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WATER QUALITY EVALUATION OF SPRING WATERS IN NSUKKA, NIGERIA

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Abstract
Water qualities of springs in their natural state are supposed to be clean and potable. Although, water quality is not a static condition it depends on the local geology and ecosystem, as well as human activities such as sewage dispersion, industrial pollution, use of water bodies as a heat sink, and overuse. The activities on land use around the water sources can increase the level and number of contaminants if not properly used. This study evaluates the water quality of four spring waters (Asho, Ajie, Iyi-Nsukka and Ikwoka-Obimo) in Nsukka, Enugu state Nigeria to ascertain their suitability for drinking since they are consumed directly without treatment. Water samples were collected from these four springs and analyzed accordingly. The physical, chemical and bacteriological tests were carried out on the water samples with appropriate equipment. After analyzing the samples, it was found that some of the water parameters tested were within WHO/NIS standard and some were outside the range provided by WHO/NIS standard. Among the parameters tested that falls outside the range provided by WHO/NIS standard that has significant health implication are coliform and E. coli. It was found that there is high concentration of coliforms especially at Ajie and Iyi - Nsukka springs with 150MPN and 280MPN per 100ml respectively. Ajie and Iyi-Nsukka springs also have E. coli of 3MPN/100ml each while Asho and Ikwoka-Obimo springs have <3MPN/100ml. The contaminations is as a result of indiscriminate dumping of refuse, defecation around the water sources especially at the uphill side of these spring and the agricultural activities. Base on the findings, the water from these four springs is not safe for drinking without treatment.

Keywords: Spring waters, Water quality, E coli, Coliform, Portable water.

1. Introduction

Water is vital to the existence of all living organisms, but this valued resource is increasingly being threatened as human populations grow resulting in increase in demand for water for domestic and economic purposes. Springs are a naturally occurring outcrop of ground water to the earth's surface, either from the force of gravity or hydrostatic pressure (water pressure pushes the water to the surface) [1]. Spring water is collected directly from an underground formation from, which water flows naturally to the surface or from a bored hole that taps the source of the spring. If the rate of flow is rapid, a pool of clear water will form around the area of ground water discharge. The water running out of the pool creates an eroded channel and marks the

beginning of a spring-fed stream. Ground water becomes surface water when it exits at the spring site. Surface water can be easily contaminated as it flows over the land's surface. If water from the spring becomes muddy or is discolored shortly after a rainstorm, it is evidence that surface runoff is readily entering the spring. This may mean the spring is contaminated with pollutants from sources upslope from the spring's emergence [1]. Although spring water requires minimal treatment before it is bottled, it must retain the same physical properties and composition as the natural spring water [1]. Water abstraction for domestic use, agricultural production, mining, industrial production, power generation, and forestry practices can lead to deterioration in water quality and quantity that impact not only the aquatic ecosystem, but also the availability of safe water for human consumption.

The quality of any body of surface or ground water is a function of either or both natural influences and human activities. Spatial variations in water quality may be influenced by many different environmental factors like climate, geology, weathering processes, vegetation cover and anthropogenic [3]. Without human influences, water quality would be determined by the weathering of bedrock minerals, atmospheric processes of evapotranspiration, and the deposition of dust and salt by wind. Others include the natural leaching of organic matter and nutrients from soil, hydrological factors that lead to runoff, and by biological processes within the aquatic environment that can alter the physical and chemical composition of water [4]. Water pollution is said to occur when a chemical, physical or biological substance exceeds the capacity of water body to assimilate or break down the substance that can cause harm to the aquatic ecosystem [5]. Some of the major contaminants of surface water include: Escherichia coli (E. coli), Giardia, Cryptosporidium, viruses, pesticides, organic and synthetic compounds, pharmaceutical compounds; and major contaminants of groundwater include most of the above and heavy metals and metalloids such as arsenic and other ions [6].

Water quality and quantity are intimately linked although not often measured simultaneously. Water quantity is often measured by means of remote hydrological monitoring stations, which record water level, discharge, and velocity. Monitoring of water quantity can be undertaken, to a certain degree, with a minimal amount of human intervention, once a monitoring station has been set up. In contrast, water quality is usually determined by analyzing samples of water collected by teams of personnel visiting monitoring stations at regular intervals. Typically, water quality is determined by comparing the physical and chemical characteristics of a water sample with water quality guidelines or standards. Drinking water quality guidelines and standards are designed to enable the provision of clean and safe water for human consumption, thereby protecting human health as well as the environment. Drinking water treatment [7] is done to remove microorganisms and solid from water through different methods such as coagulation and filtration. Drinking water standards are especially important for evaluating ground-water quality because many consumers utilize untreated ground water that is pumped directly from a well [8]. The guidelines are usually based on scientifically assessed acceptable levels of toxicity to either humans or aquatic organisms.

Water quality is neither a static condition of a system, nor can it be defined by the measurement of only one parameter. Rather, it is variable in both time and space and requires routine monitoring to detect spatial and temporal patterns. There is a range of chemical, physical, and biological components that affect water quality and hundreds of variables could be examined and measured. Some variables provide a general indication of water pollution, whereas others enable the direct tracking of pollution sources.

Contaminants that may be in untreated water include microorganisms such as viruses and bacteria; inorganic contaminants such as salts and metals; organic chemical contaminants from industrial processes and

petroleum use, pesticides and herbicides, and radioactive contaminants [9]. Water quality depends on the local geology and ecosystem, as well as human activities such as sewage dispersion, industrial pollution, use of water bodies as a heat sink, and overuse. Therefore, the activities on land use around the water sources can increase the level and number of contaminants if not properly used. Organic matter in the form of domestic sewage, municipal wastes and effluents from agricultural industries makes up the most ubiquitous source of water pollution [10].

In many African countries, it has been reported that 80% of human illnesses are attributable to contaminated water supplies [11]. The objective of this study is to evaluation the water quality of four spring waters (Asho, Ajie, Iyi-Nsukka and Ikwoka-Obimo) in Nsukka to ascertain their suitability for drinking. In Nsukka, spring waters are seen as clean and safe water, but this study will ascertain whether this is true or not.

2. Study Area

Nsukka is located on longitude $7^0$22'E and latitude $5^0$50'N in the South Eastern part of Nigeria [12]. It is in the humid tropical climatic region and is characterized by two distinct wet and dry seasons. Figure 1 and 2 shows the map of the study area.

2.1 The Spring Sources

The spring water sources are located at different areas within Nsukka and they are namely: Asho, Ajie, Iyi-Nsukka and Ikwoka-Obimo spring. Asho spring is located on the longitude of 07 23' 15.61386''E and latitude of 06 51' 35.62626''N, Ajie on the longitude of 07 22' 08.70712''E and latitude of 06 52' 28.32115''N, Iyi-Nsukka spring is on longitude of 07 25' 00.82855''E and latitude of 06 49' 38.89309''N, and Ikwoka-Obimo spring is on longitude of 07 21' 40.90141''E and latitude of 06 48' 49.97818''N. The springs are of different features. The common feature among them is that all the water sources are located at the foot of hills where water is being discharged as underground water seepage all year round. There are agricultural activities and sparse land development at the top of the hills. The spring areas are also characterized by thick and tall forests, which protect the areas from direct sunlight and excessive evaporation. These springs are major sources of water supply within their host communities especially during the dry season.

2.2 Asho Spring

Asho spring is located at the foot of the hills at Onuiyi layout area of Nsukka, with the hills as the source of the water. The Asho spring water channeled to concrete reservoirs, where outlets were made through taps for collection as shown in (Figure 3). The water is only seen at the outlets because it runs underground but with very poor or no maintenance at all. The spring is a major source of water for the people of Onuiyi, especially during the dry season. Sanitary inspections of the surroundings revealed human defecation at the upper part of the hills, which is a source of pollution. There are also land developments since the top of the hill is a table land.

2.3 Ajie spring

Ajie spring source has almost the same features as Asho with a refuse dump site at the entrance of the spring source. It is located at Odenigbo area of Nsukka, behind Erina Hotels. Like Asho spring, it is a major source of water supply for the inhabitants of Odenigbo. Ajie spring is also developed but the reservoirs are dilapidated and are out of use. The spring water is collected at the point where the reservoir pipe is broken as shown below in Figure 4.

2.4 Iyi-Nsukka spring

Iyi-Nsukka spring is located at the foot of the hills behind the timber shade in Nsukka. The spring is not well built but drains from the stone and ponds in a small open earthen depression from where water is scooped with a cup or bowl as seen in (Figure 5).

2.5 Ikwoka-Obimo spring

Ikwoka-Obimo spring is located at Ikwoka village, Obimo in Nsukka. It is located in the village but, its source is at the foot of a hill. The spring is well built and channeled to the center

of the village for domestic purposes as shown in (Figure 6).

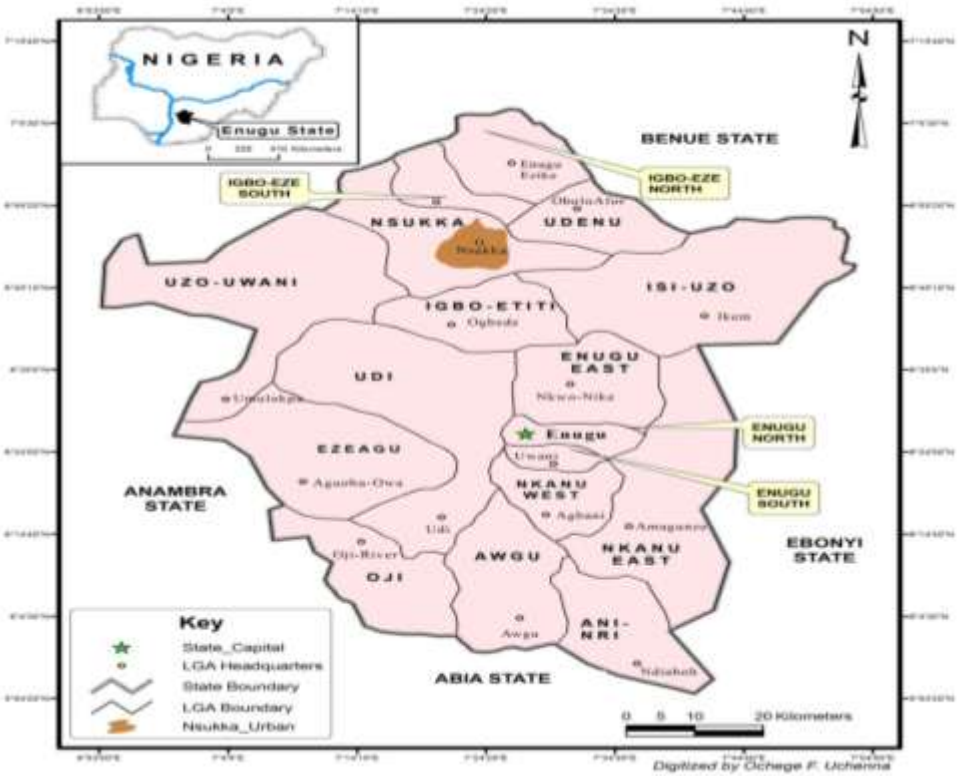

Figure 1: Map of Enugu State showing Nsukka

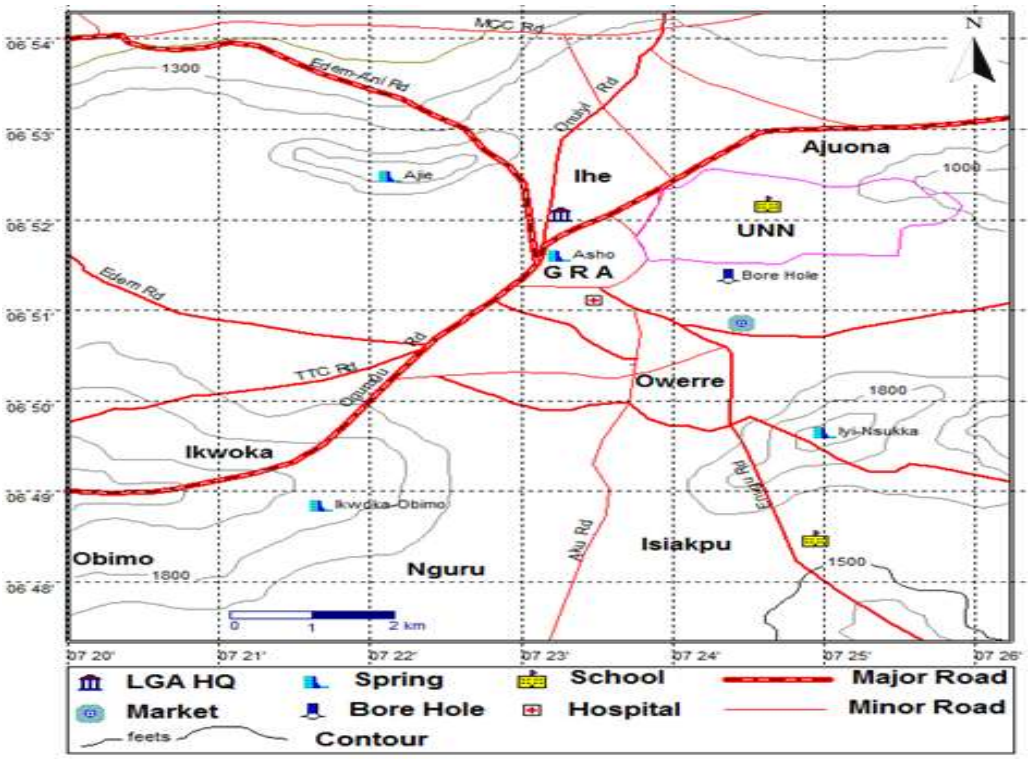

Fig 2: Map of Nsukka showing the locations of springs studied

Figure 3: Water collection at the Asho spring, Nsukka, Nigeria

Figure 4: Ajie spring in Odenigbo, Nsukka, Nigeria.

Figure 5: Iyi-Nsukka spring, Nsukka, Nigeria

Figure 6: Ikwoka-Obimo spring, Obimo, Nsukka, Nigeria

3. Materials and methods

Water samples were collected during the rainy season, in the month of May, 2012 from the four spring sites. The samples were collected and sent to the water resources laboratory of Civil Engineering Department, University of Nigeria, Nsukka for analysis on the same day. The physical tests (temperature, pH, dissolved) were carried out immediately at the source with appropriate portable equipment. Temperature was measured using thermometer, pH with pH meter and dissolved oxygen with dissolved oxygen meter. Because location, movement and storage affect these parameters, the measurement was done immediately to avoid wrong readings. For the chemical test, the samples were collected in sample bottle and were taken to the laboratory for analysis. EDTA method was used for calcium and magnesium, while agentometric method was used for chlorine. Spectrophotometer was used for nitrate and phosphate. For the remaining parameters like ammonia, fluoride, iron and aluminium, Palintest Photometer was used for the tests. For the bacteriological test, the sample bottles were cultured first before the samples were collected. For coliform, Mac conkey broth was used while an Eosin methelene blue alga was also used for E. coli. This was to keep the bacteriological activity dormant for the experiment to be carried out. The results obtained were compared with the World Health Organization and Nigerian Industrial Standards to ascertain conformity with the national and international guidelines for drinking water.

4. Results and Discussion

Results obtained for the four spring tested are shown in Table 1. From the Table 1 above, the results show that most parameters tested were within both the international (WHO) and national (NIS) standards except for the bacteriological tests, which indicate high levels of contamination. The pH of the four spring waters tested fall within the acceptable range given by WHO/NIS. There is no guideline given by WHO/NIS on dissolved oxygen though Iyi-Nsukka spring water has the highest valve compared to the other springs with a value of 7.8 mg/l. Also for temperature, there is no guideline by WHO/NIS but the temperature of Asho, Ajie, Iyi-Nsukka and Ikwoka-Obimo springs are 21^{o}C, 22^{o}C, 21^{o}C and 22^{o}C respectively. There are also high concentrations of calcium in Asho and Ajie springs of 26.65 mg/l and 24.04 mg/l respectively, but there is no stated health implication by WHO/NIS. Magnesium has high concentration levels in all the four springs, which has 0.2mg/l as maximum permitted level for NIS with Ikwoka-Obimo springs having the highest level with 48.64mg/l. The health implication of magnesium is only consumer acceptability [13].

The four spring waters tested have acceptable values for chloride, nitrate, iron, aluminium and flouride. Iyi-Nsukka spring have no iron at all while all the four spring waters have zero values for aluminium test. There is also no guideline for ammonia, phosphate and biocarbonate by WHO/NIS. Although, Iyi-Nsukka springs have highest levels of ammonia and phosphate with values of 0.28 mg/l and 1.06 mg/l respectively; and Ikwoka-Obimo spring have highest level of biocarbonate with a value of 12 mg/l. There is high concentration of coliforms especially at Ajie and Iyi - Nsukka springs with 150MPN and 280MPN per 100ml respectively. The Iyi-Nsukka and Ajie springs also have E. coli concentrations of 3MPN/100ml each while Asho and Ikwoka-Obimo springs have <3MPN/100ml.

4. Sources of contaminations to these Spring waters

The contamination can be attributed to the following: indiscriminate dumping of refuse, defecation around the water sources especially at the uphill side of these spring and the agricultural activities. These communities around these spring sources use more of animal waste as fertilizer for agricultural activities than inorganic fertilizers.

All these pose the threat of contamination of these spring waters. When rain falls, all these pollutants will be washed down from the upstream by runoff to contaminate the springs. Some of these spring sources have not been developed like Iyi –Nsukka spring, which is still open to fallen leaves and animals with defecations around the source. That is why it has the highest concentration of coliforms followed by Ajie spring.

Table 1: Water quality parameters of four springs in Nsukka, Nigeria

S/N	Parameters	WHO/NIS (Guidelines)	Asho springs	Ajie springs	Iyi-Nsukka springs	Ikwoka-Obimo springs
1	pH	6.5-8.5	6.8	5	7.4	6.9
2	Dissolved O_2 (mg/l)	No guideline	5	6.8	7.8	5.2
3	Temperature (^oC)	No guideline	21^oC	22^oC	21^oC	20^oC
4	Calcium(mg/l)	No guideline	25.65	24.05	4	3.2
5	Magnesuim (mg/l)	0.2	4.86	14.59	14.59	48.64
6	Biocarbonates (mg/l)	No guideline	10	10	6	12
7	Chloride(mg/l)	250	3.9	21.99	8.99	3.99
8	Nitrate (mg/l)	50mg	0.064	0.038	0.2	0.03
9	Iron (mg/l)	0.3	0.05	0.03	Nil	0.02
10	Aluminium(mg/l)	0.2	0	0	0	0
11	Flouride(mg/l)	1.5	0.08	0.04	0.02	0.06
12	Coliform (MPN)	zero	7 MPN/ 100ml	150 MPN/ 100ml	280MPN/ 100ml	9 MPN/ 100ml
13	E. Coli	zero	<3	3	3	<3
14	Phosphate (mg/l)	No guideline	0.61	0.67	1.06	0.08
15	Ammonia (mg/l)	No guideline	0.23	0.2	0.28	0.21

NB: NIS = Nigerian Industrial Standard [13]; WHO = World Health Organization [14]; MPN/100ml = Most Probable Number per 100ml of water

5. Conclusion

From the study, it is observed that the water quality of these four springs; Asho, Ajie, Iyi- Nsukka and Ikwoka-Obimo are below the accepted ranges stated by the WHO/NIS standards for some parameters tested. The

parameters that have high health implications where these four springs deviated from the WHO/NIS standard are E. coli and coliforms. There is high concentration of coliforms especially at Ajie and Iyi - Nsukka springs as well as high E. coli concentrations especially at Asho and Ikwoka- Obimo springs. One of the health implications of these parameters is exposure to disease causing bacteria, viruses and parasite [14]. Hence, this indicates that the water is not safe for drinking without treatment. The study therefore recommends that the bacteriological treatment be provided for the four springs before consumption. The surrounding environment should be kept clean and tidy to avoid or reduce contaminations from the pollutant around the springs. These human activities (dumping of refuse, defecation and use animal waste as fertilizer for agricultural activities) that pollute the water should be stopped or relocated to a farther place from the spring sources.

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