International Journal of Earth, Energy and Environmental Sciences
ISSN: 2517-942X
Vol:9, No:9, 2015

Chemical and Hydro-Geologic Analysis of Ikogosi Warm Spring Water in Nigeria

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***Abstract*—**This study focuses on the hydro-geology and chemical constituents analysis of Ikogosi Warm Spring waters in South West Nigeria. Ikogosi warm spring is a global tourist attraction because it has both warm and cold spring sources. Water samples from the cold spring, warm spring and the meeting point were collected, analyzed and the result shows close similarity in temperature, hydrogen iron concentration (pH), alkalinity, hardness, Calcium, Magnesium, Sodium, Iron, total dissolved solid and heavy metals. The measured parameters in the water samples are within World Health Organisation standards for fresh water. The study of the geology of the warm spring reveals that the study area is underlain by a group of slightly migmatised to non-migmatised paraschists and meta-igneous rocks. Also, concentration levels of selected heavy metals, (Copper, Cadmium, Zinc, Arsenic and Cromium) were determined in the water (ppm) samples. Chromium had the highest concentration value of 1.52ppm (an average of 49.67%) and Cadmium had the lowest concentration with value of 0.15ppm (an average of 4.89%). Comparison of these results showed that, their mean levels are within the standard values obtained in Nigeria. It can be concluded that both warm and spring water are safe for drinking.

***Keywords*—**Cold spring, Ikogosi, melting point, warm spring, water samples.

I. Introduction

WATER is a scarce resource and it is unevenly distributed throughout the world with over 450 million people in 29 countries suffering from shortage of water [1]. Surface water and groundwater are two major sources of water but spring water results when groundwater travels through a network of cracks and fissures until it reaches the ground surface [2]. The hydro-geology and drinking water quality of the warm spring water source on the outskirts of the agrarian town of Ikogosi-Ekiti in South-Western Nigeria for recreational and drinking purposes had been a major source of interest in the past four decades. Drinking water contamination with different chemicals and heavy metals, released from different anthropogenic sources has become a global concern [3].

It is important to establish a comprehensive and detailed database of the minerals and chemical present in the water so as to serve as a baseline for future environmental impact assessment of any developmental project in the spring. An attempt was made earlier to determine the physical and chemical properties of the water from the source by [4]. They concluded by attributing its ordinariness and the measured water temperature to the normal geothermal gradient of the area. This finding could be corroborated by geological/radiochemical studies on the abundance and potentials of Hot Dry Rocks (HDR) around the spring area.

Circulation of groundwater has a potential filtering effect and also offers the possibility of water pollution through weathering of the basement rocks. Chemical species such as Co, Ci, Ca, Mg, Na, K, Fe which have some salutary health effect as well as toxin such as Pb, Cd could easily be introduced into the water through leaching.

Reference [5] clearly puts it that water is regarded internationally as the most fundamental and indispensable of all natural resources and the massive interest in water analysis is due to enormous importance of water to all categories of living things. It is necessary for the healthy development of man, animals and plants. Water plays an important role in the bodily intake of true element by human. Even though some trace elements are essential to man, at elevated levels, essential and non-essential elements can cause morphological abnormalities: reduced growth, increase mortality and mutagenic effects [6]. Furthermore, [7] iterates that heavy metals are important; some are physiologically essential for plants and animals, though, they exist in trace amount, they have a direct bearing on human health and agricultural productivity and many are significant pollutants in ecosystem throughout the world.

Heavy metals can enter a water supply by industrial and consumer waste, or even from acidic rain, breaking down soils and releasing heavy metals into streams, rivers lakes and ground water. The concentrations of these heavy metals in sediments and water may be traced to the bed rock from which the sediments were derived through which the water flows [8].

The objective of this study is to study the Engineering geology of the study area, determine the measure values of chemical species in the water samples, determine the concentration of heavy metals (Cu, Cd, Zn, As and Cr) in the water samples and establish the various anthropogenic sources of these heavy metals by comparing the results obtained with certain standard. Remedial ways of controlling the pollution caused by these heavy metals in the study area would also be suggested if found present.

II. Study Area

Ikogosi warm spring is located in Ikogosi, South-Western Nigeria, just north of the 7°35'N latitude and slightly west of the 5°00' E longitude.

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TABLE I
NOMENCLATURE OF THE ABBREVIATIONS USED

Ca	Calcium
Mg	Magnesium
Na	Sodium
Fe	Iron
TDS	Total dissolved solid
Cu	Copper
Cd	Cadmium
Zn	Zinc
Ar	Arsenic
Cr	Chromium
pH	Hydrogen iron concentration
K	Potassium
Pb	Lead
Cl^{-}	Chlorine ion
PPM	Part per millions

The elevation of the general area is between 457.0 - 487.5m [4]. The spring is a low enthalpy system, its temperature being around 36 °C and this has been attributed to the circulation of the normal groundwater to a depth of one to several thousand feet [9]. The geothermal system as described by [10], [11] discharges a virtually constant volume of water all year round. It is a popular global tourist attraction.

The spring consists of two different sources namely: the cold spring and the warm spring. The stream resulting from the mixing of the warm and cold springs, a tributary of the Owena River is used for cooking. It is important to establish a comprehensive and detailed database of the minerals and chemical present in the water so as to serve as a baseline for future environmental impact assessment of any developmental project in the spring. [4] made an attempt earlier to determine the physical and chemical properties of the water from the source, they concluded by attributing its ordinariness and the measured water temperature to the normal geothermal gradient of the area. This finding could be corroborated by geological/radiochemical studies on the abundance and potentials of Hot Dry Rocks (HDR) around the spring area.

Circulation of groundwater has a potential filtering effect and also offers the possibility of water pollution through weathering of the basement rocks.

III. Geologic Structure of the Study Area

The study area is at Latitude of 7° 35' 38.9'', Longitude of 4° 58' 52.6'' and at average elevation of 479m above mean sea level (msl). The study area is underlain by a group of slightly migmatised to non-migmatised paraschists and meta-igneous rocks. This group contains rocks which have been previously described as being younger or newer metasediments derived from the Effon Psammite formation and the associated epidiorite schist and amphibolite complex. The Effon Psammite formation [12]-[13] comprises quartzites, quartz schists and granulites which occur largely east of Ilesa and run for nearly 180 km in a North North East-South South West direction.

There are three varieties of quartzite in the study area. These include massive quartzite, fissile quartzite and mica schist or quartz schist. Geological features such as faults and shear zones are concealed; however, fractures can be identified on a few outcrops along river valleys and on hill tops or slopes. The study area consists of rugged terrain with undulating hills and thick vegetation. The topographical elevation determined from topographic map varies from less than 473m in the valleys to 549 m on the hills.

An integrated surface geophysical investigation involving resistivity and magnetic methods was carried out by [14] in the immediate vicinity of the Ikogosi warm spring with a view to delineating its subsurface geological sequence and evaluating the structural setting beneath the warm spring. It was deduced that the fractured/faulted quartzite may have acted as conduit for the movement of warm groundwater from profound depths to the surface while the spring outlet was located on a geological interface (lineament).

IV. Research Methodology

Standard method of sample collection was used for collecting the water samples [15]. The samples were kept in a refrigerator (4°C) prior to analysis. One litre sample each was collected in clean white plastic bottles from the four points within the site of the warm spring. The sampling points are:

- Oozing point of the warm spring source
- Oozing point of the cold spring source
- The mixing point of the warm and cold stream
- Gossy bottled water produced by UAC plc

All the water samples were prepared for analysis by treating a 95.0 ml with 5.0ml concentrated nitric acid (HNO_3) and filtered through 0.45μm filter [16].

A. Procedure for Analysis

The Alpha 4 atomic absorption spectrophoto – meter of the Agronomy Department of the University of Ibadan, Nigeria was used to analyse for Na, Mg, K, Ca, Fe, Zn, Cd, and Pb in the samples with flame atomization. The major operating conditions for each element are listed in Table II. The analytical protocol for these elements in fresh water by Atomic Absorption Spectroscopy (AAS) is well documented. Analysis of water samples for Total Dissolved Solid (TDS) and Suspended Solid (SS) was done by gravimetric method.

Alkalinity, Hardness and Cl^{-} concentrations were determined according to the standard procedures [17]. Samples for heavy metals were analysed for Cu, Cd, Zn, As and Cr using a Perkin Elmer model 306 Atomic Absorption Spectrometer. All chemicals used were of analytical reagent grade and deionised water was employed throughout for dilutions and washing. Means and standard deviation of all the values were determined.

TABLE II
COMPARISON OF WARM SPRING, COLD SPRING AND BOTTLED WATER PARAMETERS

Parameter	Warm Spring	Cold Spring	Bottled water	Meeting Point
T°C	36.00	29.6	29.5	35.2
pH	6.37	6.95	6.80	7.13
Alkalinity (ppm CaCo3)	10.0	9.80	1.6	9.20
Ca (ppm)	11.63	14.73	17.41	21.06
Mg(ppm)	6.69	7.13	8.71	10.06
K (ppm)	3.85	4.80	4.17	5.78
Na (ppm)	1.89	2.14	2.04	3.05
Fe (ppm)	0.56	0.61	0.49	0.62
Zn (ppm)	0.34	0.26	0.24	0.33
Pb (ppm)	0.16	0.09	0.11	0.21
TDS (ppm)	0.00	0.00	0.10	0.00
Cl (ppm)	10.65	3.55	7.10	7.10
Carbonate (ppm)	0.00	0.00	0.00	0.00
Bi – Carbonate (ppm)	42.7	30.5		36.6
SS (ppm)	0.99	0.99	1.09	0.89
Hardness (ppm CaCo3)	5.65	6.70	7.95	9.40

V. RESULTS AND DISCUSSION

A. Chemical Examination

The result of measured chemical values of samples from the warm spring source, cold spring source, the meeting point and the swimming pool are presented in Table II and Fig. 1. Also presented in Table III are the Drinking Water quality standards parameters as released by [18]. These parameters serve as a check for the suitability of the Ikogosi water to be used for drinking purposes.

A direct comparison of the figures in columns 1 and 2 of Table II shows the relationship between the cold spring and the warm spring. Major similarities between Warm and Cold are noted with respect to pH, Alkalinity, Hardness, Ca, Mg, Na, Fe, TDS. Significant variations are observed for temperature and Chlorine. Between the warm spring and the meeting point, a close relationship is observed for Temperature, pH, Suspended solids, Total dissolved Solids, Alkalinity, Fe, Zn and Pb. Major differences are noted for Cl^{-}, Mg, Zn, Ca, K, Na, and hardness.

The four studied water samples have similar water chemistry and comparable temperature. Measured levels of alkali and alkaline earth metals, trace element (Pb, Zn) other chemical species (Cl^{-}) as well as Dissolved Solids are consistent with what is expected from fresh groundwater. Levels of all the measured chemical species are well below World Health Organization maximum levels for drinking water.

A direct comparison shows the relationship between the warm spring, cold spring and the bottled water. With respect to pH, hardness, Ca, Mg, K, Na and Fe, the values for the cold spring is higher than that of the warm spring. Significant variations were observed for T, Cl, Zn and particularly Bi-Carbonate where the value for the warm spring is greater than that of the cold spring.

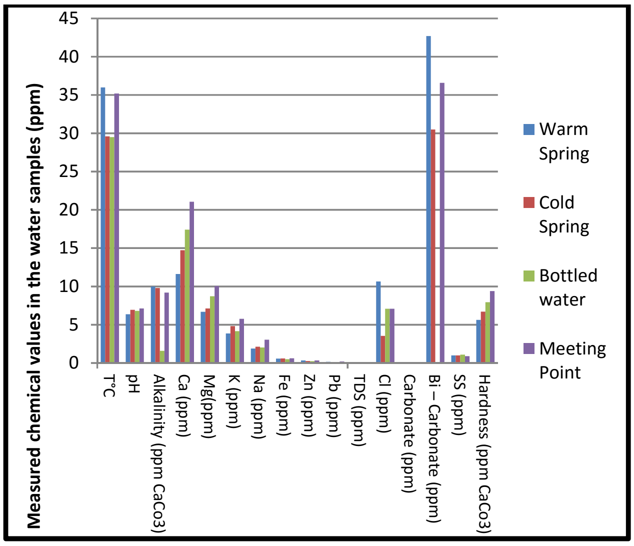

Fig. 1 Measured chemical values in Ikogosi warm spring (part per millions)

For the bottled water sample, the values of Ca, Mg, is much compared with both the warm and cold springs. Also, the alkalinity of the bottled water has been reduced drastically to 1.6, whereas the value for warm spring is 10.0.

B. Heavy Metals

The result of the heavy metals present in water samples are presented in Table IV and Fig. 2. The mean value in ppm of the heavy metal content of the water were, 0.48±0.23 for copper, 0.15±0.06 for cadmium, 0.31±0.04 for zinc, 0.60 ±0.28 for Arsenic and 1.52 ±0.72 for chromium.

TABLE III
STANDARD CHEMICAL PARAMETERS PERMITTED FOR DRINKING WATER IN NIGERIA[18]

Parameter	Unit	Maximum Permitted	Health Impact
AluMiNium (Al)	Mg/L	0.2	Potential Neuro-degenerative disorders
Arsenic (As)	Mg/L	0.01	Cancer
Barium	Mg/L	0.7	Hypertension
Cadmium (Cd)	Mg/L	0.003	Toxic to the kidney
Chloride (Cl)	Mg/L	250	None
Chromium ($Cr6^{+}$)	Mg/L	0.05	Cancer
Copper ($Cu^{+}2$)	Mg/L	1	Gastrointestinal disorder
Cyanide (CN^{-})	Mg/L	0.01	Very toxic to the thyroid and the nervous system
Fluoride (F^{-})	Mg/L	1.5	Fluorosis, Skeletal tissue (bones and teeth) morbidity
Hardness (as CaCO3)	Mg/L	150	None
Hydrogen Sulphide (H2S)	Mg/L	0.05	None
Iron ($Fe^{+}2$)	Mg/L	0.3	None
Lead (Pb)	Mg/L	0.01	Cancer, interference with Vitamin D metabolism, affect mental development in infants, toxic to the central and peripheral nervous systems
Magnesium (Mg^{+2})	Mg/L	0.20	Consumer acceptability
Manganese (Mn^{+2})	Mg/L	0.2	Neurological disorder
Mercury (Hg)	Mg/L	0.001	Affects the kidney and central nervous system
Nickel (Ni)	Mg/L	0.02	Possible carcinogenic
Nitrate (NO_3)	Mg/L	50	Cyanosis, and asphyxia ("blue-baby syndrome") in infants under 3 months
Nitrite (NO_2)	Mg/L	0.2	Cyanosis, and asphyxia ("blue-baby syndrome") in infants under 3 months
pH	-	6.5 – 8.5	None
Sodium (Na)	Mg/L	200	None
Sulphate (SO_4)	Mg/L	100	None
Total Dissolved Solids	Mg/L	500	None
Zinc (Zn)	Mg/L	3	None

TABLE IV
CONCENTRATION OF HEAVY METALS IN THE WATER SAMPLE (PPM)

Samples	Cu	Cd	Zn	As	Cr
Warm Spring	0.72	0.1	0.34	0.96	0.8
Cold spring	0.64	0.2	0.26	0.71	2.4
Bottle water	0.28	0.2	0.31	0.4	1.1
Meeting Point	0.3	0.1	0.33	0.36	1.8
Average	0.48	0.15	0.31	0.6	1.52

TABLE V
COMPARISON OF HEAVY METAL CONTENTS IN THE WATER SAMPLES (PPM) [6]

Metals	Range	Mean	Heavy metals in South East Nigeria (Comparison)
Cu	0.28 – 0.72	0.48	-
Cd	0.1 – 0.2	0.15	0.0 – 0.2
Zn	0.26 – 0.34	0.31	-
As	0.36 – 0.96	0.60	0.24 – 1.30
Cr	0.8 – 2.4	1.52	0.11 – 0.12

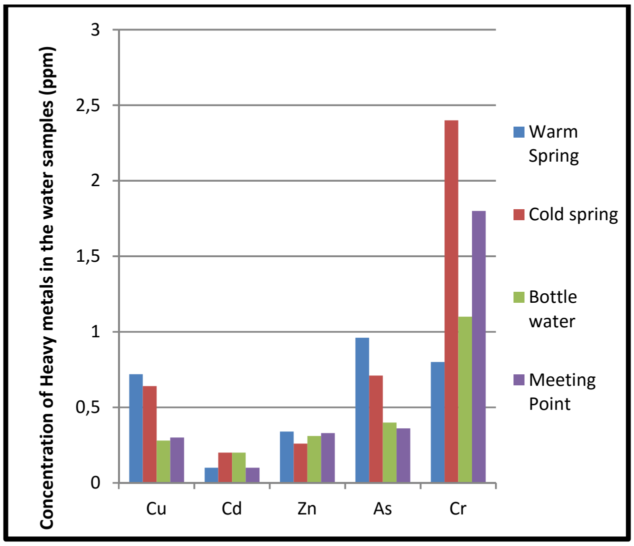

Fig. 2 Heavy metal concentration in the water samples (part per million)

The distribution of the heavy metals in the water is Cromium>Arsenic>Copper>Zinc>Cadmium. Therefore, the metals with the highest and lowest levels are Cromium (1.52±0.72ppm) and Cadmium (0.15±0.06ppm) respectively. Comparison of the mean concentration of these metals with results from Nigeria and other countries showed that, all the metals demonstrated low concentrations as indicated in Table V. In addition, copper level at Ikogosi warm spring is lower than 1.3ppm (the approved minimum standard regulated by United States Environmental Protection Agency (EPA) and Nebraka Department of Health and Human Services (DHHS).

VI. CONCLUSION

The purpose of this study is to examine and analyze the water quality of the Ikogosi warm spring waters and their compliance with national and international regulations .Warm water whose temperature is measured to be around 36°C oozes out of six active sources in the rain forest of Ikogosi town and is thought to result from groundwater, finding its way through faults in the bedrock of the area. This high temperature could be explained not only by the normal geothermal gradient expected from such a deep circulation, but also enhanced by the abundance of Hot – Dry – Rocks (HDR) in the basement.

This study gives an insight into the diversity of spring water as an important natural resource as well as its shortcomings in terms of physical and chemical quality. Results of this analysis have shown that even waters of the same type can have a significantly different composition concerning the major constituents and trace elements.

Three studied samples apart from the bottled water produced from Ikogosi warm spring waters have similar water chemistry and comparable temperature. Levels of all the measured chemical species are well below Nigerian Standard for Drinking Water Quality and World Health Organisation maximum levels for drinking water.

Comparing the water chemistry of the warm spring with cold and bottled water samples, it shows a lot of similarities and that tends to support the conclusion of [4] on the ordinariness of the spring sources. The concentrations of the heavy metals in the water at the area of study were also found to be lower. This is an indication of low contamination of the area of study from anthropogenic sources. It can be concluded that both cold and warm water are adequate and very safe for drinking.

VII. Recommendations

From the analysis of both chemical and physical properties of the spring, the following recommendations are made;

1. Efforts should therefore be intensified to guide against pollution of the warm spring area. More so that, Ikogosi Warm Spring is a global tourist centre.
2. Water samples must be collected and analysed periodically for evidence of fecal contamination.

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