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The Beryllium-7, ^{7}Be Depth Penetration in Two Seasons Study At Timah Tasoh, Perlis

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This paper examines the ^{7}Be penetration onto the soil surface within two seasons of different agricultural activity areas. This study was conducted during the wet and dry seasons in October 2015 until March 2016.Timah Tasoh is a catchment area located in Perlis State, Northern Peninsular of Malaysia and has been identified as the most suitable study site due to a small size of the catchment area. A total of sixteen core soil samples were taken over the course of the study using corer made of metal with a depth of 4cm each. All the results from this study site indicate that the ^{7}Be penetration decreases exponentially decay in soil depth.The distribution of soil depth profile onto the soil surface or *ho* values for both seasons varied from 2.98 to 4.98 kgm^{-2} and from 3.57 to 5.57 kgm^{-2}, respectively.Therefore, all the *ho* values of two seasons from this study are slightly higher from the results that have been reported by others. However, more extensive studies such as the addition of research areas should be carried out to obtain analytical data that can be used as future comparative data.

Keywords: penetration; wet season; dry season; distribution; comparative data

I. INTRODUCTION

Malaysia, which is located at the equator lines has provided a distinct pattern of rainy season and heat which is quite significant throughout the year. It can be clearly seen, where Malaysia has a high relative humidity between 10% and 90% vary by location and the month.Therefore, the pattern of rainfall on the west coast of Peninsular Malaysia is characterised by the occurrence of 'Sumatra' in May to August and the range of maximum and minimum variety does not exist. October and November are the months with maximum rainfall, while February is the month with minimal rainfall.This can be seen in the annual rainfall amount recorded in Perlis State of 5927 mm for the whole year. The amount of rainfall received from Wang Kelian (1909 mm), followed by Lubok Sireh (1587 mm), Bukit Kaki (1319 mm) and Padang Besar (1111 mm). In general, the pattern of rain distribution in Tasoh and Pelarit is almost the same as the average of 64 mm. Moreover, there was no significant difference ($p < 0.01$) for the average annual rainfall between the stations recorded (General Climate Information, 2001). The dry season often occurs early in the year, during January until early March with an average rainfall of 34 mm per day. However, rainfall is not exhaustive throughout the dry season as some places receive relatively high rainfall in January.

Whereas, frequent and high rainfall frequencies are observed during the rainy season from August to November. This rain pattern seems to be concentrated in a two-week interval by giving a significant increase in August and higher in early September. Whereas, frequent and high rainfall frequencies are observed during the rainy season from August to November. This rain pattern seems to be concentrated in a two-week interval, with a significant increase in August and higher in early September. Such conditions continue with higher intensity and soared to rain at Lubok Sireh, Bukit Kaki and Wang Kelian to the highest level in November (Wan & Ku, 2004). Two areas have recorded the highest values of Kaki Bukit and Lubok Sireh

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within a day period, measuring 140 and 160 mm in November.

The term "environmental isotope" refers to the isotopes that are usually widely distributed in the environment or in the landscape. In most cases, these isotopes are naturally occurring but in some cases is man-made. It is also known as Fallout Radionuclides (FRNs) such as 7Be, 210Pb and 137Cs which has been widely used as a sediment tracer of soil erosion and sedimentationstudies by scientists all over the world. 137Cs is a man -made isotope that is widely used as a sediment detector and its half -life is 30.2 years. It was formed into the atmosphere through the process of thermonuclear weapons over a period of time ranging from the mid-1950s to the 1960s. Naturally derived 210Pb another relatively long-lived fallout isotope with a half-life 22.2 yr, is then absorbed by soil particulate matter and subsequently redistributed into landscapes similar to 137Cs, but its potential as a detector to study soil redistribution has so far received only limited attention. Whereas, 210Pb is a naturally produced product through the 238U decomposition series obtained from the decomposition of 222Rn gas (half-life 3.8 d), daughter 226Ra (half-life 1622 years) as shown as Figure 1. Meanwhile, Radium-226 which being in soil and rocks occurs naturally. 210Pb also found in the soil is produced by decomposition of 226Ra and is later named supported 210Pb after being in equilibrium equivalent with its parents, 226Ra (Robbins, 1978).

7Be is a natural radionuclide and is produced naturally in the upper atmosphere by the cosmic space of nitrogen and oxygen (Lal and Peters, 1967). Furthermore, 7Be has a half - life of 53.29 days that results when the process of nuclear spallation interacts with oxygen and nitrogen and produced 70% and 30% in the upper troposphere and lower stratosphere (Lal and Suess, 1968). 7Be is normally removed from the troposphere by wet and dry deposition. Scavenging (washout) is a process that usually occurs during the early stages of precipitation events and this in turn rapidly cleans the lower troposphere containing 7Be as an aerosol (Kaste *et al.,* 2002a). In the meantime, evidence also suggests that about 90% of the total 7Be deposition in the temperate zone usually occurs through a process known as wet deposition (Benitez-Nelson *et. al.,* 1999; Brown *et al.,* 1989). Thus, the Be2+ ion as the main component found in 7Be to reach the soil surface is so competitive to act as a cation exchange site due to its so high charge density (Kaste *et al.,* 2002b). Furthermore, 7Be is absorbed so rapidly and strongly by particles found in soils in most environments (Hawley *et al.,* 1986). The studies of ^{7}Be depth penetration onto the soil surface and have demonstrated that it is predominantly retained in the uppermost of the soil layers have been reported by other scientists, which is less than 2cm (Wallbrink & Murray, 1996; Blake *et al.,* 1999).

This research paper conducted is to examine the penetration of 7Be onto the soil surface within two seasons of different agricultural activity areas. Moreover, the 7Be has been shown to offer considerable potential to provide information over shorter timescales in depth distributionstudy.

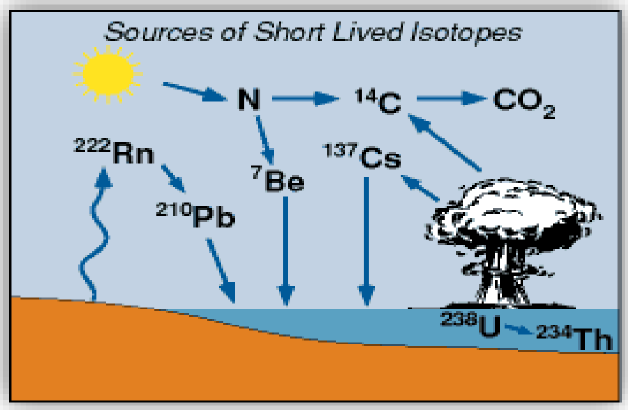

Figure 1. Sources of Short Lived Fallout Radionuclides(FRNS) Isotopes

II. MATERIALS AND METHOD

A. Sampling and Sample Preparation

Research studies was conducted in Timah Tasoh during the rainy and dry seasons in October 2015 until March 2016. Timah Tasoh is a small catchment area located in Perlis State, Northern Peninsular of Malaysia and has been identified as the most suitable study site due to the diversity of land use area. It is located near the Thailand border and 13 km north of Kangar town (6° 36'N and 100° 14'E) which consists mean surface area of 13.33 km² and a storage capacity of about 40 million m³. Meanwhile, Figure 2 shows the diversity of land useat Timah Tasoh catchment has been surrounded by different agricultural land use such as sugarcane, rubber tree, paddy, forest and mixed crop.

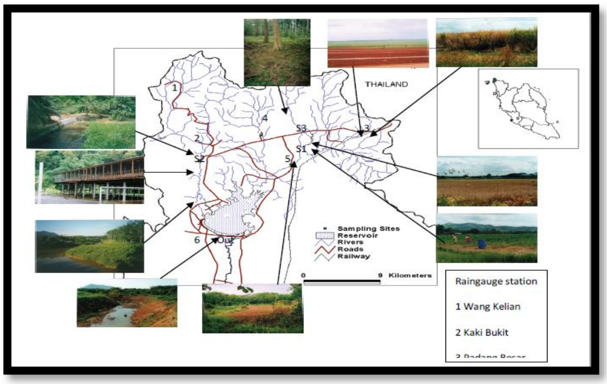

Figure 2. Selected study sites surrounded by various land use activities

Core soil sampling was conducted using plastic core in bare area in TimahTasoh, Perlis, Malaysia. A total of sixteen core soil samples were taken from four different land use areas during the study period conducted using suitable metal cutters. All core soil samples that were taken and subsequently section into increments of 2 mm to 4 cm depth were brought and performed at the Radiochemistry and Environment Group Laboratory (RAS), Nuclear Malaysia in Bangi, Selangor for further sample processing (Figure 3). Samples were dried using an oven at 45 - 60 °C for several days slowly until they reached a constant degree of dryness. Next, the dried sample was then ground until fine and sieved at 2 mm using a sieve before the sample was transferred and packed into a plastic pot beaker (Figure 4).

These samples are inserted into the plastic pot for the purpose of calculating and analysing after the sieving process is carried out.

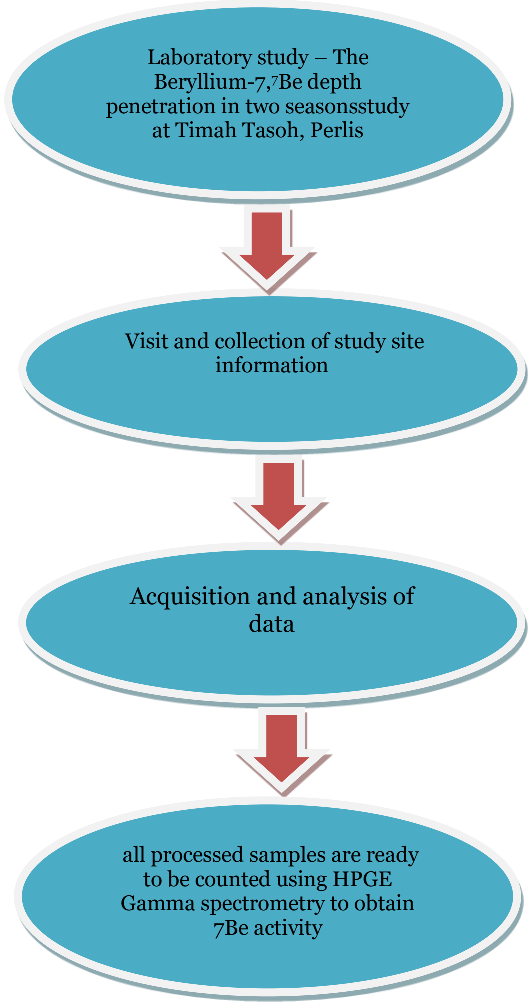

Figure 3. Flow chart for the measurement of 7Be activity in the sample

Figure 4. Soil core sample in the plastic core is ready to slice

B. Counting of ^{7}Bein Soil Samples

The counting process has been using Gamma Spectrometry for 24 hours with 20% detector efficiency (Figure 5). Whereas, the uncertainty of each sample as calculated as a detector error γ at confidence levels according to in the order of 95% ± 10%. determination of ^{7}Be activities in the soil was done using Gamma Spectrometry counting system, consists of Hyper-Germanium detector (HPGe) for 86400 seconds or 24 hours. The energy of 7Be is 477.6 KeV with 20% efficiency of the detector with the uncertainty for each sample taken into account as γ - the error of calculating the detector which is at 95% ± 10% confidence level according to the order. Meanwhile, the 7Be results that have been taken into account from the sample are based on the concentration or activity according to the calculations usingEquation (1) as below:

$$A = \frac{N}{\varepsilon . p_{\gamma} . m . t} \quad (1)$$

Figure 5. All samples that have been processed are ready for counting

Furthermore, effective methods for obtaining detector efficiency calibration can be calculated or classified as:

$$f(Mo) = (Co/To - Cb/Tb) \times (1/Mo \times Aoe - \lambda(t-t)o)$$

where the efficiency τ (rate of emission) which needs to be multiplied by r (probability of gamma ray emission) to obtain the value of f which is the efficiency of the detector activity. Mo is the standard mass in kg, Co is the total count in obtained over the counting time period, Cb is the background of the unspiked sample, T_o is time count for the sampling was being counted, Tb is the corresponding background count time. Meanwhile, the radionuclide decay constant is categorised as λ and further defined as:

$$\lambda = \ln_2/T_{0.5}$$

where T0.5 is a symbol for the half -life of the radionuclide to be identified. Meanwhile, using the model by (Walling & Quine, 1990; Zhang *et. al.,* 1990; Walling *et al.,* 2002), which can be assumed and characterised 7Be depth distribution in the soil with the exponential function used. The depth distribution of 7Be is represented by an exponential decrease with depth:

$$C(x) = ce^{(-x/ho)}$$

where C(x) is the mass concentration density of ^{7}Be at mass depth x, $Bqkg^{-1}$, h_o is a coefficient that describes the shape of the kgm-2 profile and is also known as the depth of relaxation mass. As the value of h0 increases, the penetration of 7Be can be assumed to be greater into the depth of the soil profile.

III. RESULT AND DISCUSSION

The characteristic depth increment (cm) of ^{7}Be for two seasons in different agricultural activity areas are presented in Table 1 and Figure 8. All figures show that the penetration of 7Be decreases exponentially decay into the soil, as reported by scientists in most of the previous literature (Matisoffet. al., 2002; Blake, 2000).The^{7}Be depth penetration onto the soil surface was absorbed more than 2 centimetres (cm) for both seasons except mixed crop (Figure 6 and Figure 7). An overall, the depth increment values are varying between 1.2 cm to 2.8 cm for both seasons, respectively. Therefore, the analytical results from this study did not differ significantly with the analytical results as previously reported by the scientists in the studies they had conducted (Wallbrink & Murray, 1996; Bonniwell *et. al.,* 1999; Blake *et. al.,* 1999; Walling & He, 1999).

The dry season have yielded the lowest and highest depth incrementover a period of sampling is carried out in the rubber tree and mixed crop plantation area which that 1.2 cm and 2.8 cm, respectively. The difference between these two results was decided mainly because of several factors that need to be considered such as soil type and amount of rainfall received during the dry season during the period of the study conducted.

Table 1. The *ho*(kgm^{-2}) and depth increment (cm) values in different land use

	Land Use	*ho* value (kgm^{-2})		Depth increment (cm)	
		Dry season	Wet season	Dry season	Wet season
1.	Sugar cane	4.98	5.57	2.2	2.6
2.	Rubber tree	5.12	5.45	2.8	2.2
3.	Forest	2.98	3.57	2.4	2.6
4.	Mixed crop	4.65	4.21	1.2	1.6

The distribution of soil depth profile onto the soil surfaceor*ho* values vary between 2.98 - 4.98 kgm^{-2} and 3.57 - 5.57 $kgm^{-2}$for both seasons as shown in Figure 9. The data has presented thewet season has given higher *ho* values compared to dry seasons in all different land uses except mixed crop. This situation can be clearly seen, where the value of *ho* from all land uses has given higher value in the wet season except in mixed crop areas of 4.65 kgm^{-2} and 4.21 kgm^{-2}, respectively.This condition may be due to the low content of ^{7}Be in rainwater penetrated onto the soil surface during wet seasons when compared to dry seasons. However, this condition is also possible due to several other factors such as the more rocky soil type in the mixed crop area. Another study also has reported that sand-sized particles can be characterised by a relatively high ^{7}Be activity (Magilligan, 2008). Meanwhile, the *ho* value in the rubber tree area has given more than 5.0 $kgm^{-2}$for both seasons during the study period,which the both values are 5.45kgm^{-2} and 5.12 kgm^{-2}, respectively. The *ho* values in both are not significantly different although the frequency of precipitation occurs in wet rainy seasons compared with the dry season for this extraordinary. This not so significant difference in *ho* value may be due to the newly planted rubber tree factor and causes the ^{7}Becontained in the rainwater to absorb the soil. However, this situation is unlikely to occur in the forest area, where both *ho* yields have shown the lowest results for all land use in the study site, 2.98 kgm^{-2} and 3.57 kgm^{-2}, respectively. The ^{7}Be depth penetration or h_o value from this study is slightly higher compared to Valdivia, Chile and other studies have been conducted by researchers in Brazil. For example, Walling and Collins (2008) have determined the h_o values in the agricultural area at Valdivia, Southern Chile for a few months study area ranging from 1.28 to 2.15 Kgm^{-2}.

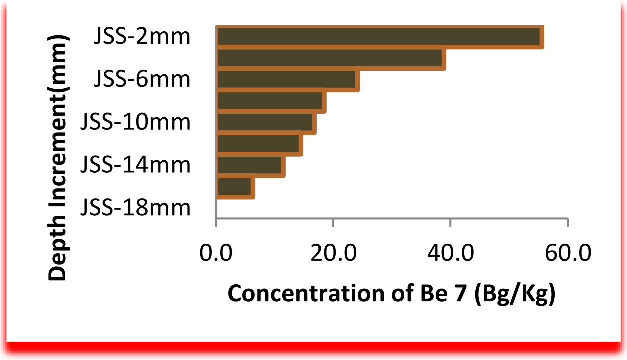

Figure 6. The depth distribution in Mixed crop with ho value, 4.21 kgm^{-2}

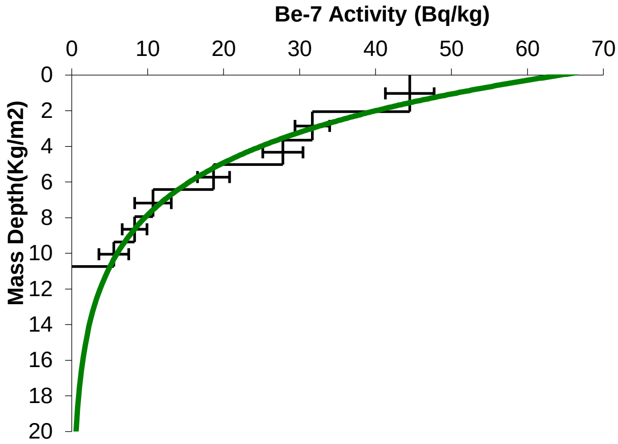

Figure 7. The depth distribution in Mixed crop with ho value, 4.21 kgm^{-2}

Almost a large part of the Timah tasoh catchment area is overgrown with forests that are hundreds of years old and act as a canopy or shade for the plants and communities below them. It is based on the term canopy itself which is applied to the outer layer of the leaves of a tree or individual trees. Shade trees usually have a solid canopy that prevents sunlight and rain from reaching the lower plants or ground level. This causes most of the rainwater of much or little capacity during the monsoon season and the drought brings along with the 7Be concentration content prevented its penetration into the soil surface.

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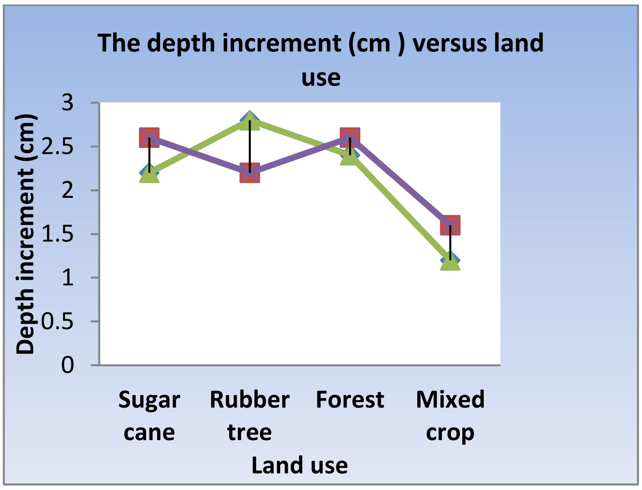

Figure 8. The depth increment (cm) versus land uses in two seasons

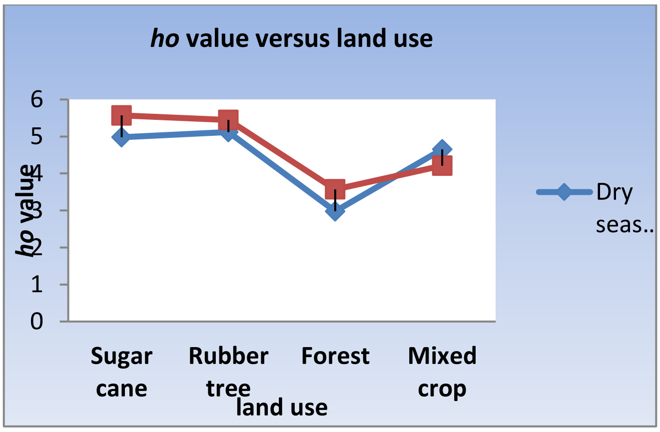

Figure 9. *ho* (kgm^{-2})value versus land uses in two seasons

Depth increment has also played an important role in determining *ho* values for this study. Based on Table 1 again, the second highest depth increment has given the highest *ho* impact value for a wet season at sugar cane land use. However, it does not occur in the rubber tree land use during the dry season, where *ho* value contributes 5.12 kgm^{-2}, from the highest depth increment of 2.8 cm.Most likely at this point, the frequent rains that fall during this wet season contain the higher concentration of ^{7}Be . This condition may cause the soil surface to be more saturated with Be^{2+} cation and a strong gravitational allowing more ^{7}Be concentration penetration deeper exponentially with depth and vice versa does not occur during the dry season. Thus, the short half-life of ^{7}Be should be taken into account as well and is necessarily limit any possible increase penetration during the short and long period of rainfall occurred.

IV. CONCLUSION

As a conclusion, the ^{7}Be depth distribution from this study area was decreased exponential with depth and limited in the top few centimetres and not much different from other works as previously reported by other scientists. Meanwhile, this study also found that the h_o value and depth increment are not affected by both seasons during the study period. Consequently, the h_o value from this study is slightly higher compared to Valdivia, Chile and other studies have been conducted by researchers in Brazil (Walling & Collins, 2008). However, more extensive studies such as the addition of research areas should be carried out to obtain analytical data that can be used as future comparative data.

V. ACKNOWLEDGEMENT

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