EXAMINATION OF THE IMPACT OF SEASON ON CHEMICAL AND MICROBIOLOGICAL QUALITY OF GROUND WATER SUPPLIES IN UPPER EDDA

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Abstract

Concentrations of trace metals and the microbial load in the spring water were determined at Ekoli Edda in Afikpo South Local Government Area using standard methods. The study investigated the influence of season on the concentrations of Cr, Fe, Pb, Zn, Cd, Mn, Ni, Cu and the microbial load in the spring water. The trace metals were analyzed using Atomic Absorption Spectroscopy (AAS) while the Pour Plate Method was used to analyze the microbiological load. The results showed that the Cr, Pb, Cd and Ni were below detectable level and pose no threat of any kind. Also the results showed that Fe concentration ranged from 0.01 – 0.45, Zn 0.01 - 0.03, Mn 0.00 – 0.85 and Cu 0.21 – 0.78 mg/L. Apart from Location DS every other location was below the WHO drinking water standard. The results of the microbiological quality of the samples were unsatisfactory except Locations BS and DS that met the recommended standard for drinking water. The Total Viable Bacterial Count (TVC) on the spring water samples ranged from 0.00 - 9.0×10^2 cfu/ml. The Total Coliform count (TCC) for water samples ranged from 1.00 - 4.0 cfu/ml. The absence of any organisms in Locations BS and DS could be attributed to the locations of these water sources which are heavily protected from human and animal contact. The presence of coliform in most water samples is of great worry and may be an indicator of faecal contamination which is suggestive of the presence of pathogenic organisms. These pathogenic organisms might have gained access to the water through refuse dump sites and landfills. The water should be subjected to sufficient treatment before usage in order to take care of the pathogenic organisms.

Keywords: Trace metals, microbial load, season, spring, faecal

INTRODUCTION

Water is an integral part of the environment and its availability is indispensable to the efficient functioning of the biosphere (Xu and Usher, 2006). The importance of water can be comparable to that of life and is covering more than two third of the earth's surface Dara and Umare (2010). Not minding the abundance, the need for drinkable water in most emerging economy of the world particularly, Nigeria. Demand for water far outweighs the supply as long queues suffice with people clutching containers at public water supplies. In hinterland, people trek several miles looking for water especially during the dry season. The city dwellers suffer the same fate at this period too.

Spring and boreholes have been some major sources of water for domestic and agro-allied uses in areas where they exist. These sources of water may be polluted by domestic and industrial wastes, fertilizers and pesticides, refuse dump, landfill and acid rain (Wagh, Kokate, Aher and Kuchekar, 2009).

Water that has not been treated for drinking can transmit diseases that are infectious. In addition, the chemical and microbiological evaluation of water needs a serious attention. Water that has been polluted is very risky to human health due to probable outbreaks of water borne diseases or other pathogenic diseases such as Cholera, diarrhea or dysentery. The interactions of geologic materials and its conditions on any area has tremendous influence on the quality of water, and this affects the concentration of introduced ions in the water body, rendering it unfit for drinking and other domestic uses (Ako, Adeniyi and Adepoju, 1990). There are many studies cited in the literature on the examination of the chemical and microbiological quality of spring water and its improvement and also on trace metal contamination of sources of water.

The problem of groundwater supply is a global issue and it is a feature which is common in all rural areas especially in Ebonyi State. The groundwater which is the major water supplies to Upper Edda people remained in short supplies and unreliable for domestic consumption, including drinking. The quality is in such a state that consuming the water is a health risk to the unsuspecting consumers. This study is a fallout from the recommendations of earlier studies on the groundwater status in Upper Edda Afikpo South Local Government Area by Afiukwa and Eboatu (2013).

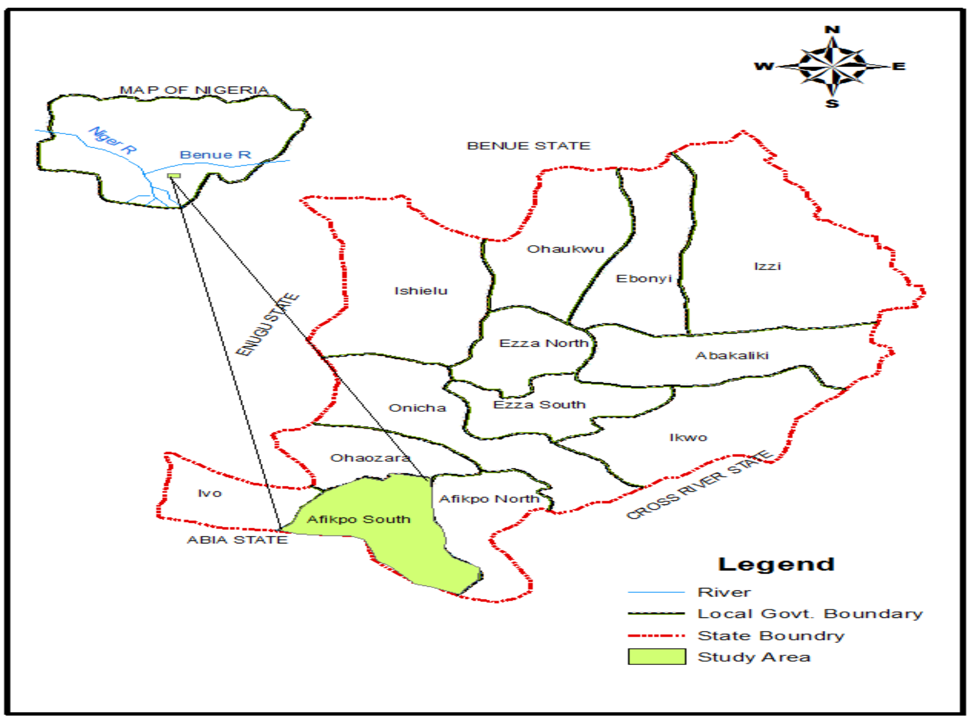

Table 1: Locations, Codes and GPS Co-ordinates of the sample sites

Sample locations	Codes	Elevation (m)	Latitude (N)	Latitude (E)
Spring				
Iyi-Anyoji	AS	167.50	05°45'10.20"	007°50'25.10"
Achi-Ogba	BS	148.00	05°45'09.40"	007°50'43.50"
Iminika	CS	116.00	05°56'10.50"	007°46'59.80"
Ogba-Agu	DS	152.50	05°45'04.40"	007°50'34.20"
Iyi-Amaichakara	ES	112.70	05°45'18.30"	007°50'38.70"

Sample Collection

The plastic containers used for sample collection were thoroughly washed with detergent, rinsed with distilled water to remove any trace of contaminant which may remain in the containers and dried. It was further rinsed with 0.1M HNO_3 and preserved with the acid prior to sampling. Composite samples were collected in one litre polyethylene containers. The containers were labeled according to sample source using masking tape and a permanent marker for easy identification. At the point of sampling, the sample bottles were emptied and rinsed three times with the very water. The hand held borehole was pumped for 3 minutes to homogenize the mix before filling the container to the brim and capped. In order to prevent some metal loss through surface adsorption and to immobilize the metals in solution 4 cm^3 of concentrated HNO_3 was added into the 1-litre of the water sample to preserve the metals prior to laboratory analysis. Sterilized 1-litre borosilicate glasses were used for the samples collected for microbiological analysis. The same procedure was followed for the spring water samples. In the collection of samples for microbiological analysis, the containers were filled to the brim and capped under water. For quality assurance, batch samples were collected twice in a day (morning, 7.30 – 10.00 am and evening 5.00 – 7.30 pm) and mixed to obtain the composite sample used in the study. Triplicate determinations of each parameter were carried out for ach sample.

Analytical Procedures for Heavy metal determination

The heavy metals were determined using AAS 205 Bulk Scientific Model according to the method described by APHA (1998).

3.5 Analytical Procedures for Bacteria

The Total Coliforms of the water samples was determined using Pour Plate Method according to the method described by Balance (1996).

Sterilization of Materials

All the glassware, dissolved nutrient Agar, dissolved MacConkey Agar, distilled water were sterilized in an autoclave at a temperature and pressure of 121 ℃ and 15 psi for 15 minutes, respectively.

Preparation of Nutrient Agar, Eosin Methylene Blue (EMB) agar and MacConKey Agar Plates

Agar plates were prepared by dissolving 28 g, 37.5 g and 52 g respectively of nutrient agar, Eosin Methylene Blue (EMB) agar and MacConkey agar in 1000 cm^3 of distilled water each according to the manufacturer's instructions. This was heated over a Bunsen burner flame to dissolve and $20cm^3$ach was dispensed aseptically into McCartney bottles and was sterilized by autoclaving at 121^oC for 15 minutes at 15psi (Cheesbrough, 2006).

Serial Dilution

Since millions of bacteria can be found in a single drop of water, bacterial suspension was not diluted serially so as to reduce the bacterial population by few $cells/cm^3$ (Sharma, 2007).

Sterilized test tubes, three in number, were properly labeled. The three tubes were each filled with 9 cm^3 of distilled water. The first tube was topped with 1 cm^3 of the sample solution before it was homogenized. Thereafter, 1 cm^3 of the sample suspension from the first tube was added into the second tube containing 9 cm^3 of sterilized distilled water. This gave 1:10 dilution. After, 1 cm^3 of the dilution was added into the third tube already containing 9 cm^3 of sterilized distilled water. This gave 1:100.

Pour Plate Method

A 1 cm^3 of the dilution was transferred to a sterilized Petri dish containing 20 cm^3 of molten MacConkey agar medium. The sample and melted medium were thoroughly mixed by rotating the plate several times, clockwise and then anticlockwise, with the Petri dish on the sterilized bench top. The control was equally prepared, but without adding the sample. The media were allowed to solidify; then the plates inverted and finally incubated at a temperature of 37℃ for 48 hours. After incubation, the colonies were counted using a Colony Counter and hand tally.

Results and Discussion

Table 2: Mean concentrations of Trace metals in spring water samples during the dry and rainy seasons

Parameters	Season	AS	BS	CS	DS	ES	FS	GS	Control	WHO (2011)
Cr	Dry	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	1.0
	Rainy	bdl	bdl	bdl	bdl	bdl	bdl	Bdl		
Fe	Dry	0.01 ± 0.01	0.02 ± 0.01	0.02 ± 0.00	**0.58 ± 0.05**	**0.45 ± 0.02**	**2.10 ± 0.01**	**0.75 ± 0.01**	bdl	0.3
	Rainy	0.01 ± 0.00	0.01 ± 0.0	0.03 ± 0.01	**0.64 ± 0.00**	**0.20 ± 0.00**	**0.91 ± 0.00**	**0.90 ± 0.01**		
Pb	Dry	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.01
	Rainy	bdl	bdl	bdl	bdl	bdl	bdl	Bdl		
Zn	Dry	0.02 ± 0.00	0.02 ± 0.01	0.01 ± 0.00	0.02 ± 0.01	0.02 ± 0.00	0.03 ± 0.00	0.02 ± 0.00	0.03 ± 0.00	3.0
	Rainy	0.03 ± 0.00	0.02 ± 0.00	0.02 ± 0.00	0.02 ± 0.01	0.01 ± 0.00	0.02 ± 0.00	0.02 ± 0.00		
Cd	Dry	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.003
	Rainy	bdl	bdl	bdl	bdl	bdl	bdl	Bdl		
Mn	Dry	0.09 ± 0.01	0.00 ± 0.00	0.11 ± 0.01	0.13 ± 0.01	0.11 ± 0.01	0.12 ± 0.01	**0.53 ± 0.01**	0.01 ± 0.00	0.5
	Rainy	0.01 ± 0.00	bdl	0.03 ± 0.00	**0.85 ± 0.02**	0.07 ± 0.00	**0.66 ± 0.00**	0.11 ± 0.00		
Ni	Dry	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.02
	Rainy	bdl	bdl	bdl	bdl	bdl	bdl	bdl		
Cu	Dry	0.78 ± 0.03	0.51 ± 0.01	0.66 ± 0.01	0.23 ± 0.01	0.55 ± 0.01	0.45 ± 0.02	0.61 ± 0.01	0.17 ± 0.01	2
	Rainy	0.73 ± 0.00	0.60 ± 0.01	0.67 ± 0.00	0.21 ± 0.01	0.53 ± 0.01	0.46 ± 0.01	0.60 ± 0.03		

bdl: Below detectable limit

Discussion

Tables 2 and 3 showed the results of the concentration of trace metals in spring and borehole water samples. The concentration of Cr in the groundwater samples in both the dry and rainy seasons of the spring and borehole waters were below detectable limit. The concentrations of Fe in the spring water samples during the dry and rainy seasons ranged 0.01 ± 0.00 - 2.10 ± 0.01 and 0.01 ± 0.00 - 0.91 ± 0.00 mg/l with mean concentrations of 0.26 ± 0.26 and 0.55 ± 0.01 mg/l, respectively. The results shown in Table 3 revealed that the Fe concentrations in the borehole water samples in the dry and rainy seasons ranged 0.25 ± 0.01 - 1.12 ± 0.01 and 0.01 ± 0.00 - 0.96 ± 0.01 mg/l with mean concentration of 0.75 ± 0.11 and 0.48 ± 0.12 mg/l, respectively. Apart from Location AB, Location BS, Location CS and Location CB with Fe concentrations of 0.10 ± 0.01, 0.02 ±0.01 , 0.02 ± 0.00 and 0.25 ± 0.01 mg/l, respectively in dry season and Locations AS, BS, CS ES, AB, BB and DB with concentrations of 0.01 ± 0.01, 0.01 ± 0.00, 0.03 ± 0.01 , 0.20 ± 0.00 , 0.10 ± 0.01, 0.01 ± 0.00 and 0.19 ± 0.00 mg/l, respectively in rainy season that were below the permissible limits of WHO (2011) drinking water standard of 0.3 mg/l, all other locations were above the WHO guideline value of drinking water. Also, the results of the analysis were all above the result of the Control. However, the high concentrations of Fe in the samples may be attributed to the geologic formation of the area and low pH which is an important factor that could influence the solubility and resultant concentrations (Parker and Foster, 1986). The high concentration values of iron have the potential of staining laundry, metal pipes for reticulation and scaling in pipes. It may also give undesirable taste (Etu-Efeotor and Akpokodje, 1990; Olarewajum *et al*, 1996; Ibe and Sowa, 2002; Ngah and Allen, 2005); this explains the reddish brown colour stain commonly seen on most metal tanks and fence within the study area (Nwankwoala *et al*, 2011).

Table 3: Mean concentrations of Trace metals in Borehole Water Samples during the dry and rainy seasons

Parameters (mg/l)	Season	AB	BB	CB	DB	EB	FB	GB	HB	Control	WHO (2011)
Cr	Dry	bdl	Bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	1.0
	Rainy	bdl	Bdl	bdl	bdl	bdl	bdl	bdl	Bdl		
Fe	Dry	**0.32 ± 0.01**	**1.09 ± 0.01**	0.25 ± 0.01	**0.69 ± 0.01**	**1.12± 0.01**	**0.56 ± 0.01**	**0.94 ± 0.01**	**0.99 ± 0.02**	0.09 ± 0.01	0.3
	Rainy	0.10 ± 0.01	0.01 ± 0.00	**0.96 ± 0.01**	0.19 ± 0.00	**0.85 ± 0.01**	**0.63 ± 0.01**	**0.65 ± 0.01**	**0.48 ± 0.01**		
Pb	Dry	bdl	Bdl	0.01 ± 0.00	bdl	bdl	bdl	bdl	bdl	bdl	0.01
	Rainy	bdl	Bdl	0.01 ± 0.00	bdl	bdl	bdl	bdl	Bdl		
Zn	Dry	0.03 ± 0.01	0.03 ± 0.01	0.05 ± 0.00	0.03 ± 0.01	0.03 ± 0.01	0.03 ± 0.01	0.03 ± 0.00	0.04 ± 0.00	0.03 ± 0.00	3.0
	Rainy	0.01 ± 0.00	0.02 ± 0.00	0.04 ± 0.00	0.01 ± 0.00	0.03 ± 0.00	0.04 ± 0.00	0.01 ± 0.00	0.02 ± 0.00		
Cd	Dry	bdl	Bdl	bdl	bdl	bdl	0.00 ± 0.00	0.00 ± 0.00	bdl	bdl	0.003
	Rainy	bdl	Bdl	bdl	bdl	bdl	bdl	bdl	Bdl		
Mn	Dry	0.11 ± 0.01	0.44 ± 0.01	0.13 ± 0.01	**0.66 ± 0.01**	0.37 ± 0.02	0.09 ± 0.00	0.14 ± 0.01	0.13 ± 0.01	0.01 ± 0.00	0.5
	Rainy	0.02 ± 0.01	Bdl	0.50 ± 0.01	bdl	0.17 ± 0102	0.11 ± 0.00	0.22 ± 0.01	0.03 ± 0.03		
Ni	Dry	bdl	Bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.02
	Rainy	bdl	Bdl	bdl	bdl	bdl	bdl	bdl	Bdl		
Cu	Dry	0.64 ± 0.01	0.81 ± 0.01	0.86 ± 0.00	0.63 ± 0.01	0.46 ± 0.01	1.08 ± 0.03	0.91 ± 0.01	0.11 ± 0.00	0.17 ± 0.01	2
	Rainy	0.56 ± 0.00	0.60 ± 0.01	0.77 ± 0.01	0.53 ± 0.00	0.45 ± 0.01	1.15 ± 0.01	0.86 ± 0.00	0.73 ± 0.00		

bdl: Below detectable limit

Apart from Location CB with a concentration of 0.01 ± 0.00 every other location in both spring and borehole water sample has below detectable limit (bdl) of lead. This concentration detected in Location CB was within the permissible limit of WHO (2011) drinking water standard of 0.01mg/l. Pb in water is a serious problem. It is reported (Jennings *et al*, 1996) that high concentrations of Pb in the body can cause death or permanent damage to the central nervous system, the brain and kidney. The Zn concentrations of the spring water during the dry and rainy seasons ranged from 0.01 ± 0.00 - 0.03 ± 0.00 and 0.01 ± 0.00 - 0.03 ± 0.00 mg/l in Locations CS and FS, respectively with mean concentrations of 0.02 ± 0.00 and 0.02 ± 0.00 mg/l, respectively. The results in the same tables showed that the Zn concentrations in the boreholes during the dry and rainy seasons ranged from 0.03 ± 0.00 - 0.05 ± 0.00 and 0.01 ± 0.00 - 0.04 ± 0.00 mg/l with mean concentrations of 0.03 ± 0.00 mg/l and 0.03 ± 0.00 mg/l, respectively. All the results of the analysis were well below the permissible limits of WHO (2011) drinking water standard of 3.0 mg/l and within the result of the control (0.03 ± 0.00 mg/l). Zinc, generally is an essential element and is considered to be non-toxic, but exposure to very high concentrations of Zn may bring adverse health effects to human beings. Apart from Locations FB and GB with the same Cd concentrations of 0.00 ± 0.00 mg/l, in dry season, all other locations in both dry and rainy seasons have their concentrations below detectable limit.

The concentration of Mn in the spring water during the dry and rainy seasons ranged from 0.00 ± 0.00 - 0.53 ± 0.01 and 0.01 - 0.85 ± 0.02 mg/l with mean concentrations of 0.16 ± 0.06 and 0.29 ± 0.12 mg/l The results in the same tables showed that the Mn concentrations of the borehole water in dry and rainy seasons ranged from 0.09 ± 0.00 - 0.66 ± 0.009 and 0.02 - 0.50 ± 0.005 mg/l with mean concentrations of 0.26 ± 0.08 and 0.16 ± 0.06 mg/l, respectively. Apart from Locations GS and DB showing concentration values of 0.53 ± 0.01 and 0.66 ± 0.01 mg/l, respectively during the dry seasons and 0.85 ± 0.02 and 0.66 ± 0.00 mg/l in Locations DS and FS, respectively during the rainy season all other locations showed concentration levels below the permissible limits of WHO (2011) drinking water standards of 0.5 mg/l. The results of the water samples were all below the control (0.01 ± 0.00 mg/1) with exception of Locations BS and DB during the rainy season, which was below detectable limit. It is reported (Udom *et al*, 2018) that at a concentration higher than 0.5mg/l, manganese impacts a bitter taste to water, stains cloths and metal parts and precipitate in foods when used for cooking and it also promotes the growth of algae in reservoirs, while above 0.2mg/l in drinking water causes neurological disorder.

The concentration of Cr in the groundwater samples in both the dry and rainy seasons were below detectable limit and could not pose any danger to the groundwater quality. The Cu concentration in the spring water during the dry and rainy seasons ranged from 0.23 ± 0.01 - 0.78 ± 0.03 and 0.21 ± 0.01 - 0.73 ± 0.00 mg/l with mean concentrations of 0.54 ± 0.06 and 0.54 ± 0.06 mg/l, respectively. The results in the same tables showed that the Cu concentrations in the dry and rainy seasons of the borehole water ranged 0.11 ± 0.00 - 1.08 ± 0.03 and 0.45 ± 0.01 - 1.15 ± 0.01mg/l with mean concentrations of 0.69 ± 0.10 and 0.71 ± 0.07 mg/l, respectively. Apart from Location HB of the rainy season of the spring water that has a concentration of 0.11 ± 0.00 mg/l every other location has a concentration above the control 0.17±0.01 mg/l. However, the concentrations of Cu in all the locations were below the permissible limit of WHO (2011) drinking water standard of 2 mg/l. According to WHO (2011), Cu causes harsh taste but is essential trace element for metabolism and deficiency results in anaemia in infants, excess may result in

Table 4: Total Viable Count and Total Coliform Count of Isolates from Groundwater Samples

Sample Code	Total viable count (cfu/100 ml)	Total coliform count (cfu/100 ml)
AS	9.00×10^2	3
BS	1.00×10^2	0
CS	7.00×10^2	1
DS	0.00×10^2	0
ES	6.00×10^2	2
FS	4.00×10^2	1
GS	9.00×10^2	4
AB	8.00×10^2	3
BB	1.4×10^2	5
CB	5.00×10^2	2
DB	1.40×10^3	8
EB	1.50×10^3	4
FB	7.00×10^2	2
GB	1.00×10^2	3
HB	5.00×10^2	0
Control	0.00×10^2	0
WHO (2011)	0 cfu/100 ml	0 cfu/100 ml

There was much considerable variation in the microbiological quality of the samples across the Locations as shown in Table 4. The microbiological quality of the samples was unsatisfactory except Locations BS and DS that met the WHO (2011) recommended standard for drinking water. The Total viable bacterial count (TVC) on the spring water samples ranged from 0.00 - 9.0×10^2

cfu/ml, while the TVC for the boreholes water samples ranged from 1.0×10^2 - 1.5×10^3 cfu/ml. The Total coliform count (TCC) for spring water ranged from 1.00 - 4.0 cfu/ml and that of the boreholes ranged 1.0 - 8 cfu/ml. The presence of coliform in most water samples is of great worry and may be an indicator of faecal contamination suggestive of the presence of pathogenic organisms (Itah *et al*, 2005). It is reported in Zabbey (2009) that a faecal coliform contamination level of 15 to 25 cfu/ml was detected in a borehole water sample. These pathogenic organisms might have gained access to the water through various sources. Some of these spring water and boreholes are located close to refuse dump sites and landfills which probably may be the source of the organisms finding their ways into the water bodies. Some of the water sources are located in places where the environments are heavily untidy and filthy and these do not guarantee safety to the water sources. Preanalysis survey in the area under study showed that there were reported cases of enteric diseases such as diarrhea, cholera and dysentery in the community health centers (Zabbey, 2009). This may not be unconnected with the presence of the isolated pathogenic organisms in the water sources as they are possible causes of the various diseases. The absence of any organisms in Locations BS and DS could be attributed to the locations of these water sources which are heavily protected from human and animal contact.

Conclusion

The quality of the water samples analyzed did not pose any threat as the results of the locations were below the detectable limits of the WHO permissible drinking water standard. The results of the microbiological quality of the samples were unsatisfactory.

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