Journal of Bioscience and Biotechnology Discovery
Volume 10(2), pages 21-27, April 2025
Article Number: A7E487C73
ISSN: 2536-7064
https://doi.org/10.31248/JBBD2025.228
https://integrityresjournals.org/journal/JBBD

Full Length Research

Assessment of environmental nuclear radiation impact in some industrial areas of Lagos State

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Received 5th February 2025; Accepted 26th April 2025

ABSTRACT: This study examined the effects of external background radiation in Lagos State, specifically focusing on six locations: Iganmu, Ilupeju, Apapa, Ikeja, Oregun, and Matori, selected for their frequent industrial activities. Using calibrated Geiger-Muller tubes with MX123-type tubes and a Digilert200 nuclear radiation monitor, we recorded an overall average background radiation level of 0.014 mR/h in these industrial areas. This level is significantly higher than the recommended standard for background radiation by 20%. The elevated background radiation may be from devices and materials used in production processes. We investigated likely sources of background radiation aside from human activities. Consequently, employees working in these industrial facilities may be at risk due to their regular exposure to elevated levels of radiation.

Keywords: Cosmic rays, Industrial areas, Lagos State, nuclear radiation.

INTRODUCTION

Environmental radioactivity and the associated radiological hazards are subjects of increasing global concern due to the potential risks to human health. Naturally occurring radioactive materials (NORM), such as ^{238}U, ^{232}Th, and ^{40}K, are ubiquitous in the environment, varying concentrations depending on geological formations, soil types, and human activities. Several studies have been conducted to determine the activity concentrations of these radionuclides in various environmental samples, including soil, sediment, water, and rocks, and to assess the consequent radiological risks (Steinhäusler, 2005; Yusuf *et al*., 2024).

These investigations often involve measuring activity concentrations using gamma-ray spectrometry and calculating radiological hazard parameters such as absorbed dose rate, annual effective dose equivalent (AEDE), radium equivalent activity (Raeq), and excess lifetime cancer risk (ELCR). Comparing these parameters with internationally recommended values and standards is crucial for evaluating potential threats to human life and the environment (Akingboye *et al*., 2021; Ibitoye *et al*., 2023; Jegede *et al*., 2024).

Human exposure to ionizing radiation is most times without consent, and due to its damage to health, it is necessary to monitor and assess the level of exposure, thereby keeping the exposure levels as low as reasonably achievable (Sadiq and Agba, 2011). The quality of the human environment provides the basis for development in economic and social lives. So, it is important to maintain its quality in a good state to have a high level of social delivery. This quality can be attained by ensuring that our environment is pollution-free. Environmental degradation is of great concern because of its resultant health and economic implications. Background ionisation radiation whose value is above the recommended safe value is considered to be an environmental pollutant (Usikalu *et al*., 2024). Highlighted below are the sources of ionising radiation in the environment:

Cosmic radiation continually bombards the Earth's atmosphere and is often modulated by solar activity in an 11-year cycle called the solar cycle. While some ionising radiation from this process penetrates the atmosphere and is absorbed by humans, resulting in natural radiation exposure, this exposure increases at higher altitudes (UNSCEAR, 1988; Chancellor *et al.,* 2014).

Terrestrial radiation is released during the natural decay of uranium, potassium, and thorium deposits. These elements are found everywhere on Earth, including in building materials. The level of terrestrial radiation varies depending on location and geology (Jegede *et al.,* 2024). These naturally occurring radioactive materials (NORM) found in the environment impact human health. Geological formations, rivers, soil types, and human activities determine the dominance of NORM (Ogungbemi *et al*., 2023).

Radioactive gases like radon and thorium, which are produced from the decay of uranium-238 and thorium-232, are inhaled by humans and contribute to radiation exposure. Radon is the largest source of natural radiation exposure (Ogungbemi *et al.,* 2023). The levels of these gases vary depending on the location's soil and bedrock composition.

Trace amounts of radioactive minerals are found in food and drinking water and are ingested by humans. For instance, Potassium-40 is a radioactive isotope in many everyday foods that significantly adds to the background radiation dose.

Radiation from medical facilities and industrial activities can make a significant contribution to background radiation, and the level can sometimes exceed occupational exposure levels and the international recommended dose limit (Ibitoye *et al.*, 2023).

Radiation is an unavoidable feature of life, and humans have adapted to the levels of ionising radiation naturally occurring in the environment. Excessive exposure to radiation beyond safe and acceptable limits can lead to a variety of illnesses, including cancer and genetic damage (Yusuf *et al*., 2024).

Recent studies have focused on specific areas such as quarry sites, industrial areas, waste dump sites, and even diagnostic centres to assess radiation safety levels and potential risks to workers and the public. The data obtained from such monitoring efforts are essential for establishing radiological baselines, identifying potential increases in radiation levels over time, and formulating effective radiation protection strategies.

As highlighted above, apart from human activities, high-energy particles, known as cosmic rays, travel through space at nearly the speed of light. These particles originate from various sources: solar cosmic rays come from the Sun, galactic cosmic rays are emitted from the outer regions of the galaxy, and even more distant galaxies contribute to their presence (Sedrati and Bouchachi, 2022).

When cosmic rays reach Earth, they interact with atomic nuclei in the atmosphere, resulting in a series of nuclear reactions. This interaction generates numerous secondary particles, creating what is known as extensive air showers (EASs). Additionally, cosmic rays are influenced by Earth's magnetic field. The time-varying magnetic field within the heliosphere, which aligns with the 11-year solar activity cycle, significantly affects the behaviour of these particles (O'Brien *et al*., 1996). These highly energetic particles enter the atmosphere depending on latitude and altitude, interacting with the soil and contributing to the measured background radiation.

Therefore, this work was carried out to measures the radiation levels in some industrial areas in Lagos and reports the percentage contributions from various sources.

MATERIALS AND METHODS

The research was carried out to cover the industrial areas in Lagos State (see Figure 1). The areas purposely selected were Iganmu, Ilupeju, Apapa, Ikeja, Oregun and Matori, where industrial activities are actively carried out daily. The six areas are characterised by different forms of pollution due to various industrial activities releasing volatile organic compounds and foundries, especially in the Apapa industrial area. Lagos State is the most congested state with the highest population density in Nigeria. It is in the southwestern geopolitical zone of Nigeria. It is arguably the most economically important state of the country, bounded by Ogun state on the North and East and in the west, it shares boundaries with the Republic of Benin. The Atlantic Ocean is on its southern border. The State of Lagos has an area of about 3,577 km^2, and water and creeks cover about 22% of its land area. The equipment used has two calibrated Geiger-Mueller counters with MX123-type tubes and a Digilert200 nuclear radiation monitor. A standard height of 1.0 m was maintained between the tubes and the ground. The windows of the tubes were facing vertically downwards, and the readings of the meters were taken at intervals of 30 minutes for 10 successive readings per particular area. The six industrial areas were strategically selected for this work to ensure that there is adequate coverage of the various companies operating in Lagos. It was ensured that the batches of measurements were taken simultaneously. The count per minute was expressed in milli-roentgen per hour (mR/h) using the standard conversion factor for the Geiger-Mueller tubes (Gbarato *et al*., 2018). Roentgen is considered a form of exposure (x) which refers to the charge transmitted (ΔQ) by a certain mass of air (m), which can thus be expressed as in Equation 1.

$$X = \frac{\Delta Q}{m} \qquad 1$$

The ground-level cosmic rays dose in Lagos was estimated using EXPACS ver 4.41 using solar activity indices (W) of 0 and 150 (Sato, 2015), representing solar minimum and solar maximum, respectively, and 0.2 ground-level water fraction (Hubert, 2016; Sato and Niita, 2006; Sedrati and Bouchachi, 2022).

RESULTS AND DISCUSSION

Muons and neutrons are the primary contributors to

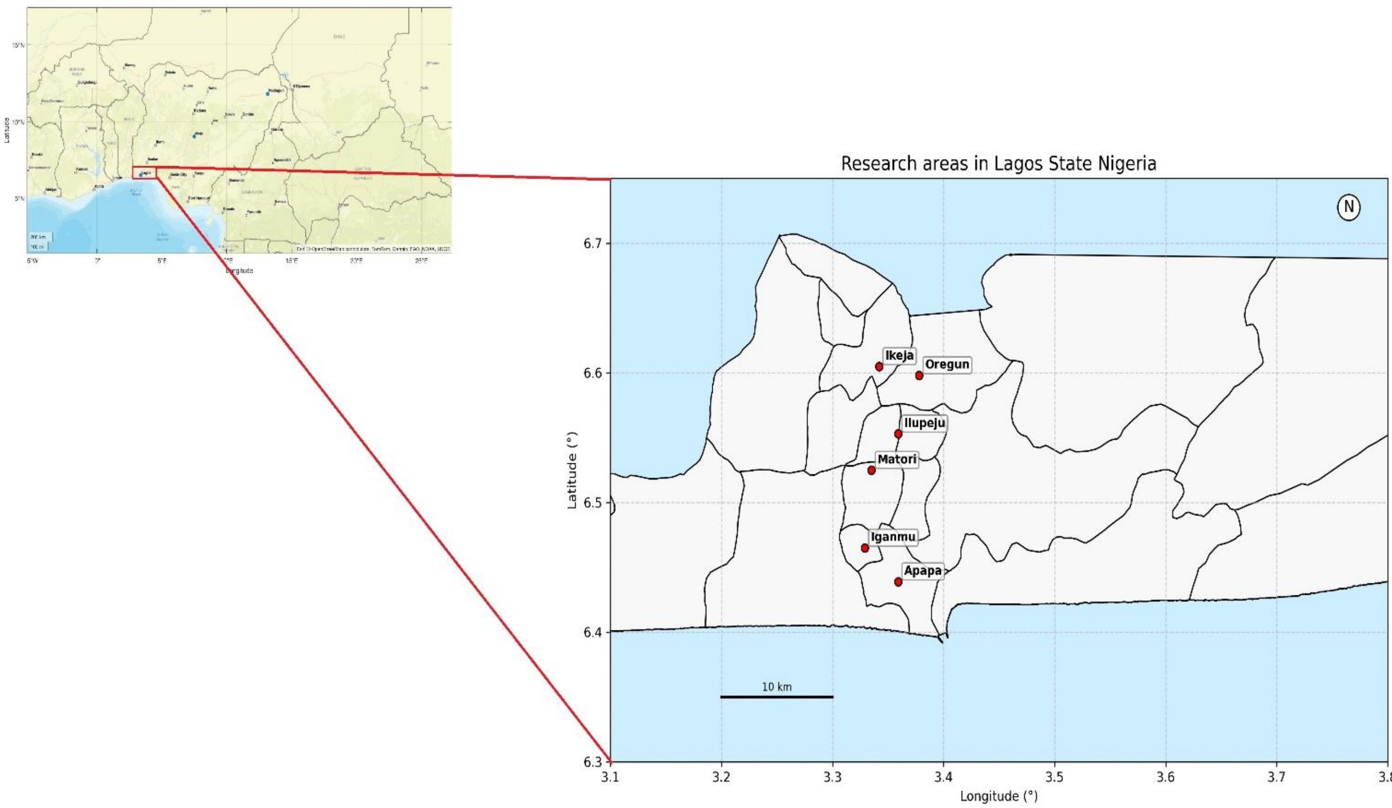

Figure 1. Map of Nigeria showing the city of Lagos, and inset are the study areas marked in solid red.

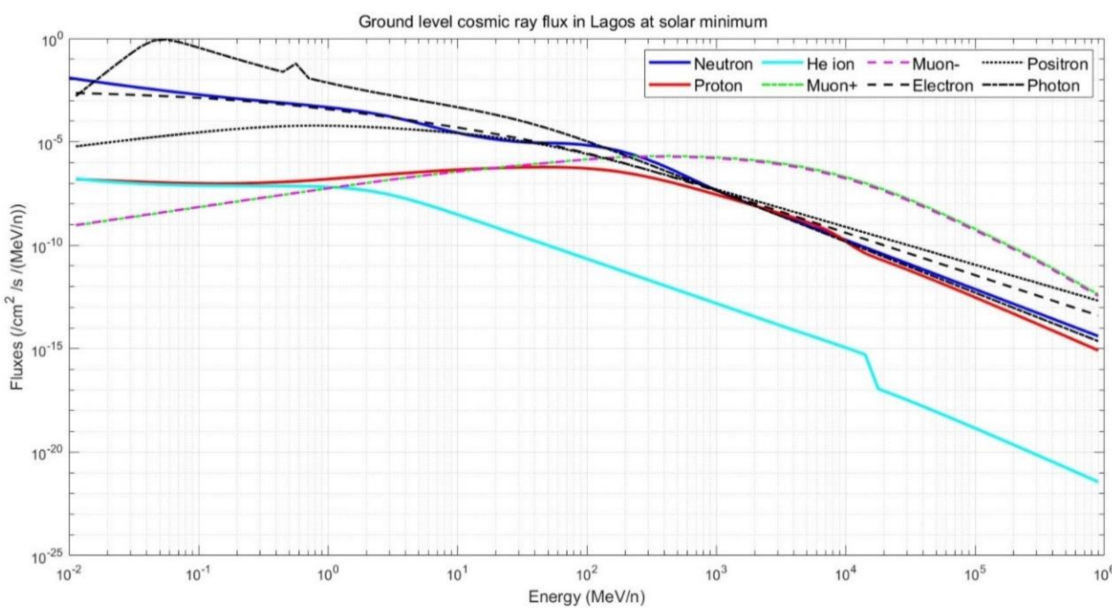

Figure 2. Ground-level cosmic ray flux in Lagos during solar minimum.

ground-level cosmic rays (Nwankwo and Akoshile, 2005). The neutron flux is more prominent at lower energies, while the muon flux dominates at higher energies during solar minimum and maximum (see Figures 2 and 3). The effective dose for cosmic rays is 0.03 µSv/h at solar maximum and 0.027 µSv/h at solar minimum, corresponding

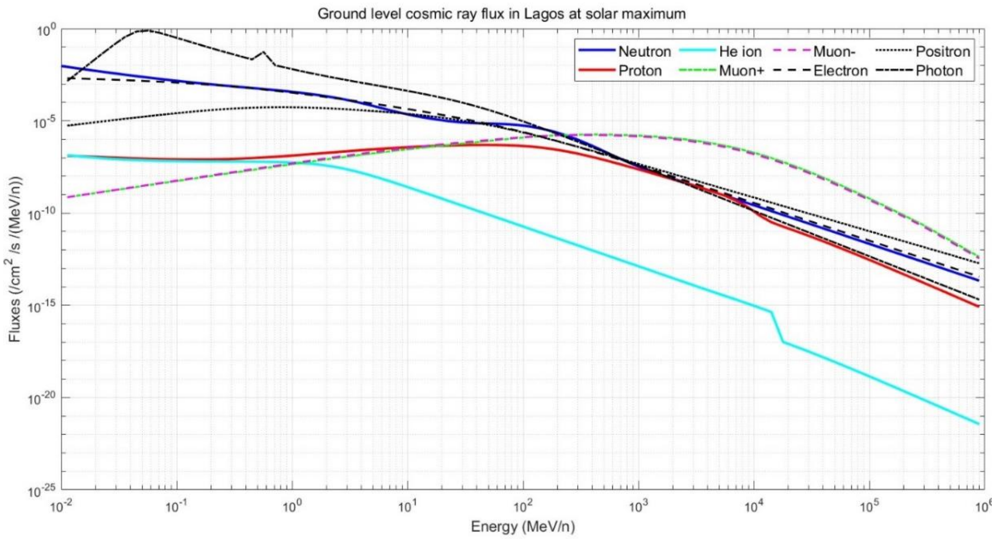

Figure 3. Ground-level cosmic ray flux in Lagos during solar maximum.

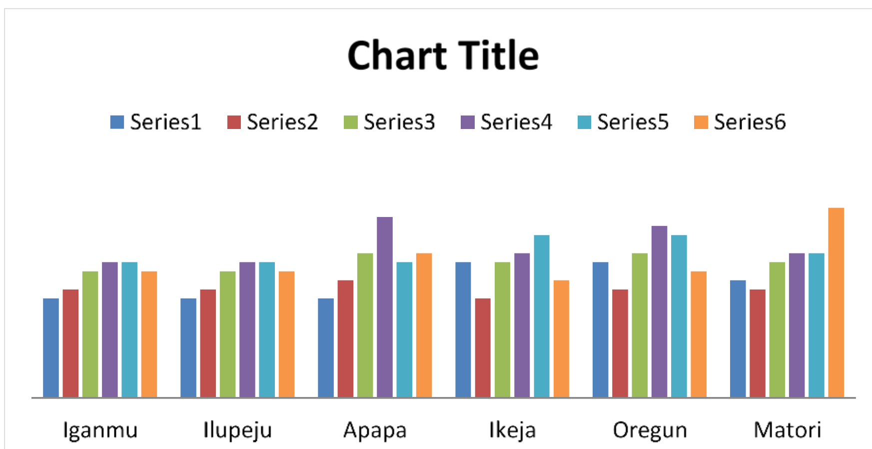

Figure 4. Measured count rate at each station.

Table 1. Standard external radiation levels (Gbarato *et al.,* 2018).

No	Exposure	Significance
1.	0.011 mR/h, continuous whole body	Background radiation, sea level outdoors
2.	0.010 mR/h, continuous whole body	Radiation inside a wooden house at sea level
3.	0.021 mR/h, continuous whole body	Background radiation, ground level
4,	0.625 nmR/h	Limit for occupational exposure of the whole body
5.	9.375 mR/h	Limit for occupational exposure of hands
6.	0.0625 mR/h	Limit for non-occupational exposure (including exposure of minors)
7.	< 2mR/h and < 100mR in any 7 consecutive days	Unrestricted area. No control or sign
8.	> 2 mR/h or > 100 mR in any 7consecutive days	Radiation area, sign required
9.	> 5 mR on one hour to major portion of the body	Radiation area, sign required

to an average radiation level of 0.003 mR/hr in Lagos.

The results obtained using the nuclear radiation monitor are presented in Figures 4 and 5. Table 1 presents the standard external radiation levels for various environments as recommended by the US Nuclear Regulatory Commission (Gbarato *et al*., 2018). Figure 5 shows the

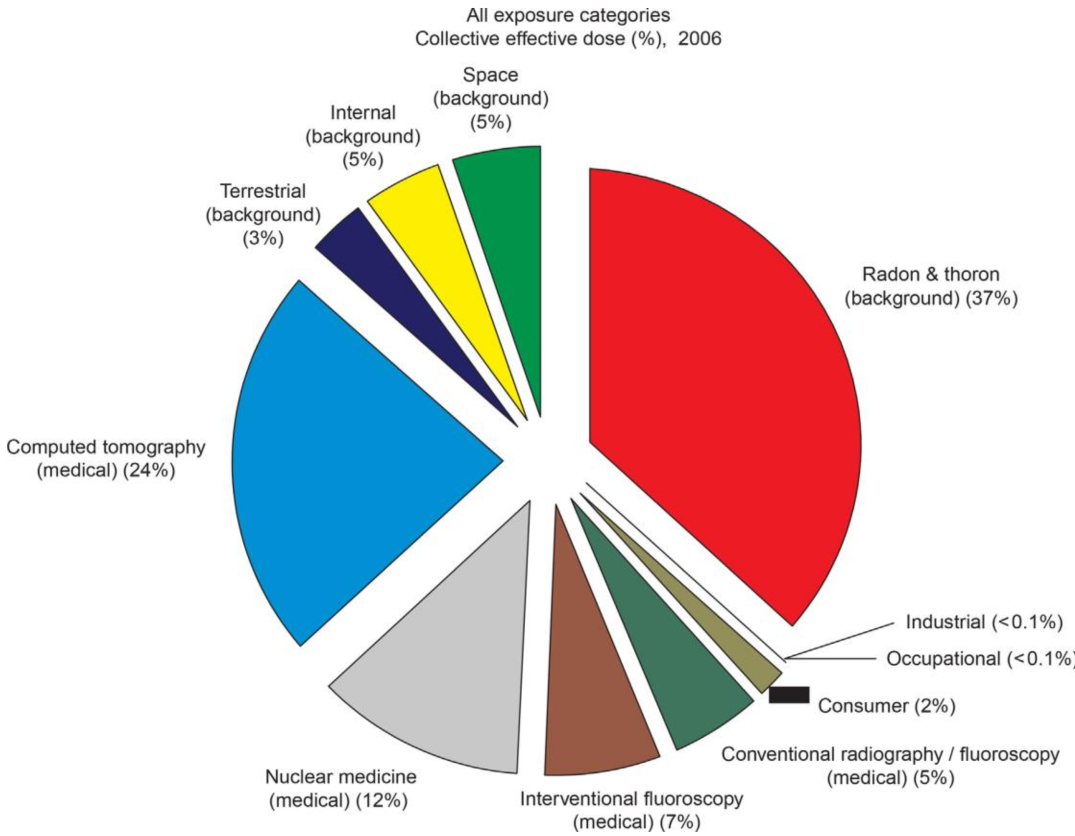

Figure 5. Per cent contribution of various sources of exposure to the total collective effective dose and the total effective dose per individual in the 2006 US population.

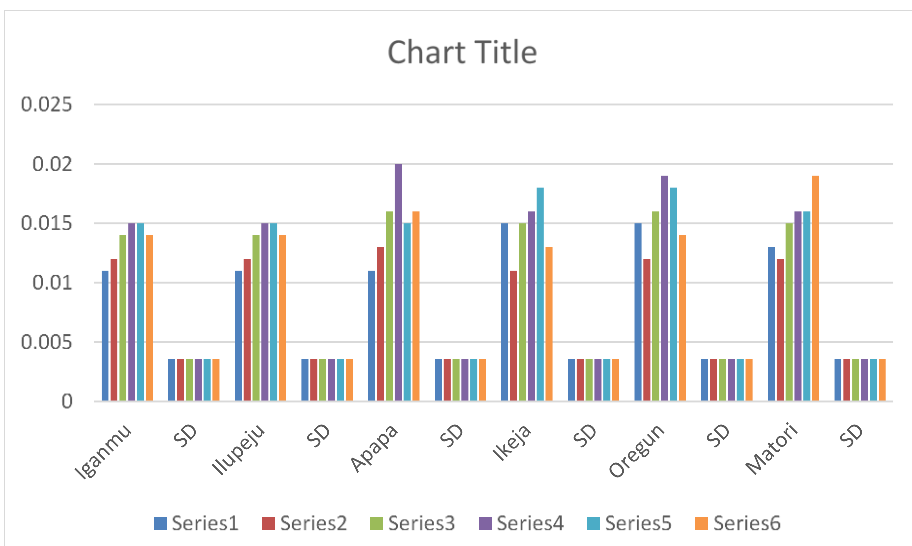

Figure 6. Comparison with the standard background radiation.

summary of the results when compared with the standard background radiation for such an environment. The results show that the readings are relatively high and could be attributed to the activities of the companies operating in the area. Stations Apapa, Oregun and Matori have the highest values. This may be associated with the input or output chemicals from companies around the station or devices used in the production processes. Companies located here are involved in fertiliser pelleting, agro and industrial oil processing, oil tools servicing and drilling chemicals marketing. The results show a significant agreement with the elevated background level radiation at the Olusosun dumpsite in Lagos (Ogungbemi *et al*., 2023), where much of the toxic industrial waste is likely disposed of.

Iganmu and Ilupeju have the lowest values, likely due to the absence of major industries in the area. This region is primarily residential, with only a few marketing companies. The values recorded at Iganmu, Ilupeju, and Ikeja stations are moderate, falling below those at Apapa, Oregun and Matori stations. Notable companies in these three zones include general metalwork, engineering, and the plastic industries. Those industries may be using devices such as non-contact thickness gauges that use Americium-241, Caesium-137, or Cobalt-60 to ensure precision and uniformity in industrial design. In addition to Uranium-238 and Thorium-232, along with other naturally occurring radionuclides (Usikalu *et al.,* 2024), which contribute approximately 37% to the measured background radiation level (Figure 5).

Generally, the environment's background radiation in this area is high, irrespective of the particular station. The ionising compounds are circulated in the environment by diffusion and wind effects. The data obtained, therefore, could be regarded as representative of the background ionisation radiation of the area.

Conclusion

We utilised calibrated Geiger-Müller tubes of the MX123 type and a Digilert200 nuclear radiation monitor to measure background radiation levels in six different industrial zones in Lagos State, Nigeria. Additionally, we estimated the percentage contribution to background radiation from various sources. Our study revealed that the environmental radiation levels in some industrial areas of Lagos have been influenced by industrial activities. This shows that some of the raw materials, including devices used by companies and the effluents generated during their production processes, are likely adding to the background radiation. This conclusion is drawn because there has not been any documented or reported evidence of the existence of radioactive materials in the subsoil in the area. Enormous health problems are normally associated with radioactive and radiation phenomena. It is therefore safe to recommend that companies operating in the area should devise means of reducing their radioactive inputs.

In the interim, companies need to provide life and health insurance policies for their employees to address the potential long-term health effects of exposure. Additionally, government agencies responsible for environmental safety should strictly enforce all existing environmental legislation to help mitigate the negative impacts caused by industrial and human activities.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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