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Seasonal Variation in Iron in Rural Groundwater of Benue State, Middle Belt, Nigeria

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Abstract: Effect of changes in season visa vise rural groundwater quality variability with respect to iron is examined in this study. Water samples were collected from 26 rural community boreholes and analyzed for iron concentrations as it affects the quality of water for drinking in line with WHO drinking water standards for both rainy and dry seasons. The analyses was carried out as prescribed according to standard method of examination of water. The result of analyses show 35% of the boreholes have elevated iron concentrations above WHO guide limit for rainy season as against that of the dry season which is only 7.7% of the boreholes. Iron concentrations in the boreholes were noted to be higher in the rainy season than in the dry season. The source of iron in groundwater may be attributed to dissolution of iron minerals from rock and soils, corrosion effect of galvanized hand pump components and land use activities. Agencies involved in rural water supply must ensure the safety of the groundwater being harnessed for use. This study demonstrate the need for groundwater quality management at the rural level because once polluted is very expensive to remedy.

Key words: Iron, season, variation, groundwater, borehole, water quality

INTRODUCTION

Over one billion people lack access to clean safe water worldwide (Bresline, 2007; NAS, 2009). In sub-Saharan Africa alone, up to 300 million rural people have no access to safe water supplies. Without safe water near dwellings, the health and livelihood of families can be severely affected (United Nations, 2000; MacDonald *et al.*, 2005).

Groundwater exploitation is generally considered as the only realistic option for meeting dispersed rural water demand (MacDonald *et al.*, 2005). Groundwater include all water found beneath the earths surface in a saturated zone of the aquifer (Todd, 1980). They are formations that contains sufficient saturated permeable materials to yield sufficient quantities of water to wells and springs (Loham, 1972). Groundwater can be abstracted by means of hand dug wells and boreholes at various depths. A large percentage of the world population depends on groundwater as their main source of drinking water (Rajagopal, 1978; Shiklomanov, 1993; Shah, 2004). This is because it is accessible anywhere; it is less capital intensive to develop and maintain; it is less susceptible to pollution and seasonal fluctuations and of natural good quality (Bresline, 2007; Habila, 2005). However, the quality is under intense stress from increasing demand and withdrawal, significant changes in land use pattern, climate change and pollution arising from geology and geochemistry of the environment (Mackey, 1990; Edmunds and Smedley, 1996).

Benue State is predominantly a rural state with about 80% of the population residing in rural areas. This segment of the population is faced with problems of extreme water scarcity during dry season. Traditional sources of water such as streams, rivers and lakes available to this rural population are under pressure from deforestation activities like bush clearing and burning, lumbering, and various land uses. The consequence is these sources are exposed to direct effect of solar radiation leading to their drying up. Women and children who are the major drawers of water suffer untold hardships in the cause of searching for water for household use. In 1994, there an outbreak of disease that claimed several lives. This was however attributed to drinking of polluted water. In response, Benue State Rural water supply and sanitation Agency, a UNICEF Assisted and WaterAid a DFID funded British water charity organization commence activities of providing improved source of water through borehole water supply systems. A good number of rural communities now have boreholes. Although a welcome development, the quality of groundwater being exploited for rural water supply demand considerations. Water from some of the boreholes could not be used for drinking on account of colour, odour and taste. Consumers to a large extent have no means of judging the safety of water themselves, but their attitude toward drinking water and drinking water supplies will be affected to a considerable extent by the aspects of water quality they are able to perceive with their senses. It is natural for consumers to regard with suspicion water that appear dirty or coloured or has unpleasant taste or smell, even though these characteristics may not in themselves be of direct consequence to health (WHO, 2006). Polluted water isn't just dirty, it is deadly (NAS, 2009).

Studies on rural groundwater pollution has been carried out in different parts of Nigeria (Ezeigbo, 1988; Aiyesanmi *et al.*, 2004; Adelunle *et al.*, 2007; Olobaniyi and Owoyemi, 2008). Consistent in their findings is that groundwater is polluted from physical processes and anthropogenic activities. There are paucity of studies on the influence of season on groundwater quality variability. In this study, attempt is made to assess the influence of season on the quality of groundwater with respect to iron.

Iron in rural groundwater supplies is a common problem: its concentration level ranges from 0- 50 mg/l, while WHO recommended level is <0.3 mg/l. The iron occurs naturally in the aquifer but levels in groundwater can be increased by dissolution of ferrous borehole and handpump components (Lenntech, 2009). All natural water contained some dissolved iron in traces. Iron is present in all rocks, soil and sand. The most common is ferrious iron. Water which contains iron on exposure to air become reddish brown due to ferric hydroxide. Human beings suffer no harmful effect of water containing iron. However, long term consumption of drinking water with high concentration can lead to liver disease (Morris, 1952; Lee and Stum, 1960; Hem, 1970). High concentration of iron groundwater are widespread and sometimes underrated constraints on rural water supply. Iron can cause colour in water which may lead consumers to reject such water. This kind of water when used can cause staining of cloth, utensil and food and bitter taste. Although this has no direct health significance, problem arise if communities decide not to use this water and return to old polluted sources (MacDonald *et al.*, 2005). For example, in Ghana, 20-30% of boreholes drilled water supplies contains excessive iron concentration. Water from these wells have been rejected on account of coloration effect (Peligba *et al.*, 1991). Groundwater in the confined aquifer of sedimentary basin are particularly vulnerable to built-up of dissolved iron and manganese under anaerobic condition (Okagbue, 1988; Akujieze *et al.*, 2003; Amadi *et al.*, 1989; BGS, 2003).

The study area: The study area is rural communities of Benue State in the middle belt of Nigeria. The area has a population of 4, 219, 244 (NPC, 2006) and its economy is sustained principally by agricultural production. Crops produced include yam, cassava, rice, maize, oranges, mangoes etc. Because of the declining fertility application of chemical fertilizer is on the increase. The geology of the study area is predominantly a sedimentary formation comprising of sandstones, mudstones and limestones (Kogbe *et al.*, 1978; Offodile, 2002). Pockets of basement complex rocks are found in Gkoko, Guma, Ushongo, Vandeikya and OjuLGAs of the study area. The soil is mainly a tropical ferrugised type with hypomorphic and lateric soils along flood plain of rivers and within hills. The study area is drained by River Benue and its tributary River Katsina-Ala. Other rivers include Aya, Guma, Konshisha, logo, Obi and Okpokwu. The climate is controlled by two air masses which is responsible for both rainy and dry seasons. Annual rainfall total ranges from 1,500-2000 mm. Temperature is generally high during the dry season leading to high rate of evaporation. The vegetation is mainly of savanna type.

MATERIALS AND METHODS

Data for this study were obtained from water sample collected from 26 rural community boreholes across the study area. Two sets of water samples were collected in the months of October when rainfall is highest in the area and February one of the extreme months of dry season. The water samples were analyzed according to standard method of examination of water (APHA-AWWA-WPCF, 1995) and reported in WHO standards for drinking water. The concentration of iron in water sample were analyzed using Atomic Absorption Spectrophotometer (AAS) model Unicon sp 6-550. The method is based on absorption of radiation by free atoms in vapour state. The atoms of element whose lamp or flame is being absorbed at precisely the wave length as that emitted by its light source. The amount of energy at the characteristic wave length absorbed by the flame is proportional to the concentration in the sample over a limited concentration range. The results of AAS analyses is shown in Table 1.

RESULTS AND DISCUSSION

The results of analyses as shown in Table 1 reveal BH3, BH4, BH6, BH14, BH15, BH16, BH19, BH23, BH24 and BH26 have iron concentrations above WHO prescribed limit of 0.1-1.0 for drinking water. This translate to 35% of the boreholes having elevated iron concentrations above WHO guide limit for drinking water for the rainy season. For dry season only BH4 and BH18 have iron concentrations exceeding WHO maximum limit for drinking water. This translates into 7.7% of the boreholes having iron concentrations above the WHO allowable limit for drinking water. It was also noted that water from some of the boreholes could not be used for drinking due to objectionable colour problem. However, water from some of the boreholes with objectionable colour were used for drinking in the absence of any other alternative. Prolonged consumption of this kind of water may cause health risks over time. The cause of iron in these wells may be traced to the geology of the environment, dissolution of iron minerals from rocks, corrosion emanating from the use of galvanized handpump construction and land use activities. From Table 2 iron concentration in the boreholes have a mean of 0.82 and CV 81.71% for rainy season as against a mean and CV of 0.33 and 324.24% for the dry season. Although iron concentration are higher in the rainy than in the dry season their variation in groundwater is lesser

Table 1: Atomic absorption spectrophotometer (AAS) analysis

Rural community	Code	Iron mg/l (Rainy season)	Iron mg/l (Dry season)
Ikpayongo	BH1	0.85	0.14
Tsenor	BH2	0.50	0.43
Awajir	BH3	1.11	0.43
Kyoor	BH4	2.38	5.02
Ega	BH5	0.54	0.52
Uje	BH6	2.20	0.05
Obarike-Ito	BH7	0.08	0.25
Ugbodom	BH8	0.55	0.38
Ogi	BH9	0.10	0.61
Ulayi	BH10	0.71	0.05
Asaaga-Ashe	BH11	0.21	0.65
Udei	BH12	0.59	0.51
Fiidi	BH13	0.48	0.01
Ake	BH14	0.24	0.11
Uchi-Mbakor	BH15	1.11	0.46
Annune	BH16	2.16	0.26
Ambigir	BH17	0.09	0.09
Tse Kucha	BH18	0.03	1.11
Garagbohol	BH19	1.07	0.95
Buruku	BH20	0.35	0.12
Sati- Asema	BH21	0.43	0.20
Amaafu	BH22	0.32	0.05
Mbaagba	BH23	1.11	0.39
Ushongo	BH24	1.52	0.16
Ihugh	BH25	0.10	0.04
Mbajor	BH26	1.38	0.63

BH - Borehole

Table 2: Descriptive characteristics of iron in groundwater in the study area

Season	Min.	Max.	Mean	STD	CV%
Rainy	0.03	2.38	0.82	0.67	81.7
Dry	0.01	5.20	0.33	1.07	324.24

STD - Standard Deviation; CV% - Coefficient of Variation

in the rainy season when compared to that of the dry season as reflected in the coefficient of variation. This probably may due to influence of rainfall infiltrating and dissolving iron mineral in rocks and soil which are leached into groundwater sources.

Conclusion: The study has shown the presence of iron in rural groundwater of Benue State even to objectionable level in some boreholes. The concentrations of iron are noted to vary spatially across the study area and among seasons. Although iron in water is generally perceived as aesthetic problem than health problem not withstanding some form of treatment may be required. Long consumption of this kind of water may cause health risks. Agencies involved in rural water supply must ensure quality control of the water being provided as matter of priority.

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