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Physicochemical and Heavy Metal Analysis of Well Water obtained from Selected Settlements around Dangote Cement Factory in Gboko, Nigeria

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ABSTRACT

Drinking water in developing countries especially Nigeria is susceptible to toxins as a result of effluents and pollutants. This study investigated the physicochemical characteristics and heavy metal contents of water samples collected from six different hand-dug wells from some settlements around Dangote Cement Plant Gboko. The concentration of all the physicochemical parameter studied were generally below maximum limits prescribed by WHO except for turbidity which was found in two of the samples opposite the factory (OF) and Tarhembe (T) to be 51.8 NTU and 17.5 NTU respectively which were higher than the maximum limit of (5.0 NTU) set by WHO. Total metal digestion of water samples was carried out using concentrated nitric acid (HNO_3). The digests were analyzed for heavy metals (Cd, Cr, Cu, Fe, Mn, Pb, and Zn.) using AAS. Results showed that Cd, Cr and Pb in all the water samples were not detected, the concentrations of Cu and Zn ranged from 0.01-0.05 mgL^{-1} and 0.08-0.13 mgL^{-1} respectively and were below the permissible limit set by WHO. The concentration of Fe and Mn ranged from 0.25-1.16 mgL^{-1} and 0.33-0.92 mgL^{-1}respectively and were found to be above the permissible limits recommended by WHO for drinking water. In this study, contaminants level were generally below the WHO maximum recommended limits except Fe and Mn contents which showed elevated values above the recommended levels, hence the need to put mechanisms in place to control the levels of these heavy metals in the well water sources around the area under study.

Keywords: Atomic Absorption Spectrophotometer, Heavy metals, Ground water, WHO

INTRODUCTION

Water plays a vital role in the development of a stable community and society, since human being can exist for days without food, but absence of water for a few days may lead to death (Yusufand Shuaib, 2012). Unfortunately, drinking water in developing countries especially Nigeria is susceptible to toxins as a result of effluents and pollutants (Dabi and Jidauna, 2010; Odah and Jidauna, 2013). As the human population and development in modern technology increase, the risk for water contamination also increases.

In societies like Nigeria with developing economy, the optimum development, efficient utilization and effective management of their water resources should be the dominant strategy for economic growth.

However in recent year unscientific management and use of this resources for various purposes almost invariably has created undesirable problems in its waves, water logging and salinity in the case of agricultural use and environment pollution of various limits as a result of mining, industries and municipal use (Kumar and Kumar, 2013).

Despite the larger volume of water that covers the surface of the earth, only 1% is inland fresh and easily available for human use. The quality of groundwater resources vary naturally and widely depending on climate, season and geology of bedrock as well as anthropogenic activities (Ramesh and Soorya, 2012).

Ground water is ultimate, most suitable fresh water resource with nearly balanced concentration of the salt for human consumption (Tewari *et al.*, 2010). In Nigeria, most of the population is dependent on ground water as the only resource of drinking water supply. The groundwater is believed to be comparatively much clean and free from pollution than surface water (Patil and Patil, 2010).However, prolonged discharge of industrial effluents, domestic sewage and solid waste dump etc. may cause the ground water to become polluted and create health problems.

Good quality of drinking water is very necessary for improving the life of people and to prevent from disease (Mohamed and Zahir, 2013) Only 2.5% of total water stock of the world is fresh water sources and the world wide concern is that the good quality water may become a scarce resource in the near future (Debels *et al*., 2005). For these reasons, many countries have increased their interest in fresh water quality investigation during the past decades (Tas and Yilmaz, 2015; Kutlu *et al.*, 2015; Shehu *et al.*, 2016).

MATERIALS AND METHODS

Study Area

The central location of Dangote Cement Company, Yandev is at 7°24'42.45"N and 8°58'31.28"E, with an elevation of 532 feet above mean sea level. The area is generally located within a sub-humid tropical region with mean annual temperature ranging from 23°C to 34°C, and is characterized by the dry and wet seasons. The mean annual precipitation is about 1,370 mm, with an average ambient air temperature of about 30°C. The limestone reserves at the study area are of cretaceous formation and in excess of 70 million tones.

Within the study area, the most significant water bodies are two streams -'Ahungwa' and 'Oratsor'. The Ahungwa stream is used for various production processes at the Cement Factory. The communities around the factory are Tse-Kucha, Tse-Amua and Tarhembe where the inhabitants are largely farmers.

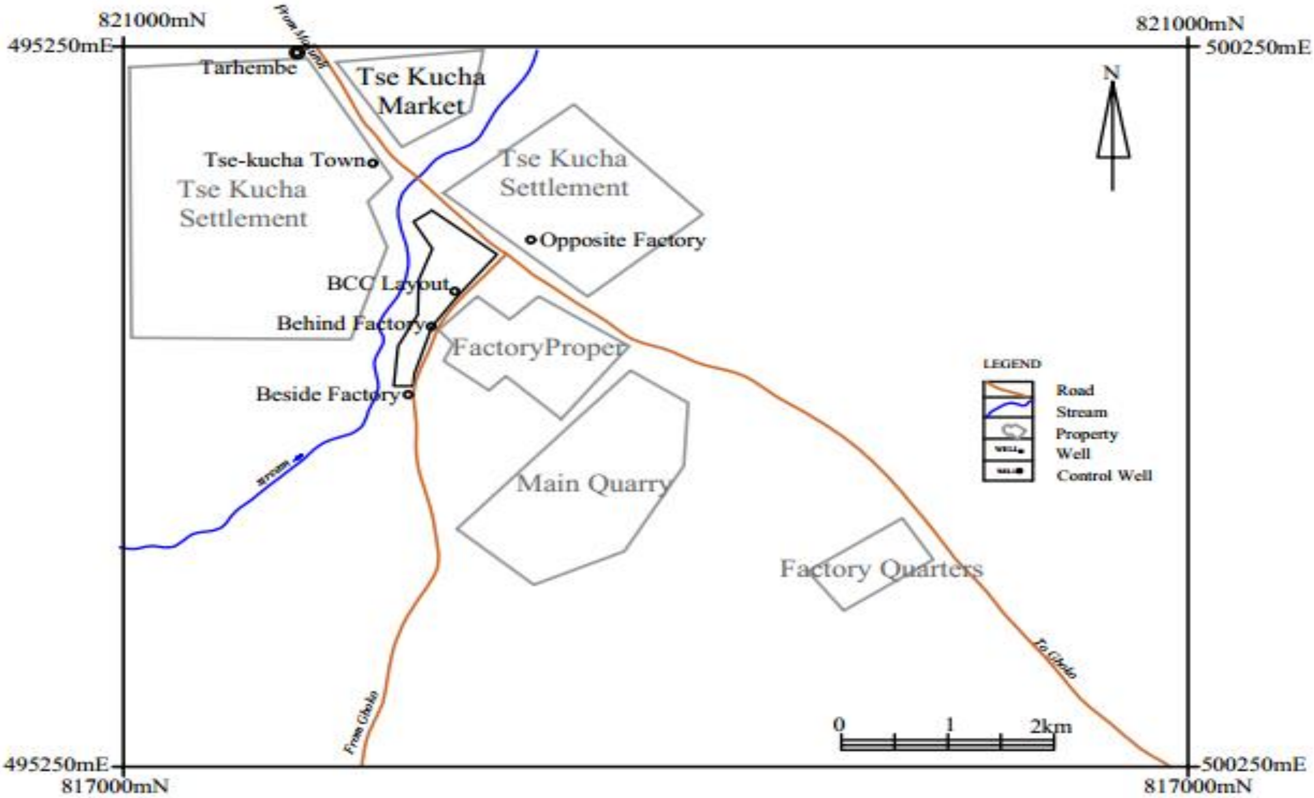

Figure1: Map showing sampling points and settlements around the Dangote Cement Factory Gboko; Source: Ministry of Lands Surveys and Solid Minerals (2019).

Sampling Site

Sampling locations were selected in the residential area and groundwater samples were collected from six different hand-dug wells for the study. Five hand-dug wells from some settlements around the cement plant, namely: Behind BCC Layout, Beside Factory, Opposite Factory, Behind the Factory and Tse-kucha town. All in Tse-kucha Mbayion Gboko Local Government, and one hand-dug well from the control community called Tarhembe.

Sample Collection

Six sampling plastic bottles (2 L capacity each) were used. Prior to sampling, bottles wererinsed with double distilled water. Neck of bottles was tightly sealed. On getting to the sampling points bottles were further rinsed several times with the water to be collected. The sample bottles were thenfilled partially with the collected water and vigorously shaken to note the odour (Radojavic, 1992).

Measurement of pH, Conductivity, Total Suspended Solids Total Dissolved Solids, and Turbidity

The pH

The pH meter used in this study was first calibrated with buffer solutions of pH 4 and 7. Thereafter, the electrode was rinsed and dried before taking measurements. The pH of the water samples was measured by inserting the electrode directly into a 10 mL solution which was agitated with a stirrer and allowed to equilibrate for about 2 min, after which the pH was recorded (Gungshik *et al*., 2018).

Electrical conductivity (EC)

The Electrical conductivity of the samples was determined using a Mettler Toledo (SevenGO^{TM}) conductivity meter in 10 mL solution after calibrating the conductivity meter using the buffer solution 84, 1288 or 1413 µS/cm (Gungshik *et al*., 2018).

Total suspended solids (TSS)

Fifty millilitre (50 mL) of water sample was vigorously shaken and filtered into a pre-weighed glass fibre filter disk fitted to suction pump, washed successively with distilled water. The filter paper was carefully removed from the filtration apparatus, dried for 1 h at 103 – 105^{0}C in an oven, cooled in a desiccator and weighed for constant weight.

Calculation:

$$TSS\ (mg\ L^{-1}) = \frac{W1 - W2}{Sample\ volume\ (mL)} \times 1000$$

W1= weight of dried glass fibre filter + residue; W2= weight of glass fibre filter disk before filtering.

Total dissolved solids (TDS)

The TDS measurement was determined using Hanna HI9835 multi parameters water checker; the probe was immersed in each of the water samples. It was gently stirred and after allowing a few minutes for the reading to stabilise, the reading was taken.

Turbidity

The nephelometer was calibrated using distilled water (zero NTU) and a standard turbidity suspension of 40 NTU. The thoroughly shaken sample was taken into the nephelometric tube and the value was recorded.

Heavy metal Analysis

The water sample bottles were shaken thoroughly in their plastic containers by use of hand. A volume of 100 mL of the sample was measured using a 100 mL measuring cylinder and put in a beaker and 5 mL of concentrated nitric acid wasthen added. The mixture was heated slowly on a hot plate and evaporated to about 20 mL ensuring that the water does not boil. A further 5 mL of concentrated nitric acid was added and the beaker was covered with a watch glass while heating continued. Nitric acid continued to be added until the solution appears light coloured and clear. The solution was filtered and the filtrate was transferred to a 100 mL volumetric flask to cool and the filtrate was made up to the mark with distilled water and taken for analysis (Radojovenic and Bashkin, 2006).

RESULTS AND DISCUSSION

The results of physicochemical parameters and heavy metal concentration investigated in the study area are presented in Tables 1 and 2 respectively. Table 3 shows the summary of the maximum and minimum levels of all the parameters measured.

Table 1: Physicochemical parameters of water samples

Sample Locations	pH	EC (µS/cm)	TDS (mg L^{-1})	TSS (mg L^{-1})	Turbidity (NTU)
TKT	4.10 ± 0.02	430 ± 10	218 ± 2	64.0 ± 4.1	4.52 ± 0.2
BF	4.77 ± 0.5	555 ± 5	288 ± 3	56.0 ± 2.0	1.79 ± 0.01
OF	4.62 ± 0.1	480 ± 7	959 ± 5	59.0 ± 3.3	51.8 ± 3.2
BR	5.03 ± 0.3	514 ± 11	270 ± 4	58.0 ± 1.7	2.45 ± 0.01
BBL	5.04 ± 0.1	463 ± 10	270 ± 7	53.0 ± 3.0	3.28 ± 0.1
T	4.63 ± 0.5	893 ± 9	190 ± 2	70.0 ± 1.5	17.5 ± 0.2

TKT = Tse-Kucha Town, BF = Beside Factory, OF = Opposite Factory, BF = Behind Factory Road, BBL = Behind BCC Layout, T = Tarhembe

Physicochemical Parameters

The pH values of the well water samples in the area under study ranged from 4.10 - 5.04 which is acidic.These values are also below the acceptable range of 6.5 - 8.5 recommended by WHO (2008) for drinking water. It has been reported by Nkansah *et al.* (2010) that pH value of water less than 6.5 is regarded as acidic for human consumption because it can cause health issues such as acidosis and damage to the digestive and lymphatic system. At lower pH, the solubility of toxic metals in water increases and makes it harmful for consumption. This result is in line with those reported by Koffi *et al.* (2014); and Mohamed and Zahir (2013) in Ivory Coast and India respectively.

Electrical conductivities obtained in this study were below the maximum limit of 1000 µS/cm prescribed by WHO (2008). The values ranged from 480-893 µS/cm. The highest level was recorded at Tarhembe (T) and lowest value was obtained at the sampling point opposite the factory (OF). This indicates that the presence of dissolved minerals in Tarhembe (T) is higher compared to samples obtained from other points.

Total dissolved solids indicate the salinity of groundwater. The result shows that TDS ranged from 190 - 959 mgL^{-1}. Concentration of TDS exceeding the WHO (2008) recommended value of 1000 mg L^{-1} is considered unpalatable for drinking water. The TDS in all the water samples were below the WHO (2008) maximum allowable limit of 1000 mg L^{-1}. Freeze and Cherry (1979), classified groundwater on the basis of TDS as follows: 0 – 1000 mg L^{-1} (fresh); 1000 – 10 000 mgL^{-1}(brackish); 10,000–100,000 mg L^{-1} (saline) and greater than 100,000 mg L^{-1} (brine). In this study, TDS of all the samples fell between 0 and 1000 mgL^{-1}. This shows that the well water samples analysed in this study are fresh.

Total suspended solids (TSS) give a measure of the turbidity of the water. Total suspended solids obtained in this study ranged from 53.0 - 70.0 mg L^{-1} as shown in Table 1. Total suspended solids like turbidity, measures the transparency of the water sample. The TSS values in this study were below the permissible limits of 1700 mg L^{-1} allowed by WHO (2004) for drinking water. The results of TSS in this study arefar less than the ranged of 200 – 700 mg L^{-1} reported by Raji *et al.* (2015) in water samples collected at River Sokoto, North-Western Nigeria.

Turbidity is another key parameter in the assessment of water quality. The turbidity of the well water samples analyzed varied between 1.79 and 51.8 NTU. The lowest value (1.79 NTU) was found in the sample obtained beside the factory (BF) while the highest amount (51.8 NTU) was recorded in the sample obtained just opposite the cement factory (OF). The Turbidity levels were generally below the WHO (2008) allowable level of 5 NTU for drinking except for well water sample obtained around Tarhembe which gave a value of 17.5 NTU and OF with 51.8 NTU. Rahmanian *et al.* (2015) reported 24 NTU and 17 NTU as the highest and lowest turbidity values respectively in their study. The presence of turbidity in well water may be due to dissolved clay and mud materials into groundwater as indicated by Olubanjo *et al.* (2019) who reported much lower turbidity values compared to the result obtained in this study.

Table 2: Concentration of heavy metals (mg L^{-1}) in well water samples

Sample Locations	Cd	Cr	Cu	Fe	Mn	Pb	Zn
TKT	ND	ND	0.021	0.72	0.33	ND	ND
BF	ND	ND	0.049	0.25	0.92	ND	ND
OF	ND	ND	0.039	2.41	0.89	ND	ND
BR	ND	ND	0.015	0.32	0.85	ND	ND
BBL	ND	ND	0.019	0.32	ND	ND	0.127
T	ND	ND	0.014	1.16	ND	ND	0.075

ND = Not detected TKT = Tse-Kucha Town, BF = Beside Factory, OF = Opposite Factory, BF = Behind Factory Road, BBL = Behind BCC Layout, T = Tarhembe

Heavy Metals in Water around the Study Area

Table 2 provides information on the contents of heavy metals in the sampled wells. Cadmium, chromium and lead were not detected in all the water sampled from hand-dug wells.

This research revealed that the minimum and maximum concentration of Cu obtained from hand-dug wells as shown in Table 2, ranged from 0.014 – 0.049 mg L^{-1}. The maximum permissible limit of Cu WHO (2008) is 2.0 mg L^{-1}. In all the well water samples analyzed, it was observed that the concentration of Cu was below the maximum permissible limit recommended for drinking water by World Health Organization WHO (2008). The level of Cu reported in this study is similar to the concentration of Cu reported by Gimba *et al.* (2015) in a similar studywhere the minimum and maximum concentration of Cu in hand-dug well samples at the study areas ranged between 0.031 mg L^{-1} and 0.596 mg L^{-1}.

The result of this study indicatedhigh concentrations of Fe (0.25 – 1.16 mg L^{-1}) and Mn (0.33 – 0.92). The World Health Organization recommended value for both Fe and Mn in drinking water is 0.1 mg L^{-1} which indicates that the values obtained for Fe and Mn in the well water samples exceed the set limit by WHO (2008). However for Mn was not detected in two (2) samples (BBL and T) probably due to level being less than the detection limit. Raji *et al.* (2010) has reported Mn level in well water samples in the range of 0.510 – 1.20 mg L^{-1}.

Table 3: Summary of Physicochemical Parameters and Heavy Metals in the Well Water Samples

Parameters	Maximum	Minimum	WHO (2008) Standard
pH	5.04	4.10	6.5 – 8.5
EC (μS/cm)	893	480	1000
TDS (mg L^{-1})	959	109	1000
Turbidity (NTU)	51.8	1.79	5.00
TSS (mg L^{-1})	70.0	53.0	NS
Cadmium (mg L^{-1})	ND	ND	0.003
Chromium (mg L^{-1})	ND	ND	0.05
Copper (mg L^{-1})	0.049	0.014	2.00
Iron (mg L^{-1})	1.16	0.25	0.10
Manganese (mg L^{-1})	0.92	0.33	0.10
Lead (mg L^{-1})	ND	ND	0.01
Zinc (mg L^{-1})	0.127	0.075	3.00

NS = No Standard

Concentration of Zn in the study area ranged from 0.075 – 0.127 mg L^{-1}. This when compared with the standard value of 3.0 mg L^{-1} WHO (2008) for drinking water, the level of Zn is below the standard set by the organization. This indicates that the sampled water contain the right proportion of Zn which is an essential plant and human nutrient element. The low concentration further implies that the water samples do not have caustic taste, hence good for consumption and other domestic uses.

CONCLUSION

From the investigation of the physicochemical characteristics and heavy metal contents of water samples collected from six different hand-dug wells around the Dangote Cement Factory, Gboko, this study revealed that physicochemical parameters of the samples collected such as; pH, conductivity, turbidity, total dissolved solids (TDS) and total suspended solids (TSS) were below maximum limits prescribed by WHO, except for turbidity which was found in two of the samples (OF and T) to be higher than the maximum limit set by WHO (2008). The heavy metals that were analyzed included Cd, Cr, Cu, Fe, Mn, Pb, and Zn. Results showed Cd, Cr and Pb in all the water samples were not detected but the concentrations of Cu and Zn were recorded below the permissible limit recommended by WHO (2008) for drinking water. The concentration of Fe and Mn were obtained above permissible limits recommended by WHO (2008). There is need to put machinery in place to control the level of these metals in well water area sources around the Cement Factory to forestall threat to human health due to continuous consumption of the water.

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