The Effects of Irrigation Water Containing the Lowest Water Quality Threshold of Plumbum (Pb) on Spinach (Amaranthussp)

最低鉛含量水質標準灌溉水對菠菜的影響

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ABSTRACT

This research aims to observe the concentration of the heavy metal Plumbum (Pb) absorbed by spinach (Amaranthus sp) grown in water containing Plumbum at the standard limitation of water quality (1 ppm) and the effect of this on the quality of spinach. Contamination occurs continually from the seed stage until harvesting after 40 days. The concentration of Plumbum (Pb) absorbed by spinach was measured. Furthermore, total width, length, and height of leaves as well as their growth from the first branch to the tip of leaves was measured. The mean concentration of Plumbum on spinach leaves and stems were 0.0525 ppm and 0.2771 ppm, respectively. Whereas spinach grown in uncontaminated water still had Plumbum (Pb) concentrations of 0.0373 ppm and 0.1774 ppm on their leaves and stems, respectively. From these observation, it can be concluded that spinach (Amaranthus sp) grown in irrigation water that contains the heavy metal Plumbum (Pb) at the standard limit of agriculture is safe for consumption because the content of metal Plumbum on the leaves and stems are below the standard of Investigation Agency of Food and Medicine (0.5 ppm).

Keywords: Spinach, Heavy metal, Plumbum (Pb).

摘　　要

本研究重點在於觀察生長於受鉛汙染水體之菠菜在標準水質限制(1 ppm)吸收的鉛(Pb)濃度，並探討含鉛水體對於菠菜品質的影響。鉛水體污染從種子階段開始灌溉直到40天後收成為止，接著針對菠菜吸收的鉛濃度進行量測。除此之外，亦針對菠菜的葉寬度、長度、高度以及及從植物第一分枝到植物葉子頂端的長度進行量測。結果顯示，菠菜葉子及莖部平均含鉛量為0.0525 ppm及0.2771 ppm，而種植於未受污染水體中之菠菜葉子及莖部平均含鉛量為0.0373 ppm及0.1774 ppm。據此可知，生長在灌溉水質雖受鉛污染但仍在標準範圍內之菠菜，因其葉子和莖部鉛的含量低於印尼之食品醫藥機構訂定之標準(0.5 ppm)，故仍可安全的消費。

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1. INTRODUCTION

1.1. Background

Water is the main factor contributing to sustainable agriculture. Research conducted by Amelia *et al*. (2015) demonstrates that contamination of water by the heavy metal Plumbum (Pb) influences the growth of paddy crops. A growing population increases demand for clean water both for agriculture and human needs. Based on Ministry of Agriculture No. 82/2011 concerning the Management of Water Quality and the Control of Water Pollution, there are two different standards used for Plumbum concentrations. The first is related to the water quality used when growing the crop itself (here the standard in the water is 1 ppm). The second deals with the crop where the BPOM (The Food and Drug Monitoring Agency) standard of 0.5 ppm is used. Sometimes, some of the crops have a higher ppm, >0.5 ppm, after being sprayed by irrigation water. Thus the crop is not safe for consumption due to safety concerns stemming from detrimental effects on human health.

Foods use the standard of ASUH (Aman, Sehat, Utuh, dan Halal) or (Safe, Healthy, Intact, and Kosher). One of these parameters, safe, must be included regarding food quality. The quality and safety of the food directly influences society. Crops are a source of food that contains lots of vitamins and minerals which play significant roles in improving health. Therefore, the hygienic condition of vegetables is an important aspect of this. In contrast, there are many vegetables unsafe for human consumption owing to heavy metal contamination, such as Plumbum (Pb), Cadmium (Cd), or Mercury (Hg). Kurniawansyah *et al*. (1999) stated that the presence of heavy metals in the soil causes the changes of CEC (Cation Exchange Capacity) and soil nutrient composition. Nutrients that are needed by plants become unavailable, inhibiting nutrient uptake and leading to decreased productivity. Hence, due to the lack of the crop nutrients, they are not fit for consumption by people.

This research aims to identify the amount of heavy metal Plumbum (Pb) absorbed by spinach (Amaranthus sp) when grown in water containing the heavy metal Plumbum (Pb) and examine the effects of contamination on growth. Spinach was selected as the study vegetable since it is one of the favorite vegetables in West Sumatera. This is true for several reasons, first it is a fast growing crop (~ 1 month) and can grow all throughout the year, in addition it is easy to care for and very affordable.

1.2. Objective of the research

The aim of this research is to identify the amount of the heavy metal Plumbum (Pb) spinach (Amaranthus sp) absorbs after growing in water which contains heavy metal Plumbum (Pb) at the water quality safety threshold set for agricultural activities.

1.3. Benefit of the research

The benefits of the research are; (1) to find out how much Plumbum (Pb) is absorbed by spinach when the water quality threshold of irrigation is at the safety threshold, and (2) to identify the influence of spraying water containing 1 ppm of heavy metal Plumbum (Pb) and the influence various parameters have, such as the amount of leaves, the width of leaves, the length of leaves, the height of stem to the first branch, and the height of stem to the tip of the leaves.

2. METHOD OF THE RESEARCH

This research was conducted from April until May 2011. This research was done in three steps; preparation, implementation, and measurement.

2.1. Preparation

Media used were polybags containing only soil. There were 8 polybags that had a diameter of 20 cm and a height of 35 cm. They were given different codes, including A, B, C, D, E, F, G, and H.

2.2. Implementation

This step included the following activities;

1. Growing Spinach Seeds

As many as 10 spinach seeds were spread out in each of the polybag. 5 of 10 spinach plants were selected as samples.

2. Preparation of water

Irrigation water with a Plumbum (Pb) concentration of 1 ppm was prepared.

3. Growing the spinach (Amaranthus sp)

Spinach was grown from seeds planted in contaminated water and harvested on the 40^{th} day.

2.3. Measurement of heavy Plumbum (Pb) absorbed by spinach

Measurement of the amount of heavy metal Plumbum (Pb) absorbed by spinach leaves and stems (Amaranthus sp) was done 40 days after planting in the Water Laboratory of Environmental Engineering, Faculty of Engineering, Andalas University, Padang.

2.4. Analysis of the Data

Data taken from measurements of Plumbum (Pb) absorbed by spinach (Amaranthus sp) was compared to the policy of BPOM regarding the content of Plumbum (Pb) allowed for crops (0.5 ppm). They were also compared to the amount of heavy metal Plumbum (Pb) in the crops grown in uncontaminated water. The amount of Plumbum (Pb) in the leaves and stems, the width of leaves, the length of leaves, and the height of stem from the first branch to the tips of leaves was also measured.

3. RESULT AND DISCUSSION

3.1. The content of heavy metal Plumbum (Pb) on spinach (Amaranthussp)

In this sub-topic, we will compare the amount of Plumbum on spinach leaves of two treatments – the pure water treatment and the 1ppm Plumbum water treatment. The result of these two different treatments showed that the content of Plumbum on spinach leaves was below the standard permitted by BPOM for both groups (Table 1). It shows that that the content of Plumbum (Pb) on the leaves sprayed with water that contains Plumbum (Pb) was 0.0525 ppm, or (10.5%) of the safe concentration limit. It is higher than that of heavy metal Plumbum (Pb) on the leaves of spinach without Plumbum (Pb), 0.0373 ppm (7.46%) but still below the standard of BPOM of 0.5 ppm. This means that the concentration is still safe to consume since it falls below the standard assigned by BPOM.

When the measurement is carried out using the content of Plumbum (Pb) on spinach stems, the concentration is still below the standard of BPOM. The content of Plumbum (Pb) on the stems of spinach that was grown without Plumbum (Pb) was 0.1774 (35.48%) ppm. Meanwhile, stems sprayed with Plumbum (Pb) had a concentration of 0.2771 ppm, which is equal to 55.42% of the standard set by BPOM. While this is higher than the content of Plumbum (Pb) on the stems of spinach without Plumbum (Pb) (0.1774 ppm), it is still within the safe limit. Plumbum concentrations in stems are

Table 1. The Concentration of Plumbum (Pb) on the leaves of spinach

Sample of Leaves	The content of Plumbum (Pb) in the sample (ppm)	Standard of BPOM in the crop (ppm)	Percentage*
Water without metal Plumbum (Pb)	0.0373	0.5	7. 46%
Water that contains metal Plumbum (Pb) 1 ppm	0.0525	0.5	10.5%

*Content of Plumbum is divided with the standard of BPOM.

higher than in leaves, regardless of whether it is grown in water with or without Plumbum (Pb). In both tests the leaf and the stem are still below the standard of BPOM – 0.5 ppm.

Table 1 and 2 show that the threshold in the crop (0.5) is still below the standard. It means that these two plant parts remain safe for consumption regardless of treatment. Similar to the discussion of (Kohar, *et al.*: 2005) which stated that kale sprayed by Plumbum (Pb) at a concentration of 2 ppm when the crop has grown for 3 weeks was still safe to eat since the content of Plumbum in the root and other parts of the plant are not taken into BPOM consideration.

3.2. The effect of heavy metal Plumbum (Pb) on the growth of spinach (Amaranthus sp)

In general, no damage occurred to the plants but the growth of spinach grown in water containing 1 ppm Plumbum (Pb) was slower than that grown in uncontaminated water. The growth of spinach on 40th day can be seen in Table 3.

From Table 3 we can see that spinach crop irrigated without heavy metal Plumbum (Pb) had an average number of 9 leaves, 4.1 cm leaf width, 4.8 cm leaf length, 11.6 cm ground to first branch length, and 17.9 cm total length (to the tip of the highest leave). In contrast, spinach irrigated with Plumbum (Pb) contaminated water had an average of 8 leaves, 3.1 cm leaf width, 3.8 cm leaf length, 6.4 cm ground to first stem length and a 13 cm total length (to the tip of the highest leave). This difference is presumably to do with the content of Plumbum (Pb) in the crop, which in turn affects growth. Luncang (2005) showed that heavy metal at high concentrations are responsible for major damages to crops such as chlorosis, color change, necrosis, and crop failure. Morphologically, heavy metals affect chemical reactions, biochemistry, physiology, and the structure of the crop.

4. CONCLUSION

From the results of the research, the following can be concluded:

1. The mean concentration of Plumbum (Pb) spinach leaves and stems found in plants grown in water with a 1 ppm concentration of Plumbum (Pb) on the 40th day of growth were 0.0525 ppm and 0.2771 ppm, respectively. Meanwhile, the concentration for spinach grown in uncontaminated water were 0.0373 ppm and 0.1774 ppm, respectively.
2. The use of irrigation water that contains 1 ppm of Plumbum (Pb) for spinach crop is still safe to consume on the 40th day. This indicates that

Table 2. The Concentration of Plumbum (Pb) on Spinach Stems on the 40th day of growth

Sample of Stem	The content of Plumbum (Pb) in the stem (ppm)	Standard of BPOM in the crop (ppm)	Percentage*
Water without metal Plumbum (Pb)	0.1774	0.5	35.48%
Water that contains metal Plumbum (Pb) 1 ppm	0.2771	0.5	55.42%

* Content of Plumbum is divided with the standard of BPOM.

Table 3. The Growth of Spinach on day 40th

Treatment	Amount of leaves	Width of leaves (cm)	Length of leaves (cm)	The pole until the first branch of leaves (cm)	The pole until the tip of leaves (cm)
Without Metal Plumbum (Pb)	9	4.1	4.8	11.6	17.9
With Metal Plumbum (Pb)	8	3.1	3.8	6.4	13.0

Pb contaminated irrigation water can be used to grow spinach if the Plumbum (Pb) concentration is lower than the 1 ppm limit set by the Ministry of Agriculture. This is true since at this irrigation concentration, uptake of Pb is still lower than the 0.5 ppm safety standard set by BPOM.

3. There is no significant difference between plants grown in water containing Plumbum (Pb) versus those that were not. The proportion of Pb residue remaining on the leaves and stems as a percentage of total allowable, as stipulated by BPOM, are similar, being 10.5% and 55.42% for Pb treatment, whereas the treatment without Pb still contained 7.46% and 35.48%, respectively.
4. This research shows that not all contaminated water is dangerous for crop irrigation. In the case of Pb, as long as contaminant concentrations are below safety standards, the resultant crops contain safe heavy metal Plumbum (Pb) levels.

ACKNOWLEDGEMENT

The researchers express many thanks to the Rector of Andalas University through the Institute for Research and Perpetuation for funding this research so that it could be completed well.

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Received: 105/06/14

Revised: 105/09/08

Accepted: 105/10/03