Assessment of Surface and Groundwater Quality in and Around Benue State Brewery Limited (BBL) in Makurdi Town, Benue State, Nigeria

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ABSTRACT

Water quality displays physical, chemical and biological characteristics of water. The quality of surface and ground water is currently an important concern with population growth and industrialization. Over utilization of water resources due to demand is causing the deterioration of surface and ground water. Periodic water quality testing must be carried out to protect our water resources. The study assessed the concentration levels of physicochemical and bacteriological pollutants in surface water and ground water in and around BBL Makurdi. The Study selected five surface (streams) and five ground water (hand-dug wells) sources around BBL Makurdi and labeled S1, S2, S3, S4, S5 and G1, G2, G3, G4, G5 respectively and obtained water samples for laboratory analysis. Samples are examined for the following heavy metal pollutants - cadmium (Cd), lead (Pb), chromium (Cr) and manganese (Mn). The results were compared with WHOs standards for drinking water. Descriptive statistical techniques such as mean, standard deviation and coefficient of variation were employed in data analysis. The results indicate that the mean concentration of Cd, Pb, Cr and Mn for surface water were 0.0110, 1.6145, 0.05182 and 0.24312; while groundwater were 0.01318, 1.6713, 0.04278 and 0.2418. The result further shows that the standard deviation surface water were 0.0056, 1.0579, 0.0295 and 0.1088 with their corresponding standard deviation of 50.91%, 65.525, 56.928 and 45.108. while those of ground water were 0.00517 (39.226%), 0.8580 (51.337%), 0.1837(429.406) and 0.19065 (77.943%) The study found that the surface and ground water sources are heavily contaminated with heavy metals with Lead and manganese exceeding WHOs, tolerant limit of 0.1mg/l-1 in all the sample points. The study therefore recommends proper treatment of water from all sources in the study area before consumption.

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Keywords: *Water quality, Surface water, Groundwater, Physical-chemical, Urbanization.*

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1.0 INTRODUCTION

Increasing demand for water arising from high rate of urbanization characterized by increasing population and concentration of social-economic activities (industrial, domestic and commercial purposes) have put pressure not only on the quantity but also on the quality of water resources which most people in urban areas of the developing countries depend on since access to pipe borne water is limited. In urban areas, the careless disposal of solid waste, industrial effluents and other waste have contributed greatly to the poor quality of water (Ugochukwu, 2007) as in Zun (2013) thereby compounding the problem of access to safe drinking water. Due to inaccessibility, inadequacy and unreliability of pipe water, greater percentage of urban residents rely on supplementary sources of water supply from hand dug wells, borne hole, spring, streams and rivers which are highly prone to all sorts of pollution with attendant implication for human health and environmental safety. Most of these water sources in the urban areas of developing world are end points of waste discharge from industrial, agricultural farms and households.

Makurdi like any Nigerian cities is experiencing rapid urbanization and industrial growth making water pollution control a difficult task. Although the government has put in place policies for effective pollution control and management, there are challenges militating against their implementation. This follows that the rapid population growth, over concentration of socio-economic activities tend to generate both liquid and solid waste that find their way into water sources (surface and ground water sources). Consequently, these water sources are polluted and posed a potential danger to urban dwellers who depend on them for sources of water for domestic consumption.

Number of studies have been conducted in assessing surface water quality in some parts of Makurdi town. For instance, Apeh and Ekenta (2012) assessed of surface water quality of River Benue at Makurdi. The water quality was monitored for a period of six months covering both dry and rainy seasons of the year for pollution modeling due to multi-usage of the river - human consumption and industrial usage. The study reports that pollution in River Benue is influenced by natural regimes such as rainfall and discharges; physical and chemical pollution increased with rainfall while microbial pollution is inversely proportional to rainfall. Microbial pollution of the river is more severe than physical and chemical pollution and has more effect on public health. The study further formulated non-linear models for physical and chemical pollution, linear and polynomial models for flow depth and water pollution. The models yielded values of coefficients of correlation(R) ranging from 0.6785 to 0.9994 implying good fitting. The regression models are reliable for monitoring and prediction of water quality in this area, with both cost and time saving advantages.

Elsewhere in Southwest region of Nigeria, Olasoji, Oyewole, Abiola and Edokpay (2019) assessed water quality of surface and groundwater sources using a water quality index method in peri-urban towns. They maintained that sustainable access to safe drinking water remains a global problem as more people in the world still consume water from unimproved sources. In their study, water quality parameters studied were pH, temperature, acidity, total alkalinity, chloride content and total CO_2. A Flame Atomic Absorption spectrophotometer was used to determine the concentrations of Ca, Mg, Cu, Cr, and Pb in the water samples. The total coliform was determined using the most probable number technique while a qualitative method was used to detect the presence of faecal coliform and E. coli in the water samples. The authors reported that all the physicochemical water quality parameters complied with regulatory standards. Similarly, most of the heavy metals also complied except for some sites. Faecal coliform and E. coli tested positive for all the samples except one of the tap water sample. Majority of the water samples (86%) were rated as excellent based on the physicochemical parameters. One sample each was rated as having poor and good water quality, respectively. All the samples tested positive for faecal coliform bacteria and E. coli except one (treated water). The study therefore recommended that microbial water quality parameters be included in all Water Quality Index (WQI) analyses in order to give the true status of the quality of a water resource. This study clearly demonstrated that microbial water contamination is a huge challenge to safe drinking water in many part of Nigeria especially in urban areas with direct implications for human health.

Furthermore, other previous studies have reported several outbreaks of water-borne diseases due to the consumption of contaminated surface and groundwater (Bessong, Odiyo, Musekene and Tessema, 2009; Hynds, Thomas and Pintar, 2014). This therefore follows that,the consumption of untreated and inadequately treated water remains a major disease burden to public health. Most studies performed on the quality of surface and groundwater fail to present the results in the simplest form possible to policymakers and concerned citizens about the state of their water resources (Boyacioglu, 2007; Timmerman, Beinat, Termeer and Cofino 2010; Wanda, Mamba, and Msagati, 2015). This problem is overcome if the results are reported using the Water quality index (WQI). Thus, complex water quality parameters investigated on water resources can be combined in a simple mathematical equation to generate results which are easy to understand by policymakers who may not be water specialists. WQI thus transforms a large number of water quality data into a single number. It aids the understanding of water quality issues.

In Makurdi town, Benue Brewery Limited (BBL) is one of the major industries located at the bank of River Benue and in close proximity with other minor tributaries of River Benue. Therefore, the effluents from this industry are likely to find their way into both the surface and groundwater sources in and around the factory. Meanwhile, residents of Benue Brewery Limited (BBL) neighborhood depend largely on water wells and streams/rivers in this area. Moreso that this neighbourhood is not connected to public water supply from Greater Makurdi Water Works.

Inspite of the fact that many people in this neighbourhood depend on alternative sources of water for their use, there has been no study to ascertain the quality of water from both surface and ground sources around BBL that are prone to pollution from affluent. In view of this the study undertakes a comparative assessment of both surface and ground water quality around Benue Brewery Limited (BBL Makurdi) with the view to establishing baseline information of its quality. This paper makes a comparative analysis of the physic-chemical characteristics of ground and surface water in the study area.

2.0 MATERIALS AND METHODS

2.1 Study Area

Makurdi town lies between latitude 737 and 747 and longitude 8 and 8 (Figure 1). The town is about 16km^2 radius, situated at the coast of the river Benue. Makurdi falls within the tropical humid and mega thermal climate with wet and dry season (Aw) according to Koppen's classification. The climate condition is influenced by two air masses; the warm moist South Westerly air mass is a rain-bearing wind that brings about rainfall from the months of March/April to October. The dry north easterly air mass blows over the region from November to April thereby bringing about seasonal dryness. The annual rainfall in Makurdi is between 1200 1500mm (Adamgbe and Ujoh, 2012). The temperature condition is however, generally high throughout the year with a daily

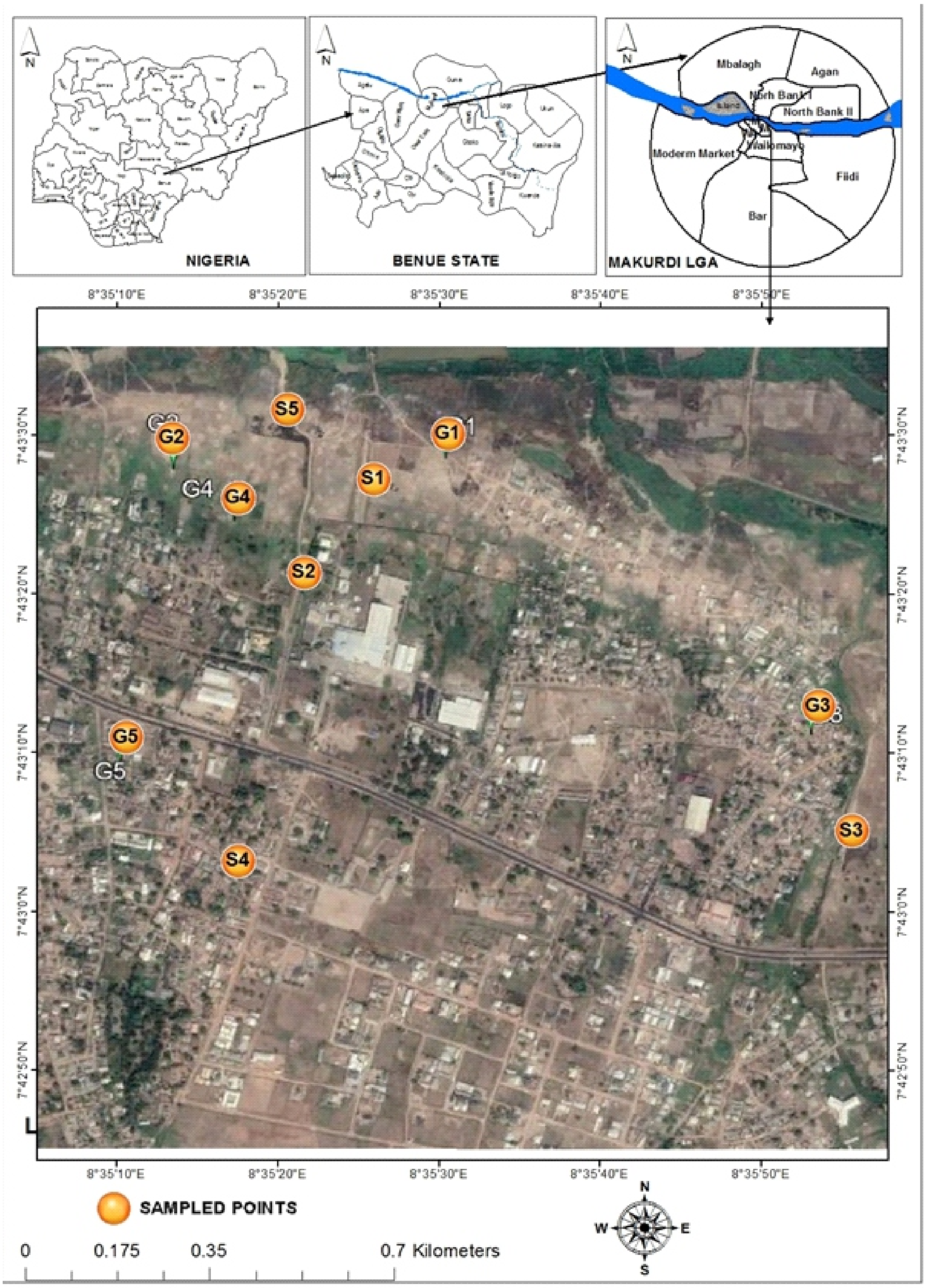

Fig. 1: Makurdi showing BBL neighbourhoods and water sample points
Source: *Benue State University GIS Unit*

range of 23 - 28 and maximum of 37 (Tyubee, 2005). The town, like most other cities in the Lower Benue Valley is drained by the Benue River and its tributaries including Idye, Fete, Kpage, Mu and Kereke streams. Due to the low relief of Makurdi town which rises from 64 66m (500ft) at Daudu settlement, Sizeable portions of the town is waterlogged and flooded during heavy rainfall or storm (Ogwuche and Abah, 2014; FMWRRD (1998, Nyagba, 1995). Makurdi is the largest city in Benue state with a projected population of 391,924 people as at 2016 (Tser, 2013). Politically, the town is the administrative capital of Benue state and Makurdi local government council. Socio-economic activities in the town include government establishments, urban daily markets, banks, industries, two universities among other educational institutions, hotels, filling stations. These activities generate various degree of effects that tend to pollute both surface and ground water sources in the study area.

2.2 Methods

The data used in this study was collected from five surface and five ground water sources around BBL Makurdi and labeled S1, S2, S3, S4, S5 and G1, G2, G3, G4, G5 respectively. The study purposively select five sample points each for surface and ground water so as to ensure adequate spatial coverage. The amounted to 10 water samples as shown in Figure 1.

In assessing the quality of water in the study area the concentration level of each physic-chemical parameters were determined in line with WHO standard. Water sample were analysed using field based and laboratory techniques. The Atomic Absorption Spectrophotometric (AAS) was used in the analysis of heavy metals such as cadmium, lead, chromium and manganese. Descriptive statistical techniques such as mean, standard deviation and coefficient of variation were employed in data analysis.

1.0 RESULTS AND DISCUSSION

The result of concentration level of Phsicochemical parameters in surface and groundwater in the study Area is presented in Table 1, while the statistical analysis of the result is presented in Table 2. The heavy metals pollutants assessed were cadmium (Cd), lead (Pb), chromium (Cr) and manganese (Mn).

Cadmium (Cd)

The concentration level of Cd in surface water sources the study area ranged from 0.0048 0.072 mg/L^{-1} with a mean value of 0.011 mg/l-[1] and a coefficient variation of 50.91. Cadmium concentration level in 3 (S1, S3 & S4) out of the 5 sample points were found to be higher than the WHO acceptable limit for drinking water (0.003 mg/L^{-1}). However, the mean value of Cd (0.0110 $mg/1^{-1}$) for this study was found to be relatively

Table 1: Concentration level of Surface and Ground water parameters

Parameters	WHO	S1	G1	S2	G2	S3	G3	S4	G4	S5	G5
Cadmium (Mg/l)	0.01	0.0110	0.0179	0.0048	0.0055	0.0158	0.0138	0.0172	0.0110	0.006	0.013
Lead (Mg/l)	0.10	2.1034	1.8191	2.1034	2.9561	0.3411	1.2506	2.8424	0.6253	0.6822	1.7054
Chromium (Mg/l)	0.05	0.0553	0.0735	0.0201	0.0604	0.0679	0.0176	0.0711	0.0176	0.3625	-0.0428
Manganese (Mg/l)	0.05	0.2275	0.1351	0.2986	0.1919	0.2559	0.427	0.0711	0.0142	0.3625	0.0455

Source: Field Survey and Laboratory Analysis, 2012

Table 2: Descriptive statistics of the surface and groundwater parameters in the study area

Parameters	Min S	Min G	Max S	Max G	Means S	Means G	STD S	STD G	CV%S	CV% G
Cd	0.0048	0.0055	0.0172	0.0179	0.0110	0.01318	0.0056	0.00517	50.91	39.226
Pb	0.3411	0.6253	2.8424	2.9561	1.6145	1.6713	1.0579	0.8580	65.525	51.337
Cr	0.0201	0.0176	0.0906	0.755	0.05182	0.04278	0.0295	0.1837	56.928	429.406
Mn	0.0711	0.0142	0.3625	0.4550	0.24312	0.2418	0.1088	0.19065	45.108	77.943

Source: Computed from Table 1.

lower compared to reported mean values of 0.112, 0.35 and 2.00 mg/L for Rivers Niger, Calabar and Lagos Lagoon respectively (Ajayi and Osibanjo, 1981). On the other hand, the concentration level of cadmium in groundwater in study area ranged from 0.0055 0.0179 with mean value and a coefficient variation of 0.0132 and 39.226%.

This implies that the mean concentration level of cadmium in groundwater in the study area is above the WHO standard of 0.01. Samples with high values above WHO standard were G1, G3, G4 and G5 (Figure 2). Generally, Cadmium occurs naturally in zinc, in lead and copper ores, in coal and other fossil fuels, in shales and is released during volcanic action or extraction of these minerals. These deposits can serve as sources to ground and surface waters, especially when in contact with low total dissolved solids (TDS) and acidic waters. Cadmium has the chronic potential to cause kidney, liver, bone and blood damage from long- term exposure at levels above the maximum contaminant level (MCL). There is inadequate evidence to state whether or not cadmium has the potential to cause cancer from lifetime exposures in drinking water.

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On the other hand, the concentration level of cadmium in groundwater in study area ranged from 0.0055 0.0179 with mean value and a coefficient variation of 0.0132 and 39.226%. This implies that the mean concentration level of cadmium in groundwater in the study area is above the WHO standard of 0.01. Samples with high values above WHO standard were G1, G3, G4 and G5 (Figure 2).

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Lead (Pb) is another heavy metal found to be in the water. Lead can end up in water and soils through corrosion of leaded pipeline in a water transporting sustain and through corrosion of leaded paints. High concentration of lead in the water is harmful to human health just as it is the case with other chemical elements.

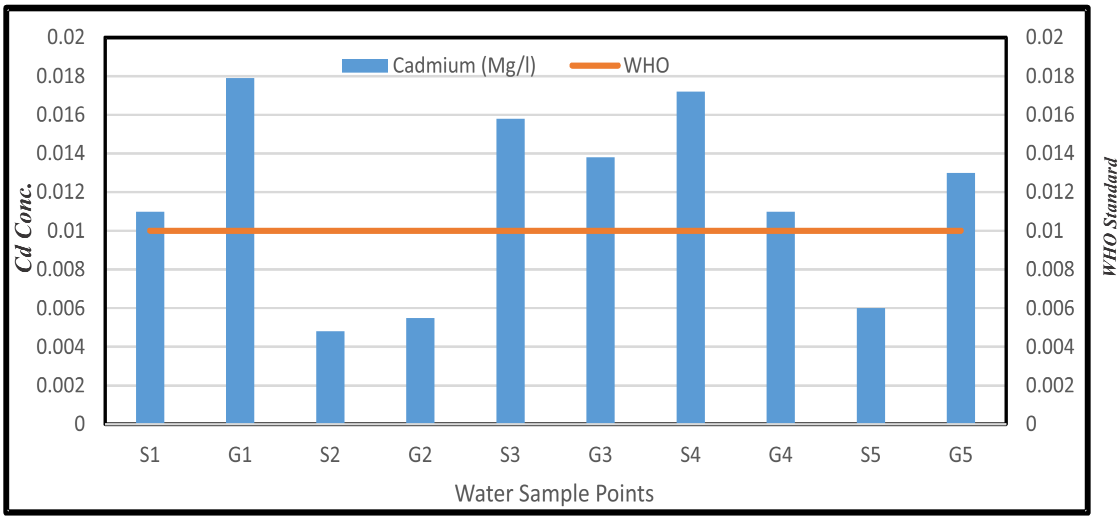

Figure 2: Concentration of cadmium in surface and ground water at BBl, Makurdi

Chromium (Cr)

The result of the water samples from surface water source in the study area reveals that the concentration level of Cr ranged from 0.0201 0.0906 mg/l-1 with a mean value of 0.052 mg/l-1 and coefficient variation of 56.9%. The concentration level of Cr in 3 (S1, S2 and S4) out of the five samples was high above the acceptable limit of WHO standard of 0.05 mg/l-1 (Figure 4). This may be as a result of industrial waste from BBL entering the water sources.

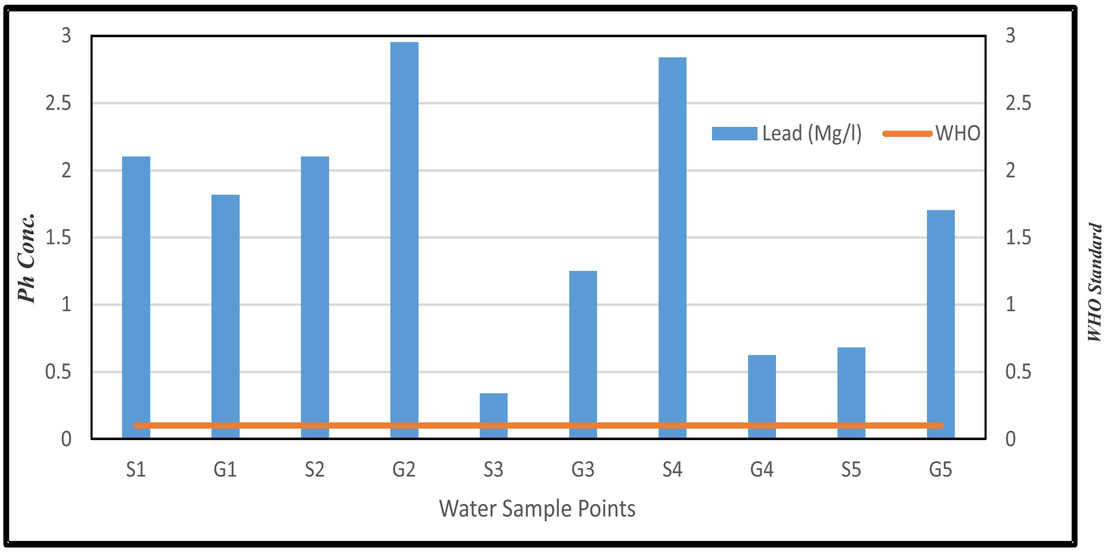

Figure 3: Concentration of lead in surface and ground water at BBl, Makurdi

The result of the groundwater analysis shown in Table 1 reveals that the concentration level of chromium in the sampled points range from 0.0176 0.0755 with a mean value of 0.0428 and a coefficient variation of 429.406%. This implies that the concentration level of chromium in the groundwater sources of the study area falls within the acceptable limit of WHO standard of 0.05. However; the concentration level of chromium in two samples (G1 and G2) were found to be high (Figure 4).

Chromium contamination has a number of health implications. For instance, people exposed to high levels of chromium are more likely to suffer_lung cancer and nasal sinus cancer. Both of these cancers have a high mortality rate. Chromium may be linked to other cancers as well. Similarly, Chromium has been linked to male infertility; stunt child development and could have lasting effects throughout your child's life. Also, Chromium exposure can cause skin and eye irritation. Hexavalent chromium may also cause asthma, nasal ulcers, convulsions, acute gastroenteritis, and damage to the liver and kidneys.

Manganese (Mn)

The result of the analysis shown in Table 1 indicates that the concentration level of Mn in the surface water sampled in the area ranged from 0.0761 0.3625 mg/L-1 with a mean value of 0.243 mg/L-1 and coefficient variation of 45.1%. This shows that Mn level is within the permissible limit of WHO standard of 0.05 5 mg/L-1 (Figure 5).

Similarly, the result Mn concentration in groundwater indicates that manganese concentration ranged from 0.0142 0.4550 with a mean value of 0.2448 and coefficient variation of 77.94%. This implies that the concentration level of manganese in the study area is within the acceptable limit of WHO standard of 0.05 0.5 (Figure 5).

Although humans need to consume small amounts of manganese to be healthy, too much

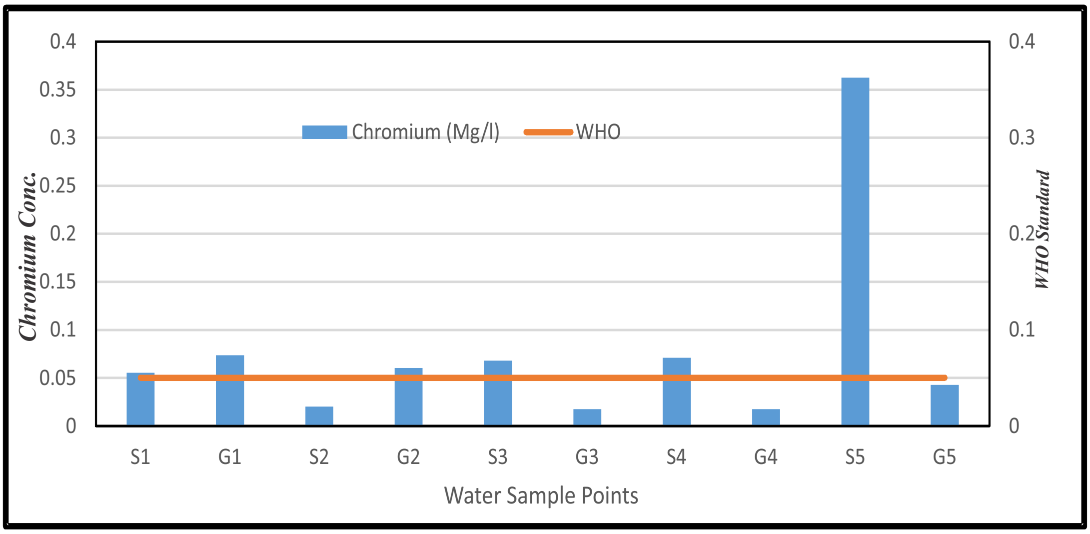

Figure 4: Concentration of chromium in surface and ground water at BBl, Makurdi

manganese in drinking water can lead to some adverse health effects. Drinking water that contains high levels of manganese, even for a short time, can be a health risk to infants. Exposure to manganese in drinking water can cause neurological and behavioural effects; deficits in memory; attention and motor skills. For adults and older children, short-term exposure to manganese in drinking water slightly above the guideline is unlikely to cause negative health effects.

Manganese compounds exist naturally in the environment as solids in the soils and small particles in the water. Mn particles in the air are present in dust particles. These usually settle to the earth within a few days. Humans enhance manganese concentrations in the air by industrial activities and through burning of fossil fuels. Manganese derives from human sources can also enter surface water, groundwater and sewage water. Through the application of Manganese pesticide, manganese will enter soils. The effects of manganese on human health occur mainly in the respiratory tract and in brains.

CONCLUSION

Based on the findings of this study, we conclude that surface and groundwater were heavily contaminated with most of the sample points exceeding the WHO's acceptable limits for drinking water. The high level of water pollution maybe connected with industrial affluent from BBl and the nearby solid waste dumpsites. More worrisome is the fact that the mean concentration of lead which exceeded WHO tolerance limits for

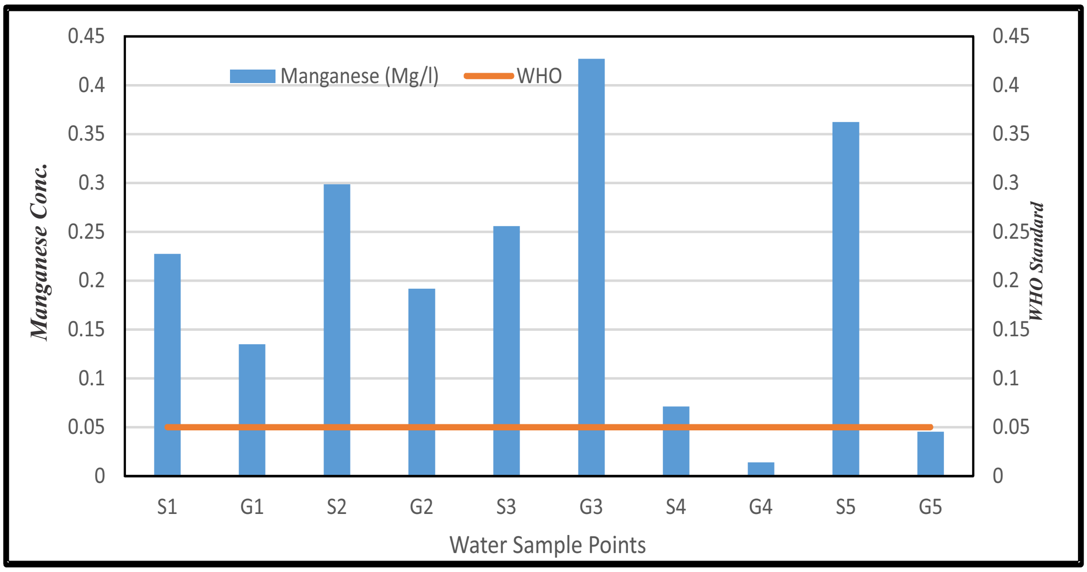

Figure 5: Concentration of manganese in surface and ground water at BBl, Makurdi

drinking water in all the sample point for both surface and ground water sources. The study therefore, recommends strict regulation of disposal of industrial affluent. More importantly, the resident should be connected to the public water source as well as proper treatment of water from all sources before consumption.

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