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Heavy Metals and Radionuclide Concentration In Various Part of *Ottelia alismoides* Collected From Ex-mining Area in Kampung Gajah, Perak

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Abstract This paper presents findings on the heavy metals and radionuclide concentration in various part of O*ttelia alismoides* collected from ex-mining area in Kampung Gajah, Perak. Heavy metals and radionuclides are naturally present in the environment. However, the anthropogenic activity may cause their content to accumulate in the environment. Due to this, the hyper-accumulation of radioactive in the environment may cause toxicity to human, animal lives and environment. Kampung Gajah has ex-mining area and it has been selected as the study area to investigate the uptake of heavy metals and radionuclide on specific plant. The objective of this study is to identify heavy metals and radionuclides presence in the aqua plant in the ex-tin mines lake in Kampung Gajah, Perak by selecting *Ottelia alismoides* to determine the concentrations of heavy metals and radionuclides in the various parts of this plant. The selected heavy metals and radionuclide are Na, K, Mn, As, Fe and U. Technique used for this study was Neutron Activation Analysis (NAA). Samples were collected four times, which was every three months for one year duration. The samples were dried in the oven and converted to powder. Irradiation procedure was performed by using TRIGA PUSPATI nuclear reactor at 750 kW. The procedure examined short and long irradiations before counting by using a gamma spectrometer. From the results, the concentrations of heavy metals and radionuclides were calculated.

Keywords: *Ottelia alismodes* ; Neutron Activation Analysis (NAA); ex-mine area; uptake

Introduction

Heavy metals and radionuclides are naturally present in the environment. However, the anthropogenic activity may cause them to accumulate in the environment. The mining activity is a common anthropogenic activity. In Malaysia, there are about 200 000 hectors of land area are ex-mining area which had been for 115 years of mining activity. The location of the study mostly located in Kuala Lumpur and also Perak [1, 2]. According to the Perak Tengah District Office, the land area is about 329,750 km^2 and part of it is an ex-mining area. Nowadays there is no mining activity and the lake is used by public as a place to do their recreational activity. However, the effect of the mining activity will affect the environment where the waste will be absorbed into the soils and the water source [1]. The hyper-accumulation of radioactive substance in the environment may become toxic**.** The study of bioaccumulation of heavy metals and radionuclides using plants are becoming popular recently due to plant availability and instrument capability. Due to the presence of heavy metals and radionuclide in plants, the process of concentration determination is very important especially in the fields such as agriculture, ecology, botanical exploration for minerals and environment surveys for pollutants [3]. The sources of uranium and thorium are naturally present in the environment [4] and can be found in the plants and soils. However the concentration in the soils and plant might be different based on the surrounding nature. Due to this, the concentration of the radionuclides might be lower than concentration of radionuclides in soils. Thus, the radionuclides concentration in the plants and soils may be determined and the background level of natural radioactivity can be measured. Moreover, the accumulation of these radionuclides in the food chains also can be determined.

In this work, the submerged plant *Ottelia alismoides* was chosen as the subject to identify the presence of metals and radionuclides that are accumulated. The root is submerged in the ex-mining lake, which has direct contact with the soil. Due to this, it tends to absorb the nutrients and also heavy metals and radionuclides that found in the sediments. *Ottelia alismoides* is one of the food sources for fishes inside the ex-mining lake together with plankton and algae. As roots depleting the nearby nutrients, diffusion of water and nutrients through the soil occurs. Because of this, if there are heavy metals and radionuclides present in the plant, it will be transferred to human after they are consumed even indirectly and finally interrupting the biochemical processes, which finally affects the major systems of the body, especially if the radionuclides are ingested in excess than safe level. The values given by United Nation Scientific Committee on the Effect of Atomic Radiation (UNSCEAR) for the daily ingestion of natural radionuclides in diets of population are ranging from 8-156 mBq of ^{238}U, 24 to 109 mBq of ^{226}Ra, 33 to 301 mBq of ^{210}Pb, 2 to 25 mBq of ^{232}Th and 36 to 180 mBq of ^{238}Ra [5]. The objectives of this study are to determine heavy metals and radionuclides presence in the *Ottelia alismoide,* to compare heavy metals and radionuclides concentrations in various parts of *Ottelia alismoides* and to determine the seasonal variation of radionuclides and heavy metals in *Ottelia alismoides.*

Experimental:

Collection and Processing of the Samples

In this study, the monitoring was carried out in the ex-mining areas in Kampung Gajah, Perak. The *Ottelia alismoides* was taken by using random sampling technique to determine the concentration of metals and radionuclide. The study area was at the latitude N 04º 14.525' and longitude E 101º 02.794'.

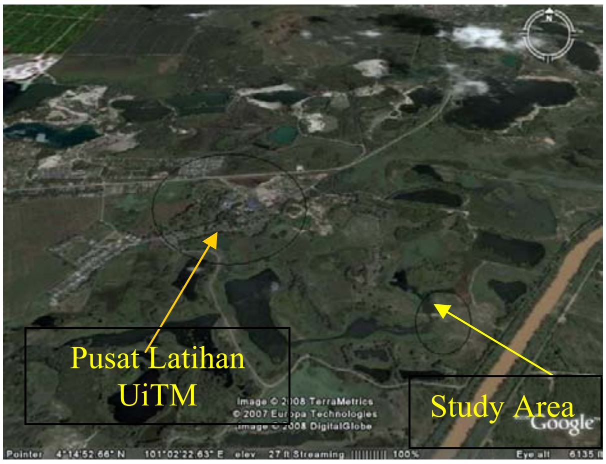


Figure 1: A bird's eye view of the sampling location

The samplings were carried out for four times in a year duration where and started on 12 September 2007. The second sampling was done at 20 November 2007, followed by 5 February 2008 and finally on 15 May 2008. After sampling, the plant was separated into 3 parts, which are roots (R), stems(S) and leaves (L). The samples for radionuclides and heavy metals determination were dried in an oven at 60ºC or less [6]. This is because the volatile compound such as mercury will be lost at the higher temperature. Then, the sample was grinded by using agate mortar set. The purpose of grinding is to reduce the size of sample from the gross size to the small size (homogeneous) which is easy to analyze. The samples were then sieved using 212 µm sieve. Then the samples were kept inside a desicator to remove the moisture content.

Method and Apparatus

The gamma radioactivity for the samples was measured by using the Instrumental Neutron Analysis method. The gamma spectroscopy by ORTEC consists of the High Purity Germinium cylindrical detector. Detector resolution (FWHM) at 1.33 MeV, ^{60}Co for this instrument was 1.84 keV.

Before identify and measurement of gamma isotope, the irradiation process was performed in the nuclear reactor TRIGA PUSPATI at 750 KW, which is available in the Malaysian Nuclear Agency at Bangi. Energies of the neutron range between 0.01 keV to 0.5 keV were used. Two types of radiation processes involved were long radiation and short radiation. For long radiation the irradiation time required was 6 hours by using Rotary Rack (RR) while for short irradiation, the time required was 30 seconds by using Pneumatic Transfer System (PTS). The decay stage is depending on the irradiation types. For short radiation the decay stage was 20 minutes while for long radiation was 3 days. However, the analysis was carried out in different irradiation periods because each element has their own activity and will detect at different photo peaks [7]. NAA is a sensitive and reliable technique because it can determine very low concentration of elements. Furthermore, NAA only requires a small sample size without any special sample pre-treatment [4, 8].The decay stage also known as cooling stage and it was carried out at room temperature.

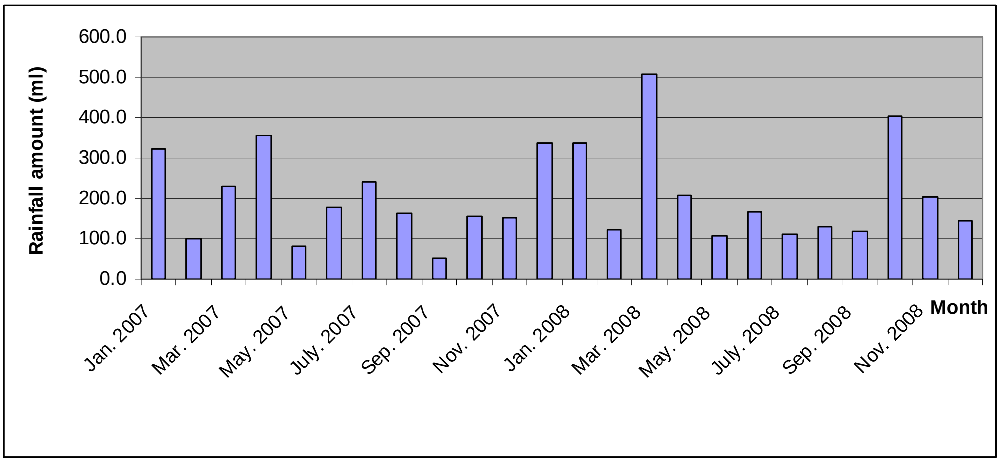
Hospital Teluk Intan meteorological station which is the nearest station to the study area was chosen to look at the amount of rainfall. Concentrations for the elements were calculated by using different method between the SRMs and samples. The Ottelia alismoides were collected and it was divided into different parts from four times sampling. The results for element concentrations in the *Ottelia alismoides* were determined.

Results and Discussion

Rainfall Amount

Table 1 shows the amount of rainfall from January 2007 until December 2008 from Hospital Teluk Intan meteorological station, which is the nearest station to the study area. According to the data, it shows the seasonal trends of the study area. The amounts of rainfall for September 2007 (51.0 ml), November 2007 (151.0 ml), February 2008 (121.0 ml) and May 2008(108.0 ml) were recorded. In general, the rainfall during November 2007 till the April 2008 can be considered as wet season because it shows the increasing amount of rainfall. The amount of rainfall on February 2008 is low but on March 2008, the rainfall was increased dramatically. On May 2008 onwards, the season can be considered as a dry season. According to the Table 1, the rainfall amount from May 2008 onwards is the dry season.

Table 1: The monthly rainfall amount at Hospital Teluk Intan, Perak.



Element Concentrations

The element presence and their concentrations will determine whether the plant is a hyperaccumulator or not. Potassium is the macronutrient that required by green plants. Higher K concentration in *Ottelia alismoides* was found in the leaves on November 2007 and Feb 2008, i.e. 12.91% and 23.94% (Table 1). This may indicate that the starch storage in the plant leaves required K.

Table 2: The metal and radionuclide present in various parts of *Ottelia alismoides* and different seasons

Sample	Concentration (ppm)					
	Na(%)	K(%)	Mn	As	Fe	U-239
1S	5.6	2.98	4.4	1.5	46.1	0.348
2S	6.83	2.63	41.9	2.82	48.4	0.401
3S	6.83	3.22	22.2	3.66	51.9	0.906
4S	5.68	1.86	44.6	2.34	66.8	0.279
MEAN	**6.2**	**2.67**	**28.275**	**2.58**	**53.3**	**0.484**
1L	0.73	3.28	51.6	0.45	63.2	0.189
2L	4.26	12.91	265.7	1.24	43.5	0.362
3L	5.3	23.94	35.9	0.75	47.6	0.226
4L	3.88	14.38	35.3	1.36	54.7	0.059
MEAN	**3.54**	**13.63**	**97.125**	**0.95**	**52.25**	**0.209**
1R	5.41	5.92	18.4	0.07	169.0	0.296
2R	5.85	5.77	17.7	0.81	85.1	0.372
3R	2.34	2.74	5.0	0.07	200.7	0.268
4R	0.99	8.19	47.3	0.66	199.3	0.885
MEAN	**3.65**	**5.66**	**22.1**	**0.41**	**163.53**	**0.455**

However, for August 2007 and May 2008, the K concentration was found in the roots which are 5.92% and 8.19% (Fig 1). Nitrogen metabolism in the soils may indicate the concentration of potassium in the roots because high concentration of potassium required for plant to activate their enzyme. The trend is related to the season during sampling.

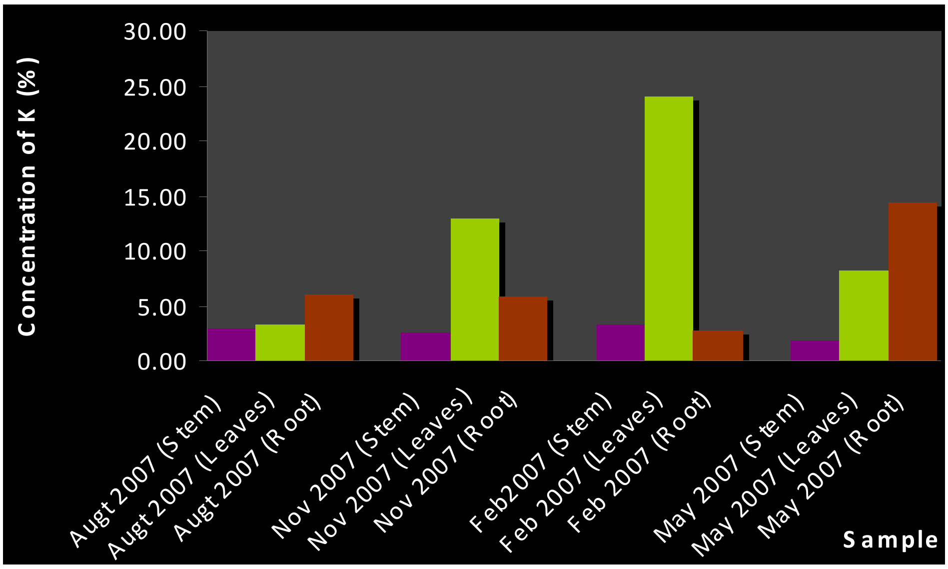


Figure 1: The concentration of K in various part of *Ottelia alismoides* in different season

According to Figure 2, the Na concentration ranged from 0.73% to 6.83%. Na shows the highest result in the leaves for every season. The Na actually required by the plant due to the ionic balance. This electrolyte helps the plant to maintaining their metabolism especially in the leaves because the bigger leaves of *Ottelia alismoides* require a high concentration of Na.

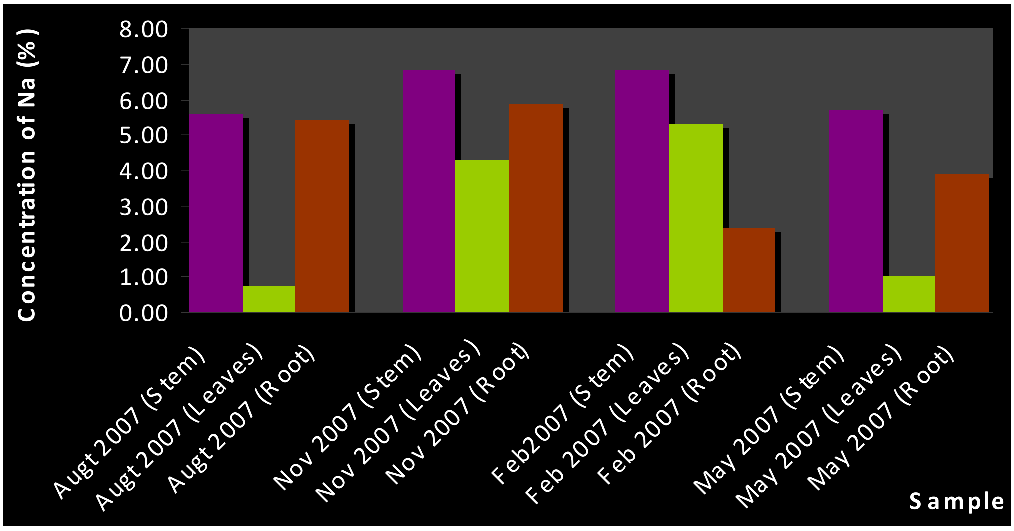


Figure 2: The concentration of Na in various part of *Ottelia alismoides* in different season

In plant metabolism, Fe is the element that involves in the redox reaction where it can be found in Fe^{2+} and Fe^{3+} forms. The mechanism takes place in the root of the plant [1, 11]. From this work, it shows that the Fe concentration (Figure 3) has similar trends in all season where the Fe in roots are high compared to others parts of the plant.

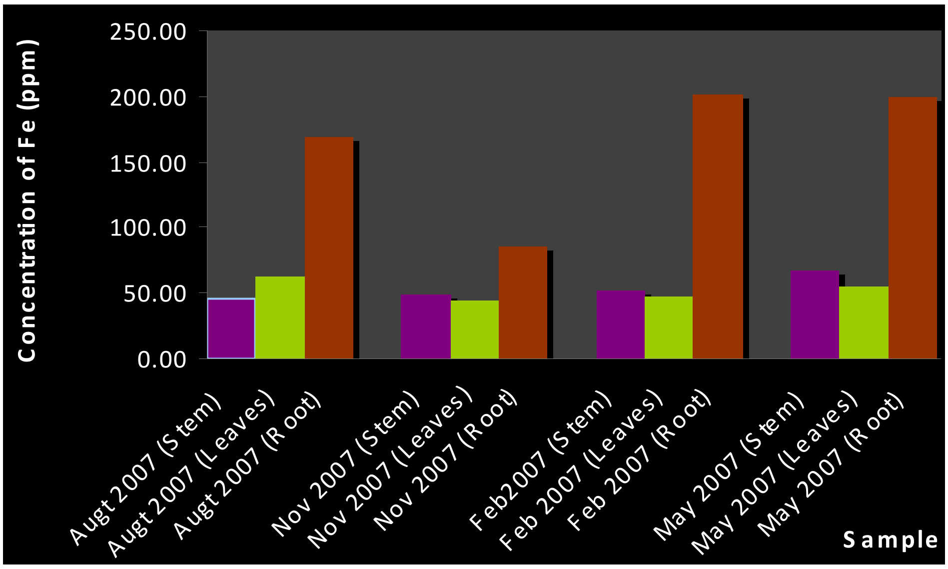


Figure 3: The concentration of Fe in various part of *Ottelia alismoides* in different season

Mn in *Ottelia alismoides* shows the range of concentration from 4.4 ppm to 265.7 ppm (Fig. 4) The highest concentration of Mn can be found in leaves for all seasons. This is because the photosynthesis process occurs in the leaves and it requires Mn to be uptake in this process [12]. Due to this, its concentration was high in the leaves rather than in the roots and stems of *Ottelia alismoides*.

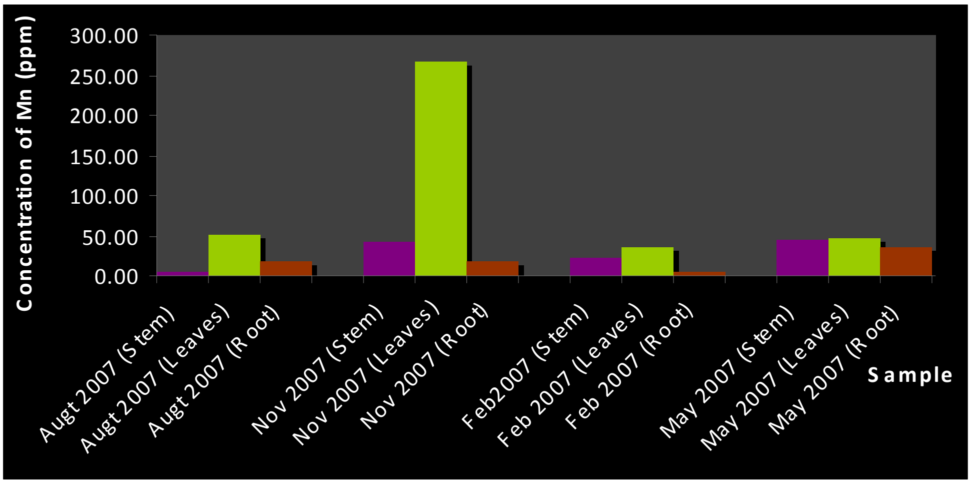


Figure 4: The concentration of Mn in various part of *Ottelia alismoides* in different season

Arsenic is a toxic element in plant. The present of As may indicate that the study area had been used as for mining previously. The range for As concentrations is from 0.07 ppm to 3.66 ppm (Fig 5). The normal concentration for As in plant is less than 1μg/g [13]. As the stem of *Ottelia alismoides* tends to growth longer it can store higher concentration of As.

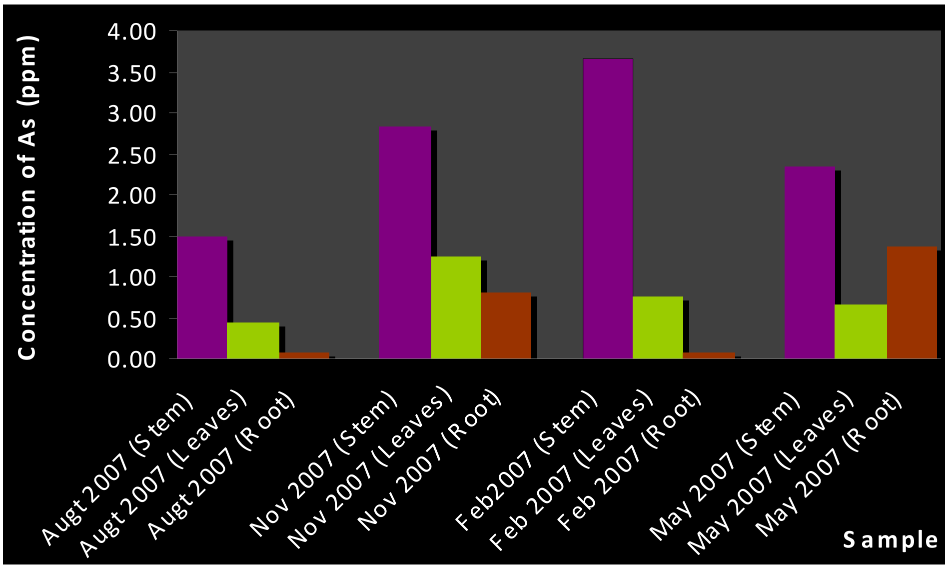


Figure 5: The concentration of As in various part of *Ottelia alismoides* in different season

According to Figure 6, the concentration range for U in the *Ottelia alismoides* is between 0.06 ppm to 0.91 ppm. Compare to other elements, the U shows very low concentration. This is because U is usually low in the plant [14]

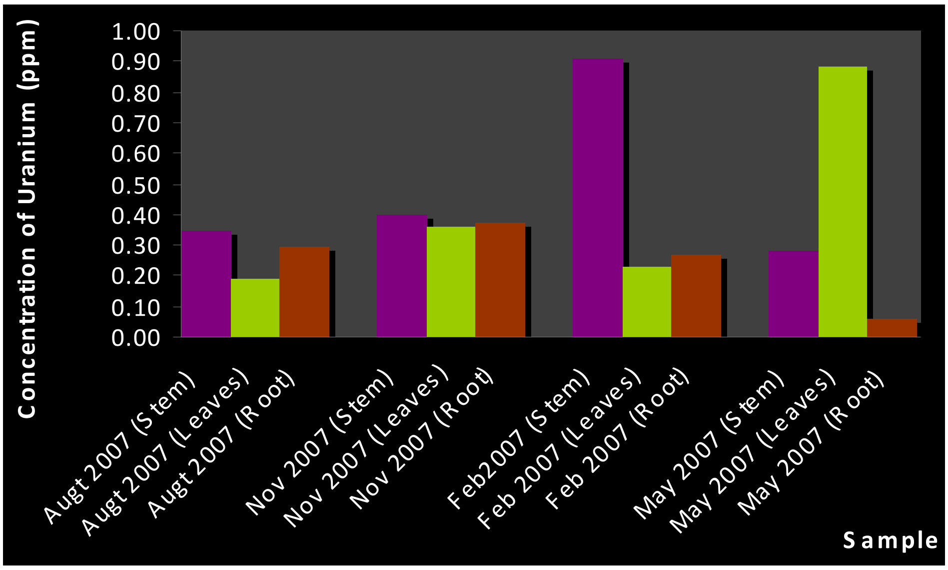


Figure 6: The concentration of U in various part of *Ottelia alismoides* in different season

Tables 2 shows the correlation between the heavy metals-heavy metals and heavy metals-radionuclides in the *Ottelia alismoides*. The strongest coefficient was observed in this plant between Fe and K (r = 0.96). The strong coefficient correlation also found in Na and As (r = 0.95) and a moderate correlation occurred between K and U in this plant (r = 0.67).

Table 2: The correlation between the heavy metals and radionuclides in *Ottelia alismoides*

	Na (%)	K (%)	Mn	As	Fe	U
Na (%)						
K (%)	-0.70					
Mn	0.10	-0.78				
As	0.95	-0.45	-0.20			
Fe	-0.87	0.96	-0.57	-0.69		
U	0.07	0.67	-0.99	0.37	0.42	

Table 3 shows the total concentration of the heavy metals and radionuclides in *Ottelia alismoides.* Total concentration of metals in the whole plant is the sum of the concentration in each part of the plant. According to the results, it shows that the highest concentration of metal elements can be found in the plant is Fe (269.08 ppm). The lowest concentration of elements present is U (1.158 ppm).

Table 3: The total concentrations of heavy metals and radionuclides in *Ottelia alismoides*

Sample	Concentration (ppm)					
	Na (%)	K (%)	Mn	As	Fe	U
L	3.54	13.63	97.13	0.95	52.25	0.209
S	6.24	2.67	28.28	2.58	53.30	0.484
R	3.65	5.66	22.10	0.41	163.53	0.455
Total	13.43	21.96	147.50	3.93	269.08	1.158

Conclusion

In conclusion, from the analysis of the data, the results showed that the concentration of heavy metals and radionuclides in plant samples can be determined by using Neutron Activation Analysis (NAA) technique. Therefore, the concentration of radionuclides is higher than standard reference value. The variation of the elemental concentrations in the *Ottelia alismoides* also observed with season.

Acknowledgments

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