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Gross alpha and beta radioactivity in surface soil and drinkable water around a steel processing facility

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ABSTRACT

The mean gross alpha and beta activities in surface soil and drinkable water in the surrounding communities of a steel processing company, following a continuous exposure of workers and dwellers is determined using a low background Gas-less counting system with a solid state silicon PIPS detector for alpha and beta detection. The average activities for gross alpha and beta in soil ranged between 48.5 ± 15.8–64.0 ± 10.0Bq/kg and 411.5 ± 11.5–2710.0 ± 150.0Bq/kg respectively, whereas in water it ranged between 0.0064 ± 0.0001–0.0182 ± 0.0001 Bq/l and 0.046 ± 0.001–0.126 ± 0.001 Bq/l respectively. The average annual committed effective dose from intake of water was between 0.0304 mSv and 0.0678 mSv which is lower than the recommended reference level for ingested dose from drinkable water.

1. Introduction

Radioactive contamination of the environment can be defined as any increase in the natural background radiation arising out of human activities involving the use of naturally occurring or artificially produced radioactive substances (Patel, 1980). It is typically the result of a loss of control of radioactive materials during the production or use of radioisotopes. Such contamination could be occasional, accidental or continuous.

The hazards to people and the environment from radioactive contamination depend on the nature of the radioactive contaminant, the level of contamination, and the extent of the spread of contamination.

Human activities such as mining, milling and processing of uranium ores and mineral sands, smelting of metalliferous ores, manufacture of fertilizers, drilling, transportation, processing and burning of fossil fuels have raised the concentrations of naturally occurring radioactive materials in the environment (Avwiri & Ebeniro, 1998; Foland, Kirland & Vinnikoov, 1995; Pujol & Sanchez- Cabeza, 2000). The dumping of large amount of waste materials in sites without adequate soil protection measures result in soil as well as, surface and ground water pollution (Eikelboom, Ruwiel, & Gounmans, 2001; Namasivayam, Radhika, & Suba, 2001) Enhanced levels of these naturally occurring radionuclides might be present in the soil as well as surface and ground water in areas that are rich in natural radionuclides. The soil acts as a source of transfers of radionuclides through the food chain depending on their chemical

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properties and the uptake process by the roots to plants and animals (Jabbar et al., 2010); hence, it is the basic indicator of the radiological status of the environment.

The presence of radionuclides in water poses a number of health hazards, especially when these radionuclides are deposited in the human body through drinking. Dissolved radionuclides in water emit particles (alpha and beta) and photons (gamma) which gradually expose living tissues (Alam, Kamal, Ghose, Islam & Anwaruddin, 1999; Gruber, Maringer & Landstetter, 2009). Human and animal studies show that radiation exposure at low to moderate doses may increase the long-term incidence of cancer (Amrani & Cherouati, 1999; Collman, Loomis & Sandler, 1991; Gofman, 1990). The potential adverse effect from ingestion of radionuclides, through drinking water, requires a standard to be set in order to protect the members of public from radiation exposure above permissible levels.

The World Health Organizations' guidelines for drinking-water quality recommended the determination of gross alpha and gross beta activity concentrations in drinking water as the first step of the radiological aspect of the drinking water quality (WHO, 2004. Generally, radiation exposure due to gross alpha is of greater concern than that due to gross beta for natural radioactivity (Bunotto & Bueno, 2008). This is due to the high LET nature of alpha particles which gives them the ability to deposit larger amount of energy within a small distance in a medium. The essence of the evaluation of the gross alpha and gross beta activities is to ensure that the reference dose level (RDL) of committed effective dose of 0.1 mSv from 1 year's consumption of drinking water is not exceeded. The RDL of 0.1 mSv is equal to 10% of the dose limit for members of the public, recommended by the International Commission for Radiological Protection (ICRP, 1990) and the International Basic Safety Standards (IAEA, 1996). Also, they are acceptable to most World Health Organization (WHO) member States, the European Commission, and the Food and Agriculture Organization (Muhammad, Jaafar, & Akpa, 2010).

The gross alpha radioactivity concentration in soil samples is defined as the total radioactivity of all alpha emitters. The values of gross alpha radioactivity originating from these alpha emitters in soil samples depend on the geological characteristic of the area, content of mineral component and the type of activities in the area. Alpha emitters mixed to ground water by filtering from soil have contributed to the increased concentrations of gross alpha in well water samples. The gross beta radioactivity in soil is due to the natural long-lived isotopes ^{40}K, ^{210}Pb and ^{228}Ra (Bunotto & Bueno, 2008; Alam, Kamal, Ghose, Islam & Anwaruddin, 1999; Gruber, Maringer & Landstetter, 2009; Amrani & Cherouati, 1999; Collman, Loomis & Sandler, 1991).

Often in radioactivity research, attentions are mostly given to gamma emitters detection and quantification even in an environment where it is possible to have alpha and beta emitters (Gu & Yaprak, 2010; Lu et al., 2012; Mehade Hassan, Ali, Paul, Haydar & Islam, 2014). While it is true that gamma rays have the highest penetrating power when compared to alpha and beta particles, the effects of alpha and beta particles within the body either through inhalation or ingestion are far more detrimental because of their ionising power. In a metal recycling facility such as the Delta Steel Company, Aladja-Ovwian, Delta State, South West Nigeria, where scrap metals are recycled, it is possible to have scrap metals that have been contaminated with one or more of gamma, beta and alpha radiation emitters. Unpublished reports has it that there exists an elevated level of radioactivity within the company as a result of highly radioactive wastes being released due to the continuous smelting and re-cycling of metalliferous ores and scrap metals, some of which have been contaminated with radioactive materials from their sources. These wastes are particulate in nature, and because they are air-borne may be dispersed into the communities surrounding the steel company, where they may eventually settle on farmlands, farm crops and in communities' sources of water (e.g. dug wells, river bodies, etc) and are as well inhaled continuously. Crops grown in such communities could absorb these radioactive elements either from the soil or through their leaves, while the sea foods or drinkable water could also be radioactive to extents that could be harmful when these radioactive particles settle on or are dissolved in them.

When these contaminated crops and aquatic animals are eventually eaten, radioactive elements get into the body and could reach hazardous levels depending on the type of radioactive element present, the rate of consumption of these food/water products or the extent to which the food/water have been contaminated. This, no doubt is a problem to the communities in the immediate environs of the steel company, in addition to the contamination arising from the inhalation of radioactive dusts.

Till date, there is no known literature of the radioactivity levels at Delta Steel Company nor the population risk of the local people within the vicinity of the company due to continuous exposure. The present research assesses the gross alpha and beta activities in surface soil and drinkable water as well as the effective dose to the dwellers in the environment of Delta steel company due to the steel processing activities.

2. Materials and methods

An initial survey to ascertain the level of radiation was carried out at the premises of Delta Steel Company using a portable alarm dose meter calibrated with an x-ray machine at the SSDL of the National Institute of Radiation Protection & Research, University of Ibadan, Nigeria.

2.1. *Sample area*

Three communities were sampled in the assessment of the extent of radiation exposure due to the discharges from Delta Steel Company. These are Ovwian, Aladja and Delta Steel Township. Ovwian is situated to the immediate right of the steel company and has its centre about 3.77 km from the steel company. Aladja is situated to the immediate left of the company with its centre at about 1.68 km from the steel company. The Delta Steel township is a settlement area provided for the staff of the company and is located from about 5 km away from the company. All three locations are situated in Udu local government area of Delta State. A fourth location which served as a control is Warri, situated to the north of Delta Steel Company and is about 5 km from the company. The map of the locations is shown in Fig. 1.