

Analysis of drinking ground water samples for heavy metals in Onitsha North local government area of Anambra State

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Abstract

This study analysed five heavy metals in some drinking ground water samples in Onitsha North local government area. A total of 10 ground water samples were analysed to determine arsenic, cadmium, copper, iron and lead content using Varian AA240 atomic absorption spectrophotometer to determine their suitability as drinking water. From the results obtained, none of the water samples contained iron and copper in concentrations above the maximum permissible limit. All the samples contained arsenic in concentration above the maximum permissible limit. The maximum concentration of lead obtained was 3.955mg/l and that of cadmium was 0.326mg/l which were above the maximum permissible limit. All the samples analysed contained one or more of the five heavy metals studied. The results obtained from this study suggest a significant risk to the population drinking the water given the toxicity of these metals and the fact that these boreholes are the only source of water supply in this environment.

Keywords: Water, Metals, Borehole, toxicity.

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1. Introduction

Water is a clear, pellucid, transparent fluid which is the major constituent of the fluids of living things, chemical compound, and the most widely used of all solvents. Water covers 71% of the earth surface [1]. On Earth, 96.5% of the planet's water is found in seas and oceans, 1.7% in groundwater, 1.7% in glaciers and 0.001% in the air as vapor, clouds (formed of solid and liquid water particles suspended in air), and precipitation[1]. Water on Earth moves continually through the water cycle of evaporation and transpiration (evapotranspiration), condensation, precipitation and runoff usually reaching the sea [1]. Water in a pure state has neutral pH which means it is neither acidic nor basic in its pure state but the pH changes when substances are dissolved in it.

Ground water are said to have emanated from the melting of meteoric water (rain, snow, and hailstone), into the ground, they have served as source of domestic water

supply. It offers cheaper and purer supply. The main ionic components are chloride, nitrate, sulphates, potassium, sodium and calcium. This includes natural springs, wells and boreholes. As it percolates into the earth it is subjected to some purification actions by the numerous chains of pervious and impervious rock strata or layers. Because of the disintegrating and dissolving power of water, it dissolves some of the rocks which make up the earth layers making it to have impurities like oxides, nitrate, sulphates, calcium, iron, magnesium. Groundwater is highly valued because of its occurrence, availability and it's consistent good quality for drinking which are properties not possessed by surface water[2]. People around the world have used groundwater as a source of drinking water because groundwater is directly in contact with soil, rocks, and plants, which might contaminate the ground water [3]. Spring water is groundwater that rises to the ground surface.

The principal causes and sources of pollution in groundwater have been grouped into four categories, namely municipal, industrial, agricultural and miscellaneous [4]. Main origins of pollution of wells and boreholes are industrial, domestic and agricultural [5]. Pollution can be continuous or accidental. Industrial pollution may involve seepage of used water containing chemicals such as metals and radioactive compounds or contaminated water from damage pipelines infiltrating into the borehole [6].

Heavy metals are metallic chemical elements that have relatively high density, toxic or poisonous at low concentration values which are natural components of the Earth's crust that cannot be degraded or destroyed. This includes the transition metals, some metalloids, lanthanides and actinides. Examples of heavy metals include copper, selenium, iron, lead, mercury, cadmium and silver etc [7]. Heavy metals can be classified based on density, atomic weight, chemical toxicity in relation to living organisms. Trace elements constitute a natural component of the earth crust and they are not biodegradable, hence persist in the environment. Trace elements may come from natural sources, leached from rocks and soils according to their geochemical mobility or come from anthropogenic sources, as the result of human land occupation and industrial pollution [8]. Although trace metals at low concentrations are essential to life, at high concentrations, may become hazardous. Industrial effluents like toxic chemicals and heavy metals pollute several surface waters. Mercury is one of the heavy metals, in a group that includes lead, cadmium, plutonium and others. A feature the heavy metals have in common is that they tend to accumulate in the bodies of organisms that ingest them, their concentrations increase up the food chain. Some marine algae may contain heavy metals of concentrations of up to one hundred times that of the water in which they are living, small fish eating the algae develop higher concentrations of heavy metals in their flesh, larger fishes who eat the smaller fishes concentrate the metal still further, and so on up to fish eating birds or animals [9]. Some non-metallic elements commonly used in industries are also potentially toxic to aquatic lives and to some extent to human beings.

Chloride is widely used to kill bacteria in municipal water, sewage treatment plants and to destroy various microorganisms are found in plumbing lines in water works stations. Chlorine can also kill algae and harm fish population. Acids from industrial operations and acid mine drainages especially in coal and sulphide areas remain serious source of surface and ground water pollutions [10].

The aim of this study is to determine concentrations of heavy metals such as iron, lead, cadmium, arsenic and copper in drinking ground water samples in Onitsha North Local Government Area of Anambra State,

Nigeria since increasing focus is being given to studies on groundwater contamination.

2. Materials and Methods

2.1 Study Area

Onitsha North Local Government Area is a L.G.A in Anambra state, Nigeria. It has only Onitsha town in it. Onitsha north local government area lies at a major east-west crossing point of the river Niger and occupies the northernmost point of the river regularly navigable by large vessels. It is a river port of the eastern bank of Niger River in Anambra state. As at 2001, this local government area was estimated to have a population of 511,000.

2.2 Sample Location

A total of 9 water samples were collected from 9 selected boreholes in Onitsha North Local Government Area of Anambra state. These boreholes were selected according to their proximity to the river Niger in the local government area. Samples A (Garbs mega plaza borehole, Awka road, Onitsha) and B (Osuma road, inland town, Onitsha) were collected from boreholes that are 5km away from the Niger river, samples C (St. Marks street, Omagba phase1, Onitsha) and D (Water works road Omagba phase 1, Onitsha) were collected from boreholes that are above 7km away from the Niger River, samples E (Benjamin street, Ose market, Onitsha) and F (Nwosisi street, Ose market, Onitsha) were collected from boreholes that are 1km away from the Niger river, samples G (Ogbatuluenyi drive, federal housing estate, 3-3 Onitsha), H (Akunwatambamalu crescent, federal housing estate, 3-3 Onitsha) and I (Park road, Government Reserved Area, Onitsha) were collected from boreholes that are 3km away from the Niger river. One water sample was collected from randomly selected public water in Brampton, Toronto, Canada as control.

2.3 Water sample collection

About 50ml of each water sample was collected into the sample container. Before the container was filled with the water sample, the container was rinsed two times with the water sample to be collected. The water sample collected from the public water in Brampton Toronto, Canada was acidified with concentrated nitric acid to a pH below 2 to minimize precipitation and adsorption of heavy metals on the container walls. It was stored in the refrigerator until further analysis.

2.4 Determination of heavy metals [9]

2.4.1 Method

Atomic Absorption Spectrophotometric method using Varian AA240 Atomic Absorption Spectrophotometer

2.4.2 Principle

This is based on the sample being aspirated into the flame and atomized when the atomic absorption

spectrophotometry's light beam is directed through the flame into the monochromator and onto the detector that measures the amount of light absorbed by the atomized element in the flame. Since metals have their own characteristic absorption wavelength, a source lamp composed of that element was used thereby removing spectral or radiational interferences. The amount of energy of the characteristic wavelength absorbed in the flame is proportional to the concentration of the element in the sample.

2.4.3 Procedure

Atomic absorption spectrophotometer was set up with simultaneous background correction and air acetylene burner according to the manufacturer's instruction. The data collection system was turned on. The burner and gas controls were set up according to manufacturer's specifications. Hollow cathode lamp of the corresponding elements was the resonance line source. The standards of each heavy metals were analysed prior to the analyses of the samples for each metal using concentration of 100ppm for arsenic standard, 40ppm for lead standard, 20ppm for copper standard, 20ppm for iron standard and 50ppm for cadmium standard. The samples were analysed for the concentration of each metal after the standard solution of the metal has been aspirated. Each heavy metal was analysed at its characteristic wavelength (193.7nm for arsenic, 228.8nm for cadmium, 283.3nm for lead, 324.7nm

for copper and 248.3nm for iron). Deionized water was aspirated between each sample to avoid cross contamination. A calibration curve was plotted and the concentration of each sample solution was calculated from the calibration curve of each metal. The samples were analysed in duplicates with the average concentration of the metal present being displayed in mg/l by the instrument after extrapolation from the standard curve.

3. Result

The concentrations (PPM) of iron, Copper, lead, arsenic and cadmium in sample A was 0.113, 0.102, 3.296, 1.476 and 0.326 while it was 0.00, 0.00, 3.460, 1.231 and 0.272 in sample B. The concentrations (PPM) of iron, Copper, lead, arsenic and cadmium in sample C was 0.024, 0.104, 3.016, 0.730 and 0.150 while it was 0.00, 0.019, 0.00, 1.577 and 0.043 in sample D. The concentrations (PPM) of iron, Copper, lead, arsenic and cadmium in sample E was 0.327, 0.030, 0.00, 2.051 and 0.156 while it was 0.010, 0.00, 0.476, 2.060 and 0.00 in sample F. The concentrations (PPM) of iron, Copper, lead, arsenic and cadmium in sample G was 0.00, 0.00, 0.00, 1.711 and 0.027 while it was 0.00, 0.00, 0.00, 1.243 and 0.056 in sample H. The concentrations (PPM) of iron, Copper, lead, arsenic and cadmium in sample I was 0.048, 0.00, 0.824, 0.767 and 0.080 while it was 0.033, 0.011, 3.955, 1.365 and 0.009 in control as shown in table 1 below.

Table 1: Concentration of some heavy metals in ground water in Onitsha

Samples	Distance from River Niger (km)	Iron (ppm)	Copper (ppm)	Lead (ppm)	Arsenic (ppm)	Cadmium (ppm)
A	5	0.113	0.102	3.296	1.476	0.326
B	5	0.00	0.00	3.460	1.231	0.272
C	>7	0.024	0.104	3.016	0.730	0.150
D	>7	0.00	0.019	0.00	1.577	0.043
E	1	0.327	0.030	0.00	2.051	0.156
F	1	0.010	0.00	0.476	2.060	0.00
G	3	0.00	0.00	0.00	1.711	0.027
H	3	0.00	0.00	0.00	1.243	0.056
I	3	0.048	0.00	0.824	0.767	0.080
Control		0.033	0.011	3.955	1.365	0.009

4. Discussion

Heavy metals are elements having atomic weights between 63.546 and 200.590 and a specific gravity greater than 4.0 (at least 5 times that of water). Heavy metals existed in colloidal, particulate and dissolved phases in water (Their occurrence in water bodies are either of natural origin which may include eroded minerals within sediments, leaching of ore deposits and volcanism extruded products)[11] or of anthropogenic origin (from solid waste disposal, industrial or domestic effluents, harbour channel dredging)[12].

Discharging of pollutants by direct or indirect means into water bodies without adequate treatment to remove harmful compounds lead to water pollution leading to ground water contamination which is an important environmental issue today[13]. Among the wide diversity of contaminants affecting water resources, heavy metal is of serious concern due to their strong toxicity even at low concentrations [12]. Some of the metals are essential to sustain life and they include calcium, magnesium, potassium and sodium which must be present for normal body functions. Also, cobalt, copper, iron, manganese,

molybdenum and zinc are needed at low levels as catalyst for enzyme activities [11]; however, exposure to high concentrations of these heavy metals can result in toxicity. Heavy metal can cause serious health effects with varied symptoms depending on the nature and concentration of the metal ingested [11].

The five metals studied in this research include; arsenic, cadmium, copper, iron and lead and they have maximum contaminant levels of 0.01mg/l, 0.003mg/l, 2mg/l, 0.5mg/l and 0.01mg/l respectively. Guidelines for the presence of heavy metals have been set by different international organisations such as World Health Organisation (WHO) and Standard Organisation of Nigeria (SON) to safeguard the protection of human health [12]. Therefore, heavy metals have maximum permissible level in water as specified by WHO and SON.

The result of the study showed that two of the water samples analysed for cadmium estimation did not contain detectable levels of cadmium while the rest contained cadmium concentrations above the maximum contaminated level (0.003mg/l) with the maximum concentration detected being 0.326mg/l. This may be as a result of toxic depositions from mechanic shops, paint industries as well as toxic refuse dumps from some of the houses around the sites of the sample collection. The result also showed that four of the samples collected did not contain detectable levels of lead. However, six of the samples collected showed lead concentrations above the maximum contaminated level (0.01mg/l) with the maximum concentration detected being 3.955mg/l. The high lead concentration may be as a result of toxic depositions from paint companies and mechanic shops near the site of sample collection. These results are of concern as lead has been recognised as a poison that can cause metabolic damage [11]. This suggests that people who drink this type of contaminated water are susceptible to central nervous system destruction as well as kidney damage [14].

The result of the study showed that all the water samples collected contained arsenic concentrations above the maximum contaminated level (0.01mg/l) with the maximum concentration detected being 1.711mg/l. Arsenic has some toxic effect on body systems [15]. This suggests that people who drink this type of contaminated water are susceptible to arsenicosis [16].

In the analysis of the water samples collected for copper and iron examination, all the water samples collected were generally within the acceptable maximum limits for lead and copper. The result of this study is in agreement with previous studies [17-19]. Presence of lead, cadmium and aluminium was reported in Surulere [17]. The result showed that there is a significant risk for the population from drinking ground water as these metals were

detected in 98% of the water samples analysed [17] while study on heavy metals in surface and ground water in Birsinghpur town in India reported that all the samples analysed contained lead and cadmium above the permissible limits recommended by WHO [19]. Overall, all the samples collected contained detectable amounts of one or more heavy metals studied, with varying concentrations. This generally may be as a result of deposition of toxic substances to the environment from paint industries and mechanic shops nearby. Toxic household refuse from residents in the local government area may also be a contributory source.

From this study, it can be concluded that these drinking ground water in Onitsha North local government area have high concentrations of heavy metals and in some cases, the levels were above WHO specified maximum contaminant level. The result suggests significant risk to population of Onitsha North local government area given the toxic nature of these heavy metals and the fact that the residents of this local government area depend solely on these boreholes as the only source of their water supply to the environment.

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