THE ASSESSMENT OF LEAD CONCENTRATION IN PARTS OF PADDY PLANT AND SEDIMENT FROM SEKINCHAN, SELANGOR.

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ABSTRACT

Oryza sativa, commonly known as rice, is a highly consumed food around the world. Accumulation of heavy metals in such a widely used crop is a major concern. Hence, continuous assessments of trace metals are of high importance. This study was conducted to assess the concentration of Pb in different parts of the paddy plant, which were the roots, straw, leaves and grains, and the sediment from Sekinchan, Selangor. The methodology involved acid digestion followed by inductively coupled plasma mass spectrometry (ICP-PMS).The quality of the soil was determined by the geoacumulation index (Igeo), enrichment factor (EF) and Maximum Allowable Concentration (MAC). Translocation factor (TF) and bioconcentration factor (BCF) were used to evaluate the uptake of Pb into the plant. Also, the health risk assessment was carried out through the calculation of the average daily intake (ADI) and the hazard quotient (HQ). Overall, the quality of the soil was found to be uncontaminated by Pb and the uptake of Pb by the plant was low. The Pb concentration obtained from the samples were decreasing following sediment > roots > leaves > grains > straw. The grains were safe for consumption as the value of ADI and HQ did not show any Pb toxicity.

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LIST OF ABBREVIATIONS

AAS	Atomic Absorption Spectrophotometry
cm	centimetre
IBM SPSS	IBM Social Packages for the Social Sciences
ICP MS	Inductively Coupled Plasma Mass Spectrometry
Lead	Pb
MAC	Maximum Allowable Concentration
mm	Millimetre
mL	Millilitre
NAA	Neutron Activation Analysis
RDA	Recommended Daily Allowance
WHO	World Health Organisation
°C	Degree Celsius
µg/g dw	Microgram per gram of dry weight
$\mu g\ kg^{-1}\ day^{-1}$	Microgram per kilogram per day
$\mu g\ kg^{-1}\ week^{-1}$	Microgram per kilogram per week

CHAPTER 1

INTRODUCTION

Rice is considered to be a staple food which is consumed by more than half of the world. In many countries, it acts as a primary source of nutrients in order to fulfill the nutritional requirements of the human being. In Bangladesh for instance, children obtained 49% and women obtained 69 % of the dietary zinc through rice consumption (Arsenault et al., 2010). Moreover, rice cultivation is the origin of revenue and employment in many developing countries found in South and Southeast Asia as it is a component of their principle agricultural activity. In Malaysia, the domestic consumption of rice was of 2.75 million tons in 2016. However, rice production does not meet the high market demand. Hence, the Government of Malaysia provides several incentives in order to encourage paddy cultivation (Wahab, 2017). By 2050, the net demand of rice is expected to be over 525 million tons due to the growth in population (Abdullah et al., 2006).

Pollution through anthropogenic activities such as combustion of fuel, mining, inappropriate waste disposal and agricultural practices are the major contributors to the increase of heavy metal concentration in soil and crops (Chary et al., 2008). Accumulation of heavy metals in soil will cause an excessive intake of those pollutants in the paddy through translocation and hence, causing contamination. High concentration of heavy metals in the crop causes adverse effects such as reduction in seed germination, decreasing of leaf area and toxicity (Chibuike & Obiora, 2014). This environmental issue is global and targets several countries such as China and Japan (Cheng et al., 2006). In China, around 10 % of the land for agriculture is contaminated by heavy metals and approximately 10 million tons of grains are contaminated annually (Teng et al., 2010).

Over exposure to heavy metals leads to the impairment of cell respiration, mitosis and malfunctioning of cell enzymes in human. Additionally, the ingestion , inhalation and dermal contact of these toxic metals in a high amount can lead to the immune system to weaken hearing loss, diabetes, cardiovascular diseases and renal ,nervous and brain damage (Tchounwou et al.,2012). Several of the contaminants, such as arsenic, are even found to be probable carcinogens (Jaishankar et al., 2014). A study carried out on 1,152 residents in China revealed a positive relationship between cancer and cardiovascular diseases related mortality and long term exposure to heavy metals (Wang et al .,2010).

There are multiple risks involved in heavy metals contamination concerning the crops and population, mostly in Asian countries due to their high consumption of rice with 107 kg per capita in 2013(Milanovic & Smutka,2016). Hence, it is important to promptly evaluate the concentrations of the elements to limit the impact. In this project, the content of one heavy metal, lead (Pb), in paddy parts which are the roots, straw, leaves and grains and the sediment were studied. Additionally, the degree of contamination of the soil and the risks involved to human health when ingesting this contaminant through paddy grains were determined.

CHAPTER 2

LITTERATURE REVIEW

2.1 PADDY CROP

2.1.1 Background

Paddy crop, also known as *Oryza sativa*, is a member of the family Graminae which evolved from *Oryza rufipogon* about 14,000 years ago. There are more than 40,000 different varieties of *O.sativa* throughout the world which are classified into four major categories comprising of: *indica*, *japonica*, *aromatic* and *glutinous* (GRiSP, 2013). *Oryza sativa* is commercially grown in 112 countries across the world as it has superior yield and milling quality (Esa et al., 2016).

Generally, rice is considered to be a semiaquatic grass which grows annually. However, in some tropical countries it can last for about two years (Wiley, 2016). While taking into consideration the morphology of the rice plants it is said that the stems are hollow and round, the leaves are flat and the shoot has panicles. Also, the plant has a shallow root system whereby more than 90 % of the roots are found to be in the top 20 cm of the soil (Woperis et al., 2009).

Moreover, the paddy grain consists of multiple layers such as the husk which is made up of silica and cellulose, the thin bran layers which are the source of fiber, vitamin B complexes, protein and fat and finally, the inner part which is composed mainly of starch as shown in figure 2.1 (Esa et al., 2016).

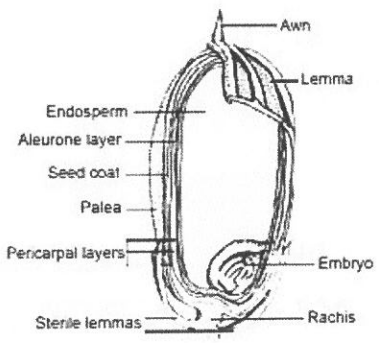

Figure 2.1: The cross section of a rice grain showing the multiple layers (Esa et al., 2016).

2.1.2 Paddy industry

Rice is a staple food in Malaysia and has statistically proven to be an industry which has promoted a stable income in the country (Fahmi et al., 2013). In 2007, rice was consumed by 27.17 million of the Peninsular and East Malaysian population (Wong et al., 2010). Moreover, the paddy industry is the main source of revenue for about 296,000 farmers with nearly 40% cultivating rice exclusively (Daño & Samonte, 2005). This industry undergoes through heavy regulation due to its economic, social and political importance (Nurul Nadia et al., 2012).

However, there are by-products from the paddy plant which are equally commonly used. Rice straw, for example, is collected during the harvest, treated in order to increase the nutritive value and used as feed for animals such as cattle and sheep (Sarnklong et al., 2010).This is the case mostly in Southeast Asian countries such as Thailand, Vietnam and Indonesia (NARC newsletter, 2004). Additionally, the rice straw can bé thermally decomposed to produce biochar which is used to improve the soil productivity, as carbon storage or as a way to filtrate draining soil water (Lehmann & Joseph, 2009). Also, a mixture of broken rice, rice germ and rice bran are used in the production of beer (Esa et al., 2016). Rice bran oil has proven to be useful as cooking oil and wax in cosmetics (Pal & Pratap, 2017).

2.2 HEAVY METALS

2.2.1 Background

Heavy metals are mostly denoted as metals having a specific density of more than $5g/cm^3$ (Järup, 2003). Traces of some of these elements such as iron, zinc, cobalt, copper and manganese are required for essential biological processes such as participating in the formation of proteins, redox processes, maintaining the ionic balance and helping in cellular division (Lane & Morel, 2000). Therefore, any deficiency will result in serious complications in human such as anemia, neutropenia, deterioration of the nervous system and Menke's syndrome. Impotence, slow growth and weakening of the immune system may also occur (Radcliffe, 2014).

However, heavy metals do exert toxic effects when taken excessively by an organism (Appenroth, 2010). When heavy metals ionize, they form charges of water soluble ions which can easily move into the cells and interact with the phosphate ion in DNA to induce damage. Also, they might cause alterations in protein-binding sites and hence preventing the latter