ASSESSMENT OF NATURAL RADIONUCLIDES AT KINTA RIVER, MALAYSIA: RELATIONSHIP BETWEEN THE TURBIDITY TO URANIUM AND THORIUM CONCENTRATIONS

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Abstract.This study aims to investigate the relationship between the turbidity to uranium and thorium concentrations. Since the radionuclides analysis is complex and time consuming, turbidity monitoring on river is proposed to be an indirect indicator for uranium and thorium concentration. Eighteen water samples were collected and turbidity measurements were conducted at several locations from Kinta River. The concentration of uranium and thorium were analyzed using inducted coupled plasma mass spectrometer (ICP-MS). The concentrations of thorium were varied from 44 ng L^{-1} to 787 ng L^{-1} while the concentration of uranium varied from 45 ng L^{-1} to 371 ng L^{-1}. Statistical analyses were applied to determine the relation between turbidity and concentrations of uranium and thorium at Kinta River. The correlation coefficients *(R)* show a strongly correlation, with *R* values of 0.915 and 0.881 for turbidity with concentrations of uranium and thorium, respectively.

Keywords Concentration of Thorium and Uranium; ICP-MS; Turbidity Meter

1.0 INTRODUCTION

Humans permanently contact with natural radioactivity and are exposed to ionizing radiation from a number of sources. There are two main categories of radiation sources which is natural and man-made. The doses from natural radiation to human beings are important because they contribute the largest component of equivalent dose received by the world population [1].

Determination of radionuclide concentrations in water is important in the effort to limit radiation exposures to members of the public to be as low as reasonably achievable. Some radionuclides in water can be released into indoor air during cooking, showers, humidifiers, clothes washer, and dishwasher. Exposure to radioactivity of water may occur due to ingestion (drinking water) and also due to inhalation (from household water). Both of those mechanisms pose potential health hazard [2]. Protection of population against high concentration of radionuclides in water is recognized in most countries.

The concentration of uranium and thorium in high radiation area is associated with soil originating from igneous rocks [3]. From previous study in Johor Bahru District, Johor, Malaysia, the radionuclide U and Th transfer to the aquatic habitat from terrestrial natural in the study area. The reason why the U concentration was higher than Th concentration due to Th has low mobility under all environmental conditions, mainly due to the high stability of the insoluble ThO_2 [4].

Higher concentration of radionuclides in some of the samples collected may be attributed to geological areas consisting of granites and gneisses which contain higher concentration of uranium series, thorium series and potassium. The concentration of uranium and thorium in water samples vary depend on geological and rock formation in that area [5].

Kinta Catchment, at Perak is one of the areas that contain high rate of radiation. Kinta area was the largest tin mining. Therefore, several researchers relate it to anthropological activities, such as mining, groundwater exploitation or food chain, and others relate it to soil type or geological condition.

2.0 EXPERIMENTAL

2.1 Materials

Terrestrial radiation dose rate was measured in situ 1 meter above the ground using Ludlum Detector Model 19, micro roentgen (μR) meter, manufactured by Ludlum, USA. The detector of the instrument uses a 2.54 cm × 2.54 cm sodium iodide (NaI) crystal doped with thallium (Tl). The instrument was calibrated at the Malaysian Nuclear Agency, which is recognized by the IAEA as a Secondary Standards Dosimetry Laboratory [6]. It has linear energy responses to gamma radiation between 0.08 to 1.2 MeV [7] which considered being acceptable for covering the majority of gamma ray emissions from major sources of ambient natural gamma radiation. The meter display was in micro roentgen per hour ($\mu R\ h^{-1}$). A total of 150 in situ gamma dose rates were measured with at least one measurement taken for each geological formations and soil types. The measurements were repeated until stable readings were obtained [8]. . After that, the turbidity of the river water also measured using turbidity meter. Next, filling the container with 5 liters of water and 5 ml of nitric acid were added into the water sample.

2.2 Location of Samples

The area of the study is in Kinta, Perak. This area was the largest tin mining. It contain high rate of radiation. The samples of the water had been collected from seven locations at Kinta catchment. 5 samples were taken at S1 (Kinta River), 4 samples at S4 (Kampar River) and 5 samples at S6 (Kinta River). Each sample was taken at S2(Kinta River), S3 (Pari River) , S5 (Chemor River) and S7 (Kinta River). The locations of the collected samples are shown in the Table 1.

Table 1: The information of the collected water samples.

Name of Sample	Location of sample	Quantity of sample	Location coordinates	Location's name
S1-1 S1-2 S1-3 S1-4 S1-5	S1	5	101° 3' 33.4" 4 ° 32' 24"	Kinta River, Balai Bomba Lahat
S2-1	S2	1	101° 6' 51.2" 4 ° 38' 4.8"	Kinta River, Taman Mirindi
S3-1	S3	1	101° 4' 10.5" 4 ° 34' 58.3"	Pari River, Bridge, Jln Raja Ariff Syah
S4-1 S4-2 S4-3 S4-4	S4	4	101° 9' 22.2" 4 ° 21' 42.4"	Kampar River
S5-1	S5	1	101° 7' 20.5" 4 ° 43' 14.1"	Chemor River
S6-1 S6-2 S6-3 S6-4 S6-5	S6	5	101° 4' 20.2" 4 ° 19' 38.4"	Kinta River, Malim Nawar
S7-1	S7	1	101° 1' 15.8" 4 ° 7' 6.1"	Kinta River, Balai Cenderong

2.3 Research Procedure

2.3.1 Sample Preparation

Eighteen water samples were taken from seven locations at Kinta catchment. About 500 ml of water sample was filtered using filter papers to separate the sediment from the sample and to get rid the contamination. The samples were acidified with Nitric acid (HNO_3) to prevent micro-organisms from stick to the wall of the container and to retain the element of water from missing. The pH value of samples were detected by using pH meter and makes the pH >2. About 10 ml of each sample were transferred to glass tubes for direct measurement to ascertain the concentration value using induce coupled plasma mass spectrometry (ICP-MS). For turbidity, the turbidity meter was immersed in the river and the values were record according to sample location.

2.3.2 Analysis

To analyze the sample, induced coupled plasma mass spectrometry (ICP-MS) was used to determine the concentrations of Th and U in water samples. It was calibrated using a standard calibration solution of Th and U. The concentration of U and Th is determined in the unit of *part per billion* (*ppb*). The statistical analysis is applied to determine the relation between turbidity and concentrations of uranium and thorium at Kinta River.

3.0 RESULTS AND DISCUSSION

The ability of light to pass through the water is called turbidity. Figure 3.1 shows the turbidity of eighteen sampling point that was measured using turbidity meter. Turbidity of river water was found in range from 25 NTU – 1200 NTU. The sampling point at S1-5 has the highest turbidity of 1200 NTU.

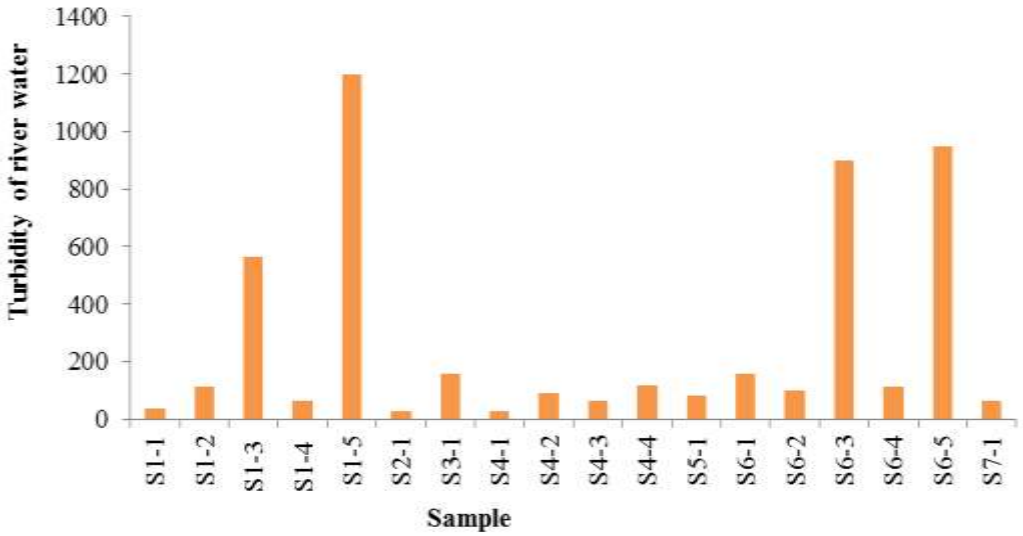

Figure 3.1: Turbidity of river water at different sample location.

The concentration of U and Th in water samples were measured using Induced coupled plasma mass spectrometer (ICP-MS). The measured concentration of uranium varied from 45 ng L^{-1} to 371 ng L^{-1} with a mean value of 126 ng L^{-1} as shown in Figure 3.2 and Table 2. Sample S1-5 has the highest concentration of uranium while the lowest was found to be S2-1.

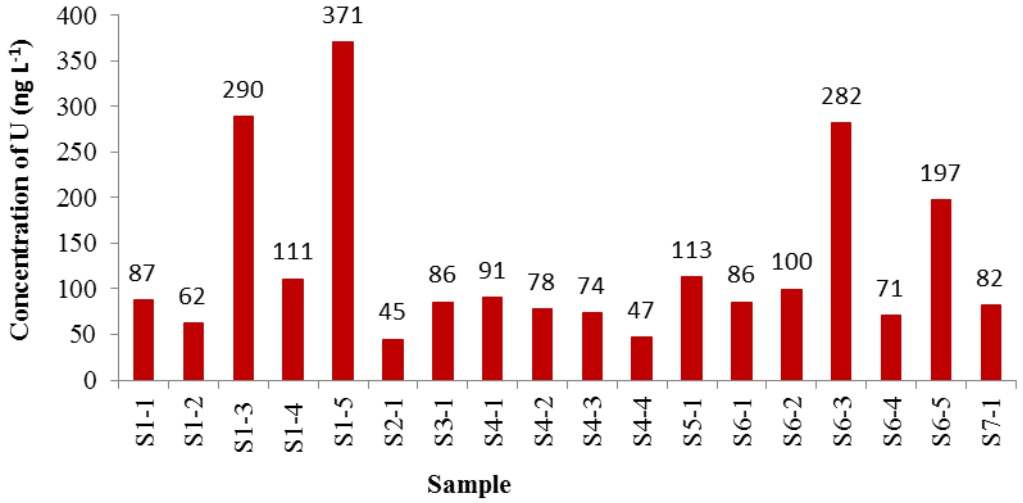

Figure 3.2: Concentration of uranium for each water sample.

The concentration of thorium in river water samples from Kinta district varied from 44 ng L^{-1} to 787 ng L^{-1} with a mean value of 256 ng L^{-1} as shown in Figure 3.3 and Table 2. Sample S1-3 and S1-5 were recorded the highest concentration of thorium in the study area. Sample S4-1 was recorded the lowest concentration of thorium.

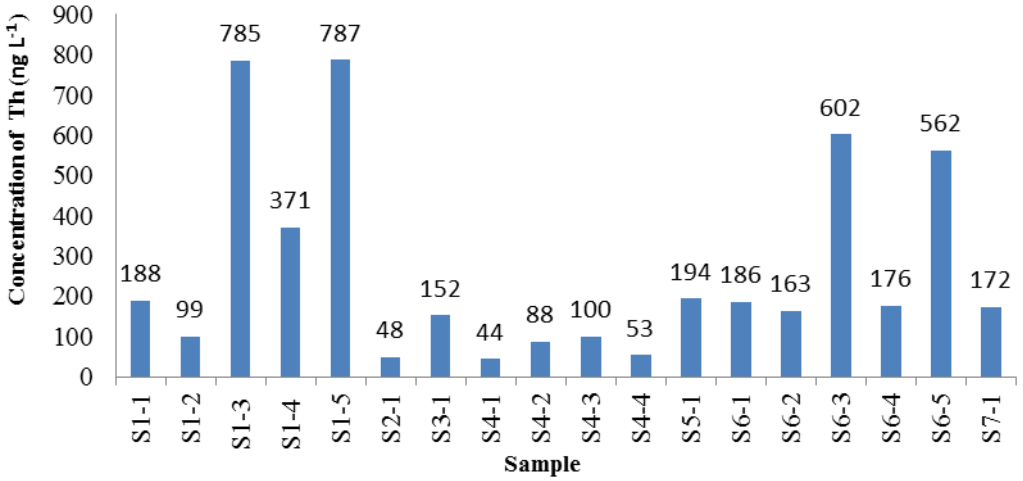

Figure 3.3: Concentration of thorium for each water sample.

Table 3 shows that sample S1-5 has the highest value in turbidity and the concentration of uranium and thorium which is 1200 NTU, 371 ng L^{-1} and 787 ng L^{-1}, respectively.

Table 2: Turbidity and the concentration of U and Th in water samples.

Sample	Turbidity (NTU)	Uranium (ng L^{-1})	Thorium (ng L^{-1})
S1-1	38	87	188
S1-2	110	62	99
S1-3	562	290	785
S1-4	64	111	371
S1-5	1200	371	787
S2-1	25	45	48
S3-1	155	86	152
S4-1	25	91	44
S4-2	90	78	88
S4-3	65	74	100
S4-4	115	47	53
S5-1	80	113	194
S6-1	155	86	186
S6-2	100	100	163
S6-3	900	282	602
S6-4	110	71	176
S6-5	947	197	562
S7-1	65	82	172
Mean	267	126	265
Mix	25	45	44
Min	1200	371	787

Figure 3.4 and 3.5 shows the correlation of the turbidity value and the concentration of U and Th of river water in Kinta District. The turbidity of river water shows a strongly relationship with the concentration of uranium and thorium. The correlation coefficients *(R)* were 0.915 and 0.881 for turbidity with concentrations of uranium and thorium, respectively. The relationship of turbidity and the concentration of uranium are higher compared to the relationship of thorium.

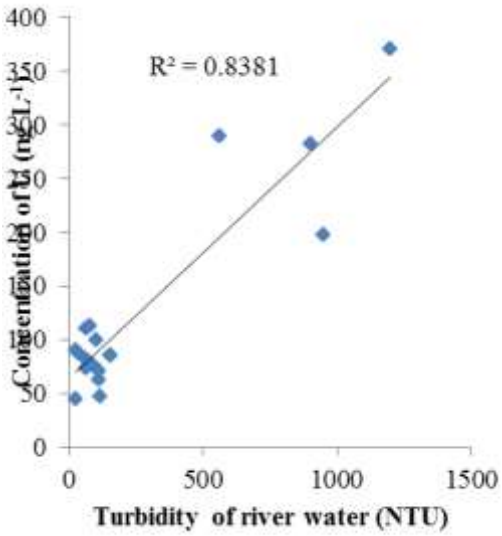

Figure 3.4: Correlation of turbidity and the concentration of U in river water.

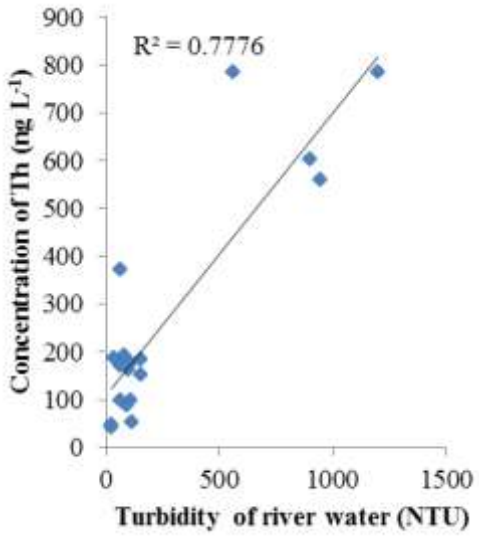

Figure 3.5: Correlation of turbidity and the concentration of Th in river water.

4.0 CONCLUSIONS

The research were measured the concentration of uranium and thorium in the Kinta River, Perak State, Malaysia. The turbidity of the samples were measured and investigated the relationship between turbidity to uranium and thorium concentrations. The mean concentration of thorium and uranium were 256 ng $L^{-1}$and 126 ng L^{-1}, respectively. A strongly correlation found to be between the concentration of uranium with turbidity was 0.915.

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