ASSESSMENT OF URANIUM AND THORIUM DEPTH PROFILE IN SEDIMENT OF TIN MINING LAKE IN KAMPUNG GAJAH, PERAK

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ABSTRACT

Uranium and thorium usually present to a high concentration in ex-mining area via tin mining activities. Lake's sediment can be used to determine the concentration of radionuclide in tin mining lake. The present study determined the concentration of uranium and thorium in sediment of one ex-mining lake in Kampung Gajah, Perak. Five sediment cores were collected from 5 locations in the lake by using manual gravity corer with PVC core tube of 45 mm inner diameter. The cores were sub-sampled by slicing into 2 cm slices enabling profile to be carried out. The samples were oven dried, grind, sieved and make into pellet before measured using Energy Disperse Fluorescent X-ray to determine uranium and thorium concentration. Calibration of the system was done by using SRM from IAEA. There is no observable trend for uranium concentration. Thorium has decreasing trend at older sediment at location K2 and K5 while K1, K3 and K4 showed regular pattern. The overall mean concentration of uranium and thorium is 17.40 ± 1.52 mg/kg and 67.46 ± 9.23 mg/kg, respectively. The highest mean concentration of uranium and thorium are 18.45 ± 1.62 mg/kg and 75.80 ± 10.37 mg/kg.

ABSTRAK

Kehadiran uranium and thorium didapati tinggi di di kawasan bekas lombong disebabkan aktiviti perlombongan bijih timah. Mendapan di tasik boleh digunakan untuk menentukan kepekatan radionuklide dalam tasik perlombongan bijih timah. Kajian ini dijalankan adalah untuk menentukan kepekatan uranium dan thorium dalam mendapan di salah satu bekas tasik lombong di Kampung Gajah, Perak. Lima teras mendapan diambil dari 5 lokasi di tasik dengan menggunakan gravity corer dengan diameter 45 mm tiub teras PVC. Persediaan kajian profil dijalankan dengan menghiris teras sub-sampel kepada kepingan 2 sm. Sampel mendapan dikeringkan di dalam oven, dikisar, diayak dan dijadikan pelet sebelum diukur menggunakan Pendaflur Serakan Tenaga Sinar X untuk menentukan kepekatan uranium dan thorium. Penentukuran sistem telah dilakukan berdasarkan SRM dari IAEA. Trend bagi kepekata uranium tidak kelihatan. Kepekatan thorium di lokasi K2 dan K5 menunjukan penurunan trend pada bahagian bawah mendapan manakala trend yang sekata dapat dilihat di lokasi K1, K3 dan K4.Purata keseluruhan masing-masing bagi uranium dan thorium adalah 17.40 ± 1.52 mg/kg dan 67.46 ± 9.23 mg/kg. Purata tertinggi bagi kepekatan uranium dan thorium dalam kajian ini adalah 18.45 ± 1.62 mg/kg dan 75.80 ± 10.37 mg/kg.

Keyword: *^{238}U, ^{232}Th, tin mining lake, sediment, EDXRF*

INTRODUCTION

Most of the radionuclides are occur naturally in nature and only minor amount formed by human activities. Radionuclides can be very harmful to organisms as causing cancer if the organisms have exposed to radiation in excess of a threshold level (UNSCEAR report, 2000). The characteristics of each radionuclides are differ to others as uranium are both radioactivity and chemical toxicity while thorium only radiotoxic (Arogunjo *et. al.*, 2008).

The human activities as tin mining is one of the oldest industries in Malaysia as its activities have started since 1820. However, due to depletion in deposits, this activity has ceased about 40 years ago (Hamzah *et al.*, 2011). These activities not only released metal contamination into environment, but also produced high degree in material of both of uranium and thorium decay series (Arogunjo *et. al.*, 2008).

Some of the radionuclides that moved into lakes will accumulate largely in sediments as the clay part in sediment's composition will chemically binds with these radionuclides. Furthermore, by measuring sediment profile in mining lake, the information on contamination of lakes such as contamination discharges according to years and land use history can be determined (Hamzah *et al.*, 2011).

In the present study, Energy Dispersive X-ray Fluorescence (EDXRF) was used to determine the concentration of uranium and thorium in every layer in each locations and pattern in sediments in ex-mining lake in Lake 7 in Kampung Gajah, Perak which this area is one of the ex-mining in Malaysia.

EXPERIMENTAL

Study area

The study area is located at ex-tin mining lake in Lake Kapal 7, Kampung Gajah area in Kinta Valley in the State of Perak. The size of lake is about 0.5 km x 1.5 km. The deepest part is about 40 m near the center of the lake. Water in Lake Kapal 7 is connected to Sungai Kampar on the west side and Lake Air Hitam on the east. The uniqueness of this lake is the water can flow in and out in two ways via the water channels which connected at Sungai Kampar and Lake Air Hitam under certain condition. If the water level in Lake Kapal 7 arises more than Sungai Kampar, the water in Lake Kapal 7 will flow in to Sungai Kampar. While, the water in Sungai Kampar will flow out to Lake Kapal 7, if water level in Sungai Kampar arises more than Lake Kapal 7. The same will happens between Lake Kapal 7 and Lake Air Hitam. There also have abundant of fish and have become the main fish supply for local residents.

Sampling and sample preparation

Sediment samples were collected in 5 point locations in the lake (Figure 1) which 5 cores have taken at each location to form representative samples of that location. The longitude and latitude of sample location was noted by using global positioning system (GPS) (Table 1). Sediment cores were collected by using manual gravity corer with PVC core tube of 45 mm inner diameter. Sediment samples in PVC core tube were left air-dried in vertical position about 3 - 4 weeks to obtain the shape of PVC column (Hamzah *et al.*, 2011). Sediment samples obtained were about 18 to 26 cm in length. The cores were sub-sampled by slicing into 2 cm slices and mixed according to same depth of core to form homogenous representative. The aggregates were oven dried at 60 $^{\circ}$C until constant mass, pulverized and sieved through 250 μm stainless steel sieves (Vichaidid *et al.*, 2009). Table 1 summarizes the coordinates of 5 locations for samples. The water depth at mostly location was around 8-10 m.

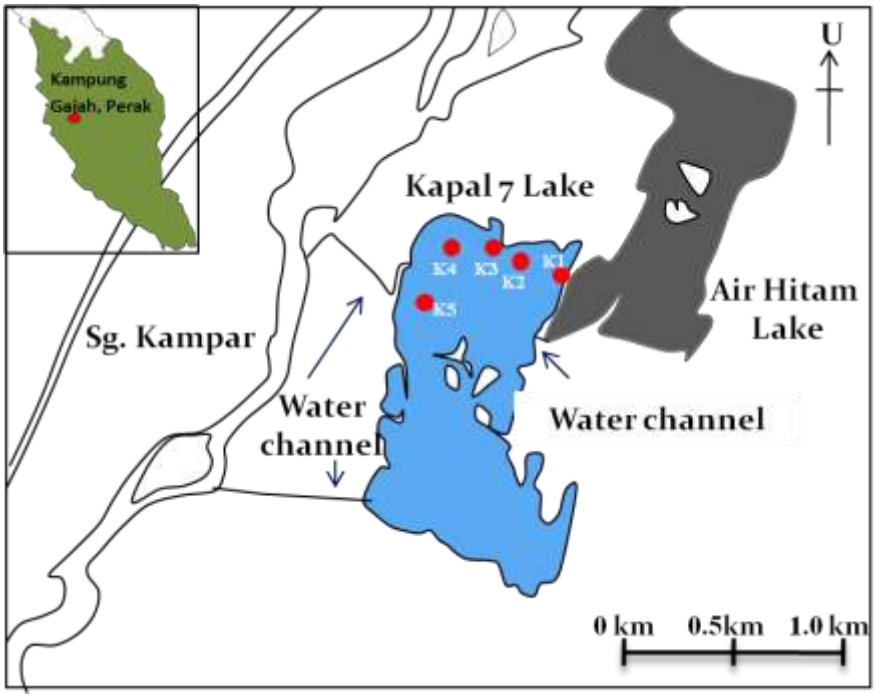


Figure 1: Sampling point location (Google earth)

Table 1: The coordinate for sampling locations

Location	Latitude	Longitude
K1	N 04º12.537'	E 101º02.631'
K2	N 04º12.527'	E 101º02.517'
K3	N 04º12.568'	E 101º02.339'
K4	N 04º12.556'	E 101º02.215'
K5	N 04º12.419'	E 101º02.179'

Measurement of uranium and thorium

Minipal4 PANalytical bench top EDXRF (Energy Dispersive X-ray Fluorescence) was used to determine uranium and thorium concentrations. Standard calibration for uranium and thorium were carried out by using Standard Reference Material (SRM) from IAEA 312, IAEA, 313 IAEA 314, IAEA SL-1 and IAEA Soil 7. Lα line was used in quantitative of uranium and thorium at energy 13.612 keV and 12.967 keV using Mo filter in 100 second measuring time (Natarajan *et al.*, 2008; Yu et al., 2002; Hamzah *et a*l., 2011). The standard and samples were prepared and measured in same condition (Jorgensen *et al.*, 2005).

RESULTS AND DISCUSSION

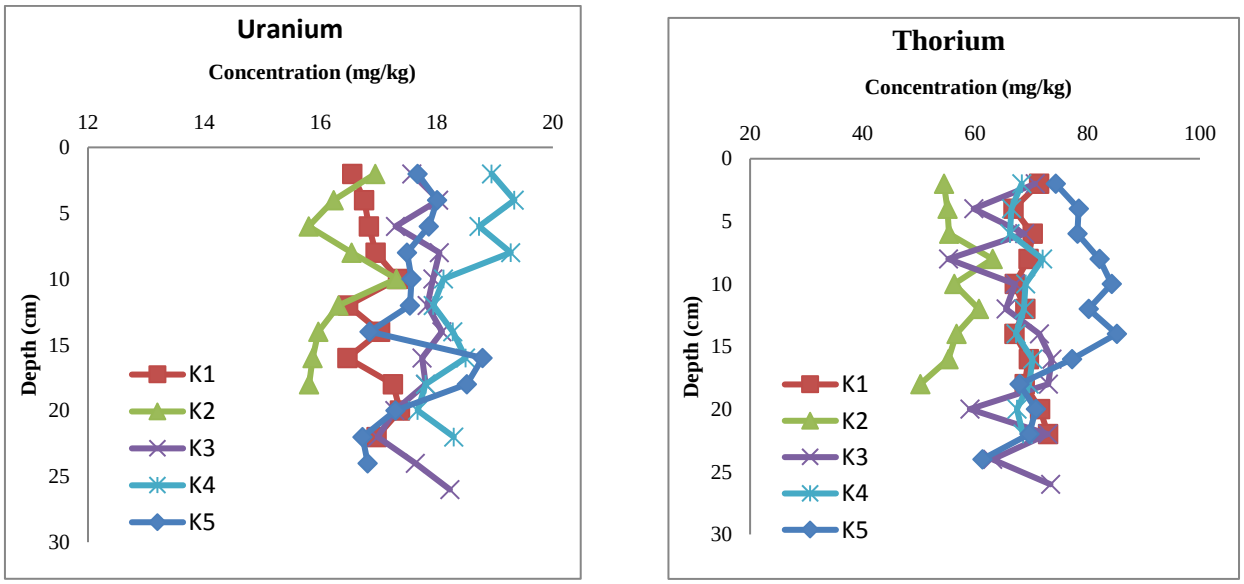
Figure 2 (a) and 2 (b) show average profile concentration of uranium and thorium. There is no specific trend for both of uranium and thorium profile (Figure 2 (a) and (b)) as they have different concentrations in different locations through the depth profile. The overall mean of the uranium and thorium concentration in all locations are 17.40 ± 1.52 mg/kg and 67.46 ± 9.23 mg/kg, respectively. A study on the ratio of Th/U of the five locations showed the average values ranged in 3.06 – 4.80. These agreed well to the world average ration of Th/U of approximately 3.5 – 4.0 (Hamzah *et. al.*, 2011). The concentration of uranium and thorium and ratio Th/U in sediment's profile are summarized in Table 2.

Table 2: Mean of uranium and thorium concentration and average ratio Th/U in sediment profile

Location	Uranium (mg/kg)	Thorium (mg/kg)	Average ratio Th/U
K1	16.91 ± 1.48	69.42 ± 9.50	3.93 – 4.31
K2	16.31 ± 1.43	56.35 ± 7.71	3.18 – 3.71
K3	17.73 ± 1.56	67.20 ± 9.19	3.06 – 4.15
K4	18.44 ± 1.62	68.52 ± 9.40	3.44 – 4.15
K5	17.59 ± 1.53	75.80 ± 10.37	3.80 – 4.80

From Table 2, the concentration of thorium is higher than uranium. The concentration of thorium always higher than uranium in sediment's lake due to fact that uranium is more soluble than thorium which has greater mobility in water (Dawood, 2010). Location K3, K4 and K5 has higher concentration of uranium compared to K1 and K2. This may explained due to the location K3, K4 and K5 are closer to the water channel in west side of Lake Kapal 7 that linked to Sungai Kampar as uranium in the stream water may transferred to the sediment in the lake and the amount of uranium will become less as pass through location K5 to K1 (Hamzah *et al.*, 2011). However, concentration of uranium is higher at location K1 compared with K2, suggested that, due to the surface runoff from embarkment as K1 adjacent to the embarkment which the deposited radionuclides will wash down into lake and store to the sediment's lake (Dawood, 2010).

For overall, almost all location shows higher concentration of uranium and thorium at top layer compared to older layer sediment. This may due to the recent transportation of radionuclides from natural process and anthropogenic that may enter into lake via water flow. Uranium in sediment's profile from all location does not show any observable pattern, suggested that, uranium is more soluble compared with thorium that has greater mobility in water and may influence the accumulation of uranium in sediment's lake. All location for thorium show identical concentration profile which in regular pattern except for K2 and K5 where they has decreasing pattern at older sediment from 14 cm (Figure 2 (b)).



(a) (b)

Figure 2: Depth profiles of uranium and thorium in sediment samples.

In table 3, stated the comparison of uranium and thorium concentration and the average ratio Th/U from certain location in worldwide. This study showed higher ratio of uranium and thorium compared to others places which about 4. Perhaps this could due to water flow from Sungai Kampar and Lake Air Hitam into Lake Kapal 7 via water channel. Uranium and thorium that probably carried out from Sungai Kampar and Lake Air Hitam will deposited in sediment of Lake Kapal 7. Anthropogenic sources and the surface runoff from embankment near the lake could also contribute the present of radionuclides into lake.

Table 3: Concentration of uranium and thorium in sediment sample (mg/kg) from work conducted worldwide

Location	Uranium (mg/kg)	Thorium (mg/kg)	Average ratio Th/U	Reference
Sultan Abu Bakar, Dam, Cameron Highland, Malaysia	21.51 – 28.81	40.73-69.58	1.50 – 3.20	Hamzah et al. (2011)
Tin Mining Lake, Malaysia	30.6 ± 6.1	85.7 ± 10.0	2.20 – 4.21	Hamzah et al. (2011)
River Nile, Egypt	0.3 – 4.82	1.2 – 14.12	0.25 – 0.34	Dawood Y. H. (2009)
Kubanni River, Nigeria	9.06 ± 2.66	21.44 ± 4.12	2.54 ± 0.72	Dim et al. (2000)

CONCLUSION

The sediments were found to be highly enriched with thorium compared to uranium in ex-mining lake in Lake Kapal 7 in ratio almost 1:4 as higher ratio compared with other places. There is no observable trend for uranium concentration. Thorium has decreasing trend at older sediment at location K2 and K5 while K1, K3 and K4 showed regular pattern (Figure 2 (a) and (b)). Determination of uranium and thorium was established using EDXRF and the mean of their concentration is 17.40 ± 1.52 mg/kg and 67.46 ± 9.23 mg/kg, respectively.

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REFERENCES

Arogunjo, A.M., Hollriegl, V., Giussani A., Leopold K., Gerstmann U., Veronese I. and Oeh U. (2008). Uranium and thorium in soils, mineral sands, water and food samples in a tin mining area in Nigeria with elevated activity. *Journal of Environmental Radioactivity: 232-240.*

Dawood, Y. H. (2010). Factors Controlling Uranium and Thorium Isotopic Composition of the Streambed Sediments of the River Nile, Egypt. *Earth Science*: 77-103

Dim, L.A. , Ewa, I.O.B. and Ikpokonte, A.E. (2000). Uranium–thorium levels in the sediments of the Kubanni River in Nigeria. *Applied Radiation and Isotopes*: 1009–1015

Hamzah, Z., Saat, A., Bakar, A.Z. and Wood, A. K. (2011). Anthropogenic Heavy Metals, U-238 and Th-232 Profiles in Sediments from an Abandoned Tin Mining Lake in Malaysia; Proceeding of 2011 3rd International Conference on Chemical, Biological and Environmental Engineering, Singapore.

Hamzah, Z, Riduan, S. H. and Saat, A. (2011). Determination of Sediment Profile for ^{210}Pb, Pb, U and Th from Sultan Abu Bakar Dam Due to Soil Erosion from Highland Agriculture Area, Cameron Highlands, Malaysia. *American Journal of Environmental Sciences* 7(3): 263-268

Jorgensen, N., Laursen, J., Viksna, A., Pind, N. and Hlm, P.E., (2005). Multi-element EDXRF mapping of polluted soil from former horticultural land. *Environ. Int.*, 31: 43 – 52.

Natarjan, V., Kulkarni, M., Porwal, N., Dhawale, and N. Hon (2008). Determination of uranium content in Th, U mixed oxides using EDXRF. Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials Atoms: 3290-3294.

UNSCEAR (2000). United Nations Scientific Committee on the effects of Atomic radiation, sources and Biological effects of ionizing Radiation United Nations, New York.

Vichaidid, T., Soodprasert, T., Sastri, N. and Moungsrijun, S. (2009). Comparative Study on U, Th and K Concentrations in Sediments at the Mae Moh Mine and Lam Phra Phloeng Dam. *Natural Science* 43: 379 – 384.

Yu, K.N., Yeung, Z.L.L., Lee, L.Y.L., Stokes, M.J. and Kwok, R.C.W.(2002). Determination of multi-element profiles of soil using Energy Dispersive X-ray Fluorescence (EDXRF). *Applied Radiation Isotopes,* 57: 279 - 284