ASSESSMENT OF RADIOLOGICAL RISK IN TIN TAILING PROCESS

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A dissertation submitted in fulfilment of the
requirements for the award of the degree of
Master of Science (Physics)

Faculty of Science
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31 DECEMBER 2O14

I dedicate this work to my dear parents

Father and Mother

To those who loved them *My Wife* sincere and my dear *Sons* and *Daughter*

To my beloved *Brothers* and *sisters*

ACKNOWLEDGEMENT

In the name of Allah, the Most Gracious, Most Merciful. Praise be to Allah S. W. T, Peace and blessings of Allah be upon His Messenger, Muhammed S. A. W, and all his family and companions.

I would like to express my gratitude to Prof. Dr. Husin Wagiran for his supervision, support, and encouragement throughout the course of these studies. I am sincerely grateful to the government of Malaysia and Universiti Teknologi Malaysia.

Special thanks also to Dr. Emad Soliman Shamsaldin for the opportunity given to me to complete my studies and for his patience in assisting in area that I needed most.

I would like to acknowledge the support of technical staff at the Physics Department, University of Technology Malaysia.

As well as I would like to thank all of the assistance provided to me and especially Dr. Mouneer Aziz Saleh.

I would like to thank all of my family for being there whenever I need them. I especially thank my parents and my dear wife for their support and encouragement. Finally, I must be grateful for all my close friends including friends who have helped me in making this study success.

ABSTRACT

This research aims to assess the radiological health risk to the workers from an amang processing plant at Kinta Valley, Perak. The gamma dose rates and activity concentrations of ^{238}U, ^{232}Th and ^{40}K of the minerals from an amang processing plant at Kinta Valley, Perak after being process were measured. The direct measurements of gamma radiation dose rates were conducted by using a portable NaI(Tl) detector and the results range from 1.3 µGy h^{-1} to 26.7 µGy h^{-1}. The activity concentrations of ^{226}U, ^{232}Th and ^{40}K were determined by using hyper pure germanium (HPGe) detector. The activity concentrations were varied from 0.31 ± 0.01 to 135.8 ± 5.9 kBq kg^{-1} for ^{232}Th, 0.48 ± 0.02 to 58.8 ± 2.8 kBq kg^{-1} for ^{238}U, and 0.09 ± 0.03 to 7.7 ±1.0 kBq kg^{-1} for ^{40}K. Pyrite, ilmenite and waste (sand) have lower concentration of ^{232}Th and ^{238}U compared to raw materials after amang tailing process. The corresponding health risk for the annual effective dose equivalent varied from 0.92 to 158.06 mSv with a mean of 34.8 mSv.

ABSTRAK

Kajian ini bertujuan untuk menilai risiko kesihatan radiologi kepada pekerja dari sebuah kilang pemprosesan amang di Lembah Kinta, Perak. Kadar dos gamma dan kepekatan aktiviti ^{238}U, ^{232}Th dan ^{40}K mineral dari kilang pemprosesan amang di Lembah Kinta, Perak selepas diproses telah diukur. Pengukuran langsung kadar dos sinar gama telah dilakukan menggunakan pengesan NaI (Tl) mudah alih dan hasil yang diperolehi adalah antara 1.3 μGy h^{-1} hingga 26.7 μGy h^{-1}. Kepekatan aktiviti ^{238}U, ^{232}Th dan ^{40}K ditentukan dengan menggunakan pengesan germanium berketulenan tinggi (HPGe). Kepekatan aktiviti yang diperolehi adalah dari 0.31 ± 0.01 hingga 135.8 ± 5.9kBq kg^{-1} bagi ^{232}Th, 00.48 ± 0.02 hingga 58.8 ± 2.8 kBq kg^{-1} bagi ^{238}U dan 0.09 ± 0.03 hingga 7.73 ±1.00 kBq kg^{-1} bagi ^{40}K. Pirit, ilmenit dan bahan buangan (pasir) mempunyai kepekatan ^{232}Th dan ^{238}U yang lebih rendah berbanding dengan bahan-bahan mentah lain selepas pemprosesan amang. Risiko kesihatan yang sepadan dengar dos berkesan tahunan berjulat dari 0.92 hingga 158.06 mSv dengan nilai min 34.8 mSv.

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LIST OF SYMBOLS

A	-	Activity
cpm	-	Count per minute
N	-	Number of nuclear
NaI	-	Sodium Iodide
HPGe	-	High purity germanium
IAEA	-	International Atomic Energy Agency
UNSCEAR	-	United Nation Scientific Committe on the Effects of Atomic Radiation
ICRP	-	International Commission on Radiological Protaction
α	-	Alpha particle
β	-	Beta particle
γ	-	Gamma radiation
λ	-	Decay constant

LIST OF UNTS

Bq	-	Becquerel
Ci	-	Curie
cm	-	Centimeter
Gy	-	Gray
h	-	Hour
Kev	-	Kilo electron volt
kg	-	Kilogram
m	-	Meter
n	-	Nano
rem	-	Roentgen equivalent man
Sv	-	Sievert
µ	-	Micron

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CHAPTER 1

INTRODUCTION

1.1 Overview

The radioactive elements from which naturally occurring radioactive materials (NORM) originates were in corporated into the earth’ s crust when the earth was created. NORM represents a wide range of materials that are radioactive in their natural state. These materials include ^{14}C and ^{40}K, both of which are present in human body. Uranium and thorium are naturally occurring radionuclide from which many radioactive materials are formed such as ^{226}Ra and the radon gas. These isotopes are called primordial elements because they have always been present on the earth (UNSCEAR, 2000).

Technologically enhanced naturally occurring radioactive materials (TENORM) are mainly found in scales and sludges from the oil and gas industries, thorium hydroxide from the processing of xenotime and monazite, and iron oxide and red gypsum from the processing of ilmenite. TENORM are tin slag produced from the smelting of tin, and ilmenite, zircon, and monazite produced from the processing of tin tailing (generically termed amang) (TED, 2007)

Tin mining activity in Malaysia started in the 1600’s, situated mainly in Kedah, Perak and Selangor. The rise in demand for tin led to the extensive exploration and extraction to other states in Malaya at that period. Tin mining has been a major activity of Maloya since 1848. Since then tin mine industries rapidly grew in order to fulfil the world's demand for that raw material. Maloya became the largest tin producer in 1883. In 1979, tin production of Malaysia is equivalent to 31% of world's tin production. Tin mine used to contribute between 80 and 90% of the total mineral export of Malaysia (Yip 1969). Mining industry has been responsible in the development of basic infrastructures such as road and railway system in order to establish network system among principal towns. It has given a massive impact on the initial rural development in Malaysia. Scarce of old tin mine activity can be seen until nowadays and some have been developed for settlement, township or recreation projects.

Year of 1983 was the starting point of significant drop in world's demand for tin. It was recorded that only 63 mines were operating in 1996 in Malaysia (Mohsein et al. 2008). The main reason was the increase in cost of operation. Disused tin mines can be a source of environmental related problems. Chiras (2001) mentioned that mining activity was responsible in the reduction of natural habitat, soil erosion and air and water pollution. It was estimated that about 200,000 hectare of ex-mine lands was found throughout Malaysia after 115 years of mining activity (Shamsuddin 1990). A common practice during that time was to dump the mines' waste products on ground surface. The waste might be shifted to nearby water courses and degraded the water quality in terms of physical and chemical aspects. The waste material consists of unstable minerals that can be purified for other valuable minerals.

1.2 Products of Amang and Ilmenite Tin Tailing in Malaysia

Amang is a widely accepted term in Malaysia for the heavy mineral rejects which remain after tin oxide (cassiterite) has been extracted from tin ore. The amang upgrading industry involves the processing of these residues or tin-tailings of the primary tin-mining industry, in an effort to obtain concentrated tin ores and other minerals of economic values such as monazite, xenotime, zircon, ilmenite and struverite. Local practice is for the processed amang and aggregated waste to be left in the open environment near to the plant. A particular concern which arises from this is that rain water may dissolve portions of the radioactive minerals associated with these processed amangs or aggregated wastes and that contaminated water may eventually find its way to nearby rivers or ponds.

Amang, a by-product of rough concentrate of cassiterite from tin mining industry is processed to extract valuable mineral such as ilmenite [FeO_TiO2], zircon [ZrSiO4], monazite [{Ce, La, Y, Th}PO4], xenotime [YPO4], columbite [{Fe, Mn}{Nb, Ta}2O6] and struvirite that most demand in other manufacturing industries. In Malaysia, the amang industry is composed of both small and relatively large-scale plants. Valuable minerals such as monazite ([Ce, La, Y, Th]PO4) are radioactive because they contain naturally occurring thorium. Zircon becomes radioactive when cations, such as Zr4+, are replaced with uranium or thorium (Hart et al., 1993). Other minerals may be contaminated with minerals that are radioactive. Whatever the method of becoming radioactive, the naturally occurring radioactive materials in the amang are technologically enhanced by the extraction process. These technologically enhanced naturally occurring radioactive materials (TENORM) have brought about radiological concerns from the Malaysian government, in particular, the Atomic Energy Licensing Board (AELB), and members of the public.

In 1991, the Atomic Energy Licensing Board of Malaysia (AELB) reported results from a survey conducted on 29 amang plants. Using data from inhalation of airborne radioactive dust, radon and thoron progeny, and external radiation, the AELB concluded that the total dose received by workers were in excess of 5 mSv (AELB, 1991). The Annual Permissible Dose Limit for radiation workers, approved by the AELB is 20 mSv y^{-1}. Zaidan and Ismail (1996) adduced that the standard of housekeeping and industrial hygiene at the place of work also played a part in determining the level of exposure to workers. Prior to 1994, the environment which prevailed in most amang plants forced the AELB to introduce safety guidelines entitled Radiation Protection Guide For Small Amang Factories (AELB, 1994), to help protect workers against unnecessary radiological exposure.

1.3 Statement of Problem

Leong Sin Nam Corp Sdn were one of the active in mining and processing of tin. The presence of radioactivity from the uranium and thorium from activities of amang processing need to be assessed in order to estimate the radiation hazard to the worker. (Hewson, 1993: TED, 1999).

The corresponding gamma dose received from the processing of tailings could be identified and the potential dangers of radiological risk of health effects in the study area for workers (Hu et al., 1981, Lee et al., 2004).

1.4 Reseach Objectives

This research aims to measured the activity concentrations in product and by-products of Amang Tin Tailing in Leong Sin Nam Corp Sdn.

1) To determine the activity concentration of ^{238}U, ^{232}Th and ^{40}K in product and by-products of Amang.

2) To assess external hazard index and annual effective dose in the study area for workers.

1.5 Hypothesis

The activity concentration of ^{238}U, ^{232}Th and ^{40}K in the waste and products produced after the processing of the amang and ilmenite ores leads to the production of materials with high radioactivity. The corresponding gamma dose has the potential to affect the health of the population of stochastic effects (Hall and Giaccia, 2006). These stochastic effects are long-term effects.

1.6 Scope of Research

This research is conducted in Leong Sin Nam Corp Sdn which is one of the the amang industry at Kinta Valley, Perak. The activity concentrations of ^{238}U, ^{232}Th and ^{40}K in the samples are determined using gamma-ray spectrometer with high resolution HPGe detector. The gamma dose rate, radium activity equivalent, external radiation hazard and annual effective dose rate were calculated in order to evaluate the natural background radiation during the amang and ilmenite processing activities.