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Measuring Radon Concentration and Toxic Elements in the Irrigation Water of the Agricultural Areas in Cameron Highlands, Malaysia

(Mengukur Kepekatan Radon dan Unsur Toksik dalam Air Saliran Kawasan Pertanian di Tanah Tinggi Cameron, Malaysia)

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ABSTRACT

Radon and toxic elements (Pb, Cd, Co, Cu, Cr, Zn and Ni) were measured in different water samples in Cameron Highlands, Pahang. RAD7 and rad H_20 were used to estimate the radon concentration. The average values for radon concentration were found to vary from a minimum of 0.21 Bq/L to a maximum of 0.297 Bq/L. Heavy metals concentration were measured using an atomic absorption spectrometer. The mean concentrations of Pb, Cd, Co, Ni, Cu, Zn and Cr were 0.07, 0.009, 0.009, 0.043, 0.076, 0.079 mg/L and ND, respectively. Comparing the results with the literature, shows that the concentrations obtained were within the allowed limits of the agricultural and domestic use.

Keywords: Cameron Highlands; radon; toxic elements; water irrigation

ABSTRAK

Radon dan unsur toksik (Pb, Cd, Co, Cu, Cr, Zn dan Ni) telah diukur dalam sampel air yang berlainan di Tanah Tinggi Cameron, Pahang. RAD7 dan rad H_2O telah digunakan untuk menganggarkan kepekatan radon. Nilai purata bagi kepekatan radon didapati berubah daripada minimum 0.21 Bq/L ke maksimum 0.297 Bq/L. Kepekatan logam berat telah diukur menggunakan spektrometer penyerapan atom. Kepekatan min Pb, Cd, Co, Ni, Cu, Zn dan Cr adalah masing-masing 0.07, 0.009, 0.009, 0.043, 0.076, 0.079 mg/L dan tidak dikesan. Membandingkan keputusan yang diperoleh dengan keputusan lain yang telah diterbitkan, didapati kepekatan yang diperoleh adalah dalam had yang dibenarkan untuk kegunaan pertanian dan domestik.

Kata kunci: Radon; saliran air; Tanah Tinggi Cameron; unsur toksik

INTRODUCTION

Radon is a radioactive noble gas, occurring in varying concentrations practically everywhere. It has a half - life of 3.82 days. When radon gas is inhaled, the highly-ionizing alpha particles emitted by the deposited short-lived decay products of Po^{218} and Po^{214} can interact with the biological tissue in the lungs leading to DNA damage. The latter is considered an important step in the carcinogenesis process (CHRE 1999; WHO 2008). In the USA, studies showed that radon in homes causes 21,100 lung cancer deaths per year; that is, it represents the second leading cause of lung cancer deaths (WHO 2009). In the UK, radon was estimated to be responsible for about 1,100 deaths per year (Gray et al. 2009). This short half-life gives Rn^{222} progenies the ability to attain a rapid radioactive equilibrium with Rn^{222} (Muhammad et al. 2012). Radon is extremely volatile and is readily released from water. Radon gas can also dissolve and accumulate in water until it aerates. There are various natural radon sources, such as soils, rocks, water, food and building materials. Water in rivers and reservoirs usually contains very little radon because it escapes into the air. However, the concentration of radon in underground water and lake sources is very important as a source of radon.

The contamination of water with heavy metals poses a critical threat to society and the environment. It further highlights serious concerns with respect to safe of drinking issues and potential health risks. In general, water is contaminated with heavy metals derived from factors, such as the application of fertilizer and sewage sludge. The amount of the metals actually absorbed from the digestive tract can vary widely depending on the chemical form of the metal, the age and nutritional status of the individual. Once a metal is absorbed, it distributes itself in tissues and organs. The process of excretion occurs primarily through kidney and the digestive tract. But, metals tend to persist in some storage sites, such as the liver, bones and kidney for years (Hu 2002). The toxicity of the metals commonly involves the brain and the kidney, in addition to other manifestations that might occur.

Cameron Highlands is a district in the state of Pahang with a total area of 71218 ha. It constitutes three mukims i.e. Mukim Ulu Telom, Mukim Ringlet and Mukim Tanah Rata. It is a popular tourist and recreational area moreover, its being the key agricultural area for vegetables, flowers and tea (Muhammad et al. 2009). There are three rivers system namely: Telom, Bertaman and Lemoi rivers in Cameron Highlands. These rivers composed the main

sources of irrigation for agricultural activities. Water is supplied to the district can be classified into two zones i.e. the Northern and the Southern zones. The Northern zone includes the areas of Kg. Raja, Kuala Terla, Tringkap, Kea Farm, Tanah Rata and Brinchang, while the Southern zone includes the areas of Habu and Ringleta (Muhammad et al. 2009). The irrigation water of the agricultural areas in Cameron Highlands is obtained by channelling the water of the river in the proximity of the areas.

In this study, the radon and heavy metal level in water were investigated using RAD7-H_2O and an atomic absorption spectrometry (AAS), respectively. These values will provide a baseline value for the radon and heavy metals found in the water used in the agricultural plots.

METHODS

SAMPLES COLLECTION

Cameron Highlands is a district in the state of Pahang (Figure 1). The weather in West Malaysia is described as wet, humid and hot. This country in nature is rainy and is still so in a large measure (Ahmad et al. 1993). Water samples were collected during two months from the agricultural area, based on the IAEA standard, HNO_3 was used to wash the container in order to help prevent the build-up of organic materials and the changes in the state of the ions in the samples and also to reduce the loss of radioactive material (IAEA 1989). The container were rinsed once with distilled water after then, with river water before samples collection. A one liter water was collected in plastic container for measuring both radon and heavy metals. The bottles were rinsed once with distilled water after then, with river water before sample collection.

SAMPLES PREPARATION AND TREATMENT

Radon concentration in these samples was measured with RAD7, an electronic radon detector connected to a RAD-H_2O accessory for a period of one month. Figure 2 shows the schematic diagram of the RAD-H_2O. RAD7 is a device manufactured by the Durridge Company (Manual RAD7 2012).

Each water sample was sealed off for 3-4 h in a 250 mL vial and was measured thereafter. The equipment was a solid-state, ion implanted, planar and silicon alpha detector. When the radon deposited on the surface of the detector decay, it emitted alpha particles of a characteristic energy that directly entered into the solid-state detector. The detector was initially purged using a $CaSO_4$ desiccant to remove as thoroughly as possible the traces of radon

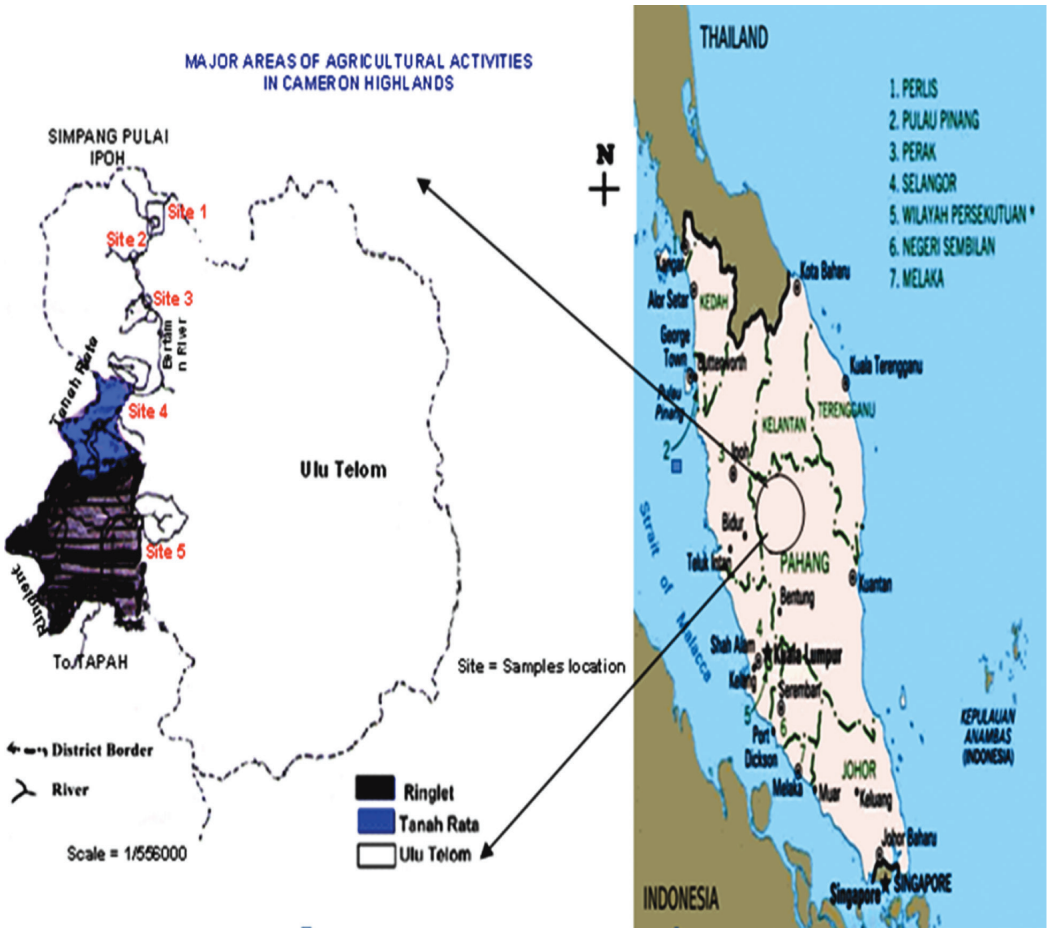

FIGURE 1. Map showing the location of the Cameron Highlands, Pahang, Malaysia

and the humid air that may be present in the RAD7 and in its air-conducting accessories. Water 250 protocol, which automatically configures RAD7 to perform a test according to the selected parameters, was chosen. RAD7 was configured to count the samples for 30 min in six cycles of 5 min each. The choice of these parameters was to avoid the high relative humidity within the sensitive detector volume, resulting from the long-time aeration. During the 5 min of aeration, more than 95% of the Rn^{222} activities were then expressed with uncertainty down to under ± 5%. The latter step was conducted at the end of the run; specifically, 30 min after the start point.

In the present study, the prepared samples were measured for the existence of heavy metals using an atomic absorption spectroscopy (AAS) method. Samples of water for the determination of heavy metals were prepared and then preserved by adding 2 drops of concentrated HNO_3 to each samples. Later, the samples were filtered before being stored below 4°C and were finally analyzed (Mwegoha & Kihampa 2010).

Results and Discussion

Radon Concentration

Table 1 shows the results obtained for measuring the concentration of radon activity Bq/L, pH, electrical conductivity µS/cm, RH and temperature °C in the irrigation

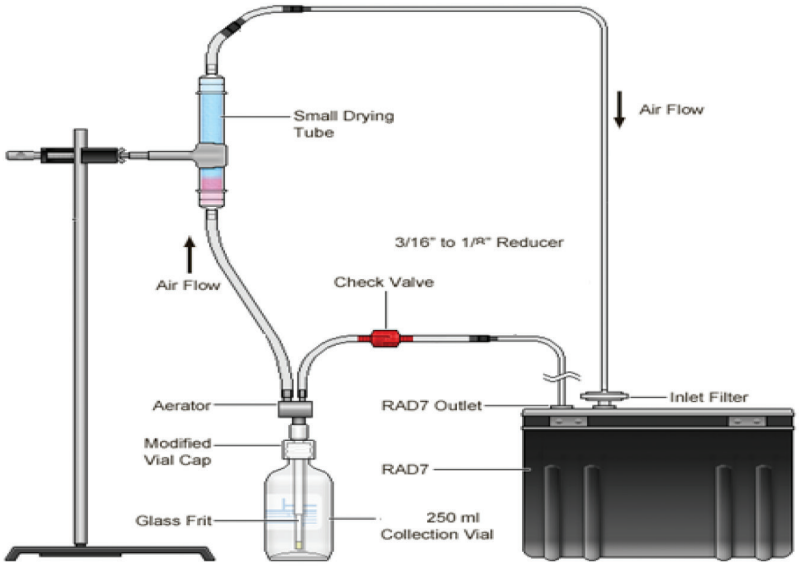

FIGURE 2. Schematic diagram of RAD7 and H_2O accessories

TABLE 1. Radon concentrations (Bq/L) in irrigation water samples in Cameron Highlands

Water samples	pH	Electrical conductivity (µS/cm)	Temperature °C	RH (%)	Radon (Bq/L)
Site -1					
W1	7.64	52.8	24.9	5	0.211 ± 0.129
W2	7.32	48.6	25.1	5	0.218 ± 0.133
Site -2					
W1	7.56	48.2	25.8	4	0.242 ± 0.136
W2	7.53	58.9	25.6	4	0.225 ± 0.138
Site -3					
W1	7.64	62.0	26.1	4	0.284 ± 0.144
W2	7.56	60.5	25.9	4	0.272 ± 0.141
Site -4					
W1	7.94	67.7	26.4	4	0.297 ± 0.148
W2	7.92	63.9	25.9	4	0.296 ± 0.147
Site -5					
W1	7.64	10.59	26.8	5	0.210 ± 0.129
W2	7.75	27.5	26.2	5	0.216 ± 0.132
Mean	**7.65**	**50.07**	**-**	**-**	**0.247 ± 0.138**

water in Cameron Highlands. Figure 3 shows the histogram that represents the observed values. It shows the mean concentration of radon 0.247 ± 0.138 Bq/L. The values show that the concentration of the ^{222}Rn activity varies from 0.297 to 0.21 Bq/L.

The results showed variations of concentration of radon in water due to different locations the samples was taken, nature and geological physiographic region. Table 2 shows the comparison of radon concentration in the present study with those from other parts of the world. The mean values of radon concentration in this study is lower than those obtained by Yogesh et al. (2009) in India; Oner et al. (2009) in Turkey; Xinwei (2006) in China and Muhammad et al. (2012) in Penang, Malaysia.

The radon concentration levels reported in this study are lower than WHO recommended level of 100 Bq/L (WHO 2008).

HEAVY METALS

A total of seven elements was examined in the water used for irrigation in the Cameron Highlands area. The results showed that the concentration of Cd and Co was the lowest for both of them (Table 3). Lead concentration ranged from 0.16 to 0.087 mg/L, which was lower than the value 0.21 mg/L, reported in Bangladesh (Jasim et al. 2010). The maximum Zn concentration in water was 0.116 mg/L, whereas that of Cd varied from 0.003 to

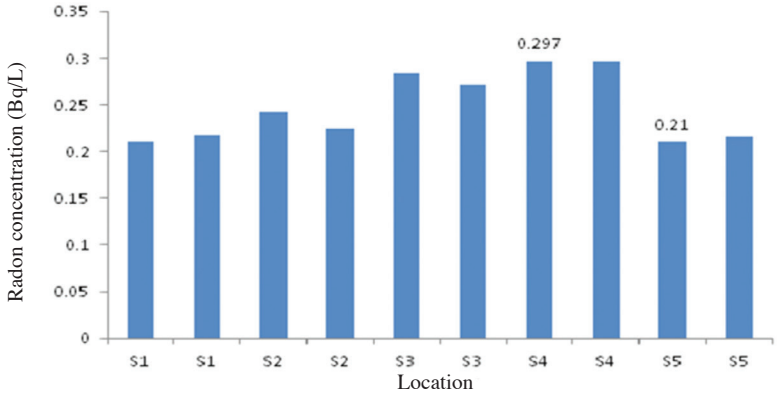

FIGURE 3. Radon concentration in Cameron Highlands according to the location criterion (0.21 Bq/L the minimum value and 0.297 Bq/L maximum values)

TABLE 2. Radon concentration (Bq/L) in the water of other parts of the world

Area	Radon concentration (Bq/L)		Reference
	Min.	Max.	
India	1.0	336	(Yogesh et al. 2009)
Turkey	0.28	1.08	(Oner et al. 2009)
China	12.0	127	(Xinwei 2006)
Penang, Malaysia	0.49	26.26	(Muhammad et al. 2012)
Cameron Highlands, Malaysia	0.21	0.297	Present work

TABLE 3. Comparing heavy metal concentration (mg/L) in the water used for irrigating vegetables in Cameron Highlands for ten samples with other references

Metal	Safe limit[a]	Contaminated water[b]	Present study			
			Mean	Minimum	Maximum	S.D
Pb	0.5	0.21	0.07	0.087	0.16	0.006
Cr	0.1	0.43	ND	ND	ND	-
Cd	0.01	0.06	0.009	0.003	0.022	0.002
Co	-	-	0.009	ND	0.02	0.001
Cu	0.2	2.17	0.076	0.017	0.082	0.003
Zn	2.0	0.95	0.079	0.051	0.116	0.005
Ni	0.2	0.19	0.043	0.039	0.048	0.005

Safe limit[a] of toxic heavy metals in irrigation water for an agricultural purpose in FAO (Pescod 1992); Reference[b] in Bangladesh (Jasim et al. 2010); ND: not detected

0.022 mg /L. It was lower than the values 0.02–0.04 mg/L, obtained from the previous findings by Sharma et al. (2006). Nickel contents ranged from 0.039 to 0.048 mg/L. Cu varied from 0.017 to 0.082 mg/L, which was lower than the standard guidelines of irrigation water (Pescod 1992). Cobalt contents ranged from ND to 0.02 mg/L, which was lower than the standards of irrigation water. The mean concentration in mg/L of the following heavy metals Pb, Cr, Cd, Co, Cu, Zn and Ni in water samples were 0.07, ND, 0.009, 0.009, 0.076, 0.079 and 0.043, respectively. Table 3 shows the heavy metal concentration is lower than the mean metal concentrations of water in Dhaka, Bangladesh (Jasim et al. 2010) and is also lower than the metal concentrations of water in the suburban areas of Varanasi, India (Sharma et al. 2006). The results of heavy metals in water in the present study is less than the standard guideline of irrigation water (Pescod 1992).

CONCLUSION

Radon concentration levels reported in this study are lower than WHO recommended level of 100 Bq/L (WHO 2008). These results have shown variations of radon concentration in water due to different locations the samples was taken, nature and geological physiographic region. The results of heavy metals in water is less than the standard guideline of irrigation water FAO. The results provide a baseline data of the radon concentration levels in surface water resources. Based on these results the water can be use for agricultural activities and domestic usage.

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