A REVIEW OF MEASUREMENT OF RADIOACTIVITY LEVELS IN SOIL AND WATER, ALONG WITH HEAVY METALS IN WATER SAMPLES, AROUND OKABA AND OKOBO COALFIELDS IN ANKPA, KOGI STATE, NIGERIA

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Abstract

The Okobo and Okaba coalfields in Ankpa, Kogi State, Nigeria, have raised significant environmental concerns due to potential contamination by radioactivity and heavy metals. This review consolidates current research on measuring radioactivity levels in soil, air, and water, specifically focusing on heavy metal contamination in water around these coalfields. The paper discusses the methodologies employed, presents key findings on environmental impacts, and highlights gaps and future research needs.

Keywords: Radioactivity, heavy metals, soil contamination, water quality, coalfields, Okobo, Okaba.

Introduction

The exploitation of coal resources in Nigeria's Kogi State, particularly around the Okobo and Okaba coalfields, has led to environmental pollution concerns. Radioactive contamination and heavy metal pollution are critical issues associated with coal mining and processing. Radioactive substances naturally exist in soil and can be released into the environment through human activities like mining. Radionuclides like Uranium-238, Thorium-232, and Potassium-40 are major sources of natural radioactivity in soils and rocks. Similarly, heavy metals like mercury, lead, cadmium, and arsenic, often linked with coal mining, pose environmental threats, particularly to water systems through runoff and leaching. Environmental monitoring plays a vital role in shaping policies aimed at safeguarding public health from radiation exposure. Some studies have analysed radiation levels in Nigeria, concentrating on places with high ambient radiation and sectors of economic significance such mining and marine environments (Hashim, 2001).

The three primary sources of natural radiation that people are exposed to are cosmic rays, terrestrial gamma radiation, and potassium-40 present inside the body. Assessing radiation quantities from natural sources and inorganic fertilizers is critical since they represent the largest contribution to the collective radiation dose worldwide. Human exposure to ionizing radiation from natural and man-made sources is continuous and unavoidable. Studying radioactive elements in soil is key to understanding how radioactivity behaves in the environment, as these substances emit radiation through the decay of natural radionuclides and contribute to the overall radiation dose through ingestion, inhalation, and external exposure (Sunaree et al., 2011). Soil acts both as a constant source of radiation and a medium for radionuclides to spread into biological systems, leading to environmental contamination. The use of fertilizers increases the concentration of uranium and thorium in the environment. Gamma radiation from long-lived radionuclides, such as potassium-40 and the decay chains of uranium-238 and thorium-232, are primary sources of external radiation exposure to humans.

Among naturally occurring radioactive materials, potassium is the most abundant, making up approximately 2.6% of the Earth's crust, while uranium and thorium are present in trace amounts (Sunaree et al., 2011). Radionuclides from bedrock can be weathered away and transported to other areas, including agricultural lands. Human activities, such as mining and the application of inorganic fertilizers, increase the concentration of radionuclides, resulting in the manufacture of technologically enhanced naturally occurring radioactive material (TENORM), which heightens radiation exposure risks for humans and animals. Manmade sources of radiation, such as debris from nuclear weapons testing, emissions from nuclear facilities, and reactor accidents, also contribute to environmental contamination. Radioactive particles are carried through the air and eventually settle on land or water bodies, where they can accumulate (Kabir et al., 2008).

Atoms consist of smaller subatomic particles, namely protons, neutrons, and electrons. Protons and neutrons are located in the nucleus of the atom, while electrons orbit around it. Protons carry a net positive charge, neutrons have no charge, and electrons carry a net negative charge (iThemba LABS, 2017). Protons within the nucleus experience repulsive forces, but a strong nuclear force binds them and the neutrons together. This force maintains the nucleus's stability, but if the balance between protons and neutrons is disrupted, the nucleus becomes unstable and undergoes radioactive decay. In beta decay, a proton may convert into a neutron ($\beta+$ decay) or a neutron into a proton ($\beta-$ decay), changing the identity of the element.

Atoms can exist in different isotopes, which may be either stable or unstable; unstable isotopes that undergo decay are called radionuclides.

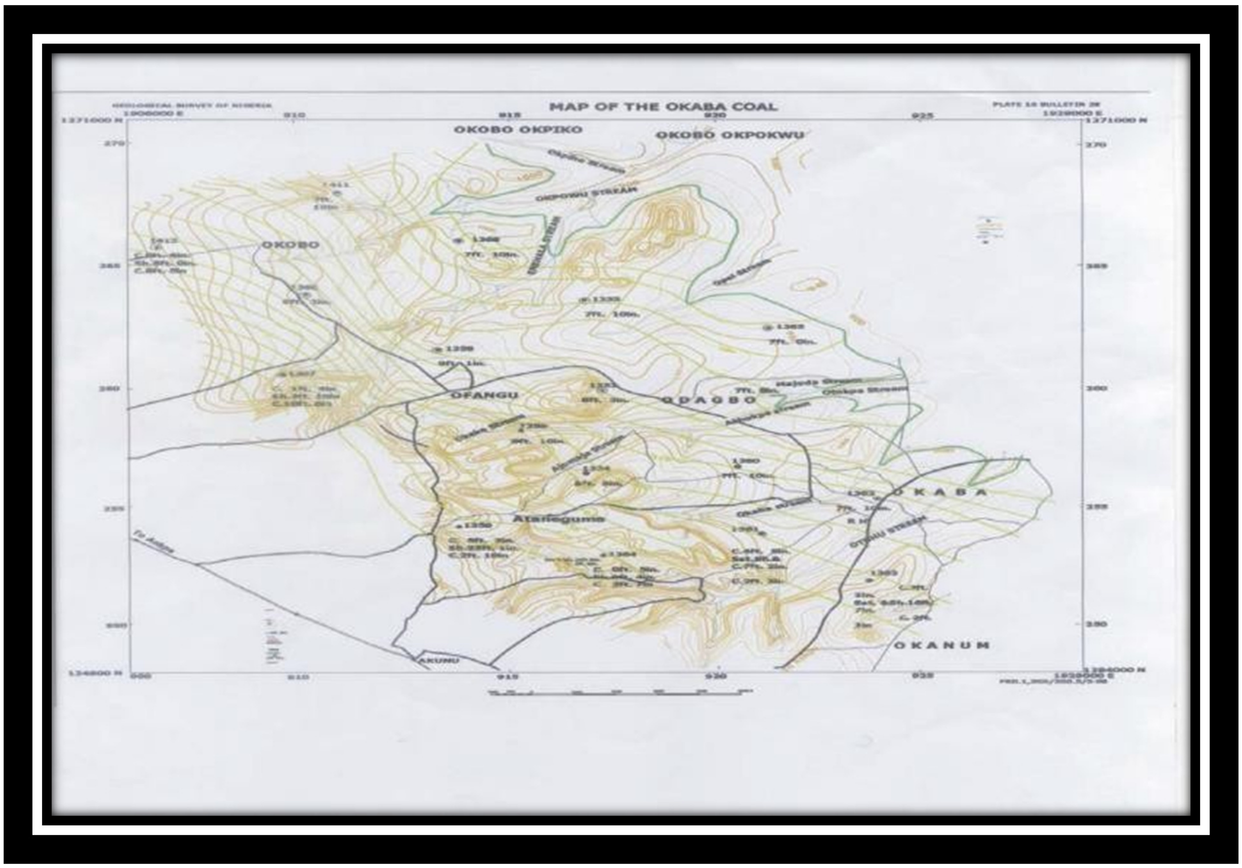
There are three main forms of ionizing radiation associated with radioactive decay: alpha particles, beta particles, and gamma radiation. Alpha particles consist of two protons and two neutrons, making them relatively heavy. Though they are more massive than beta particles, alpha particles carry a +2 charge, causing them to lose energy quickly as they ionize atoms in their path. These particles travel in short, straight trajectories, interacting with nearby atoms and releasing energy rapidly (iThemba LABS, 2017).

Beta particles, which can carry either a -1 or +1 charge, are basically electrons or positrons. Due to their lower charge, beta particles have a stronger capacity to permeate substances compared to alpha particles, but they have less ionizing power. They can be effectively shielded by materials like aluminum foil. Although they pose a minor external threat, beta particles can cause significant harm to cells if inhaled or ingested. Gamma radiation, on the other hand, is a form of high-energy electromagnetic wave composed of photons. It may interact with atoms, ionizing them and resulting to the emission of directly ionizing particles like electrons (Jerrold and John, 2011).

This review synthesizes key insights from existing research and offers a detailed summary of current knowledge on radioactivity and heavy metal contamination around the Okobo and Okaba coalfields. It provides a foundation for future studies and policy initiatives aimed at reducing environmental and health hazards in the area.

Geographical and Economic Overview

The Okobo and Okaba coalfields are located in Ankpa, Kogi State, a region with abundant coal reserves. While coal mining is a major economic activity that supplies energy resources, it also raises significant environmental concerns due to the potential release of hazardous materials into the surrounding environment.



(Itodo, etal; 2020)

Environmental Concerns

Coal mining operations may result in the discharge of radioactive elements and heavy metals into local soil, air, and water sources, creating potential health hazards for local communities and ecosystems. To address these risks, thorough environmental monitoring and evaluation of pollutants are essential.

Methods for Detecting Contaminants

Radioactivity in Soil and Air

Sampling Techniques: Soil samples are collected at varying depths and locations around coalfields to analyze the spread of radioactive elements. Air samples are gathered using high-volume air samplers that collect particulate matter for examination.

Standards and Guidelines: Results are assessed based on safety standards set by agencies like the Nigerian Nuclear Regulatory Authority (NNRA) and the International Atomic Energy Agency (IAEA).

A study from the Okaba coalfield found that uranium-238 had an average activity concentration of 35.2 Bq/kg, while thorium-232 was 52.7 Bq/kg. These values are higher than the global averages for natural radioactivity in soil, indicating a need for ongoing monitoring of radiological risks. The potential for radionuclides to leach into water supplies poses further risks, especially for groundwater-dependent communities (Essien, et al., 2017).

Heavy Metals in Water

Sampling Protocols: Water samples are taken from rivers, streams, and groundwater near coalfields, following protocols to ensure they are representative and free from contamination.

Analytical Techniques: Standard methods like Inductively Coupled Plasma Mass Spectrometry (ICP-MS) and Atomic Absorption Spectroscopy (AAS) are utilized to detect and quantify heavy metals, such as mercury, lead, cadmium, and arsenic. This research relies on Atomic Absorption Spectroscopy.

Regulatory Limits: Heavy metal concentrations are compared to recommendations published by the World Health Organization (WHO) and the Nigerian Standard for Drinking Water Quality.

Several studies have shown that heavy metal concentrations in water bodies around the Okaba and Okobo coalfields exceed WHO-recommended limits. For instance, lead concentrations in groundwater near the Okaba coalfield were found to be as high as

0.09 mg/L, significantly surpassing the WHO recommended standard of 0.01 mg/L. Similarly, cadmium concentration in water samples also exceeded the allowable limit of 0.003 mg/L, raising concerns about the safety of local drinking water (Adekola, and Dosumu, 2001)

Research Findings

Radioactivity Levels

Soil Contamination: Studies have found that soil around the Okobo and Okaba coalfields contains elevated levels of natural radionuclides, such as uranium-238 and thorium-232, which are associated with coal deposits and mining residues. These concentrations surpass typical background levels.

Airborne Radioactivity: Air quality tests indicate higher concentrations of radon gas and radionuclides attached to particles in areas near mining activities, which may pose health risks through inhalation of radioactive materials.

Water Contamination by Heavy Metals

Surface Water: Rivers and streams near the coalfields show significant contamination by heavy metals, including lead, mercury, and arsenic, likely due to runoff and leaching from mining areas (Itodo, et al., 2020).

Groundwater Quality: Abnormal quantities of heavy metals have also been observed in groundwater, posing risks to local drinking water supplies. This contamination suggests long-term leaching into aquifers (Itodo, et al., 2020)

Discussion

Environmental and Health Concerns

High levels of radioactivity and heavy metals around the Okobo and Okaba coalfields pose serious risks to the ecosystem and human health. Prolonged exposure to radioactive materials can increase cancer risk, while heavy metals are linked to various health problems, including developmental and neurological issues.

Current Mitigation Efforts

Mitigation strategies include regulatory oversight, site rehabilitation, and community education on the dangers of exposure to these contaminants. However, the success of these efforts is mixed, and more effective policies and technologies are needed to manage present and future risks.

Research Gaps and Future Directions

Remediation Strategies: It is essential to implement measures that reduce the release of radioactive elements and heavy metals from coal mining sites. These strategies may include barriers to prevent contaminants from leaching into water and treatment methods to remove heavy metals from water before it reaches drinking supplies.

Public Awareness and Policy: Educating local communities about the health risks of contaminated soil and water is critical. Policymakers must also enforce stricter environmental regulations to ensure mining companies comply with safety standards.

Despite considerable research, there remain gaps in understanding the full scope of environmental contamination and its long-term effects. Future research should focus on:

1. Comprehensive Monitoring: Developing long-term monitoring systems to assess radioactivity and heavy metal levels.
2. Health Impact Studies: Conducting health studies to understand the effects on populations living near coalfields.
3. Remediation Technologies: Advancing technology for cleaning up contaminated sites.

Conclusion

This review highlights the significant environmental and health risks associated with radioactive and heavy metal contamination near the Okobo and Okaba coalfields. Although existing research provides valuable insights, there is an urgent need for continuous study and improved mitigation strategies to safeguard human health and the ecosystem in Kogi State, Nigeria.

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