Journal of Environmental Radioactivity 153 (2016) 201–205

Contents lists available at ScienceDirect

Journal of Environmental Radioactivity

journal homepage: www.elsevier.com/locate/jenvrad

Radionuclides and toxic elements transfer from the princess dump to water in Roodepoort, South Africa

S.G. Dlamini*, M.M. Mathuthu, V.M. Tshivhase

Centre for Applied Radiation Science and Technology (CARST), North-West University, Mafikeng, Private Bag X2046, 2745, South Africa

ARTICLE INFO

Article history:
Received 26 August 2015
Received in revised form
9 December 2015
Accepted 29 December 2015
Available online xxx

Keywords:
Gamma spectroscopy
Decay chains
Transfer factors

ABSTRACT

High concentrations of radionuclides and toxic elements in gold mine tailings facilities present a health hazard to the environment and people living near that area. Soil and water samples from selected areas around the Princess Mine dump were collected. Soil sampling was done on the surface (15 cm) and also 100 cm below the surface. Water samples were taken from near the dump, mid-stream and the flowing part of the stream (drainage pipe) passing through Roodepoort from the mine dump. Soil samples were analyzed by gamma-ray spectroscopy using a HPGe detector to determine the activity concentrations of ^{238}U, ^{232}Th and ^{4} ^{40}K from the activities of the daughter nuclides in the respective decay chains. The average activity concentrations for uranium and thorium in soil were calculated to be 129 ± 36.1 Bq/kg and 18.1 ± 4.01 Bq/kg, respectively. Water samples were analyzed using Inductively Coupled Plasma Mass Spectrometer. Transfer factors for uranium and thorium from soil to water (at point A closest to dump) were calculated to be 0.494 and 0.039, respectively. At point Z2, which is furthest from the dump, they were calculated to be 0.121 and 0.004, respectively. These transfer factors indicate that there is less translocation of the radionuclides as the water flows.

1. Introduction

Naturally occurring radioactive materials (NORMs) have been there (in existence) since the beginning of times. These NORMs are found almost everywhere, from the earth's crust, walls of buildings, in plants and water (Department of Minerals and Energy, (2005)). Radioactive elements with long half-lives (long-lived) such as uranium, thorium, potassium and any of their decay products such as radium and radon are examples of NORMs.

During the mining process a lot of waste, sometimes referred to as tailings, is produced which is then dumped at selected places near the mine. These places are referred to as mine dumps and/or tailings storage facilities (TSF's) (Lesikar et al., 2009).

The slime dams and mine dumps of the Gauteng and the Northwest leak uranium and its daughters into water (Durand, 2012). The effluents from the mines contain radium, polonium, thorium, uranium and isotopes of lead. Pollution of the country's soil and water resources affect the food chain and consequently the health of the population and surrounding ecosystems. One of the major causes of water pollution worldwide is acid mine drainage (AMD) (Hierro et al., 2012).

1.1. Acid mine drainage

Wendel (1998) in his study highlights that water plays a pivotal role in the transportation or transfer of radionuclides through the environment.

The ore of the Witwatersrand Supergroup contains significant amounts of sulphide minerals (the pyrite, FeS_2, which is a significant constituent of gold bearing reefs) (McCarthy, 2011). These significant amounts of sulphide minerals make the gold mine tailings prone to the formation of acid mine drainage. The exposure of minerals to atmospheric weathering results in oxidation taking place. However, sulphides are stable and very insoluble under reducing conditions but the oxidation as a result of the weathering process releases sulphuric acid which affect the quality of streams and groundwater. Other oxidation products can include partially oxidized oxonians, such as thiosulphate, hydrogen sulphide, iron sulphate in solution and heavy metals associated with uranium mineralization (Fernandes et al., 1998). The above mentioned

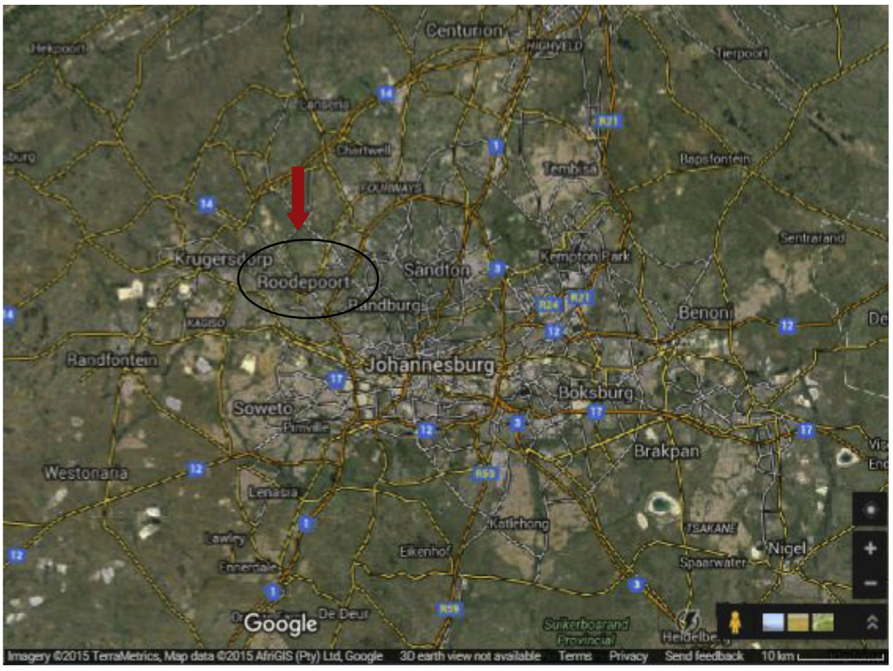
* Corresponding author.
E-mail address: gudsbuhlubie@yahoo.com (S.G. Dlamini).

http://dx.doi.org/10.1016/j.jenvrad.2015.12.026
0265-931X/

process can be further explained using the chemical equation below.

$$4FeS_2 + 15O_2 + 14H_2O \xrightarrow{yields} 4Fe(OH)_3 + 8H_2SO_4, \quad (1)$$

Pollution due to AMD, therefore, is a threat to the people staying near the dump. Exposure to humans can be through one of the following pathways (Davies and Mundalamo, 2010); ingestion of earth crops that have high concentrations of the radionuclides from the soil, consumption of fish swimming in contaminated water, consumption of meat/milk from cows grazing in contaminated land or drinking the contaminated water, inhalation of dust or particulate matter from the dump and/or direct contact with soil materials from the dump.



(a)

(b)

Fig. 1. (a): Map showing Roodepoort in Gauteng South Africa, (b): Map showing South Africa and neighbouring countries.