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# Assessement of Radiation and Determination of Heavy Metals in Underground Water in Oju, Obi and Otukpo Local Government Areas of Benue State

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**ABSTRACT**

Assessment of radiation and determination of heavy metals in underground water was achieved with the use of Atomic Absorption Spectrometer PG990 (AAS) in the determination of heavy metals at Chemistry Laboratory, Department of Chemistry in Benue State University, Makurdi. Radiation Alert Meter was used to assess the radiation level on the water at the respective study centers. The investigation showed average radiation from borehole water in the samples to range from 0.003μSv/hr to 0.020μSv/hr and was below the recommended value which guaranteed an exposure level lower than 0.10 $mSvy^{1}$. Also, the average radiation from hand dug water ranges from 0.003 μSv/hr to 0.017 μSv/hr which amounted to an exposure lower than 0.1 $mSvy^{-1}$. Cadmium (Cd), Copper (Cu), Manganese (Mn), Nickel (Ni) and Lead (Pb) were identified as heavy metals from both the hand dug well and the borehole water. The result showed safety in the use of these two sources of water.

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## Introduction

Radiation is the energy that emits particles from a source or substance and travel through some material or through space [1]. It is also referred to as the energy emitted in form of waves or streams of particles either transmitted or absorbed by matter [2]. Excess exposure to radiation could result to adverse health effects such as leukemia, chromosomal breakage, bone necrosis, bone cancer, mutation of genes, cataracts of eye lens etc. The mining of mineral resources such as granite, limestone, marbles etc can also facilitate the release of radioactive materials from the host material (ores) into the environment since most minerals (ores) co-exist with naturally occurring radionuclides [3]. Radiation can be non- ionizing and ionizing. Ionizing radiation is the radiation that produces ions (Charged atoms) and excitations in a medium through which it propagate. Examples include: hard UV, X-ray, gammer rays, Alpha and Beta and neutrons [4]. When ionizing radiation passes through cellular tissue, it produces charge water molecules, these breaks up into entities called free radicals, such as the free hydroxyl radical compose of an oxygen atom and a hydrogen atom. Initiates chemical reactions can alter molecules in cell, one molecules of a particular importance in relation to radiation damage or affect deoxyribonucleic acid (DNA), found in the nucleus of the cell. Radiation may ionize DNA molecules by resulting directly to a chemical change, or the DNA may be changed indirectly when it interact with a free radical produced in the water of cell by radiation. In either case, the chemical change can cause a harmful biological effect, leading ultimately to the development of cancer or inherited genetic defects, whereby the quantification of these effects has provided the basis for radiation protection standards [5]. Humans can be exposed to ionizing radiation through two major ways, it may be internal or external, and can be acquired through various exposure pathways.

With all the radiation from natural and man-made sources, we should quite reasonably be concerned about how all the radiation might affect our health. The damage to living systems is done by radioactive emissions when the particles or rays strike tissue, cells, or molecules and alter them. These interactions can alter molecular structure and function; cells no longer carry out their proper function and molecules, such as DNA, no longer carry the appropriate information. Large amounts of radiation are very dangerous, even deadly. In most cases, radiation will damage a single (or very small number) of cells by breaking the cell wall or otherwise preventing a cell from reproducing [6].

Generally speaking, radionuclides are also present in water in varying amounts from natural sources within the Earth or due to releases from nuclear power plants or laboratories. Water from wells, for example, can be exposed to rock formations that can contribute radiological like uranium, radium and thorium. Although all water contains some level of radiation, the type and amount are dependent on a variety of factors. The most common naturally occurring alpha particles in rocks and soil are radium-226, uranium-238, radon-222, polonium-210 and lead-206. The primary beta particles typically are manmade, like strontium-90, but some are naturally occurring, like potassium-40. Some of the decay products from radon also emit beta particles. Higher levels of radiological contaminants can be found in groundwater near mining operations or areas where rock and soil have been disturbed.

Alpha particle emitters are more dangerous when inhaled or ingested, as they can expose human organs and tissues to radiation, causing biological damage that increases the risk of cancer. Beta particles can penetrate the skin and actually cause burns. They also can be detrimental when ingested; causing more damage because they are smaller and can penetrate tissues more deeply, resulting in more damage at the cellular level.

Homeowners who use private wells as their water sources may not know what level of radiation is present in their water, because most do not test for radiological contaminants. There are several reasons why people do not test their private wells one of the foremost being that they do not even know they could be at risk. Some states require radon testing for real estate transactions and provide detailed information on the risks of radon; however, there is a lack of information about other radiological contaminants in general [6].

Discovering the present of heavy metals and possibly the concentration levels will help in determining the best water treatment solution. Some treatment options, such as carbon, actually can absorb radon and become a disposal concern if not changed out at the proper frequency, based on the level of radon.

Treatment of water with no idea of radiological levels can lead to higher radiation exposure supposing a high concentration of impurities is recorded for the homeowners as well as technicians who work on the water treatment industries [7]. Study revealed that radionuclide testing of public drinking water system has been required since the 1970's for safety; however, uranium testing has not been required until quite recently. A concentration of uranium in drinking water above the EPA's maximum containment level, over a period of years is believed to cause kidney damage and to increase one's lifetime risk of developing certain types of cancer [8].

Water is very important to human life and is therefore an important material in the enclave of human and its environment. Naturally, 53% of the populations rely on ground water as source of drinking water and other uses like water for domestic and industrials supply, transportation, irrigation, power generation, fish farming, sports, drainage and waste management. The contamination of water bodies such as lakes, rivers and underground water by human or natural activities can be harmful to organism and plants, which live in or use the water. It is necessary to carry out a study to investigate the level of contamination on the two sources of water discussed in this work.

The presence of heavy metals in drinking water pose a number of health hazards, most especially when is polluted with radionuclide. If taken in by ingestion, it causes several illnesses such as cancer and toxicity of the kidney. It is therefore necessary to determine the heavy metals present in water in Oju, Obi and Otukpo Local Government Areas to assess the quality of drinking water in these regions.

**Study Areas**

This study was focused on determining the heavy metals in drinking water from three (3) Local Government Areas in Benue South East Zone, Nigeria. The Local Government Areas are: Oju, Obi, and Otukpo. And this drinking water is restricted to hand dug Wells and Boreholes. Due to time and financial constraint 11 boreholes and 19 hand dug wells were considered. Three maps indicating the study areas are shown below (figure 1, 2 and 3).

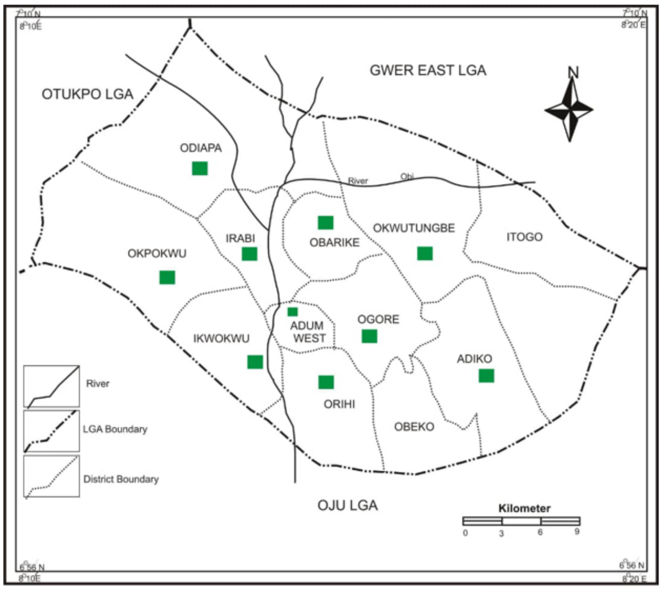


**Figure 1:** Map of Obi Local Government Area

**Source:** Ministy of Lands and Servey Makurdi

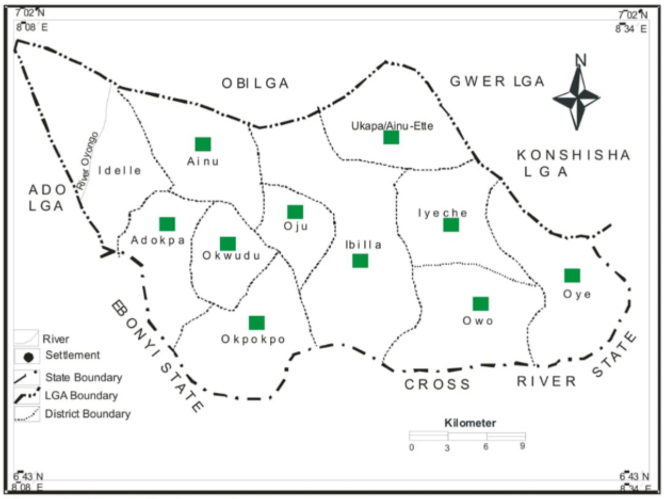


**Figure 2:** Map of Oju Local Government Area
**Source:** Ministy of Lands and Servey Makurdi

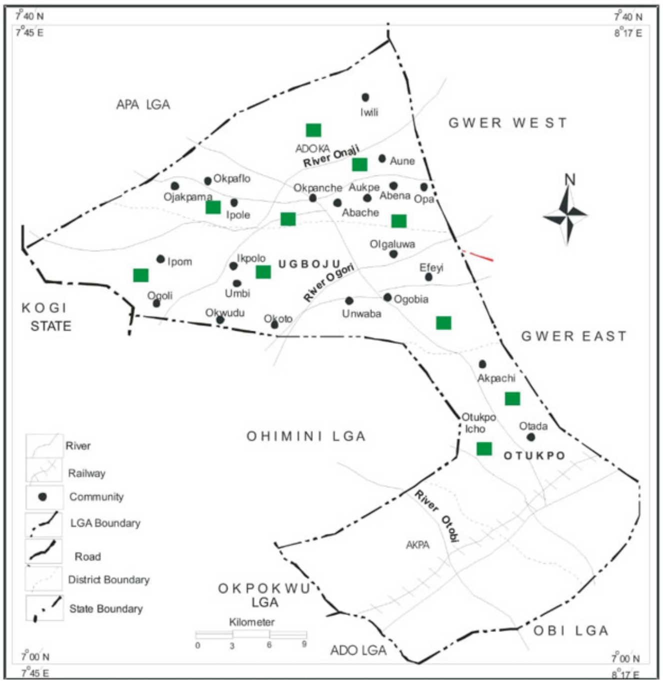


**Figure 3:** Map of Otukpo Local Government Area

**Source:** Ministy of Lands and Servey Makurdi

**Material and Method**

**Materials**

The following instruments will be used basically.

1. Atomic Absorption Spectrometer (AAS)
2. Radiation Alert Meter

**Atomic Absorption Spectrometer**

The equipment that was used for the determination of trace heavy metals is Atomic Absorption Spectrometer PG990 (AAS). The spectroscopy is the technique use to determine the type of metals present in a sample. It uses the absorption of light phase atom. The light is focus into the flame which is produced by a hollow cathode lamp, inside which is the sample and the anode. A high voltage is passed between the cathode and the anode and the metal atoms are excited into producing light with a certain emission spectrum.

The Atomic Absorption Spectrometer is versatile low cost, entry level equipment with a computer controlled Air/Acetylene flame for general laboratory requirement. It has high sensitivity and excellent performance and also it has a wide range of application.

**Radiation alert meter**

Radiation Alert meter is a digital meter that was used to take the background radiation in each of the sampling area. It is a health and safety instrument that is optimized to detect low level of radiation. It uses Geiger-Mueller tube to detect radiation. The tube generates a pulse of electrical current each time the radiation passes through the tube and causes ionization. Each pulse is electrically detected and registered as a count. The average dose rate was measured in count per minute and converted to exposure dose rate using 1200(CPM) = 1μSv/hr as conversion factor [9].

It detects low level of alpha, beta, X-ray and gamma radiation. It has an audible beep that provides information indicating that radiation is detected by the meter. The diameter of the window is about 45mm.

**Method**

**Measurement of Radiation of water**

The collection of the samples was done right at the location of the study areas; the radiation alert meter was used to measure the radiation of the water during the collection. The meter was placed 100 cm from the source of the water and the meter was put on after which values were taken and recorded for 30 seconds and average calculated to get the values of the background radiation from the water source and also after fetching the water, the meter was placed 100 cm above the water and average measurement were recorded to get the radiation on water sample at the same 30 seconds. The difference between the radiation on the sample and the background radiation gives the radiation of water sample in the source area.

**Elemental Analysis**

Determination of heavy metals was done with the use of Atomic Absorption Spectrometer (AAS) in Chemistry Laboratory in Benue State University, Makurdi.

We had approximately 70 cm3 volume of each water sample was evaporated on a hot plate at a temperature below the boiling point of water till the volume reduced to 50 cm3; 5 cm3 of Concentrated HNO3 was then added and heated in an evaporated disc to reduce the volume to 20 cm3. After cooling, 5 cm3 of Concentrated HNO3 was added to the sample and heated until a residue was formed. Finally, the residue was washed down with distilled water and then filtered to remove insoluble materials that could clog the atomizer. In each case, the filtrate volume of the sample was made up to70 cm3 with distilled water for analysis of heavy metals.

**Results**

The result of the measurements/reading from the radiation meter is as presented in the following tables (table 1 and 2).

**Table 1: Average radiation of water for borehole**

| Sample Code | Sample Location | Average background Radiation on Sample(CPM) | Average Background Radiation (CPM) | Average Background Radiation | |
|---|---|---|---|---|---|
| | | | | (CPM) | (µSv/hr) |
| OBA 4 | Onah Ochoro Obarike | 34.750 | 23.100 | 11.650 | 0.010 |
| OBA 9 | Itafor Ogori Adokpa | 48.500 | 38.300 | 10.200 | 0.009 |
| OJC 2 | Uje Anchim | 51.300 | 46.000 | 5.300 | 0.004 |
| OJC 3 | Adinu Ukpila Oboru | 73.300 | 52.300 | 21.000 | 0.018 |
| OJC 4 | Ohuhu Anyabato | 61.222 | 46.220 | 15.002 | 0.013 |
| OJC 5 | Ibila | 63.000 | 42.880 | 20.120 | 0.017 |
| OJC 6 | Oju obohu | 69.000 | 48.300 | 20.700 | 0.017 |
| OJC 7 | Obene Ikwokwu | 60.000 | 56.380 | 3.620 | 0.003 |
| OJC 8 | Igwe main Town | 87.500 | 63.720 | 23.780 | 0.020 |
| OJC 9 | Ihiejwo Itafor Ogori | 54.000 | 48.500 | 5.500 | 0.005 |
| OJC 10 | Ainu Ojaba | 46.000 | 40.350 | 5.650 | 0.005 |

**Table 2: Average radiation of water for hand dug well**

| Sample Code | Sample Location | Average Background Radiation on Sample(CPM) | Average Background Radiation (CPM) | Actual Radiation of Sample (CPM) | |
|---|---|---|---|---|---|
| | | | | (CPM) | (µSv/hr) |
| OBA 1 | Itogo Ipinu | 49.100 | 43.120 | 5.980 | 0.005 |
| OBA 2 | Okutungbe | 46.800 | 34.200 | 12.600 | 0.011 |
| OBA 3 | Ojima Ochingini | 91.000 | 85.000 | 6.000 | 0.005 |
| OBA 5 | Abofutu Ogore | 47.500 | 27.500 | 20.000 | 0.017 |
| OBA 6 | Irabi | 42.500 | 38.500 | 4.000 | 0.003 |
| OBA 7 | Odiapa Inyangbogo | 34.000 | 28.000 | 6.000 | 0.005 |
| OBA 8 | Okpokwu Market | 46.500 | 26.000 | 20.500 | 0.017 |
| OBA 10 | Adum East | 86.000 | 70.090 | 15.910 | 0.013 |
| OTB 1 | Ochito | 48.000 | 44.000 | 4.000 | 0.003 |
| OTB 2 | Ogobia | 86.000 | 69.000 | 17.000 | 0.014 |
| OTB 3 | Ogoli | 63.500 | 57.000 | 6.500 | 0.005 |
| OTB 4 | Okwudu Ugboju | 51.500 | 30.660 | 20.840 | 0.017 |
| OTB 5 | Okoto | 54.300 | 48.200 | 6.100 | 0.005 |
| OTB 6 | Opa | 45.500 | 28.000 | 17.500 | 0.015 |
| OTB 7 | Otada | 32.000 | 26.400 | 5.600 | 0.005 |
| OTB 8 | Akpachi | 55.000 | 43.000 | 12.000 | 0.010 |
| OTB 9 | Okpanche | 71.000 | 61.200 | 10.800 | 0.009 |
| OTB 10 | Ipole | 48.500 | 38.900 | 9.600 | 0.008 |
| OJC 1 | Ukpute Ainu | 51.500 | 43.000 | 17.500 | 0.015 |

From the elemental analysis, water samples for boreholes and hand dug well water were as presented. The analysis was done to identify heavy metals present. The following dominant metals were found: Cadmium (Cd), Copper (Cu), Manganese (Mn), Nickel (Ni), Lead (Pb).

**Discussion**

The result as shown in the tables (1-2), indicates the following: Table 1 which shows average radiation from borehole water in the ten samples presented ranging from 0.003µSv/hr to 0.020µSv/hr are below the recommended value which guaranteed an exposure lower than 0.10 $mSvy^{-1}$ as best recommended by international organization [10]. Table 2 which shows average radiation from hand dug water in the investigated samples ranges from 0.003 µSv/hr to 0.017 µSv/hr and this implies safety and guarantee from an exposure lower than 0.1 $mSvy^{-1}$ as globally recognized by international organization [11].

Identification of heavy metals present in the water shows dominant metals found to be:

1. Cadmium (Cd)
2. Copper (Cu)
3. Manganese (Mn)
4. Nickel (Ni)
5. Lead (Pb)

On a general note, these metals discovered from this work, depending on their level of concentration on water (borehole or hand dug water), can be very harmful to human at contamination. Though this research could not investigate all that, however a more precise investigation is recommended to ascertain exact level of their respective concentrations. Among the heavy metals, a concern should be drown on Arsenic (As), Cadmium (Cd), Lead (Pb), Chromium (Cr), Copper (Cu), Mercury (Hg) and Nickel (Ni) because due to their presence at relatively high concentrations in drinking water and their effects on human health [10]. Some heavy metals such as Arsenic (As), Cadmium (Cd), Lead (Pb) have extensively been investigates on the premise of their public health effects made known [12,13].

The heavy metals contamination in drinking water are associated most often than not to human poisoning are lead, iron, cadmium copper, zinc, chromium etc. Though they are required in human body in small amounts, but can also be toxic in large doses. They constitute one important group of environmentally hazardous substances if present. Copper for instance is an essential trace element yet has toxicity effect if it has excess amounts in our drinking water. Another heavy metal of this category is Cadmium, study revealed it is extremely toxic even in low concentrations, and will bio-accumulate in organisms and ecosystems and it has a long biological half –life in the human body, saying between 10 to 33 years. Cadmium happens to be one of the top pollutants heavy metals, raise a critical watch and monitoring in most countries and international organizations around the globe [13].

## Conclusion

This investigation has clearly shown average radiation from borehole water in the samples which ranges from 0.003μSv/hr to 0.020μSv/hr to be below the recommended value which guaranteed an exposure level lower than 0.10 $mSvy^{-1}$ and an average radiation from hand dug water which also ranges from 0.003 μSv/hr to 0.017 μSv/hr amount to an exposure lower than 0.1 $mSvy^{-1}$. The heavy metals discovered were Cadmium (Cd), Copper (Cu), Manganese (Mn), Nickel (Ni) and Lead (Pb). This result shows it's safe to use these two sources of water however, further investigation to assess the actual concentration of each heavy metal is highly recommended.

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