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Lead Content in The Soil and Leaves of Vegetables Cultivated near The Main Road in Tarus and Oesao, West Timor, Indonesia

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Abstract: Vegetables cultivated near the main road are suspected to be contaminated with heavy metals such as lead. The purposes of this research was to study the effect of distance from road and locality on lead content in soil and leafy vegetables grown in arable lands (near the main road), and to study the relationship between the lead content in the vegetables leaves with the lead content in soil, pH, total organic matter (TOM), cation exchange capacity (CEC) in Tarus and Oesao areas, and to compare the lead content in the vegetables with the National Standard (SNI 01-7387-2009) of lead in vegetables. Twenty four soil samples and 24 vegetable samples (swamp cabbage, *Ipomoea reptana* and mustard green, *Brassica rapa var. parachinensis*) were collected two sites: left and right of road; three distance from road: 1 m, 3 m, and 5 m; two replications; and two localities: Oesao and Tarus. Lead was extracted with standardized method and detected by AAS. Results showed that: (1) distance from road and locality did not significantly affected single factor of distance and locality but not by the interaction of both factors; (3) there was a weak relationship between lead in vegetables and soil factors such as lead in soil, pH, organic matter content, and CEC; (4) overall, lead contents in both soil (44.06 mg kg^{-1}) and vegetables (26.85 mg kg^{-1}) were indicated to be higher than the National Standard of lead in plant and soil (0.5 mg kg^{-1} and 10 mg kg^{-1}, respectively).

Keywords: lead, vegetable, soil, pH, TOM, CEC.

INTRODUCTION

Heavy metal is a metal with a density of five or more, with atomic number 22 to 92. Heavy metal is a term used for transition elements that have an atomic mass greater than 5g/cm^3. Mercury (Hg), lead (Pb), copper (Cu), cadmium (Cd) and strontium (Sr) are examples of heavy metals in the form of contaminants that come from outside the soil and are very concerned because they are closely related to human health, agriculture and their ecotoxicology [1].

One of the pollutants that is an indicator to detect soil pollution is heavy metal contamination in it. Factors that cause heavy metals to be included in the pollutant group are due to the properties of heavy metals that are not biodegradable (non-degradable) and easily absorbed. One heavy metal that can potentially be toxic if it is in the soil with excessive concentration is lead. The Lead element is a group of heavy metals that are not essential for plants, and can even interfere with the nutrient cycle in the soil. It is still considered as a pollutant that can cause soil and environmental pollution [2].

Cases of heavy metal poisoning from foodstuffs are increasing. Today, raw and mature food products are exposed to heavy metals in quite a number and levels that are quite alarming, especially in areas where the level of pollution by motor vehicle exhaust fumes has reached very high levels and excessive use of pesticides in vegetables and fruits. Vegetables planted on the side of the road are at risk of being exposed to high heavy metals such as lead (Pb), copper (Cu), mercury (Hg), cadmium (Cd), and zinc (Zn) in all parts of the plant i.e. the roots, stems, leaves and fruits [3].

Vegetables as one of the main staple food commodities, because these vegetables have been contaminated with heavy metals, by consuming these vegetables, humans can be exposed to heavy metals such as lead and copper [3]. Based on the provisions of the National Standardization Agency, the maximum national standard limit (SNI 01-7387-2009) on vegetables and soil is 0.5 ppm and soil samples are 10 ppm [4].

Vegetables grown in areas that are located near heavy traffic roads can be exposed to lead metal because the smoke of motorized vehicles contains lead metal. Lead produced from burning gasoline affects the accumulation of heavy metals in soil and vegetables in agricultural areas near highways. The heavy metal content of lead in cassava and cabbage vegetables in vegetable gardens on Medan Main Road was 2,229 mg/kg and 1,895 mg/kg respectively [5]. The lead content in kale vegetables obtained from the market in the Tabanan area was 2.54 mg/kg. The content of lead in vegetables from Bedugul area on carrot vegetables is 13.7218 mg/kg, then on celery at 11.9941 mg/kg, on cucumber at 10.9319 mg/kg, in tomatoes as big as 8.7988 mg/kg, in potatoes of 3.2160 mg/kg and in cabbage vegetables, namely 1.4912 mg/kg [6]. The results of the study of content have exceeded the maximum limit of lead contamination in vegetables which is 0.5 mg/kg [7].

Plants can absorb lead during fertility conditions, low organic matter content and CEC. In this state the lead will be released from the soil bond and in the form of ions that move freely in the soil solution. If other metals are not able to inhibit their existence, absorption will occur by plant roots. Lead is mostly accumulated by plant organs, namely leaves, stems, roots and root roots. The transfer of lead from soil to plants depends on the composition and pH of the soil, as well as the CEC (Cation Exchange Capability). Plants can absorb lead when conditions of soil fertility, organic matter content, and low soil CEC. High lead concentration (100-1000 mg / kg) will result in toxic effects on photosynthesis and growth. Lead only affects plants if their concentration is high [6].

Location and distance also influence the lead content on soil and vegetables. The lead emitted with motor vehicle exhaust fumes causes air pollution and can pollute plants planted near the roadside. The previous study showed that papaya fruits in different distance from the roadside significanty different in lead levels. There is an increase in lead levels followed by the distance closer to the roadside [8].

If dangerous heavy metals have accumulated with high levels on agricultural land, there will be a decrease in soil quality and soil contamination. One example of dangerous heavy metals in agricultural land that will be studied for heavy metal content is lead on agricultural land in the Tarus and Oesao regions. Agricultural land managed by communities in the Tarus and Oesao areas is rice fields and vegetable crops located right along the highway. Some of the agricultural areas of Tarus and Oesao are on the side of the Kupang to Atambua main road laden with motorized vehicles. Hazardous waste substances released by motor vehicles are lead and other chemicals. Therefore, researchers will analyze lead on agricultural land in the Tarus and Oesao areas to find out whether soil and vegetables in the area are contaminated or not.

The purpose of this research is 1) to know the influence of distance and location and interaction on lead content in soil and vegetables; 2) to know the relationship between lead in soil, soil pH, organic matter content and cation exchange capacity (CEC) with lead in vegetable content; 3) compare the levels of soil and lead in vegetable in the Tarus and Oesao regions with National Standards (SNI 01-7387-2009).

MATERIALS AND METHODS

This research was conducted on agricultural land in the Tarus and Oesao regions of Kupang Regency, East Nusa Tenggara Province. The research was carried out in September 2014 to October 2014.

Materials and Equipment

The materials used in this study are soil, vegetable, swamp cabbage land and mustard greens. The tools used for soil and vegetable sampling are Hand augers, knives and spoons, plastic, buckets, water proof markers, information sheets. Laboratory equipment used in the study of the content of lead in soil and vegetables (ground spinach and mustard greens) are analytical balance, destructive tools, dispensers, test tubes, centrifuge tubes, AAS (Atomic Absorption Spectrophotometry).

Sampling Procedure

Sampling for both types of vegetables, namely land spinach and mustard greens ready to be harvested was carried out in four locations, namely two locations in Tarus and two locations in Oesao. Samples were taken on the left and right segments along the Tarus and Oesao roads with a sampling distance of 1 meter, 3 meters and 5 meters from the edge of the body. At each location (locations 1 to 4) six soil samples and six vegetable samples were taken.

Samples of vegetables washed thoroughly with distilled water. Then cut into small pieces, and then the sample is dried in an oven at a temperature of 600^{0}C for 24 hours or up to a constant weight. Samples that have dried are then blended into powder.

Carefully weighed as much as 1 gram of vegetable samples that have become powder and put into a 100 ml beaker glass. Added 10 ml of concentrated HNO3 mixture with HCl with a ratio of 3: 1, then authenticated with an ultrasonic bath for 45 minutes at 60^{0}C. The sonication results were then heated on a hotplate for 45 minutes at 1400^{0}C, cooled, and filtered. The digestion results are then made into 50 ml and then taken 10 ml and diluted to a volume of 50 ml. This filtrate is then measured with an Atomic Absorption Spectrophotometer [9].

A calibration curve is made by plotting the concentration vs. absorbance of the standard solution that has been made, then a linear line is drawn which shows the relationship between absorbance and the concentration of the standard solution. The absorbance solution is measured at λ 217.0 nm for lead [9].

Analysis of Lead

Extract solution from vegetable samples was measured with AAS with a gap width of 1 nm for lead. Determination of lead concentration in the sample is carried out using a calibration curve technique in the form of a linear line so that the metal concentration of the measured absorbance can be determined. The actual concentration of metals in the sample can be determined by calculation:

$$M = \frac{c.V.f}{b}$$

Where:
M = Concentration of lead in the sample (mg/kg)
c = Concentration based on absorbance value (mg/l)
V = Volume of solution from sample destruction (ml)
b = Dilution factor
f = Weight of the sample that is distrusted (g)

Analysis of Statistic

The analysis used is multiple linear regression test. The general formula used is as follows [10]:

$$Y = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + e$$

Where:
Y = Dependent Variable (Plant Lead Content)
X = Independent Variable (Lead in soil content, soil pH, Organic Material Content, and CEC).
b0 = Intercept
b1, b2, b3, b4 = Regression Coefficient

The significant level used was 95% with α = 0.05. To get the results of calculations based on the formula above, the author uses a computer system with the help of SPSS Software. Two way Anova was used to determine the effect of distance and location on lead content of soil and vegetable in the Tarus and Oesao regions. The level of significance (α) chosen was 0.05 (5%).

RESULTS AND DISCUSSION

Effect of Distance and Location and Interaction on Lead Content in Soil and Vegetables

Lead Content in Soil

Determination of the influence of distance and location on the lead content in soil, 3 (three) points are taken, namely at a distance of 1 (one) meter, 3 (three) meters and 5 (five) meters. The difference in distance was taken differently to determine the effect of each location on the lead content in soil.

Based on the calculation results in the ANOVA lead soil table, it can be said that the taking of soil samples based on location was not significantly different on the lead content in soil and taking soil samples based on distance too. So there was no interaction between distance and location on the lead content in soil.

Distance and location do not affect the lead content in soil because the sampling points are close together that is a distance of 1 meter, 3 meters and 5 meters. There is also the influence of wind speed factors in the Tarus and Oesao regions that make the location and distance do not affect the lead in soil content. When viewed from the traffic density, the volume of motorized vehicles passing through the Tarus and Oesao areas is quite dense so the lead content in soil and vegetables is quite high. There were no significant differences in results at locations 1 to 5 meters in the Tarus and Oesao.

The accumulation of lead is often found on the edge of the highway, namely the plants and soil that surround it. Traffic density will affect the lead content in the soil and vegetation along the roadside [11]. The closer the distance of a location to the highway, the higher the lead content. The lead content in the soil decreases along with the distance from the road and the deeper the soil. But in the study in the Tarus and Oesao areas, the sampling distance was close enough so that the distribution of lead content in soil and vegetables was only at a distance of 1 to 5 meters from the highway.

Lead Content in Vegetable

Determination of the effect of distance and location on the lead content of plants, 3 (three) points were taken, namely at a distance of 1 (one) meter, 3 (three) meters and 5 (five) meters. The goal is also the same as lead in soil which is to determine the effect of each distance and location on the lead content of the plant.

Based on the results of the ANOVA lead in vegetable calculation, it showed that vegetable sampling based on location influences the content of lead in vegetable and the sampling of vegetables based on distance also influences the lead content of vegetables while the interaction table shows that there is no effect of interaction between distance and location on content of lead in vegetable.

Location and distance influence the lead content of vegetables because bioaccumulation of lead on leaves in plants will occur more in roadside plants that are densely packed with motorized vehicles. Motor vehicles generally use premium gasoline added lead in the form of tetraethyl lead and tetramethyl lead. This addition of lead increases the octane number, so that the burn point drops so that gasoline is more flammable. However, in the 98% combustion process the lead contained in it will be released and cause pollution [12].

Plants can be mediators of the spread of heavy metals in other living things. Plants absorb heavy metals through roots, stems and leaves (stomata). Tea plants planted on the edge of the highway proved to contain high lead [13]. Location and distance also have an influence on the lead in vegetable, because usually agricultural and plantation yields are higher when compared to locations far from the highway. This illustrates that potential lead pollution comes from motorized vehicles. Lead pollution is a major problem for the poor in urban areas, soil and dust around the highway in general have been contaminated by leaded gasoline for years. According to the official specifications of the Directorate General of Oil and Gas, the maximum content of lead in the permitted fuel is 0.45 grams per liter. Meanwhile, according to international standards, the maximum threshold for lead content is 0.15 grams per liter.

The relationship between lead in soil, soil pH, total organic matter and cation exchange capacity (CEC) with the content of lead in vegetable

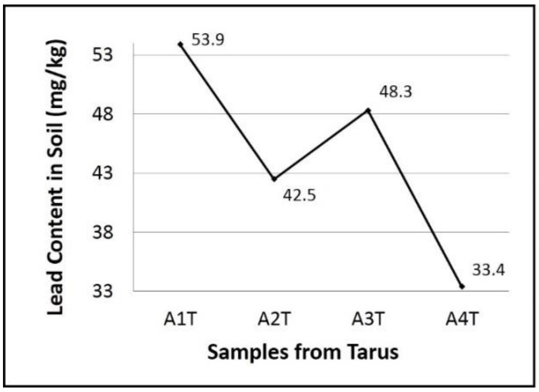
Based on lead in soil data, soil pH, total organic matter, and cation exchange capacity (CEC) on lead in vegetable obtained a relationship in the form of a regression equation that can be formulated as follows: Y = 81.107 - 0.186 X1 - 9.589 X2 - 1.582 X3 + 0.738 X4 + e, with the R2 value being 0.069. Because R2 is too small so that the regression model cannot be used as a predictor model of the relationship between lead in vegetable with lead in soil, soil pH, total organic matter, and cation exchange capacity (CEC), meaning that lead levels cannot be predicted using lead in soil, soil pH, organic material content, and cation exchange capacity (CEC).

Y=Lead Vegetable, X1=Lead in soil, X2=Soil pH, X3=Organic Material and X4=Cation Exchange Capacity.

Comparison of Lead Levels in Soil and Vegetable with National Standards (SNI 01-7387-2009)

Based on the provisions of the Food and Drug Supervisory Agency (BPOM) and the National Standardization Agency (BSN) in 2009, the limit of lead metal contamination in food, especially fruits and vegetables is 0.5 ppm [4]. The maximum national standard limit (SNI 01-7387-2009) on vegetables and soil are 0.5 ppm and 10 ppm soil, respectively.

Distribution of lead content on the soil at each location. Based on the results of laboratory analysis, the content of lead on the soil at the location of 1 (one) and 2 (two) in Tarus and the location of 3 (three) and 4 (four) in Oesao has exceeded the maximum limit of lead contamination on the soil (Figures 1, 2 and 3). The maximum national standard limit (SNI 01-7387-2009) on soil is 10 ppm. Based on the graph above, it can be seen that the results of the highest lead content on the soil lie at the E3T point of 58.1 mg / kg. The average lead content in the Tarus and Oesao regions is 44.06 mg / kg. Lead content spreads evenly at each point and lead soil content. The results of the analysis of lead content on the soil are relatively different. These results also show that the soil in Tarus and Oesao has been contaminated with lead.



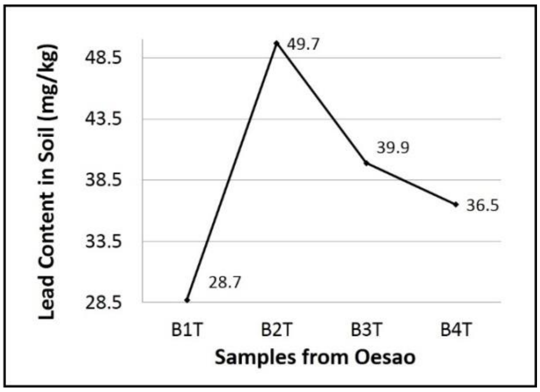


Fig1: Graphic of Lead Content in Soil (1 m from the Highway)

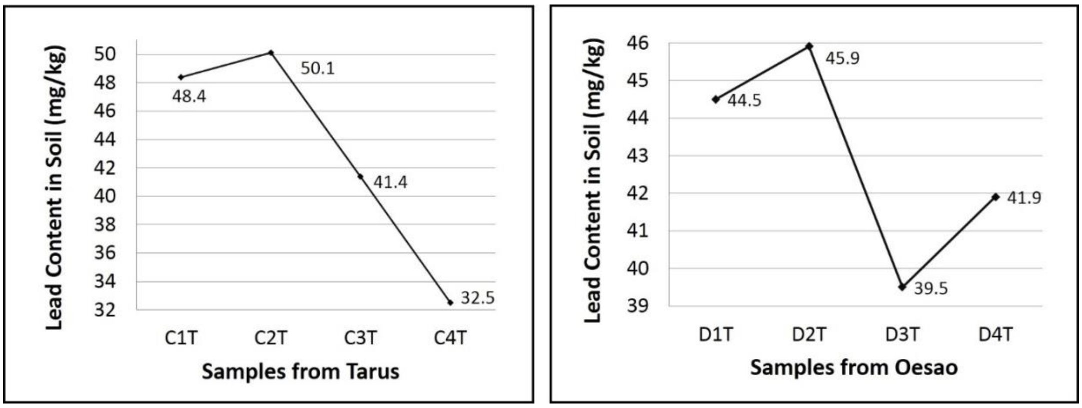


Fig-2: Graphic of Lead Content in Soil (3 m from the Highway)

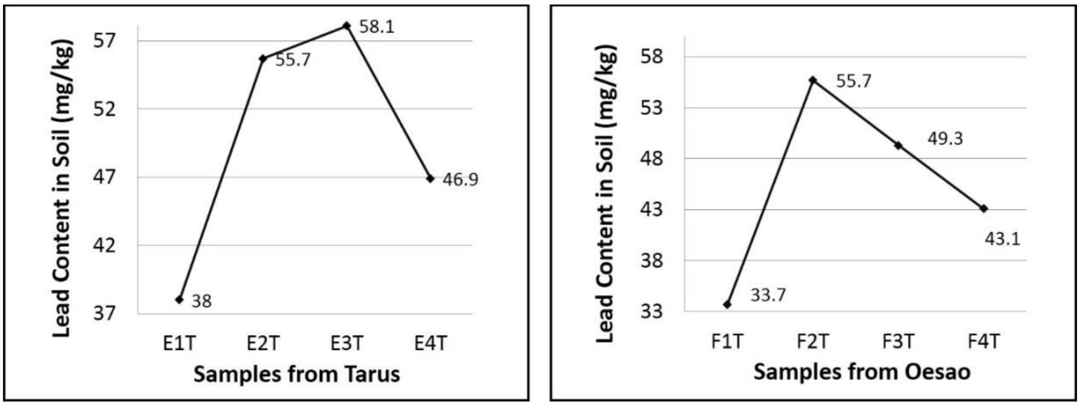


Fig-3: Graphic of Lead Content in Soil (5 m from the Highway)

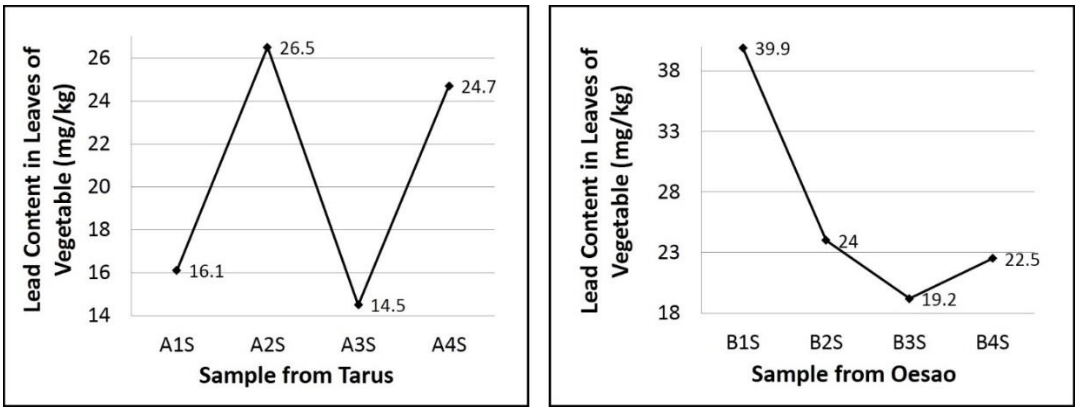


Fig-4: Graphic of Lead Content in Leaves of Vegetables (1 m from the Highway)

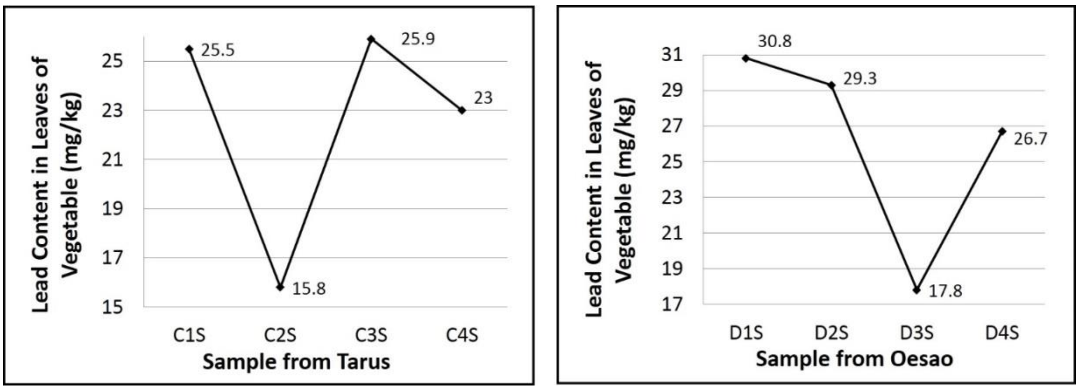


Fig-5: Graphic of Lead Content in Leaves of Vegetables (3 m from the Highway)

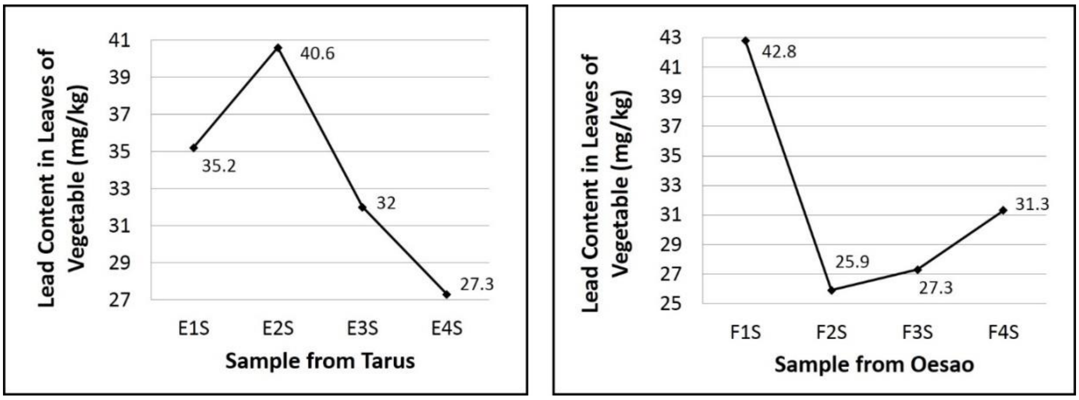


Fig-6: Graphic of Lead Content in Leaves of Vegetables (5 m from the Highway)

In Figures 5, 6 and 7 can be seen the distribution of lead content in vegetables at each location. Based on the results of laboratory analysis, the content of lead in vegetables at the location of 1 (one) and 2 (two) in Tarus and the location of 3 (three) and 4 (four) in Oesao has exceeded the maximum limit of lead heavy metal contamination in vegetables. This result shows that lead content in ground spinach (Ipomoea reptana) and mustard greens (Brassica rapa var. Parachinensis) along the Tarus and Oesao highways has exceeded the lead content threshold in vegetables and fruits set by National Standard. The maximum national standard limit (SNI 01-7387-2009) on vegetables is 0.5 ppm, while the safe limit permitted by the Directorate General of Drug and Food (BPOM) Control is 2 ppm.

Based on the graph above, it can be seen that the results of the research on the highest lead content in vegetables is at the point of F1S of 42.8 mg / kg. The average content of lead in vegetable in the Tarus and Oesao areas is 26.85 mg / kg. The lead content spreads evenly at each point and the content of lead in vegetable. These results also show that vegetables in Tarus and Oesao are already contaminated with lead. The type of food that contains high lead contaminants is vegetables grown on the edge of the highway [14]. The average content is 28.78 ppm.

Fertilizers used by farmers for vegetable fertilization along the Tarus and Oesao highways are phosphate and nitrate and some other fertilizers. The possibility of lead spread evenly on soil and vegetables comes from motor vehicle exhaust emissions but can also come from various types of fertilizers used by farmers, because inorganic fertilizers (phosphate and nitrate groups) contain lead 7-225 mg / kg and 2-27 mg / kg respectively. If the fertilizer is used continuously with high doses and intensity, it can increase the Pb and Cd available in the soil, thus increasing the uptake of Pb and Cd by plants [6].

The study on tomato plants (Solanum lycopersicum L) planted on the edge of the Aur Birugo Tigo Baleh Bukittinggi sub-district highway stated that the lead metal content in fruit samples (A1, A2 and A3) was 1.0725 mg / kg ; 0.9977 mg / kg; 0.5848 mg / kg and in leaf samples (B1, B2 and B3) is 0.1983 mg / kg; 0,1361 mg / kg; 0.1370 mg / Kg and in soil samples (C1, C2 and C3) are 2.6719 mg / kg; 3,1039 mg / kg; 2,1904 mg / kg. The content of lead contamination in tomato samples has passed the threshold, which is 1.0725 mg / kg at a spacing of 3.5 meters from the edge of the highway in Aur Birugo Tigo Baleh Bukittinggi Subdistrict, while the threshold value for tomatoes according to the Decree of the Director General of the Agency Drug and Food Control No. 03725/B/S/VII/89 concerning the Maximum Limit of Metal Contamination in Food is 1 mg/kg [15].

The amount of lead metal contained in each sample comes from motor vehicle exhaust gases that will fly into the air, some will stick to vegetable plants that are on the side of the highway and partly by the presence of wind and rain will cause the dust to fall to the ground and Highway. Lead compounds attached to plants will eventually be adsorbed into the leaves, while those that fall to the soil will be absorbed by the plant through the roots and will be distributed throughout the plant. Plants easily absorb heavy metals from the soil and transport them to shoots (meristem tissues), thus achieving human nutrition through the food chain [16]. The lead compound from the combustion of motor vehicle fuel will partially form particulates and be absorbed by plants that grow on the roadside. Lead compounds released into the air as aerosols, by the presence of wind and rain can fall to the ground. Therefore, the soil can also experience lead contamination from gasoline [17].

The consumption of vegetables as a source of food for humans can cause the transfer of heavy metals contained in these vegetables such as lead into the body of other living beings. Heavy metals that enter the human body will interact with enzymes, proteins, DNA and other metabolisms. The presence of excessive amounts of heavy metals in the body will adversely affect the body. In the human body metal lead can be compounds with active enzymes to be inactive, so that the synthesis of human blood (Hb) granules can be inhibited, as a result can cause anemia [3].

CONCLUSION

Based on the results of the study and discussion, some conclusions can be drawn as follows: First, lead levels in soil and vegetables in the Tarus and Oesao regions have exceeded the maximum limit of lead contamination on soil and vegetables determined by national standards (SNI 01-7387-2009). The average lead content in soil is 44.06 mg/kg, while the average lead content in vegetables is 26.85 mg / kg. Second, the location and distance do not give effect to the lead content in soil and there is no effect of interaction between location and distance on the lead content in soil. Third, the location and distance have an influence on the content of lead in vegetable, but there is no effect of interaction between location and distance on the content of lead in vegetable and the fourth, there is no relationship between the content of lead in vegetables with lead in soil, soil pH, organic matter content, CEC.

The suggestions given are as follows: First, Land and ground spinach vegetable (Ipomoea reptana) and mustard greens (Brassica rapa var. Parachinensis) in the Tarus and Oesao areas have been contaminated with lead, therefore it is recommended that people not consume vegetables planted along the road in the Tarus and Oesao areas. Second, there is a need for risk analysis and risk management. Third, in the next study sampling soil and vegetables with a distance that is not too close together. Fourth, deeper study of other heavy metals in soil and vegetables in the Tarus and Oesao regions.

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REFERENCES

1. Darmono. Logam dalam Sistem Biologi Makhluk Hidup. UI Press. Jakarta,1995;122-136.
2. Juhaeti T, Sharif F and Hidayati N. Inventarisasi Tumbuhan Potensial untuk Fitoremediasi. *Jurnal Biodiversitas*. 2004; 6 (1): 31-33
3. Widaningrum, Miskiyah, and Suismono; Bahaya dan Kontaminasi Logam Berat dalam Sayuran dan Alternatif Pencegahan Cemarannya. Buletin Teknologi Pasca Panen Pertanian. 2007; 8: 112-120.
4. Indonesia SN. Batas maksimum cemaran logam berat dalam pangan. SNI. 2009;7387(2009):29.
5. Ayu CC. Mempelajari Kadar Mineral dan Logam Berat pada Komoditi Sayuran Segar di Beberapa Pasar di Bogor. Skripsi. Fakultas Teknologi Pertanian. IPB. Bogor. 2002.
6. Charlena. Pencemaran Logam Berat Timbal (Pb) dan Cadmium (Cd) pada Sayur-sayuran. Falsafah Sains. Program Pascasarjana S3 IPB. 2004; 6-23.
7. Dewi KP, Saeni MS. Tingkat Pencemaran Logam Berat (Hg, Pb, dan Cd) di Dalam Sayuran, Air Minum dan Rambut di Denpasar, Gianyar dan Tabanan.
8. Liana BW. Pengaruh Jarak Tanam Pohon pada Perkebunan dari Pinggir Jalan Terhadap Kadar Timbal dalam Buah Pepaya (Carica Papaya L.). *Skripsi.* Universitas Sanata Dharma. Yogyakarta, 2011; 34-41.
9. Siaka M, Owens CM, Birch GF. Evaluation of some digestion methods for the determination of heavy metals in sediment samples by flame-AAS. Analytical letters. 1998 Feb 1;31(4):703-18.
10. Walpole ER. Pengantar Statistika. Gramedia Pustaka Utama. Jakarta. 1997; 98-128.
11. Ormrod DP. Impact of trace element pollution on plants. Air pollution and plant life/edited by Michael Treshow. 1984.
12. Sastrawijaya AT. Pencemaran Lingkungan. Penerbit Rineka Cipta. Jakarta, 1996; 134-233.
13. Arisanti DO. Penyerapan Pb, Cd dan Zn pada Pucuk Daun dan Kulit Batang Tanaman Teh. *Skripsi*. Jurusan Kimia FMIPA IPB. Bogor, 1997; 37-52.
14. Winarno FG, Pangan Gizi, Teknologi dan Konsumen Jakarta: Gramedia Pustaka Utama, 1993; 48-67.
15. Sanra Y, Hanifah TA, Bali S. Analisis Kandungan Logam Timbal pada Tanaman Tomat (Solanum lycopersicum L.) yang ditanam di Pinggir Jalan raya Kecamatan Aur Birugo Tigo Baleh Bukittinggi. Jurnal Online Mahasiswa Fakultas Matematika dan Ilmu Pengetahuan Alam Universitas Riau. 2014 Dec 30;2(1):136-44.
16. Drazic G, Mihailovic N. Modification of cadmium toxicity in soybean seedlings by salicylic acid. Plant science. 2005 Feb 1;168(2):511-7.
17. Palar H. Pencemaran dan toksikologi logam berat. Jakarta: Rineka Cipta. 1994 Dec;148.