falls in six different places where there was only one single channel of water. The plants were taken in only two spots where stone bed gave room for little mud soil. Parameters evaluated were physico-chemical characteristics and minerals of the water samples, mineral profile of the soil samples and also of the plants (leaves, stems and roots). The total bacteria count was also determined in the water. The study was carried out to determine the level of potability of the water and also evaluate pollutional or contamination level where the soil and the plants were used as markers.

## MATERIAL AND METHODS

### Collection of samples

Six different samples of water and underlying soil sediments (5.0 cm below the surface) were collected along the sampling sites (at intervals) which lied along the course of stream. Details of interval of sample collections are shown in Table 1.

Water samples were collected with clean, sterile one litre wide mouthed plastic bottles previously leached with 1:1 HCl. The bottles were fitted with screw caps and the stopper and neck of the bottles were protected with aluminium foil. Bottles were rinsed with appropriate samples before being filled. The soil and plant samples were collected into acid leached polythene bags. Appropriate labels are shown in Table 1. The work was carried out under aseptic techniques.

**Table 1: Sampling sites of water and plant samples from Arinta Water Falls**

| Sampling site designation | Distance (cm) |
|---|---|
| $M_1$ | 0 |
| $M_2$ | 77 |
| $M_3$ | 231 |
| $M_4$ | 308 |
| $M_5$ | 462 |
| $M_6$ | 477 |

The plants found in the stream were *Maranga stauatii* Fax (Euphorbiaceae) in $M_5$ and *Pnematopteris afra* syn. *Cyclosorus afer* (Thelypteridaceae) in $M_6$. *M. stauatii*[4] is a swamp forest tree, its Yoruba name is *Asasa igbo* or *Arasa-odo* or *Asasa odo. P. afra*[5] is a terrestrial fern, up to 1m in height, commonly found near water and moist environment; its English name is water-side fern and Yoruba name is *Imu or Imu eti omi.*

### Sample treatment

The water sample temperature was taken at the site of collection using a simple thermometer calibrated in °C, electrical conductivity was measured with a CDM 83 conductivity meter (Radio Meter A/S Copenhagen, Denmark). Turbidity and pH were determined at site using Water Proof Scan 3+ Double Junction by Wagtech International UK and HI 98311 – HI 98312 (Hanna) Water Proof EC/ TDS and Temperature Meters by Wagtech International (manufactured in the UK). The water samples were then stored in the deep freezer until analysed.

Once in the laboratory, the soil sediments were air dried. After drying the soil particles were ground into fine particles using the laboratory mortar and pestle. The fine soil particles were sieved using a 200 mm-mesh sieve. The finer soil particles were packed in sample bottles and labelled. The treatments for soil samples were repeated for the plant samples.

### Digestion of samples

A portion, 0.5g of each soil sediment was weighed in 50 ml beakers. Concentrated HCl, $HNO_3$,$HClO_4$ and HF were added in that order to each of the samples of 5 ml applications. The samples (soil and plants) were then heated until digested in a fume cupboard[6]. For a portion of water sample, 5 ml of concentrated HCl was added to 250 ml of water and evaporated to 100 ml.

The concentrate was transferred into labelled bottle containers after cooling[7].

**Analyses of samples**

The physical parameters determined/ observed were the temperature, appearance, odour, taste and conductivity. Other physico-chemical characteristics determined were pH, hardness was determined by titrimetry[8]; total solid, total dissolved solid and total suspended solid were determined by gravimetric method[8]; alkalinity and sulphate were determined by titrimetry[8]; both nitrate and phosphate were determined colorimetrically by Spectronic 20 (Gallenkamp, UK)[8]. Atomic absorption spectrophotometer (Perkin-Elmer Model 403, Norwalk, CT, USA) was used to determine the levels of Zn, Ca, Pb, Cu, Fe, Mn, Cr, Cd, Co and Mg while Na and K were determined using a flame photometer (Corning, UK, Model 404) using NaCl and KCl to prepare standards[9]. Chloride was determined by Mohr's method[10].

**Determination of total bacteria**

This test was used to estimate the bacteria population present in the water samples. Both the microbial growth determination (bacteria count) and microbial staining methods were as described in Fawole and Oso[11].

## RESULTS AND DISCUSSION

Table 1 shows the distances of sample collections for all the samples (soil and water) but plant samples were only from $M_5$ (*M. stauatii)* and $M_6$ (*P. afra)*. The distance ran from 0.0 metre (where the water falls down) and 477 m where the water channel broke into two. Total number of samples for water and soil were six each (making 12) and plants were two but in roots, stems and leaf group (making six samples). The site of sample collection was determined by the ease of collection.

Table 2 shows the mineral content of the soil samples. In all the samples, Cd, Co, Cr, Ca and Pb were not detected in any sample. Cu was detected in only $M_4$ and $M_5$ with a value of 1.0 ppm each while Mn was only detected in $M_5$ with a value of 1.0 ppm. Generally speaking, Mg was consistently high in the soils with levels of 558-712 ppm, followed by Na with values of 410-429 ppm and followed by K with values of 89-916 ppm but having hot spots in $M_3$ (902 ppm), $M_4$ (899 ppm) and $M_5$ (916 ppm). Among the trace metals, Fe was best concentrated with values of 47-101 ppm and followed slightly by Zn (1.0-3.0 ppm and followed slightly by Zn (1.0-3.0 ppm). Results in the trace metals are not much different from the results

**Table 2: Mineral composition (ppm) of the soil samples along the water sample sites**

| Parameter | $M_1$ | $M_2$ | $M_3$ | $M_4$ | $M_5$ | $M_6$ |
|---|---|---|---|---|---|---|
| Sodium | 415 | 410 | 429 | 417 | 419 | 419 |
| Potassium | 89 | 95 | 902 | 899 | 916 | 94 |
| Zinc | 1.0 | 1.0 | 2.0 | 1.0 | 2.0 | 3.0 |
| Iron | 72 | 72 | 101 | 47 | 93 | 95 |
| Lead | ND[a] | ND | ND | ND | ND | ND |
| Calcium | ND | ND | ND | ND | ND | ND |
| Copper | ND | ND | ND | 1.0 | 1.0 | ND |
| Manganese | ND | ND | 1.0 | ND | 1.0 | ND |
| Chromium | ND | ND | ND | ND | ND | ND |
| Cadmium | ND | ND | ND | ND | ND | ND |
| Cobalt | ND | ND | ND | ND | ND | ND |
| Magnesium | 586 | 587 | 558 | 627 | 618 | 712 |

[a]ND = not detected.

obtained from Ikogosi Warm Springs (unpublished report) soil sediments. Rogers et al[12] had adduced the probable reasons for the low soil sediment contents of Cr, Mn and Cu as being due to scarcity of magnetite, and calcium- and iron- bearing silicates in the rock samples; this may also explain why Ca was not detected in the soil. The values of Mn being less than those of Fe might be explained thus: $Mn^{3+}$ will be carried by acidic solutions but a slight increase in hydroxyl ion concentration would result in its precipitation as the hydroxide thereby making it unavailable[13]; if a solution contained both $Fe^{3+}$ and $Mn^{2+}$ then the following reaction is possible: $Fe^{3+}(aq) + Mn^{2+}_{(aq)} \rightleftharpoons Fe^{2+}(aq) + Mn^{3+}(aq)$ and the values for Mn suggest that it would indeed proceed to the right; thus further reducing the level of Mn in water.

Table 3 shows the mineral levels in the leaves, roots and stem of *Pnematopteris afra*. For the major minerals, the general trend of concentration was stem > leaves > roots particularly in Mg, Ca and Na. The following trace metals were not detected: Pb, Cu, Mn, Cr, Cd and Co. While Zn was highly concentrated in the roots (1467 ppm), Fe was mostly concentrated in the leaves. For Fe value in stem > root whereas in Zn, value in leaf > stem. To monitor pollution in the Arinta Water Falls, root of *P. afra* would be best to monitor Zn whereas the leaf would be best to monitor Fe. In Table 4, *Macaranga stauatii* mineral levels are shown. In Na, K and Ca, the stem > leaf > root whereas in Mg, stem > root > leaf. Levels of Fe in *M. stauatii* were much higher than the Zn; trend of

**Table 3: Mineral composition (ppm) of the plant samples (*Pnematopteris afra* collected from $M_5$ site**

| Parameters | Plant part | | |
|---|---|---|---|
| | Leaf | Stem | Root |
| Na | 39000 | 50500 | 33667 |
| K | 33667 | 52000 | 34333 |
| Zn | 303 | 228 | 14467 |
| Ca | 8570 | 8557 | 6303 |
| Pb | ND | ND | ND |
| Cu | ND | ND | ND |
| Fe | 612 | 394 | 350 |
| Mn | ND | ND | ND |
| Cr | ND | ND | ND |
| Cd | ND | ND | ND |
| Co | ND | ND | ND |
| Mg | 25957 | 31759 | 24321 |

**Table 4: Mineral composition (ppm) of the plant samples (*Macaranga stauatii)* collected from $M_6$ site**

| Parameters | Plant part | | |
|---|---|---|---|
| | Leaf | Stem | Root |
| Na | 25000 | 50000 | 16667 |
| K | 25750 | 52000 | 16517 |
| Zn | 114 | 228 | 115 |
| Ca | 9247 | 18205 | 3761 |
| Pb | ND | ND | ND |
| Cu | ND | ND | ND |
| Fe | 787 | 1837 | 1006 |
| Mn | ND | ND | 37 |
| Cr | ND | ND | ND |
| Cd | ND | ND | ND |
| Co | ND | ND | ND |
| Mg | 13287 | 41759 | 21296 |

concentration in Fe: stem > root > leaf > and in Zn: stem > root > leaf. Also, Pb, Cu, Mn, Cr, Cd and Co were not detected in *M. stauatii.* To use *M. stauatii* to monitor pollution, Fe would be better monitored by the stem whereas Zn would be by stem as well. However from *P. afra* and *M. stauatii,* Zn would be better monitored by the stem of *P. afra* whereas stem of *M. stauatii* would better monitor Fe.

Table 5 shows the bioconcentration of metals in *P. afra* and Table 6 shows those of *M. stauatii.* All the metals in the Tables: Na, K, Zn, Fe and Mg showed that the degree of accumulation is intensive for all the values. The ability of different plants and plant parts to absorb both trace and major elements varies greatly (Tables 5 and 6) with marked differences in the metal uptake between both plant species.

**Table 5: Bioconcentration[a] of metals by plant (*Pnematopteris afra)* from soil in $M_5$ site**

| Parameters[b] | Plant part | | |
|---|---|---|---|
| | Leaf | Stem | Root |
| Na | 93.1 | 121 | 80.4 |
| K | 36.8 | 56.8 | 37.5 |
| Zn | 152 | 114 | 7234 |
| Fe | 6.6 | 4.2 | 3.8 |
| Mg | 42.0 | 51.4 | 39.4 |

[a]Ratio in plant/soil.

[b]Values shown are index of bioaccumulation: $10^{-3}$-$10^{-2}$ (lack), $10^{-2}$-$10^{-1}$ (slight), $10^{-1}$ -1 (Medium, 1-$10^{1}$ (intensive).

**Table 6: Bioconcentration of metals by plant (*Macaranga stauatii)* from soil in $M_6$ site**

| Parameters | Plant part | | |
|---|---|---|---|
| | Leaf | Stem | Root |
| Na | 59.7 | 119 | 39.8 |
| K | 27.4 | 55.3 | 17.6 |
| Zn | 38.0 | 76.0 | 38.3 |
| Fe | 8.3 | 19.3 | 10.6 |
| Mg | 18.7 | 58.7 | 29.9 |

**Table 7: Some physico-chemical characteristics of the water samples of Arinta Water Falls along the site of collection**

| Parameters | $M_1$ | $M_2$ | $M_3$ | $M_4$ | $M_5$ | $M_6$ |
|---|---|---|---|---|---|---|
| Appearance | Clear | Clear | Clear | Clear | Clear | Clear |
| Odour | Odourless | Odourless | Odourless | Odourless | Odourless | Odourless |
| Taste | Tasteless | Tasteless | Tasteless | Tasteless | Tasteless | Tasteless |
| Temperature (°C) | 25.0 | 24.3 | 24.7 | 24.7 | 24.5 | 24.2 |
| pH | 8.0 | 7.9 | 8.1 | 8.1 | 8.2 | 8.2 |
| Alkalinity (ppm) | 28 | 12 | 16 | 28 | 28 | 8 |
| Turbidity (NTU) | 8.13 | 10.2 | 7.57 | 6.98 | 9.81 | 8.0 |
| Total hardness (ppm) | 238 | 182 | 152 | 204 | 32 | 210 |
| Conductivity × 100 (µS/cm) | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| Chloride (ppm) | 28.4 | 21.3 | 21.3 | 28.4 | 35.5 | 28.4 |
| Total solid (ppm) | 2.41 | 1.74 | 2.47 | 1.84 | 4.29 | 2.16 |
| Total suspended solid (ppm) | 1.04 | 0.50 | 1.06 | 2.10 | 1.10 | 1.06 |
| Total dissolved solid (ppm) | 1.37 | 1.32 | 1.41 | 0.60 | 2.19 | 1.10 |
| Sulphate (ppm) | 6 | 10 | 6 | 12 | 4.4 | 6 |
| Phosphate (ppm) | ND | 4 | 6.4 | 6.4 | 10 | 4 |
| Nitrate (ppm) | 2 | 8 | 4.4 | 0.8 | 2.0 | 1.6 |

Table 7 contains the aesthetic qualities of the water samples. They were all colourless, tasteless and of clear appearance. The conductivities were all generally low with a range of 0.01-0.02 × 100 μScm$^{-1}$ showing that mineral suspension was low in the water samples. The value of 0.02 x 100 μScm$^{-1}$ corresponded to the value of sample with highest temperature (25.0°C). The pH, alkalinity, hardness, turbidity, total solid, total suspended solid, total dissolved, solid, phosphate, nitrate, sulphate and chloride of the water samples are shown in Table 7. The pH range was 7.8 – 8.2 which were all in the alkaline region of the pH. Rogers et at[12] had reported pH of 7.45 (warm spring), 7.50 (cold spring) and 7.65 (mixed water). The alkalinity values (ppm) range was low at 8-28. Alkalinity could likely had been high in $M_1$, $M_4$ and $M_5$ (28 ppm each) due to the likely contribution by the roots of decaying plants in the course of the water flow. Our current report is generally higher than the report of du Preez and Barber[14] whose partial chemical analysis of the Wikki Spring water has 11.5 ppm alkalinity which is only close to 12 ppm in $M_3$. The total solids (TS), total suspended solids (TSS) and total dissolved solids (TDS) were all low (Table 7) and also widely varied. The TDS and TS in our results were much lower than the literature results[12, 14]. Phosphate level ranged from ND in $M_1$-10 in $M_5$. With the exception of $M_1$, all our values were higher than 0.11 (warm spring), 0.11 (cold stream) and 0.13 (mixed region) [12]. Both the sulphate and nitrate levels were low: in sulphate the range was 4.4-12 ppm whereas it was 0.8-8 ppm in nitrate. Hardness levels were high in $M_1$ (238 ppm), $M_4$ (204 ppm) and $M_6$ (210 ppm) while others were lower than 200. Chloride levels range was 21.3- 35.5 ppm. The World Health Organization (WHO)[15] drinking water guideline values are higher than our results in pH, alkalinity, total hardness (50%), TS, TSS, TDS, $SO_4^{2}$, $Cl^{-}$, $NO_3^{-}$ and conductivity whereas turbidity and phosphate were antagonistic to the guidelines.

Table 8 contains the metal contents of the water samples. Both Cr and Cd were not detected in any of the samples. Cu was detected only in $M_2$ and $M_4$ with a value of 0.1 ppm each. Pb was also detected only in $M_3$ and $M_4$ with a value of 0.1ppm each. Compared with the WHO guidelines, the followings were observed: Na was within in all samples, K was antagonistic in $M_1$ (761 ppm), Zn was antagonistic in $M_3$ (6.4 ppm), Fe in $M_1$, $M_5$ and $M_6$ (0.5 and 0.4 ppm), Pb was higher by 0.05 ppm, Ca was only within in $M_2$, $M_5$ and $M_6$, Mg was completely antagonistic in all the samples, Cu is good enough while Mn is poor in $M_2$ (0.2 ppm). It is however gratifying that all the trace metals were not at deleterious levels.

**Table 8: The mineral content (ppm) of the water samples of Arinta Water Falls along the site of collection**

| Parameters | $M_1$ | $M_2$ | $M_3$ | $M_4$ | $M_5$ | $M_6$ |
|---|---|---|---|---|---|---|
| Na | 58.1 | 48.9 | 63.2 | 64.3 | 55.2 | 67.4 |
| K | 761 | 90.3 | 66.2 | 70.8 | 72.0 | 61.6 |
| Zn | 0.2 | 0.1 | 6.4 | 0.1 | 0.3 | 0.3 |
| Fe | 0.5 | 0.3 | 0.2 | 0.3 | 0.4 | 0.5 |
| Pb | ND | ND | 0.1 | 0.1 | ND | ND |
| Ca | 713 | 60.4 | 75.7 | 80.1 | 50.5 | 60.1 |
| Mg | 60.1 | 65.8 | 71.9 | 74.2 | 61.1 | 62.9 |
| Cu | ND | 0.1 | ND | 0.1 | ND | ND |
| Mn | 0.1 | 0.2 | 0.1 | 0.1 | ND | 0.1 |
| Cr | ND | ND | ND | ND | ND | ND |
| Cd | ND | ND | ND | ND | ND | ND |

Table 9 contains the total bacteria count per ml after 24 hours incubation at $10^{-1}$ and $10^{-2}$ dilutions with cfu/ml levels of < 20. Colony counts provide an estimate of general bacteria purity, which is of particular value when water is used industrially for the preparation of food and drink. They may also give forewarning of pollution. Colony counts are not essential for assessing the safety of domestic water supplies, they are however useful for indicating the efficiency of certain processes in water treatment, for example coagulation, filtration and chlorination, and the cleanliness of the distribution system[16]. Rogers et al[17] in their analyses of numerous water samples in Nigeria reported that ground water may contain bacteria such as anaerobic nitrogen fixers, protein decomposers, ammonifiers, nitrifiers, denitrifiers, cellulose decomposers, sulphate reducers, sulphur oxidizers and starch decomposers. The staining reaction was negative for all the samples. This means that the organisms are likely to be pathogenic.

**Table 9: Total bacteria count and Gram reaction of Arinta Water Falls samples**

| Samples | Colony forming unit per ml(cfu/ml)[a] | | Gram staining reaction |
|---|---|---|---|
| | $10^{-1}$ | $10^{-2}$ | |
| $M_1$ | 17.5 | 13.5 | Negative |
| $M_2$ | 15.5 | 3.0 | Negative |
| $M_3$ | 11.0 | 5.0 | Negative |
| $M_4$ | 9.5 | 5.0 | Negative |
| $M_5$ | 23 | 12.5 | Negative |
| $M_6$ | 25 | 17.0 | Negative |

[a]After 24 hours incubation.

In conclusion, this work might lay a baseline information for the characteristics of Arinta Water Falls in Ipole-Iloro, Nigeria, for the water, underlying soil sediments and the in-stream plants.

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