Solid State Technology
Volume: 63 Issue: 2s
Publication Year: 2020

Concentration of Heavy Metal in Selected Vegetables Sold in Pasar Siti Khadijah, Kota Bharu, Kelantan, Malaysia

Aweng, E.R.[1*], Lim, J.H.[1], Arham Muchtar, A.B.[1], Sharifah Aisyah, S.O.[1], M.A. Salam[2] and Liyana, A.A.[3]

[1]Faculty of Earth Science, Universiti Malaysia Kelantan, Locked Bag No. 100, 17600 Jeli, Kelantan, Malaysia
[2]Department of Environmental Science and Disaster Management, Faculty of Science, Noakhali Science and Technology University, Noakhali-3814, Bangladesh, s_salam1978@yahoo.com
[3]Centre for Language Studies and Generic Development, Universiti Malaysia Kelantan

*Corresponding Author: Phone: +6019-9830619; E-mail: aweng@umk.edu.my

Abstract
The use of chemical fertilizer and contamination of soil and water to some extent may affect the vegetables grown by farmers throughout the country. So far, there is no structured monitoring in terms of content of pollutants, especially heavy metals in vegetables sold in markets across the country in place. Therefore, consumers are exposed to the threat of heavy metals contained in vegetables consumed daily and largely purchased at wet markets. Siti Khadijah Market is the largest wet market in Kota Bharu which sells a variety of raw materials including vegetables. These vegetables come from various places, including Cameron Highland and even imported from the neighbouring country, Thailand. Thus, to assess whether the vegetables sold at Siti Khadijah Market are safe to consume, the study was conducted. The aim of this study is to determine the concentration level of heavy metals namely aluminium (Al), cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), lead (Pb), maganese (Mn), and zinc (Zn) in vegetables sold in Pasar Siti Khadijah. There were three types of leafy vegetables namely luffa (*Luffa acutangula*), water spinach (*Ipomoea aquatica*) and spinach (*Spinacia oleracea*) and three types of fruiting vegetables namely cucumber (*Cucumis sativus*), bitter gourd (*Momordica charantia*) and beansprout (*Vigna radiata*) were sampled. Wet digestion method was used to extract the samples and tested with the Atomic Absorption Spectrophotometer (AAS). The results of the study showed that, Al and Cr were found in bitter gourd with the concentrations of 1.20 $mgkg^{-1}$ and 0.01 $mgkg^{-1}$ respectively. On the other hand, Cu was found in all the vegetables sampled with the concentrations of 0.02 $mgkg^{-1}$ in luffa, spinach and beansprout, 0.05 $mgkg^{-1}$ in bitter gourd, 0.04 $mgkg^{-1}$ in cucumber and 0.01 $mgkg^{-1}$ in water spinach. Fe was found in spinach (0.04 $mgkg^{-1}$), beansprout (0.01 $mgkg^{-1}$), bitter gourd (0.16 $mgkg^{-1}$) and cucumber (0.06 $mgkg^{-1}$). Mn was found in spinach (0.05 $mgkg^{-1}$), bitter gourd (0.06 $mgkg^{-1}$) and cucumber (0.01 $mgkg^{-1}$). Meanwhile, Zn was also found in all the vegetables sampled with the concentrations of 0.03 $mgkg^{-1}$ in luffa, 0.12 $mgkg^{-1}$ in spinach, 0.06 $mgkg^{-1}$ in beansprout, 0.22 $mgkg^{-1}$ in bitter gourd, 0.43 $mgkg^{-1}$ in cucumber and 0.02 $mgkg^{-1}$ in water spinach. Only cadmium (Cd) and lead (Pb) are absence. The concentrations of heavy metals studied in these vegetables were far below the maximum level allowed by the Malaysian Food Act (1983) and Food Regulations (1985). The results of this study would give an initial overview of the quality of the vegetables sold in Pasar Siti Khadijah, Kota Bharu, Kelantan to the authorities in follow-up and long-term planning to protect the interests of consumers.

Keywords: Siti Khadijah wet market, fresh vegetable, food safety, heavy metal, Atomic Absorption Spectrometer (AAS)

Introduction

Food safety is a scientific discipline that deals with cultivation, handling, preparation and storage of foods to avoid contamination and foodborne illness (Wallace *et al*., 2011). According to Hathaway (1999), food safety objectives (FSOs) are defined as statements based on risk analysis process which includes an expression of the level of hazard in food that is tolerable in relation to an appropriate level of consumer protection. When justified by the risk assessment, the FSO should include expression of the level of the hazard as a maximum tolerable concentration or frequency. In food safety management strategies, issues such as microbial pathogens, heavy metals, undeclared allergens, foreign material contamination and economic adulteration are concerned to prevent the product failure. Therefore, food safety violation that causes the rejection of imported foods is an important economic consideration (Carol *et al*., 2011).

It is known that in the right concentration, many metals are important to life and ecosystem to maintain the metabolism and balance (Salanki, 1992). However, an excessive amount of same metals can be poisonous (Nriagu, 1988). The main metals threats are associated with heavy metals such as lead, arsenic, cadmium and mercury (Long *et al*., 1995; Thani *et al.*, 2019;). Researchers now are more concerned about the transport and accumulation of heavy metals by air (Nriagu, 1989), water (Boening, 2000) and soil (Holmgren *et al*., 1993). A number of research that deals with the management of metal pollution by different methods has been published such as adsorption (Babel and Kurniawan, 2003; Shamsuddin, *et al.*, 2017; Sulaiman, *et al.* 2017), activated sludge (Brown and Lester, 1979), phytoextraction (Lasat, 2002), electrokinetic methods (Pamukcu and Wittle, 1992), electroosmosis (Acar *et al*., 1995) and ion exchange (Ryan *et al*., 1994).

The use of chemical fertilizer and contamination of soil and water to some extent may affect the vegetables grown by farmers throughout the country. So far, there is no structured monitoring in terms of content of pollutants, especially heavy metals in vegetables sold in markets across the country in place. Therefore, consumers are exposed to the threat of heavy metals contained in vegetables consumed daily and largely purchased at wet markets. Siti Khadijah Market is the largest wet market in Kota Bharu which sells a variety of raw materials including vegetables. Vegetables are sold here come from various places, including Cameron Highland and imported from neighbouring country, Thailand. Thus, this study was conducted in order to assess whether the vegetables sold at Siti Khadijah Market are safe to consume.

Materials and Methods

Six types of vegetables were collected randomly from Pasar Siti Khadijah, Kota Bharu, Kelantan namely luffa (*Luffa acutangula*), cucumber (*Cucumis sativus*), bitter gourd (*Momordica charantia*), beansprout (*Vigna radiata*), water spinach (*Ipomoea aquatica*) and spinach (*Spinacia oleracea*). All samples are then brought to the laboratory for further analysis. Siti Khadijah Market is a wet market that sells a variety of dried and fresh foods including vegetables. It is a major market located in the state of Kelantan. The market is located in the heart of Kota Bharu (Figure 1.0) surrounded by commercial buildings such as shopping complexes and large wholesale and retail stores such as Mydin, Pantai Timor and The Store. It is also located near Kota Bharu bus station.

Wet digestion method was used for plant (vegetable) extraction. Rotten portions of samples were removed and the edible parts were used. Vegetable samples are washed with distilled water and then dried with tissue paper and put into the oven at 70°C for 24 hours. Sample was weighted for 100 g before grounded with mortar followed by wet digestion by using HNO_3 and HCl (3:1) in a universal bottle. The samples were put into the oven for 3 hours at 70°C. The digested samples were then filtered with Whatman filter paper (110 mm) and made up to 100 ml with distilled water in volumetric flask. Atomic Absorption Spectrophotometer was used to identify the heavy metals in extracted vegetables (Rohasliney Hashim, *et al.* 2014; Mohammed Abdus Salam, *et al.* 2019). Eight heavy metals namely Al, Cd, Cr, Cu, Fe, Pb, Mn, and Zn were identified for this study.

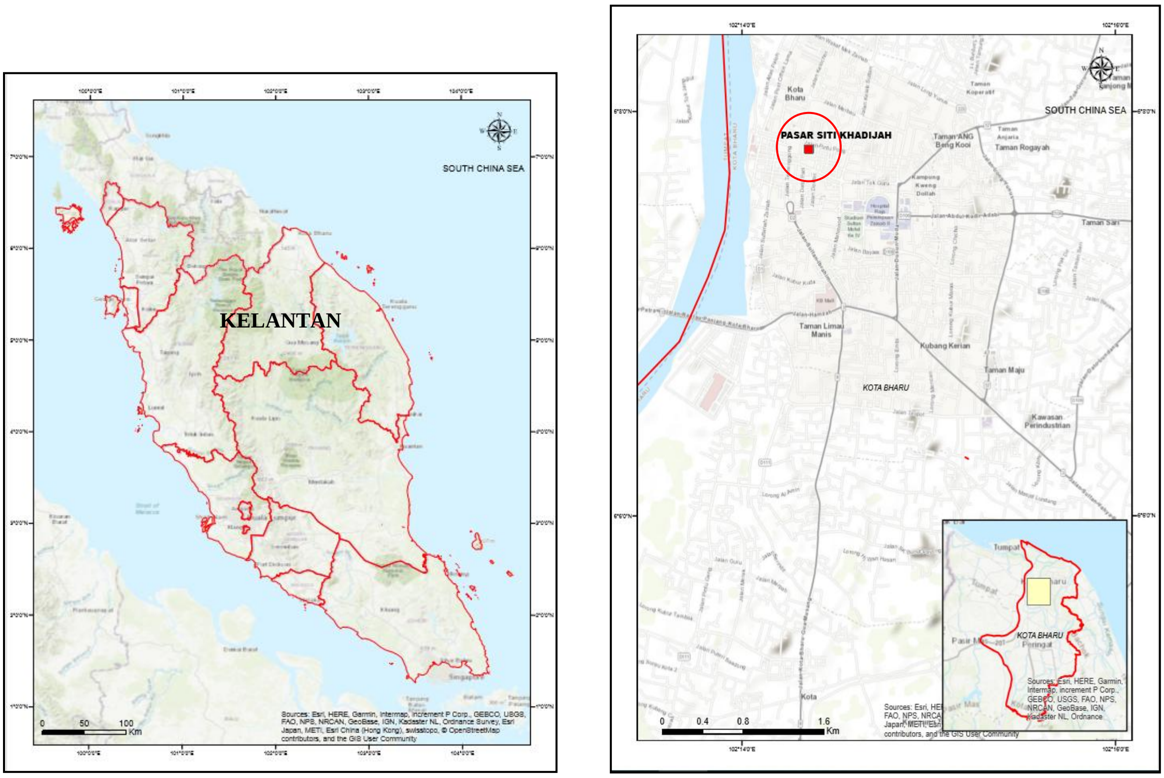

Figure 1.0: Study site

Results and Discussion

The comparison of heavy metal concentrations in selected vegetables collected from Pasar Siti Khadijah, Kota Bharu, Kelantan, Malaysia with the Malaysian Food Act (1983) and Regulations (1985) was shown in Table 1 below.

Cu and Zn were the only heavy metal elements contained in luffa with concentration of 0.02 $mgkg^{-1}$ and 0.03 $mgkg^{-1}$. Other elements such as Al, Cd, Cr, Fe, Pb and Mn were not detected. However, the concentration of Cu and Zn is far below the standard stated in the Malaysian Food Act (1983) and Regulations (1985) where the limits of Cu is 30.0 $mgkg^{-1}$ and Zn is 20.0 $mgkg^{-1}$. The concentration of Cu in this study is also much lower than the level reported by Ashita Sharma, *et al.* (2016) which is 81.33 $mgkg^{-1}$, where they study the concentration of Cu in vegetables irrigated with wastewater.

On the other hand, the heavy metal elements contained in spinach are Cu, Fe, Mn and Zn. Concentration of Zn was found to be the highest in spinach as compared to other samples which is 0.12 $mgkg^{-1}$ followed by Mn, Fe and Cu which is 0.05 $mgkg^{-1}$, 0.04 $mgkg^{-1}$ and 0.02 $mgkg^{-1}$ respectively. Other elements namely Al, Cd, Cr, Pb were not detected. The concentrations of Cu and Zn are also far below the standard stated in the Malaysian Food Act (1983) and Regulations (1985). At the same time, the concentrations of Cu, Zn, Fe and Mn were also lower as compared to the one recorded by Ismail *et al.* (2011), on the vegetables collected from Hyderabad Retail Market, where they recorded 0.50 $mgkg^{-1}$ for Cu, 22.0 $mgkg^{-1}$ for Fe, 0.12 $mgkg^{-1}$ for Zn and 0.14 $mgkg^{-1}$ for Mn. The concentration of Cu also much lower than the level reported by Ashita Sharma, *et al.* (2016) which is 81.33 $mgkg^{-1}$, where they study the concentration of Cu in vegetables irrigated with wastewater.

The heavy metal elements contained in water spinach are Cu and Zn with the concentrations of 0.01 $mgkg^{-1}$ and 0.02 $mgkg^{-1}$ respectively. Al, Cd, Cr, Fe, Pb and Mn were not detected. The concentrations of Cu and Zn are also far below the standard stated in the

Malaysian Food Act (1983) and Regulations (1985) and the level reported by Ashita Sharma, *et al.* (2016) in their study on the heavy metal contents in vegetables irrigated by wastewater.

Results show the Beansprout contained Cu, Fe and Zn with concentrations of 0.02 $mgkg^{-1}$, 0.01 $mgkg^{-1}$and 0.06 $mgkg^{-1}$. However, other elements such as Al, Cd, Cr, Pb and Mn were not detected. The concentrations of Cu and Zn are far below the standard stated in the Malaysian Food Act (1983) and Regulations (1985) and the level reported by Ashita Sharma, *et al.* (2016) in their study on the heavy metal contents in vegetables irrigated by wastewater. Heavy metal elements contained in bitter gourd are Al, Cr, Cu, Fe, Mn and Zn. Concentration of Al was found to be the highest in bitter gourd which is 1.20 $mgkg^{-1}$ followed by Zn, Fe and Mn, Cu and Cr which is 0.16 $mgkg^{-1}$, 0.06 $mgkg^{-1}$, 0.05 $mgkg^{-1}$ and 0.01 $mgkg^{-1}$ respectively. Other elements namely Cd and Pb were not detected. The concentrations of Cu and Zn are far below the standard stated in the Malaysian Food Act (1983) and Regulations (1985). At the same time, the concentrations of Cu, Zn, Fe and Mn also lower as compared to the one recorded by Ismail *et al.* (2011), on the vegetables collected from Hyderabad Retail Market, where they recorded 11.6 $mgkg^{-1}$ for Fe, 0.13 $mgkg^{-1}$ for Mn, 0.11 $mgkg^{-1}$ for Cu and 0.40 $mgkg^{-1}$ for Zn. It is also much lower than the level reported by Ashita Sharma, *et al.* (2016) in terms of Cu concentration where they detected 81.33 $mgkg^{-1}$, in vegetables irrigated with wastewater. The concentrations of Al and Cr also much lower as compared to the one recorded by Allabaksh Murad Basha *et al.*, (2014) on the vegetables collected from Andhra Pradesh, India, where they recorded 7.8 – 47.5 $mgkg^{-1}$ for Al and 1.0 – 9.7 $mgkg^{-1}$ for Cr.

The heavy metal elements contained in cucumber are Cu, Fe, Mn and Zn. Concentration of zinc was found to be highest in cucumber which is 0.43 $mgkg^{-1}$ followed by Fe, Cu and Mn which is 0.06 $mgkg^{-1}$, 0.04 $mgkg^{-1}$ and 0.01 $mgkg^{-1}$. Other elements namely Al, Cd, Cr and Pb were not detected. The concentrations of Cu and Zn are far below the standard stated in the Malaysian Food Act (1983) and Regulations (1985). At the same time, the concentrations of Cu, Fe, Mn and Zn also lower as compared to the one recorded by Ismail *et al.* (2011) on the vegetables collected from Hyderabad Retail Market, where they recorded 0.10 for Cu, 4.40 $mgkg^{-1}$ for Fe, 0.12 $mgkg^{-1}$ for Mn and 0.55 $mgkg^{-1}$ for Zn. The concentration of Cu in this study is also much lower than the level reported by Ashita Sharma, *et al.* (2016) in their study on the heavy metal contents in vegetables irrigated by wastewater which is 81.33 $mgkg^{-1}$.

The results obtained from this study shows that Cu, Fe and Zn concentration in leafy vegetables is lower as compared to fruit vegetables and Mn concentration is almost the same level with both leafy and fruit vegetables. The results of this study are contrary with the findings made by Ismail *et al*. (2011) where they found that, leafy vegetables has higher uptake of heavy metals as compared to fruit vegetables accept for Zn. It is also contradict with findings from Mohamed, *et al.* (2012) where they reported that, leafy vegetables were found to contain the highest metal values. Elbagermi, *et al.* (2012) also reported similar findings with Ismail *et al.(*2011) and Mohamed *et al.* (2012), where they found the highest mean levels of Zn was detected in spinach leafy vegetable. The existences of heavy metals in the samples were believed to be due to the high concentration of heavy metals in the irrigation water, soil and the use of fertilizer.

Table 1.0: The concentration of heavy metals of vegetables for Pasar Siti Khadijah, Kota Bharu, Kelantan Compared with the Malaysian Food Act (1983) and Regulations (1985): Fourteen Schedule.

Elements	Luffa ($mgkg^{-1}$)	Spinach ($mgkg^{-1}$)	Water spinach ($mgkg^{-1}$)	Beansprout ($mgkg^{-1}$)	Bitter gourd ($mgkg^{-1}$)	Cucumber ($mgkg^{-1}$)	Maximum permitted proportion ($mgkg^{-1}$)

Aluminium (Al)	0.00	0.00	0.00	0.00	1.20	0.00	-
Cadmium (Cd)	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Chromium (Cr)	0.00	0.00	0.00	0.00	0.01	0.00	-
Copper (Cu)	0.02	0.02	0.01	0.02	0.05	0.04	30.00
Iron (Fe)	0.00	0.04	0.00	0.01	0.16	0.06	-
Lead (Pb)	0.00	0.00	0.00	0.00	0.00	0.00	2.00
Manganese (Mn)	0.00	0.05	0.00	0.00	0.06	0.01	-
Zinc (Zn)	0.03	0.12	0.02	0.06	0.22	0.43	20.00

Conclusions

The concentration of Al, Cd, Cr, Cu, Fe, Pb, Mn and Zn in vegetables collected at Pasar Siti Khadijah, Kota Bharu, Kelantan are varied between the vegetables due to the irrigation water, fertilizer and soil factor. Six types of vegetables namely luffa *(Luffa acutangula)*, spinach *(Spinacia oleracea)*, water spinach *(Ipomoea aquatica)*, beansprout *(Vigna radiata)*, bitter gourd *(Momordica charantia)* and cucumber *(Cucumis sativus)* were analyzed and some element is present while some is not. Bitter gourd is among the six type of vegetables that contained many heavy metals such as Al, Cr, Cu, Fe, Mn and Zn. Then followed by spinach that contained four types of heavy metals which include Cu, Fe, Mn and Zn. The beansprout contained three types of heavy metals which are Cu, Fe and Zn. Luffa and water spinach are the vegetables that have the lowest amount of heavy metals as they only consist of Cu and Zn. However, the concentrations of heavy metals found in all types of vegetables tested are below the permitted level. Therefore, they are considered safe for consumption.

Acknowledgements

The authors would like to extend their greatest appreciation to Universiti Malaysia Kelantan for the approval to use the facilities at the Jeli Campus and to the Faculty of Earth Science for the kind permission to publish this article.

References

1. Ashita Sharma, Jatinder Kaur Katnoria and Avinash Kaur Nagpal, (2016). Heavy metals in vegetables: screening health risks involved in cultivation along wastewater drain and irrigating with wastewater. *Springerplus*, 5:488
2. Allabaksh Murad Basha, Nookala Yasovardhan, Suggala V. Satyanarayana, Gopireddy V. Subba Reddy and Aerattukkara Vinod Kumar, (2014). Trace metals in vegetables and fruits cultivated around the surroundings of Tummalapalle uranium mining site, Andhra Pradesh, India. *Toxicology Reports, Elsevier*, 1:505-512.
3. Acar, Y.B., Gale, R.J., Alshawabkeh, A.N, Marks, R.E., Puppala, S., Bricka, M. and Parker, R. (1995). Electrokinetic remediation – Basics and technology status. *J. Hazardous Mater*., 40: 117 – 137.
4. Babel, S. and Kurniawan, T.A. (2003). Low-cost adsorbents for heavy metals uptake from contaminated water; A review. *J. Hazardous Mater*., 97: 219 – 243.

5. Boening, D.W. (2000). Ecological effects, transport, and fate of mercury: A general review. *Chemosphere*, 40: 1335 – 1351.
6. Brown, M.J. and Lester, J.N. (1979). Metal removal in activated-sludge treatment plant. Water Res., 8: 869 – 874.
7. Carol, A.W., Sara.E.M & William H.S. (2011). *Food Safety for the 21st Century: Managing HACCP and Food Safety Throughout the Global Supply Chain* . UK: Wiley-Blackwell.
8. Hathaway, S. (1999). *Management of food safety in international trade. Food Control* (pp 247 – 253).
9. Holmgren, G.G.S., Meyer, M.W., Chaney, R.L. and Daniels, R.B. (1993). Cadmium, lead, zinc, copper and nickel in agricultural soil of the United States of America. *J. Environ. Qual*., 22: 335 – 348.
10. Ismail, F., Anjum, M.R., Mamon, A.N. and Kazi, T.G. (2011). Trace Metal Contents of Vegetables and Fruits of Hyderabad Retail Market. *Pakistan Journal of Nutrition*, 10 (4): 365-372.
11. Lasat, M.M. (2002). Phytoextraction of toxic materials: A review of biological mechanisms. *J. Environ. Qual*., 31: 109 – 120.
12. Long, E.R., Macdonald, D.D., Smith, S.L. and Calder, F.D. (1995). Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments. *Environ. Manage*., 19: 81 – 97.
13. Mohammed Abdus Salam, Shujit Chandra Paul, Farrah Izzaty Shaari, Aweng Eh Rak, Rozita binti Ahmad and Wan Rashidah Kadir, (2019). Geostatistical Distribution and Contamination Status of Heavy Metals in the sediment of Perak River, Malaysia. *Hydrology*.
14. M.A. Elbagermi, H.G.M. Edwards and A.I. Alajtal, (2012). Monitoring of Heavy Metal Content in Fruits and Vegetables Collected from Production and Market Sites in the Misurata Area of Libya. *International Scholarly Research Notices*.
15. Mohamed H.H. Ali and Khairia M. Al-Qahtami, (2012). Assessment of some heavy metals in vegetables, cereals and fruits in Saudi Arabian markets. *The Egyptian Journal of Aquatic Research*, 38(1): 31-37.
16. Malaysia Food Act, 1983 and Malaysia Food Regulation 1985. Warta Kerajaan Malaysia Vol. 29. Kuala Lumpur: Ministry of Health Malaysia.
17. Nriagu, J.O. (1988). A silent epidemic of environmental metal poisoning. *Environ. Pollut*., 50: 139 – 161.
18. Nriagu, J.O. (1989). A global assessment of natural resources of atmospheric trace metals. *Nature*, 338: 47 – 49.
19. Pamukcu, S. and Wittle, J.K. (1992). Electrokinetic removal of selected heavy-metals from soil. *Environ. Progr*., 11: 241 – 250.
20. Rohasliney Hashim, Tan Han Song, Noor Zuhartini, Md. Muslim and Tan Peck Yen, (2014). Determination of Heavy Metal Levels in Fishes from the Lower Reach of the Kelantan River, Kelantan, Malaysia. *Tropical Life Sciences Research*, 25(2):21-39
21. Ryan, J.A., Ma, Q.Y., Traina, S.J. and Logan, T.J. (1994). Effects of aqueous Al, Cd, Cu, Fe (III), Ni and Zn on Pb immobilization by hydroxyapatite. *Environ. Sci. Technol*., 28: 1219 – 1228.
22. Shamsuddin, M. S., Sulaiman, M. A., Yusoff, N., Raihan, N., Yusoff, M., & Subki, N. S. (2017). *Morphology of CuO-Doped Activated Carbon from Kenaf Core Fiber. In Solid State Phenomena* (Vol. 264, pp. 169-172). Trans Tech Publications Ltd.
23. Sulaiman, M. A., Shamsuddin, M. S., Yusoff, N., Raihan, N., Yusoff, M., & Subki, N. S. (2017). *Microstructure of CuO Assisted Activated Carbon Adsorbent from Rubber Wood Sawdust Produced by Mechanochemical Processing.* In Solid State Phenomena (Vol. 264, pp. 215-219). Trans Tech Publications Ltd.
24. Salanki, J., Lickso, I., Laszlo, F., Balogh, K.V., Varanka, I. and Mastala, Z. (1992). Changes in the concentration of heavy-metals in the Zala Minor Balaton-Zala system (Water, Sediment, Aquatic life). *Water Sci. Tech*., 25: 173 – 180.
25. Thani, N. S. M., Ghazi, R. M., Amin, M. F. M., & Hamzah, Z. (2019). Phytoremediaton Of Heavy Metals From Wastewater By Constructed Wetland Microcosm Planted With Alocasia Puber. *Jurnal Teknologi*, 81(5).
26. Wallace, C.A., Sperber, W.H. and Mortimore, S.E. (2011). *Food Safety for the 21st Century: Managing HACCP and Food Safety Throughout the Global Supply Chain*. New York: John Wiley & Sons.