THE INVESTIGATION OF SOIL DIELECTRIC INFLUENCE TOWARDS TERRESTRIAL BACKGROUND RADIATION

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Dear Lord,
today I really want to thank you, for giving me this lovely life, this experience of joy, pain, sadness, there is nothing I could ask for more, and when my time comes, I know in my heart that you will be with me.
Ameen

Dedicated to:
For My lovely family,
Puan Hajah Maryam Bte Abd Samad and Tuan Haji Jafery Bin Musa
My brothers Mohd Izanie and Mohd Izmeer
Friends
My future beautiful wife

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ABSTRACT

A study on correlation between terrestrial radiation and dielectric property of various soil species in Johor state, Malaysia were investigated in this research. Total 11 soil species were randomly selected around Batu Pahat, Kluang and Johor Bahru. The soil species identified were Kranji, Linau-Sedu, Selangor-Kangkong, Peat, Telemong-Akob, Holyrood-Lunas, Batu Anam-Melaka-Tavy, Rengam-Jerangau, Kulai–Yong Peng and Steepland soils. All the samples were dried, grinded and sieve into fine powder for the elemental compositions and dielectric properties measurement. The correlation between terrestrial radiation and dielectric property of soils were measured statistically to measure the significance between each parameter study. Prior to that, terrestrial gamma radiation was found in Rengam Jerangau has the highest average reading of exposure dosage (97.33 ± 40.27 μR hr $^{-1}$) while the Peat soil gives the lowest reading of (7.67 ± 1.15 μR hr $^{-1}$). This was due to the differences in geological formation for Rengam Jerangau and Peat. For SEM/EDX, the average major atomic percentages found in each soil type are Si, Al, and C, while Fe and K are only minor. In addition, the ^{238}U, ^{232}Th and ^{40}K concentrations were determined using HPGe and it was found that the majority of these three elements existed in Rengam Jerangau and Steepland based on the results of radionuclides and concentration activities. While for the dielectric property, all the samples soil was measured using Dielectric Assessment Kit (DAK) between frequencies 100 MHz to 3 GHz. Selangor Kangkong soil dominated the higher value of complex permittivity (2.6-4.5) and the lowest was found in Peat (1.5 -2.5). While for dielectric constant, Selangor Kangkong 'B' led the higher value of dielectric constant and the lowest still belonged to Peat soil. In conclusion, correlation was achieved by using Pearson's correlation and hypothesis testing, which states that there was no significant evidence based on r-value was below 0.5 and p-value exceed the significant level 0.05. It indicates that there was a no relationship between the natural background radiation and the dielectric properties of the soil.

ABSTRAK

Kajian kaitan antara radiasi latar belakang semulajadi dan harta dielektrik pelbagai spesies tanah di negeri Johor, Malaysia telah disiasat dalam kajian ini. 11 spesies tanah telah dipilih secara rawak di sekitar Batu Pahat, Kluang dan Johor Bahru. Spesies tanah yang dikenal pasti ialah Kranji, Linau-Sedu, Selangor-Kangkong, Gambut, Telemong-Akob, Holyrood-Lunas, Batu Anam-Melaka-Tavy, Rengam-Jerangau, Kulai-Yong Peng dan tanah Steepland. Semua sampel telah diproses menjadi serbuk halus melalui pengeringan, pengisaran dan ayakan untuk menganalisa komposisi unsur dan pengukuran sifat dielektrik. Korelasi antara radiasi latar belakang semula jadi dan sifat dielektrik tanah diukur secara statistik untuk mengukur kekuatan korelasi antara setiap kajian parameter. Sebelum itu, bacaan dos dedahan olah tanah jenis Rengam Jerangau mempunyai bacaan purata tertinggi iaitu (97.33 ± 40.27 μR hr^{-1}) manakala yang terendah adalah tanah gambut (7.67 ± 1.15 μR hr^{-1}). Ini adalah kerana terdapat perbezaan dalam pembentukan geologi bagi Rengam Jerangau dan Gambut. Bagi SEM / EDX, purata peratus atomik utama yang terdapat dalam setiap jenis tanah ialah Si, Al, dan C, manakala Fe dan K hanya segelintir. Di samping itu, kepekatan 238U, 232Th dan 40K telah ditentukan dengan menggunakan HPGe dan didapati majoriti ketiga-tiga unsur ini wujud di Rengam Jerangau dan Steepland berdasarkan keputusan kepekatan aktiviti radionuklid. Bagi sifat dielektrik, semua tanah sampel diukur menggunakan Kit Penilaian Dielektrik (DAK) pada jarak frekuensi 100 MHz hingga 3 GHz dan tanah Selangor Kangkong menguasai nilai yang tertinggi bagi kompleks ketelusan iaitu (2.6-4.5) dan paling bacaan yang rendah didapati pada gambut (1.5 -2.5). Manakala untuk pemalar dielektrik, Selangor Kangkong 'B' mengetuai nilai yang lebih tinggi daripada pemalar dielektrik dan paling rendah masih milik tanah gambut. Kesimpulannya, korelasi dicapai dengan menggunakan korelasi dan ujian hipotesis Pearson, yang menyatakan bahawa nilai r adalah bawah daripada 0.5 manakal nilai p berada melebihi paras signifikan iaitu 0.05. Ini membuktikan bahawa tidak ada faktor yang mempengaruhi di antara hubungan antara radiasi latar belakang semulajadi dan sifat dielektrik tanah.

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LIST OF ABBREVIATIONS AND SYMBOL

A	Area cross-sectional
Al	Aluminium
At%	Atomic percentages
Bq	Becquerel
$Bqkg^{-1}$	Becquerel per kg
C	Carbon
cm	Centimetre
DAK	Dielectric Assessment kit
DAK GUI	Dielectric Assessment kit
E	Applied voltage
FAO	Food and Agriculture Organization
FAST	Faculty of Applied Science and Technology
Fe	Ferum
GUI	Graphic User interface
Gy	Gray
H_0	Null Hypothesis
H_1	Alternate hypothesis
I	Current (A)
j	Imaginary number
K^{40}	Potassium-40
km	Kilometre
L	Length
mSv	millisievert
$nGyhr^{-1}$	Nano gray per hour
O	Oxygen
p	p-value
ppm	Parts per million
r	Pearson's correlation
RECESS	Research Centre for Soft Soil
SEM/EDX	Scanning Electron Microscopy/Energy Dispersive X-ray

Si	Silicon
Th^{232}	Thorium-232
U^{238}	Uranium-238
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
UTHM	Universiti Tun Hussein Onn Malaysia
VNA	Vector Network Analyser
XRF	X-Ray Fluorescence

Greek symbols

μR	microRoentgen
μRhr^{-1}	microRoentgen per hour
α	Alpha decay
β	Beta decay
γ	Gamma
ε '	The real part of Complex permittivity (Dielectric constant)
ε "	The imaginary part of Complex permittivity (Dielectric loss)
*ε**	Complex permittivity

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CHAPTER 1

INTRODUCTION

The crust of earth has four elements which include minerals, rocks, soil and water, covering 29% of land and 71% water. The soil naturally broadens material, capable of supporting plant growth (Lee, 2005). As a medium, the soil provides harbour in supplying nutrients, water and for vegetation (Lee & University, 2005). Soil can also be defined as a group of natural bodies which has been created from a variable mixture of broken and decaying organic matter and weathered minerals (Behari, 2005). It is also varied, particulate, and porous, composed of water, minerals, inorganic and organic matters (National Academy of Sciences, 2001). The mineral matters consist of particles that vary in chemical compositions as well as in form and size.

Furthermore, the geography formation was created in different ways according to its natural condition. Its formation is due to the mantle fluid core of the earth-moving (Menard *et al.*, 2012) and since that, various earth materials that have been naturally produced for centuries in the soil came out including the radioactive elements. It is learned that the natural radionuclide is everywhere but has a low concentration (Pöschl, 2007). In addition, the geographical situation of a place also influences the content of radionuclides elements of soil such as hills, mountains, and plains (Ramli *et al.*, 2001; Saleh *et al.*, 2015; Sanusi *et al.*, 2016). At the same time, radionuclides are a part of the earth's ecosystem. For instance, Anderson (1989) stated that the crust of the earth represents 0.5 percent of the Earth's mass and roughly about 35 percent of Uranium and Thorium are contained in the crust-mantle system.

To start with, all the studies of the going on in the soil were surveyed in this study on its connection to the dielectric properties of soil. Dielectric is an insulating material that polarized when the electric field is applied to the material (Britannica, 2011; Dospatliev *et al.*, 2014; Navar Khele *et al.*, 2009; Oh *et al.*, 2007). Besides electrical, physical and chemical properties of soil, dielectric properties are also important for soil study because it is related to the electrical behaviour of soil (Yaldiz & Bayrak, 2003). Over the last few centuries, the dielectric studies of the soil have always been associated with its moisture in the soil (Bittelli, 2011; Robinson *et al.*, 1994). The water itself affects the dielectric properties (Oh *et al.*, 2007). Most of these dielectric studies were carried out using microwaves transmitted over the soil. This is because microwaves are related to the electromagnetic radiation of frequencies ranging from 300 MHz to 300 GHz. This allows it to penetrate into the soil (Behari, 2005).

1.1 Background of the study

Natural radioactivity of the soil is due to the decay of unstable radionuclides, mainly associated to the Uranium and Thorium series, which were originated from maternal rock during soil origin (Ahmad *et al.*, 2015). This natural radiation can be classified into four types which are cosmic radiation, terrestrial sources, intake of radionuclide inhalation and ingestion.

In this study, terrestrial radiation is examined. This is due to the condition of the soil that contains various elements especially Uranium, Potassium, and Thorium which are natural deposits in the process of natural decay (Commission, 2013). Thus, the site of this study is focused on several soil species which are in Southern Peninsular of Malaysia, Johor. According to the Department of Statistics (2010), Johor is the second most populous state in Malaysia and the fifth largest state by land area, with a total land area of 19,210 km^2 (7,420 sq. ft.), and a population of 3,233,434 as of 2010. Consequently, the terrestrial radiation study has been carried out in accordance with the type of soil available in Johor, such as alluvial soil, sedentary soil and miscellaneous soil (Saleh, Ramli, Alajerami, & Aliyu, 2013).

The soil likewise has chemical, physical as well as electrical properties. Texture, grain size, bulk density and so on, are the physical properties. Nutrients, organic matter, pH, and so on are the chemical properties while electrical properties include dielectric constant, electrical conductivity and permeability (Dospatliev et al., 2014). In practice, most of the dielectric materials are solid such as glass, mica and ceramics, among many. It is an expression of which material can concentrate on the electric flux. It is known that permittivity is an ability of the substance to store potential energy, electrical potential under the influence of an electric field while conductivity is the ability of the substance to flow the charge.

In this research, the investigation of soil dielectric properties influence towards terrestrial background radiation of various soil species was conducted in Johor, Malaysia and the gap of this topic was accomplished based on several parameters such as radionuclide activity (Uranium-238, Thorium-232 and Potassium-40) while soil dielectric according to complex permittivity, dielectric constant and dielectric loss.

Additionally, some previous study has stated that both elemental compositions and types of soil also can influence the terrestrial background radiation (Khater *et al.*, 2013; Yasmin *et al.*, 2018) and soil dielectric (Ahire *et al.*, 2013; Dospatliev *et al.*, 2014; Nahire & Sushant, 2018; Oh *et al.*, 2007) although it is not a major factor. However, the influence of terrestrial radiation and soil dielectric has not yet been made. Therefore, the study may be a novel approach to prove either relationship between background radiation and soil dielectric properties that can be used in further studies.

1.2 Problem statement

Radionuclides in soil emit gamma radiation and human lives are exposed to it (Gavrilescu *et al.*, 2009). In Johor, there are twenty-three soil species and they are categorised in three broad groups of soil which are sedentary soil, alluvial soil and miscellaneous soil (Malanca *et al.*, 1995; Saleh *et al.*, 2015). Each type of soil has a different terrestrial gamma dose rate due to its location, geological formation (Ahmad *et al.*, 2015; Malanca *et al.*, 1995; M. S.M. Sanusi *et al.*, 2017). Therefore, this study can prove the type of soil which has different exposure dose. Because of this, the study will provide knowledge to the residents in the area about their dose rate. However, it is still safe and harmless if exposure doses are below the level of world average value of 30 μR hr^{-1} (UNSCEAR, 2000). For example, the human that had been exposed to the high radiation dose could have some significant health risks such as cancer and cardiovascular disease.

Meanwhile, dielectric measurement technique has been conducted a long time ago to measure soil water content due to the moisture content that could affect the

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