Human Health Risk Assessment Related with Heavy Metals Contamination in Rice: A Case Study in Palembang, South Sumatra, Indonesia

Miss Dian Islamiati

A Thesis Submitted in Partial Fulfillment of the Requirements
for the Degree of Master of Public Health in Public Health
COLLEGE OF PUBLIC HEALTH SCIENCES
Chulalongkorn University
Academic Year 2022

การประเมินความเสี่ยงผลกระทบต่อสุขภาพ
จากโลหะหนักปนเปื้อนในข้าว: กรณีศึกษาในเมืองพาเล็มบัง สุมาตราใต้
ประเทศอินโดนีเซีย

น.ส.ไดแอน อิสลามเมียติ

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาสาธาร
ณสุขศาสตรมหาบัณฑิต
สาขาวิชาสาธารณสุขศาสตร์ ไม่สังกัดภาควิชา/เทียบเท่า
วิทยาลัยวิทยาศาสตร์สาธารณสุข จุฬาลงกรณ์มหาวิทยาลัย
ปีการศึกษา 2565

Thesis Title	Human Health Risk Assessment Related with Heavy Metals Contamination in Rice: A Case Study in Palembang, South Sumatra, Indonesia
By	Miss Dian Islamiati
Field of Study	Public Health
Thesis Advisor	Assistant Professor Pokkate Wongsasuluk, Ph.D.
Thesis Co Advisor	Professor Mark G. Robson, Ph.D.

Accepted by the COLLEGE OF PUBLIC HEALTH SCIENCES, Chulalongkorn University in Partial Fulfillment of the Requirement for the Master of Public Health

.... Dean of the COLLEGE OF PUBLIC HEALTH SCIENCES
(Professor CHITLADA AREESANTICHAI, Ph.D.)

THESIS COMMITTEE

.... Chairman
(Associate Professor WATTASIT SIRIWONG, Ph.D.)

.... Thesis Advisor
(Assistant Professor Pokkate Wongsasuluk, Ph.D.)

.... Thesis Co-Advisor
(Professor Mark G. Robson, Ph.D.)

.... External Examiner
(Professor Ratana Somrongthong, Ph.D.)

ไดแอน อิสลามเมียติ : การประเมินความเสี่ยงผลกระทบต่อสุขภาพ จากโลหะหนักปนเปื้อนในข้าว: กรณีศึกษาในเมืองพาเล็มบัง สุมาตราใต้ ประเทศอินโดนีเซีย. (Human Health Risk Assessment Related with Heavy Metals Contamination in Rice: A Case Study in Palembang, South Sumatra, Indonesia) อ.ที่ปรึกษาหลัก : ปกเกศ วงศาสุลักษณ์, อ.ที่ปรึกษาร่วม : Mark G. Robson

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ปัญหาโลหะหนักปนเอนในสิ่งแวดล้อม ยังคงเป็นหนึ่งในปัญหาสิ่งแวดล้อมทั่วโลก รวมถึงในประเทศอินโดนีเซียด้วย หนึ่งในปัญหาการปนเปื้อนที่พบนี้ คือการปนเปื้อนใยผลิตผลทางการเกษตร เช่น ข้าว การปนเปื้อนของโลหะหนักในข้าว อาจก่อให้เกิดปัญหาสุขภาพต่างๆต่อผู้บริโภคได้ การศึกษานี้ มีวัตถุประสงค์ ดังนี้ 1) เพื่อหาความเข้มข้นของโลหะหนัก ในข้าวพื้นเมืองของชาวอินโดนีเซีย 2) เพื่อหาความเสี่ยงที่ไม่ใช่มะเร็ง จากการบริโภคข้าวที่ปนเปื้อนของโลหะหนัก 3) เพื่อหาความเสี่ยงในการเกิดมะเร็งที่เกี่ยวข้องกับการบริโภคข้าวปนเปื้อนโลหะหนัก 4) เพื่อหาความสัมพันธ์ระหว่างปัจจัยเสี่ยง ที่เกี่ยวข้องกับการปนเปื้อนของโลหะหนักในข้าว การเก็บตัวอย่างนั้น จะเก็บตัวอย่างข้าวพื้นเมือง จากตลาดท้องถิ่นที่ใหญ่ที่สุด 3 แห่งในเมืองปาเล็มบัง ประเทศอินโดนีเซีย รวมทั้งสิ้น 6 ตัวอย่าง ตัวอย่างละ 100 กรัม โดยศึกษาข้าว 2 พันธุ์ ได้แก่ ข้าวพันธุ์ Pandan Wangi และพันธุ์ Pulen เพื่อความเข้มข้นของ As, Cd, Pb และ Cu ปนเปื้อนในข้าว ด้วย ICP นอกจากนี้ ยังมีการเก็บข้อมูลประชากรผู้บริโภคข้าว โดยใช้แบบสอบถามออนไลน์ ผลการศึกษาพบว่าความเข้มข้นของโลหะหนักทุกชนิด ต่ำกว่ามาตรฐานความปลอดภัยของอาหาร อย่างไรก็ตามจากการประเมินความเสี่ยงต่อสุขภาพ พบว่า ข้าวทั้งสองชนิดมีความเสี่ยงต่อการก่อโรคที่ไม่ใช่มะเร็ง เนื่องจากอัตราการบริโภคข้าวที่สูง สำหรับข้าว Pandan Wangi มีค่า HI เฉลี่ยอยู่ที่ 1.38+0.70 (ในช่วง 0.16 ถึง 3.93) และ 1.53+0.78 (ในช่วง 0.18 ถึง 4.36) สำหรับข้าว Pulen ในทำนองเดียวกันสำหรับความเสี่ยงของการก่อมะเร็ง สำหรับข้าวพันธุ์ Pandan Wangi มีค่า TCR เฉลี่ยอยู่ที่ 3.10 x 10^{-3}+1.5 x 10^{-3} (อยู่ในช่วง 3.79 x 10-4 ถึง 8.80 x 10-3) และ 2.76 x 10^{-3}+1.5 x 10^{-3} (อยู่ในช่วง 3.38 x 10^{-4} ถึง 7.84 x 10^{-3}) สำหรับข้าว Pulen นอกจากนี้ ผลการศึกษาด้วยไคสแควร์ พบว่า ปัจจัยที่เกี่ยวข้องอย่างมีนัยสำคัญต่อความเสี่ยงต่อการเกิดโรค ได้แก่ อายุ ค่าดัชนีมวลกาย แหล่งน้ำดื่ม และแหล่งน้ำสำหรับปรุงอาหาร ($p<0.05$) จากผลการศึกษาที่กล่าวมานี้

สาขาวิชา	สาธารณสุขศาสตร์	ลายมือชื่อนิสิต ....
ปีการศึกษา	2565	ลายมือชื่อ อ.ที่ปรึกษาหลัก ....
		ลายมือชื่อ อ.ที่ปรึกษาร่วม ....

6474503653 : MAJOR PUBLIC HEALTH

KEYWORD: Heavy metals, Rice, Risk assessments, contamination, Indonesia

Dian Islamiati : Human Health Risk Assessment Related with Heavy Metals Contamination in Rice: A Case Study in Palembang, South Sumatra, Indonesia. Advisor: Asst. Prof. Pokkate Wongsasuluk, Ph.D. Co-advisor: Prof. Mark G. Robson, Ph.D.

-Heavy metal pollution is still one of the environmental problems globally, including Indonesia. One of these contaminations comes from agricultural products such as rice. Heavy metal contamination in rice is known to cause various health problems. This study aimed (1) To find Heavy metals concentration in Indonesian local rice (2) To find Non-cancer risk related to heavy metals contaminations in rice (3) To find cancer risk related to heavy metals contaminations in rice (4) To find association between associated factors with risk related to heavy metals contaminations in rice. The rice was collected from the 3 biggest local markets in Palembang, Indonesia. The total sample of rice was 6 samples with 2 types of rice, namely Pandan Wangi rice and Pulen rice. Rice was collected 100 grams per sample and then figured out the concentrations of As, Cd, Pb, and Cu by the ICP analysis. In addition, respondent data was obtained using an online questionnaire. The results of this study indicated that the concentrations of all heavy metals were lower than safety standard for food. However, the health risk assessment showed Non-cancer risk for both types of rice according to the high consumption rate. The average HI was 1.38+0.70 (ranged 0.16 to 3.93) for Pandan Wangi rice, and 1.53+0.78 (ranged 0.18 to 4.36) for Pulen rice. Similarly for cancer risk, the average TCR was 3.10×10^{-3}+1.5×10^{-3} (ranged 3.79×10^{-4} to 8.80×10^{-3}) for Pandan Wangi rice, and 2.76×10^{-3}+1.5×10^{-3} (ranged 3.38×10^{-4} to 7.84×10^{-3}) for Pulen rice. For the Chi-square results, the significant associated factors of health risk were age, BMI, source of drinking water, and source of water for cooking ($p<0.05$). Risk prevention must be carried out to reduce potential risks that may occur in the future by decrease the consumption rate. Moreover, minimizing the use of pesticides and chemical fertilizers can be an effort to reduce contamination in the paddy fields also agricultural products.

Field of Study:	Public Health	Student's Signature ....
Academic Year:	2022	Advisor's Signature ....
		Co-advisor's Signature ....

ACKNOWLEDGEMENTS

I would like to thank God, for letting me through all the difficulties. I have experienced your guidance day by day. You are the one who let me finish my degree. I will keep on trusting you for my future.

I would like to acknowledge and give my warmest thanks to my advisor Assistant Professor Pokkate Wongsasuluk, Ph.D. who made this work possible. Her guidance and advice carried me through all the stages of writing my thesis. I would also like to thank my co-advisor Professor Mark G. Robson, Ph.D., my chairman Associate Professor Wattasit Siriwong Ph.D. and my external examiner, Professor Ratana Somrongthong, Ph.D. for letting my defense be an enjoyable moment, and for your brilliant comments and suggestions, thanks to you. I am really grateful to have all of you on my journey not only as my lecturer but also to make me feel like home.

I would also like to give special thanks to my family especially my mother as a whole for their continuous support and understanding when undertaking my research and writing my thesis. Your prayer for me was what sustained me. I would like to say thank you also for my friend for their support.

The authors thankfully acknowledge the support of Chulalongkorn University to let me pursue my dream in this prestigious campus. I would like to say thank you for the chance and scholarships. Also to the College of Public Health Sciences, where I learn so many things and gain wonderful experiences as a student. Last but not least, I want to say thank you to Central Laboratory Thailand, and the Health Laboratory Center of Palembang for their invaluable support in terms of scientific facilities and equipment.

Finally, the authors want say thank you to my self for always do well even yesterday, today and tomorrow.

Dian Islamiati

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Chapter 1

Introduction

This chapter will present 9 sub-chapters including background, research questions, research objectives, research hypothesis, scope of study, conceptual framework, operational definition, research ethics and research expected outcomes. The following are the details of these nine sub-chapters.

1.1 Background and Rational

This sub-chapter presents background information which consists of 5 parts, including heavy metals contamination in the environment, health effects from heavy metals exposure, heavy metals in agricultural area, contamination in paddy field and rice grains and rice in Indonesia. Following are the details of each section above.

1.1.1 Heavy Metals Contamination in Environment

Heavy metals are metalloids and metals group which has relatively high density and are toxic. Heavy metal contamination is one of the problems that still occurs worldwide. Heavy metals can be sourced directly from the environment or human activities. Arsenic can be find in soil, water, and food (FDA, 2013). Arsenic contamination, one of which is also found in drinking water, has a negative impact on human health (Bhattacharya et al., 2001). Besides arsenic, cadmium is also a dangerous heavy metal sourced from fossil fuels, press and steel generation, cement nonferrous metals generation, squander incineration, smoking, fertilizers, etc. (EFSA, 2009). In addition, heavy metals are sourced from work-related activities such as lead from leaded gasoline, mechanical forms such as refining of lead and its combustion, ceramics, pontoon building, lead-based portray, lead-containing channels, battery reusing, lattices, arms industry, shades, the printing of books, etc. (Wani et al., 2015). In addition, heavy metal contamination can be sourced from the use of pesticides and has an impact on agricultural products. Heavy metal contamination in this environment will give potential for human health who are exposed to high exposure concentrations, exposure frequency and long periods of time.

1.1.2 Health Effects from Heavy Metals Exposure

Contamination of Heavy Metals can affect humans through oral, dermal, and respiratory routes. Contaminants in food, especially rice have been found. Although the amount of concentration found is small, the level of toxicity is high (Bunsen, 1994). This will be directly proportional if the consumption of rice per day is high, especially for people in Indonesia who consume 200-350 grams of rice per day (BPS, 2017). Exposure to heavy metals in humans certainly have an impact on health. Heavy metals can cause cancer disease which is Indoensia is in 8th place of incidence rate of cancer in Southest Asia. Heavy metals exposure causes health effects depending on the amount of exposure dose and the part where the heavy metal is bound in the body (Widowati et al., 2008). Heavy metals that enter through the oral route will be absorbed by each target organ and cause health problems both in the short and long term. Some heavy metals are also not needed by the body and will accumulate in the blood, hair, and urine.

1.1.3 Heavy Metals in Agricultural area

Heavy metal contamination in agricultural area can come from the use of pesticides in the agricultural process. The pesticides use fall on the leaves and fall to the ground. Plants absorb the nutritional and contaminant elements of the soil through the roots. This causes agricultural products to be contaminated with heavy metals (Sharma et al., 2018, SHARMA et al., 2019, Alengebawy et al., 2021). Besides pesticides use, heavy metals contamination come from fertilizer use and natural condition. Chemical fertilizer use and PH of soil has correlation of the availability of some heavy metals (Wei et al., 2020, Kim et al., 2015, Zhang et al., 2018). Some study was found contamination of heavy metals in agricultural product. It was found some heavy metals such as cadmium, iron, arsenic, lead, copper and mercury was contaminated agricultural product. In Argentina, it knows that there was arsenic contamination in potato (Sigrist et al., 2016). In addition, heavy metal contamination such as lead, cadmium and arsenic contamination was found in cabbage, ackee, bananas, melons, beans and spinach (Antoine et al., 2017).

1.1.4 Contamination in Paddy Field and Rice Grain

Heavy metal contamination is also found in other agricultural products such as rice. It was found that rice was contaminated with heavy metals such as arsenic, lead, cadmium, copper, copper, and iron. In a study in Argentina, arsenic content was found in rice (Sigrist et al., 2016). Another study in China also found arsenic contaminations in rice (Chen et al., 2014). Apart from arsenic, other heavy metals were also found in rice. Research in Indonesia found cadmium, copper, and iron contaminate rice (Taghi, 2021, Rasydy et al., 2021). Heavy metals contamination is known have risk in human by consume the rice in certain amount and period of time. In a previous study in Bangladesh, it was known that there was a Non-cancer risk and a Cancer risk from consuming rice that was exposed to the heavy metal arsenic (Harine et al., 2021). Research in Indonesia shows that consumption of various types of rice such as brown rice, brown rice, white rice and sticky rice is known to indicate a Cancer risk (Saraswati, 2018, Ginting, 2018).

1.1.5 Rice in Indonesia

Palembang is one of the cities in Indonesia, which is known to make rice as a staple food consumed every day in large quantities. The consumption of the amount of rice that rice can pose a health risk in the community in Palembang. It is also exacerbated by the findings of heavy metal contamination in rice in other studies both in Indonesia and in other countries. Many studies that analyze concentration of heavy metals in rice have been found, but research has only been carried out until the analysis of the heavy metal concentration in rice. It was not in-depth until the risk calculation was carried out. Research that calculates the risk due to consumption of rice containing heavy metals is limited in Indonesia, even though rice is the staple food of Indonesian people. People in the city of Palembang generally consume white rice with two varieties which are generally available in the local market in Palembang. The two varieties that are easy to find are fragrant pandan rice and Pulen rice (IR 64).

This study aim to assess the health risk due to consumption of rice contaminated with large amounts of heavy metals in the community in the city of Palembang. Through the calculation of this risk amount, it can be one step for risk control so that rice consumption does not pose a health risk of cancer and non-cancer in humans, especially the people in Palembang.

1.2 Research Questions

The research questions in this study consisted of three questions, including the following:

1. Is there heavy metals contamination in rice in Palembang, Indonesia?
2. What are heavy metals find in rice in Palembang?
3. Is there any cancer risk related to heavy metals contaminations in rice?
4. Is there any non-cancer risk related to heavy metals contaminations in rice?
5. Is there any association between associated factors with risk related to heavy metals contaminations in rice?

1.3 Research Objectives

The main objective is to find human health risk assessment related to heavy metals contamination in Rice, Palembang, South Sumatra, Indonesia.

Sub-objectives

1. To find heavy metals contamination in rice in Palembang, Indonesia
2. To find cancer risk related to Heavy metals contaminations in rice in Palembang, Indonesia.
3. To find non-cancer risk related to heavy metals contaminations in rice in Palembang, Indonesia.
4. To find association between associated factors with risk related to heavy metals contaminations in rice, Indonesia.

1.4 Research Hypothesis

Based on the three research questions of this study, the research hypothesis of this study are as follows:

1. There are heavy metals contamination in rice in Palembang, Indonesia.
2. There is cancer risk related to heavy metals contamination in rice in Palembang, Indonesia.
3. There is non-cancer risk related to heavy metals contamination in rice in Palembang, Indonesia.
4. There is association between associated factors with risk related to heavy metals contaminations in rice, Indonesia.

1.5 Scope of study

1.5.1 Study area

The research will be conducted in Palembang, which is in the southern part of the Indonesian island of Sumatra. According to data from the National Statistics Center, the total population in the city of Palembang is 1,668,164 people from 18 sub-districts in 2020.

1.5.2 Subjects (Inclusion and Exclusion Criteria)

In this study, the number of people who will participate in the study is 440 people. Research respondents are aged 20-60 years and have lived in Palembang for at least one year. Research respondents also consume rice as a staple food from markets or supermarkets in the city of Palembang. Respondents with a history of cancer, heart disease, or kidney failure and respiratory diseases and have carbohydrate allergies will be excluded from this study.

1.5.3 Sampling method (Questionnaire, and Sample collection)

Respondent data such as personal data, health conditions, anthropometric data and exposure data were obtained through online questionnaires. Google form is the media that will be used for collecting personal data of respondents. It will be collect by random sampling. On other hand for rice samples were obtained by buying rice in 3 biggest local markets in Palembang. These local markets located in left, central and right side of city. In each market, the sample will be take from 3 shops with random sampling method. Researcher will be buy two common type rice from each shops. The total number of sample is 18 sample. Rice shop in each market will be choose by random sampling method. The sample used is 100 grams taken from each sample of rice which is generally consumed by people in the city of Palembang. The rice will be analyzed at the Palembang Laboratory Center, which is own by Ministry of Health use ICP-OES and Central Laborator Center of Thailand use ICP-MS.

1.5.4 Sample analysis (Sample Preparation, HMs conc. Analyze)

In this study, heavy metal analysis in rice used the Inductively Coupled Plasma (ICP) method. Arsenic and lead analyze with ICP-MS, on other hand cadmium and copper analyze with ICP-OES. The initial step of the analysis is sample preparation, in this step the rice is converted into smaller particles by the milling method until it is shaped like flour. The rice will wash using deionized water and then dry at a temperature of 70-100 C and obtained a constant weight. The next process is to grind rice into rice flour. After the sample preparation method, the next step of analysis was the destruction method. The destruction method is a step in the breakdown of compounds into elements. The final step of the heavy metal analysis method in rice is the inductively coupled plasma (ICP) analysis method that uses magnetic and electric field induction as energy sources. The element analyzed by this method must be a solution where the main principle of this method is to obtain an element that emits light that can be measured at a wavelength.

1.5.5 Data analysis (Descriptive, and 4 Steps of Risk Assessment)

Analysis of the data in this study will use the method of environmental health risk analysis. Environmental health risk analysis has four steps, namely hazard identification, dose response assessment, exposure assessment and risk characteristics. Through these four steps, it will be known whether or not there is a risk if consuming rice in a certain amount and period of time in the city of Palembang.

1.6 Conceptual Framework

The conceptual framework is based on a literature review on Environmental Health Risk Assessment. The conceptual framework contain independent and dependent variable for this research.

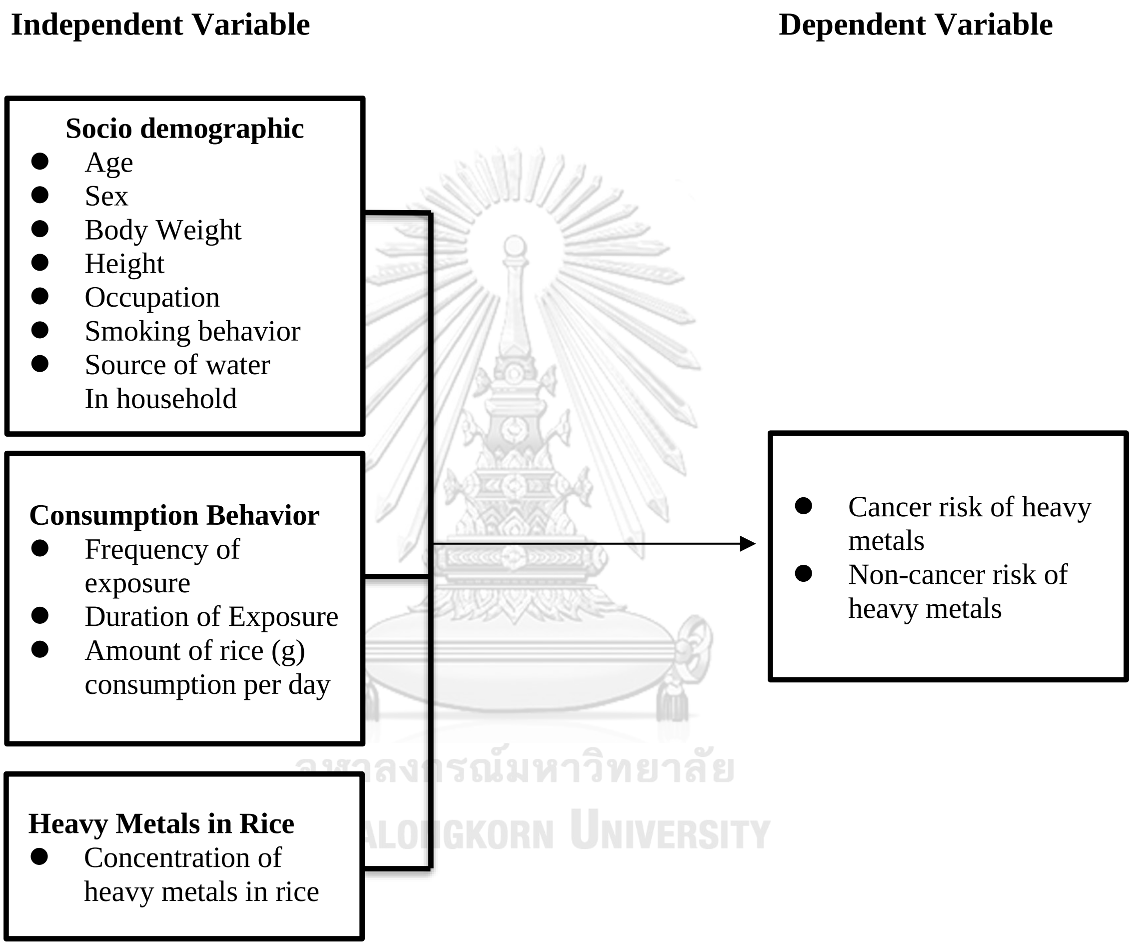


Figure 1.1 Conceptual Framework

1.7 Operational Definition

Table 1.1 Operational Definition

Variable	Definition
Heavy Metals	Chemical compounds such as arsenic, lead, cadmium, chromium, copper, and iron that found
Ingestion Rate	The amount of rice consumption per day by respondents in Palembang
Frequency of Exposure	Number of days consuming rice in a year by respondents in Palembang with days/year as unit
Duration of Exposure	Duration in years of rice consumption by respondents in Palembang with years as unit
ADD	Average daily dose of rice consumption containing heavy metals by respondents in Palembang which causes non-cancer effects. (ADD = $\frac{C\ x\ ED\ x\ EF\ X\ IR}{WB\ x\ AT}$)
LADD	Average daily dose of rice consumption containing heavy metals by respondents in Palembang which causes cancer effects (LADD = $\frac{C\ x\ ED\ x\ EF\ X\ IR}{WB\ x\ AT}$)
Weight	Respondent's weight (kg)
Age	Age for respondents between 20-60 years old
Reference Dose or RfD	References dose is a safe number in oral exposure to heavy metals for Non-cancer effect by US EPA
Slope Factor or SF	Slope factor is a safe number in oral exposure to heavy metals for cancer effect by US EPA, CALEPA and Zeng et al. 2015
Non-cancer risk	Health effects such as disorders of the cardiovascular system, respiratory system, nervous system, digestive system and lymph system due to consumption of rice contaminated with heavy metal
Hazard Quotient or HQ	The value of calculation use formula for calculate Non-cancer risk (HQ >1 : Risk, HQ ≤1 : acceptable)
Hazard Index or HI	Total of Hazard Quotient, ∑HQ (HI >1 : Risk, HI ≤1 : acceptable)
Cancer risk	Cancer effect due to consumption of rice contaminated with heavy metals (Cancer risk >1 x 10^{-06} : Risk, Cancer risk ≤1 x 10^{-06} : acceptable)
Risk Management	Efforts to control the risk due to consumption of rice contaminated with heavy metals in Palembang
Non-cancer effects	effect of heart disease, or kidney failure and respiratory diseases because of exposure by heavy metals
Carcinogenic effect	effect of cancer because of exposure by heavy metals

1.8 Research Ethics

This study will be proposed to Research Ethics of Institution Review Board within University of Sriwijaya, Indonesia and Chulalongkorn University, Thailand. The submission of an ethical review will be made after the proposal examination has been carried out and the research proposal has been approved.

1.9 Research Expected Outcomes

Through this research, there are 3 expected outcomes. The expected outcomes of this research include:

1. Heavy metals contamination in rice in Palembang, Indonesia.
2. Cancer risk related to heavy metals contaminations in rice in Palembang, Indonesia.
3. Non-cancer risk related to heavy metals contaminations in rice in Palembang, Indonesia.

Chapter II

Literature Review

This chapter, present several sub-chapters related to the rationale of this research. The literature review was from previous research which includes the characteristics of heavy metals, heavy metal contamination in rice and other agricultural products, heavy metals exposure, health effects, heavy metals sources, and risk characteristics of heavy metals in rice and agricultural products.

2.1 Characteristics of Heavy Metals

Heavy metals known as metalloid and metals group have relatively high density and are toxic. Examples of heavy metals were arsenic, lead, mercury, cadmium, etc. (Duruibe et al., 2007). Heavy metals know as inorganic compounds. Heavy metal concentrations will remain the same even after passing through the heating stage such as cooking. A study in Iran found that there was no significant difference in the concentration of heavy metals in raw and cooked rice (Naseri et al., 2014). Heavy metals themselves have their own characteristics. The following are characteristics of some heavy metals such as arsenic, lead, cadmium, iron, and copper.

2.1.1 Arsenic (As)

Arsenic widely distributed element in nature (NCBI, 2022). Arsenic has a synonym Arsenic, colloidal arsenic, arsenic-75, gray arsenic, metallic arsenic, Arsenic has a powder form with a metallic gray color with the number atomic 33, molecular weight 74.9 g/mol, insoluble in water, and odorless (BPOM, 2010). Arsenic can be found in soil, water, and food (FDA, 2013). The number of arsenic in media such as food, water, and soil is relatively low, on other hand, the toxicity is very high (Bunsen, 1994). Arsenic ranked as the first heavy metal which has a significant potential threat to humans between toxicants based on suspected toxicity (Hughes et al., 2011).

2.1.2 Cadmium (Cd)

Cadmium (Cd) is one of the four metals that have been raising dread around the world as natural, agrarian, and wellbeing risks in later decades (Hasanuzzaman, 2013). Cadmium concentration in the soil hull was 0.15 ppm and the foremost common cadmium mineral is greenockite. Cadmium is hazardous to the environment and human creatures. Cadmium display in the environment, water, or nourishment when uncovered to humans in moo concentration cause genuine well-being issues and likely the passing (Page and Bingham, 1973). Sources of cadmium human exposures were fossil fuels, press and steel generation, cement nonferrous metals generation, squander incineration, smoking, fertilizers, etc (EFSA, 2009).

2.1.3 Lead (Pb)

Lead could be an overwhelming, low melting, bluish-gray metal that happens actually within the Earth's outside. Lead could be an actually happening component and may be a part of Gather 14 (IVA) of the intermittent table (Abadin et al., 2007). Lead was the heavy metal closest to the level in which toxic signs show than any other substance according to environment concentration (Baird, 2002). Lead was fond mostly in related occupations with different sources like leaded gasoline, mechanical forms such as refining of lead and its combustion, ceramics, pontoon building, lead-based portray, lead-containing channels, battery reusing, lattices, arm industry, shades, the printing of books, etc (Wani et al., 2015).

2.1.4 Copper (Cu)

Copper is non-polymorphous metal with confront centered cubic grid. Pure copper could be a ruddy color, zinc expansion produces a yellow color, and nickel addition produces a silver color. Softening temperature is 1083 °C and the thickness is 8900 kg.m-3, which is three times heavier than aluminum (Konečná and Fintová, 2012). Copper was a fundamental supplement for people, creatures, and plants, it can posture dangers to human well-being with a raised introduction (CDA, 2016). Copper discovered in businesses to deliver copper channels, cables, wires, copper cookware, etc. It is additionally utilized to form copper intrauterine gadgets and birth control pills. The copper within the shape of copper sulfate was included in drinking water and swimming pools (Dorsey et al., 2004).

2.1.5 Chromium (Cr)

Chromium is a following component that's normally displayed in numerous nourishments and is accessible as a dietary supplement. Chromium too exists as hexavalent (+6) chromium, a harmful by-product of stainless steel and other fabricating forms (Anderson et al., 2010). Environmental sources of chromium were cement dust, topsoils, cement dust, etc (ATSDR, 2013).

2.1.6 Iron (Fe)

Iron or Ferrum (Fe) may be a brilliant white metal, loamy, and can be shaped. Fe in nature is gotten as hematite and in case the drinking water can cause color (yellow), taste, testimony on the pipe divider, the development of press microscopic organisms, and turbidity. Iron (Fe) components are required within the blood to tie oxygen (Yudo, 2006). In adults, most of the iron was in hemoglobin (Erdman Jr et al., 2012). Some were stored in the spleen, muscle tissue, bone marrow, and liver (Ross et al., 2014).

2.2 Heavy Metals Contamination

Heavy metals can be found in water, soil. Air and food. Heavy metals in food were found in small concentrations but have high levels of toxicity. One of the foods that were exposed to heavy metals is rice. The following are the findings of previous research regarding rice exposed to heavy metals.

Table 2.1 Heavy Metals Contamination in Rice

Country	Rice Area	Heavy Metal	Concentration
Argentina (Sigrist et al., 2016)	From supermarkets in Santa Fe province	As	0.87-3.16 mg/kg
China (Chen et al., 2014)	From Markets and supermarkets in China, Taiwan, Japan, Germany, and Switzerland	As	0.21-0.3 mg/kg
Japan (Takamoto et al., 2020)	Collection Rice from Japan, Vietnam and Indonesia	As	JPN = 0.036 mg/kg IDN=0.022 mg/kg VTM=0.035 mg/kg
Iran (Fakhri et al., 2018)	Golestan Gilian Shahrekord	As As Pb	0.01 mg/kg 3 mg/kg 0.02 mg/kg

	Mazadaran.	Pb	35 mg/kg
Bangladesh (Harine et al., 2021)	Irrigation Practice all over Bangladesh	As	0.25-0.52 mg/kg
Thailand (Hensawang and Chanpiwat, 2017)	Bangkok	As Cd	0.008 - 0.205 mg/kg 0.001-0.019 mg/kg
Vietnam (Chu et al., 2021)	Rice collected from Red River Delta and mining zone activity in Vietnam	As Cd Co Cr Cu	0.115 mg/kg 0.111 mg/kg 0.279 mg/kg 0.296 mg/kg 3.138 mg/kg
Indonesia (Ginting, 2018) (Saraswati, 2018) (Rasydy et al., 2021) (Taghi, 2021)	 From markets and Supermarket in Medan From markets and Supermarket in Medan Industrial Area In Karet Mekar Jaya Loa Village	 As As Cu Fe Cd	 0.07-3.71 mg/kg 0.06-0.30 mg/kg 4.13-4.76 mg/kg 5.025-6.8 mg/kg 0.008-0.01 mg/kg
Standard (FDA, 2013)[a] (WHO, 2017)[b] (WHO, 2014)[c] (WHO, 2004)[d] Indonesia Standard (SNI, 2009)	Recommended maximum allowable Concentration in rice	As Cd Pb Fe Cu Cr Cd Pb	0.2 mg/kg[a] 0.4 mg/kg[b] 0.2 mg/kg[b] - 20 mg/kg[c] 23.3 mg/kg[d] 0.4 mg/kg 0.3 mg/kg

From the table above, it can be seen that the findings of heavy metals in rice occur in several countries. Heavy metals found include arsenic, cadmium, lead, iron, copper and chromium. The concentration of heavy metals in rice also varies depending on the risk agent and the location of rice planting which is one of the sources of heavy metal contamination in rice. In Argentina, arsenic was found in rice collected from traditional markets and supermarkets in the province of Santa Fe. In this finding, arsenic levels were found in concentrations of 0.87-3.16 mg/kg (Sigrist et al., 2016). In which the safe limit of arsenic content in the rice itself is 0.3 mg/kg (WHO, 2014). The discovery of arsenic above the safe limit was also found in Indonesia. In a study conducted to examine the arsenic content of rice, it was found that the concentration of arsenic in rice was 0.07-3.71 mg/kg (Ginting, 2018). Besides rice, heavy metals were found in other agriculture products. The following present some agricultural products with heavy metals contamination.

Table 2.2 Heavy Metals Contaminations In Agricultural Product

Country	**Agricultural Product**	**Heavy Metal**	**Concentration (Unit)**
Argentina (Sigrist et al., 2016)	Potato	As	3 µg/g
Jamaica (Antoine et al., 2017)	Acke	Al	6.89 mg/kg
		As	0.011 mg/kg
		Cd	0.248 mg/kg
		Pb	0.033 mg/kg
	Banana	Al	93.12 mg/kg
		As	0.104 mg/kg
		Cd	0.057 mg/kg
		Pb	0.010 mg/kg
	Cabbage	Al	8.49 mg/kg
		As	0.001 mg/kg
		Cd	0.041 mg/kg
		Pb	0.003 mg/kg
	Carrot	Al	4.25 mg/kg
		As	0.004 mg/kg
		Cd	0.031 mg/kg
		Pb	0.006 mg/kg
Algeria (Cherfi et al., 2014)	Potato	Pb	23.76 mg/kg
		Cu	29.49 mg/kg
	Melon	Pb	19.17 mg/kg
		Cu	4 mg/kg
	Spinach	Pb	39.33 mg/kg
		Cu	18.33 mg/kg
	Beans	Pb	12.33 mg/kg
		Cu	13.83 mg/kg
Pakistan (Abbas et al., 2010)	Leafy Vegetables	Cd	0.083 µg/g
		Pb	0.05 µg/g
		As	0.042 µg/g
		Hg	0.008 µg/g
	Cucurbit Vegetables	Cd	0.021 µg/g
		Pb	0.051 µg/g
		As	0.056 µg/g
		Hg	0.0089 µg/g
		Cd	0.035 µg/g
	Fruity Vegetables	Pb	0.067 µg/g
		As	0.054 µg/g
		Hg	0.007 µg/g

Indonesia (Khaira, 2017)	Chili	Pb	0.23 mg/kg- 0.73 mg/kg
Standard (WHO, 2001)[a] (WHO, 2007)[b] Indonesia Standard (SNI, 2009)	Recommended maximum tolerance value in vegetables (mg/kg)	As Cd Pb Fe Cu As Cd Pb	0.1 mg/kg[a] 0.02 mg/kg[b] 0.3 mg/kg[b] 450 mg/kg[b] 40 mg/kg[b] 1 mg/kg 0.2 mg/kg 0.5 mg/kg

2.3 Heavy Metals Exposure

Exposure pathways are the way of contaminants enter to the human body after some exposure (IPCS, 2004). Heavy metals can expose the human body through dermal, inhalation, and oral exposure. Heavy metals exposure are known as toxicity contaminants e.g. arsenic, lead, cadmium, iron, chromium, copper (Chemistry, 2016). The following are the pathways of heavy metals to the human body.

2.3.1 Inhalation Exposure

Inhalation exposure is one of the pathways of heavy metals exposed to the human body. Inhalation exposure can be exposed to humans from breathing air that contaminated with vapors, particulate matter such as dust and aerosols (US-EPA, 2021). Exposure to inhaled particles can have health effects, including irritation to the respiratory system such as shortness of breath. It can also worsen medical conditions such as asthma and heart disease. Cardiovascular effects may be worsened by exposure to carbon monoxide or particulate matter (State, 2020).

Heavy metals contamination through inhalation can cause cancer or non-cancer effects even for both effects depend on the heavy metals elements. It is known, exposure to heavy metals such as cadmium and lead from cigarettes can cause cancer effects in humans. It was reported that there was a cancer effect due to cadmium and lead with the highest risk of 2.52 x $10^{-2}$and the smallest of

1.05×10^{-3}. In addition, non-cancer effects were also generated with an HQ value more than 1 (Benson et al., 2017).

2.3.2 Dermal Exposure

Dermal exposure is the entrance of contaminants into the body through the skin. This exposure can come from contaminated soil or water. Activities such as gardening, swimming, bathing, washing, or other activities related to touching or being exposed to water and soil can cause heavy metal exposure through the skin (US-EPA, 2021). Another activity that allowed exposure to heavy metals through dermal exposure was in a series of activities in the batik industry. It was known that there was exposure to heavy metals Zn, Mn, Fe, and Cu. Although the RQ value does not indicate a risk, exposure to these heavy metals must be minimized along with activities to minimize risk for workers in the batik industry (Oginawati et al., 2022). In addition, exposure of heavy metals through dermal exposure also occurs in mining area. It is known that exposure of heavy metals by dermal exposure have Non-cancer and cancer effects on humans. In previous studies, it was found that there are heavy metal contamination of Arsenic, Cadmium, mercury and lead in gold mining, where the hazard index value exceeds the acceptable value, which is more than 1. In addition, the predicted exposure for the next 9 years shows a Cancer risk to mining workers with the value greater than 1×10^{-06} (Wongsasuluk et al., 2021).

2.3.3 Oral Exposure

Exposure to heavy metals in humans can be through inhalation, oral or dermal pathways. Exposure through food has been found, one of this was exposure of heavy metals in rice. According to the American Environmental Protection Agency, only by consuming 32 grams of rice per day, the level of arsenic in the urine was the same as consuming 1 L of drinking water. The standard arsenic content for drinking water was 10 g/L. This means that consuming 32 grams of rice was equivalent to being exposed to 10 g/L arsenic. This will be especially dangerous for Indonesian people who consume 0.2-0.3 kg of rice per day (BPS, 2017). It is known that exposure to heavy metal arsenic in rice indicates a cancer health risk. The value of the amount of cancer risk found is $> 1 \times 10^{5}$. It can be concluded that there was a cancer effect due to the consumption of rice containing arsenic in the population in this study (Ginting, 2018).

2.4 Health Impacts

Heavy metal exposure can have an impact on health such as cancer disease. Based on data from the Indonesian Ministry of Health, the incidence of cancer in Indonesia is is in eighth place in Southeast Asia with an incidence of 136.2/100,000 population. The highest incidence rate is lung cancer of 19.4/100,000 population with an average mortality rate of 10.9/100,000 population which occurs in male population. Followed by the incidence of liver cancer of 12.4 / 100,000 population with an average mortality rate of 7.6 / 100,000 population. While in the female population, the highest incidence of cancer occurs in breast cancer at 42.1/100,000 population with an average mortality rate of 17/100,000 population. This is followed by the incidence of cervical cancer of 23.4/100,000 population with an average mortality rate of 13.9/100,000 population (Ministry of Health, 2019).

Beside that, heavy metals exposure was known have impact to human health both in the chronic and acute effect. Chronic effect was long term effect meanwhile acute effect is short term effect. Chronic effects are effects caused by long-term exposure to heavy metals with low concentrations and symptoms can develop over time, for example, consumption of vegetables containing heavy metals in low concentrations but continuously for a long period of time. While the acute effect is the effect caused by exposure to heavy metals in large quantities in a short period of time, for example, ingestion of toys containing heavy metals (Cassata, 2020). Each heavy metal has its target organ and has health effects on humans. Heavy metals can cause health effects depending on the amount of exposure dose and the part where the heavy metal was bound in the body (Widowati et al., 2008). The following are health effects on humans are due to exposure to several heavy metals such as arsenic, lead, copper, cadmium, iron, and chromium.

2.4.1 Arsenic (As)

Arsenic is the 20th most abundant element on earth in the order that its organic forms are like arsenite and arsenic compounds. Arsenic compounds are compounds that are deadly to living things and have a negative impact on the environment. Arsenic can be found naturally, industrially, and in other accidental sources. Arsenic known as a heavy metal that has adverse effects on humans and ecology (Hughes et al., 1988). Arsenic has acute and long-term effects. Inorganic arsenic has a cancer effect on humans and globally known as a chemical contaminant in water. In addition to inorganic, arsenic can also be in organic form. Organic arsenic compounds are known to be highly toxic and usually found in water, while organic compounds are known to be less harmful to human health and are usually found in seafood (WHO, 2018).

Arsenic was known to cause death in humans. The fatal dose of arsenic trioxide is 70 to 180 milligrams (mg). This causes cardiovascular collapse and hypovolemic shock (ATDSR, 2007). Arsenic has effects on humans according to the route of entry into the human body. If ingested arsenic can cause dysphagia, anorexia, heartburn, dehydration, and bloody or rice water diarrhea. Arsenic exposure can also be via dermal exposure pathways that can cause dermatitis, vesiculation and melanosis. The last route of exposure is inhalation, where arsenic exposure can cause respiratory problems in humans (ATSDR, 2011a). Symptoms of arsenic poisoning in the human body include muscle cramps, abdominal pain, dark urine, changes in the skin such as warts, headache, nausea and vomiting, heart rhythm disturbances, abdominal pain, and tingling in the fingers and toes (Davis, 2017).

2.4.2 Cadmium (Cd)

According to the ATSDR ranking, cadmium is the 7th most toxic heavy metal. Cadmium can cause health effects in humans. Humans can get cadmium poisoning through food or inhalation of cadmium. It can cause adverse effects on human health if food is contaminated with cadmium at certain doses. Foods containing cadmium and ingested can cause Gastrointestinal effects (ATSDR, 2011b). Recuperation can happen from an intense scene of harm with no side impacts. Given an adequate dosage, in any case, hemorrhagic gastroenteritis, liver and kidney corruption, cardiomyopathy, and metabolic acidosis can happen (Davidson et al., 1988).

2.4.3 Lead (Pb)

Lead is a heavy metal that is slightly silvery in color and bluish in the atmosphere. The main sources of lead included drinking water, cigarettes, domestic and industrial sources, and food. Lead that enters soil or flows into the water can be absorbed by plants and cause lead exposure in food or drinking water (Wani et al., 2015). Prolonged exposure to lead in humans can cause health problems, including organ system disorders such as the kidneys, reproductive system, blood, nervous system, and gastrointestinal tract (Manahan, 1992). Indications of lead contamination are seen in the urine in the presence of leveling acid (ALA) (Cope et al., 2004).

The nervous system is an important target tissue for lead toxicity, especially in infants and children whose nervous systems are still developing. Exposure to low levels of lead in children has hyperactivity, memory loss, and visual impairment. Exposure to lead levels can cause encephalopathy in both children and adults Pb can damage arterioles and capillaries, causing cerebral edema and hypoxia. Clinically this damage causes ataxia coma and seizures. Another system that is affected by; lead was the reproductive system. Lead exposure can cause toxicity to the female and male reproductive systems such as the Occurrence and Kaya in offspring (Endrinaldi, 2010).

2.4.4 Copper (Cu)

Copper is an essential element in living things including humans, but in large doses, it can cause toxic effects (CDA, 2016). Copper was a heavy metal that often used in industries that produce cables, copper pipes, copper equipment, and others. In water, such as drinking water and swimming pools, copper is found in the form of copper sulfate. Exposure to copper dust for a long time will irritate the eyes, mouth, and life, causing headaches, nausea, dizziness, and diarrhea. Copper-contaminated water with doses above the safe limit cause kidney damage, liver, and even death (Dorsey et al., 2004).

2.4.5 Chromium (Cr)

Chromium the trivalent form of chromium is an element that occurs naturally in foods and is usually found in dietary supplements (Anderson et al., 2010). Chromium in high doses cause severe hematological, renal, respiratory, hepatic, cardiovascular, and neurological effects that can lead to death (Shekhawat et al., 2015).

2.4.6 Iron (Fe)

Ferrum is an element that the body needs to bind oxygen in the blood. Ferrum is moldable, brilliant white metallic color and clay. In nature, Ferrum can be found as hematite. Water containing Ferrum had a taste, yellow color, and cloudy when drunk (Yudo, 2006). In addition, iron was needed for the formation of iron-sulfur and heme complexes in the body. Consumption of iron more than 20 mg/kg from supplements or drugs can cause gastric disorders such as stomach pain, nausea, constipation to fainting. This can get worse especially if the consumption of medications or supplements is not at the same time (Board, 2001). In some cases, such as excessive consumption of iron as much as 60 mg/kg in one-time consumption can cause organ system failure, seizures, coma, and even death (Manoguerra et al., 2005, Chang and Rangan, 2011).

2.5 Heavy Metals Sources

Exposure to heavy metals in rice come from several sources, such as the use of pesticides, fertilizers, industrial activities near agricultural areas and contamination that comes directly from nature. One of that was pesticides, pesticides itself are defined as all chemicals, viruses, microorganisms, and other substances used to kill or prevent pests from damaging crops grown on agricultural land. Pesticides can also kill weeds and prevent unwanted growth. In short, pesticides are substances that kill, eliminate, or prevent pests. Pesticides are important agricultural tools that can indirectly increase crop yields (Permentan, 2014). As of late, due to the fast advancement of innovation, the biological system and people have been uncovered to numerous sorts of chemical toxicants, in specific, pesticides (herbicides, bug sprays, and fungicides) (Özkara et al., 2016).

Pesticides suspected to contain arsenic, which included insecticides, algaecides, fungicides, and herbicides (Hooda, 2010). The previous study found herbicides was most highest concentrations of heavy metals compare to other types of pesticides. In this study, some heavy metals such as Cd, Pb and Fe was found

(Garcia et al, 1996). Meanwhile in Indonesia, herbicides are widely used, including in the paddy field. The ALS group of herbicides are known to be the most common types found in the paddy field. This herbicide belongs to the 2,4-D auxin class which can control the growth of several groups of weeds (Prakoso et al, 2018). The use of pesticides in Indonesia has been regulated in the Regulation of the Minister of Agriculture Number: 24/Permentan/SR.140/4/2011 concerning requirements and procedures for registration of pesticides. However, there are still many farmers who choose to use chemical pesticides and choose to pay more to avoid crop failure than the negative impact on the environment (Situmorang et al, 2021).

Industry, agribusiness, mining, and wastewater were considered anthropogenic sources of overwhelming metals. These sources cause noteworthy increments in overwhelming metal concentrations and contamination within the biological system, for example, refining coming about within the discharge of Cu, Zn, and As; bug sprays that contribute to As discharge (Masindi and Muedi, 2018). The following is the picture that shows the mechanism of pesticides toxicity in soil and plant (SHARMA et al., 2019, Sharma et al., 2018, Alengebawy et al., 2021).

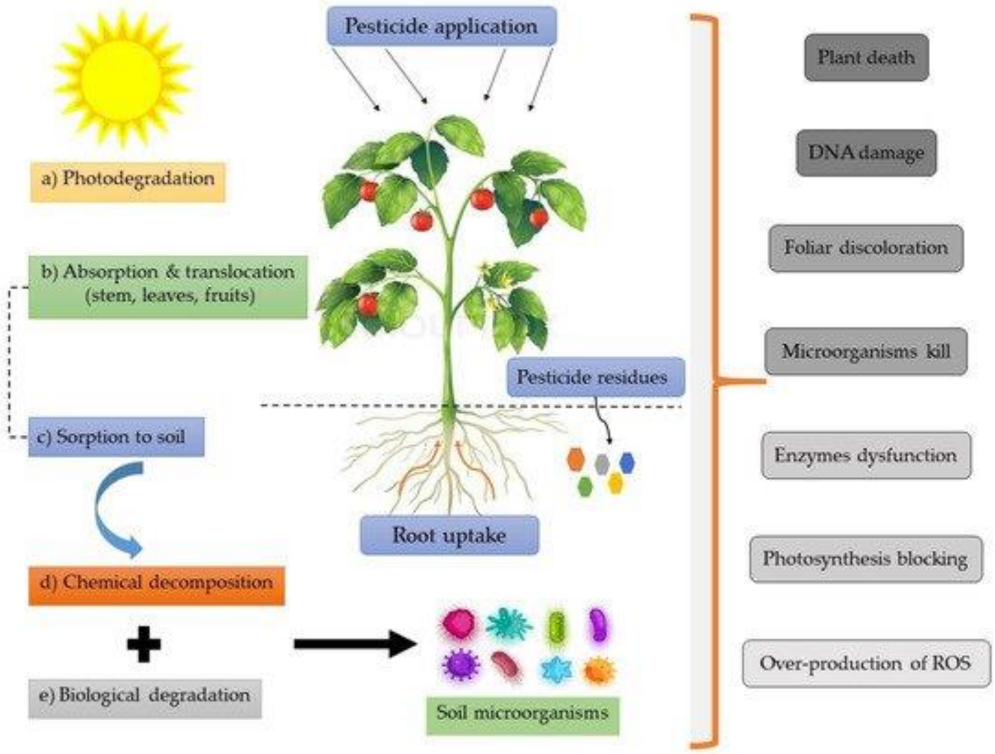


Figure 2.1 Pesticide in Plant

Sources : (Alengebawy et al., 2021, SHARMA et al., 2019, Sharma et al., 2018)

From this picture, we can see that pesticides application make pesticides residues that contaminate soil, and through the soil, contaminated roots absorb chemical exposure. This contamination can cause agricultural products exposed to pesticides residues and heavy metals as well. In addition to the use of pesticides, the use of fertilizers is known to have an impact on heavy metal contamination in agricultural areas. Previous research has shown a strong positive relationship between the presence of heavy metals such as Zn, Cu, Pb and Ni with the use of chemical fertilizers (Wei et al., 2020). In natural condition, heavy metals and soil pH are known to have a correlation, where soil pH is the main factor that can affect the presence of heavy metals in the soil. In previous studies, it was shown that generally soil pH had a correlation with the presence of heavy metals such as CU, Zn, Ni and Pb (Zhang et al., 2018, Kim et al., 2015).

2.6 Risk Assessment

Risk analysis begins with the term Health Risk Assessment (HRA) which is used to analyze health risks in humans. Apart from the term HIA (Analysis of Health Impacts) that are negatively or positively. From this term developing terms of environmental health risk analysis where this term is more specific (Menkes, 2012, Menkes, 2001). Environmental health risks assessment is a method that aims to analyze risks both in health, industry, hygiene, environment, and work safety (Soemirat and Ariesyady, 2017). According to WHO, environmental health risk assessment aims to estimate the risk of organisms by identifying uncertainty of exposure to certain agents and paying attention to the characteristics of agents and targets. There are 4 steps of Environmental Health Risk Assessment, First step is hazard identification, dose-response assessment, exposure assessment, and lastly is risk characterization. If the value of the risks shows a risk due to exposure to a risk agent in the sample, risk management is carried out to control risk by stakeholders (NRC, 1983).

2.6.1 Risk Assessment in Rice

Heavy metals can have an impact on human health, both cancer and non-cancer effects. The following is a list of the impacts of rice consumption being exposed to heavy metals globally.

Table 2.3 Risk Assessment in Rice

Country	**Heavy Metals**	**HQ**	**Cancer risk**
Poland (Bielecka et al., 2020)	Arsenic Cadmium	White rice : 0.0110-0.402 Brown rice : 0.0269-0.0749 Red rice : 0.0375-0.1339 White rice : 0.0003-0.0058 Brown rice : 0.0001-0.0074 Red rice : 0.0002-0.0032	
Bangladesh (Harine et al., 2021)	Arsenic	5.55-10.70*	2.5 x 10^{-3} – 4.81 x 10^{-3*}
China (Fan et al., 2017)	Arsenic Cadmium Lead Manganese	0.7264 11.798* 0.0484 0.0025	3 x 10^{-4*} 1.8 x 10^{-1*}
Thailand (Kukusamudea et al., 2021) (Hensawang and Chanpiwat, 2017)	Arsenic Arsenic	Pka Am Pun rice : 4.34* Jek Chuey Sao Hai rice : 2.09* Leb Nok rice: 4.43* White jasmine : 1.5-3* White : 1.2-2.5*	White Jasmine : 2.2 x10^{-8}- 4.55 x10^{-8} White : 1.69 x10^{-8} – 3.47 x10^{-8} Glutinous : 1.76 x10^{-8} - 3.62 x10^{-8}

	Cadmium	Glutinous : 1-2* Brown jasmine: 2.8-5* White Jasmine : 0.04-0.08 White : 0.04-0.06 Glutinous : 0.08-0.18 Brown jasmine : 0.04-0.06	Brown jasmine : 3.92 $x10^{-8}$ – 8.04 $x10^{-8}$
Indonesia (Saraswati, 2018)	Arsenic	-	White rice : 1.6 x 10^{-4*} Brown rice : 1.9 x 10^{-4*} Red rice : 7.1 x 10^{-4*} Black sticky rice: 2.5 x 10^{-4*}
Indonesia (Ginting, 2018)	Arsenic	-	White rice :1.86 x 10^{-5*} – 87 x 10^{-5*} Brown rice : 10.35 x 10^{-5*} – 894 x 10^{-5*} Red rice : 1.36 x 10^{-5*} – 975 x 10^{-5*} Black rice : 28,8 x 10^{-5*}- 33,6 x 10^{-5*}

*Means exceed acceptable level (>1 x 10^{-06})

From the table above, we can see the amount of risk value due to arsenic exposure to rice. The risk amount here shows a cancer health risk where the ECR value is > 1 x 10^{-6}. This cancer risk needs to be controlled by risk management by estimating safe concentration for risk agents, the amount of consumption of rice per day, the frequency of exposure, and the duration of exposure.

2.6.2 Risk Assessment in Agricultural Products

Heavy metals were also known to contaminate other agricultural products such as carrot, potato, turnip, etc. The following are the list of risk assessment of heavy metals contamination in agricultural product.

Table 2.4 Risk Assessment in Agricultural Products

Country	**Heavy Metals**	**RQ**	**ECR**
Jamaica (Antoine et al., 2017)	Arsenic	Tomato : 0.017 Cabbage : 0.017 Banana : 0.171 Coco : 0.064 Irish Potato : 0.004 Ackee : 0.025 Carrot : 0.005 Dasheen : 0.084 Pumpkin : 0.031 Sweet potato : 0.010 Turnip : 0.007 Sweet Pepper : 0.004	Tomato : 7.61 x 10^{-6*} Cabbage : 7.48 x 10^{6*} Banana : 7.7 x 10^{-6*} Coco : 2.88 x 10^{-6*} Irish Potato : 1.95 x 10^{-6*} Ackee : 1.14 x 10^{-6} Carrot : 2.19 x 10^{-6*} Dasheen : 3.77 x 10^{6*} Pumpkin : 1.4 x 10^{-6} Sweet potato : 4.69 x 10^{-6*} Turnip : 3.19 x 10^{-6*} Sweet Pepper : 3.19 x 10^{-6*}
	Cadmium	Tomato : 0.116 Cabbage : 0.163 Banana : 0.028 Coco : 0.240 Irish Potato : 0.032 Ackee : 0.171 Carrot : 0.137 Dasheen : 0.073 Pumpkin : 0.010 Sweet potato : 0.049 Turnip : 0.093 Sweet Pepper : 0.109	
	Lead	Tomato : 0.005 Cabbage : 0.005 Banana : 0.002 Coco : 0.025 Irish Potato : 0.002 Ackee : 0.011 Carrot : 0.001 Dasheen : 0.032 Pumpkin : 0.002 Sweet potato : 0.014 Turnip : 0.001 Sweet Pepper : 0.002	
Brazil (Guerra et al., 2012)	Cadmium	Adults : 0.107 Children : 0.130	

	Lead	Adults : 0.417 Children : 0.499	

*Means exceed acceptable level ($>1 \times 10^{-06}$)

From this table, we can see the value of the non-cancer effects and cancer effects related to heavy metals contaminations in agricultural products. The table shows the value of the cancer effect is less than 1. This can be concluded that there was no non-cancer effect by contamination of heavy metals in agricultural products, meanwhile, there will be a cancer effect due to consumption of the agricultural products contaminated by heavy metals with cancer value was greater than 1×10^{-3}.

Chapter III

Methodology

3.1 Study area

This study aimed to predict the magnitude of the risk due to the consumption of rice containing heavy metals in Palembang, South Sumatra, Indonesia. Palembang was the capital of the province of South Sumatra. According to BPS (National Statistic Data) data in 2021, the total population of the city of Palembang was 1,686,073 people who come from 18 sub-districts. Adults population was 56.49% of total population with the total number 952,420 people (BPS, 2021). The residents of Palembang city consume rice as a staple food. According to BPS data in 2017 about rice consumption in Indonesia, the average Indonesian people consume rice was 200-350 grams of rice per day. This high consumption of rice was one of the factors that cause the need for an environmental health risk assessment to estimate the magnitude of the risk due to consuming large amounts of rice every day.

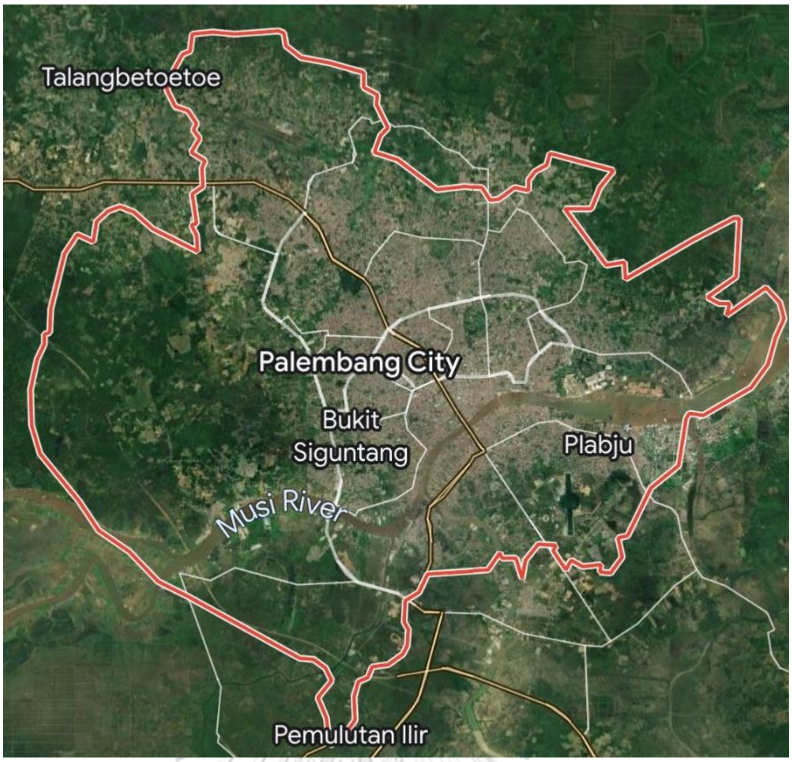


Figure 3.1 Indonesia and Palembang City MAPs

(Source : Google Maps)

3.2 Subjects (Inclusion and Exclusion Criteria)

This study was a study that aimed to estimate the magnitude of the risk due to heavy metal exposure in rice in Palembang, South Sumatra. The sample in this study was the population of adult in Palembang in the age of 20-60 years. The following were the sample size, inclusion and exclusion criteria in this study :

3.2.1 Sample Size Calculation

The sample size simply defines as a number of respondents in a study that must be prepared before a clinical study starts to avoid any bias (Kadam and Bhalerao, 2010). The sample size calculation depends on margin of error, confident level, population size and population proportion. In this study, the population size was known so that the following formula was used slovin's formula (Slovin, 1960).

$$n = \frac{N}{1 + N\varepsilon\text{^}\mathbf{2}} = \frac{952{,}420}{1 + 952{,}420\,(0.05)\text{^}\mathbf{2}} = 399.83 = 400 \text{ people}$$

Note.

n is Sample size

ε is the margin of error, ε is 0.05

N is the population size, N is 952,420 (BPS, 2021)

The result of calculating the sample size using the above formula was 400 where the total population was added by 10% of sample size so that the total number of respondents in this study was 440 people. Data collection used random sampling method.

3.2.2 Inclusion Criteria

Inclusion criteria were defined as criteria where the research subject can represent the research sample as a whole that can meet the requirements as respondents. The following were the inclusion criteria in this study.

1. Palembang residents aged 20-60 years.
2. A native of Palembang and has never moved or settled in another area for more than 1 year.
3. Consuming rice at least 3 days in a week.
4. Consuming rice from local market in Palembang.
5. Willing to be a respondent.

3.2.3 Exclusion Criteria

Exclusion criteria were criteria in which research subjects cannot represent the research sample because they do not meet the requirements as research samples (Notoatmodjo, 2022). The exclusion criteria in the study were as follows.

1. The participant who has a history of cancer.
2. The participant who has heart disease, or kidney failure and respiratory diseases that are clinically and pathologically confirmed.

3. The Participant who has Carbohydrate allergy, allergy by consumed rice and other food containing carbohydrate.
4. The subjects who cannot use internet or has difficulty filling out the online questionnaire.

3.3 Sampling method (Questionnaire, and Sample collection)

3.3.1 Data Collection

Respondent data such as personal data, health conditions, anthropometric data and exposure data were obtained through questionnaires. The questionnaire in this study used an online questionnaire to overcome the limitations of data collection during the COVID-19 pandemic. The online questionnaire media in this study used google form. The questionnaire written and distributed in Indonesian. Before distributed to all respondents, questionnaire was test by validity and reliability. Validity test used IOC method which send to one expert from Thailand and two experts from Indonesia. The reliability test was conducted on 30 respondents in Palembang. The validity test score were 0.83 and reliability test results obtained were 0.861. The data collected by random sampling. Before starting to fill out, the prospective respondent filled out a questionnaire screening sheet to ensure that the prospective respondent was a sample that fits this research. The questionnaire screening sheet were contained age, period of live in Palembang, and history of disease of the prospective respondent. In the questionnaire screening sheet, if the prospective respondent answers "No" to questions number 1-3 or answers "Yes" to questions number 4-5, then the prospective respondent can stop filling out the questionnaire because at this step the prospective respondent does not meet the criteria as respondents in this study. Filling out the screening questionnaire took 5 minutes and questionnaire took 10-15 minutes and the respondent's answers uploaded to the researcher's email and used to calculate the risk of consumption of rice containing heavy metals in the city of Palembang as well as to be used for research results and discussion.

3.3.2 Sample Collection

Rice was a sample to be analyzed to determine the concentration of heavy metals contained in it. The rice that will be analyzed was the rice that was sell in local market in the city of Palembang. This rice comes from paddy fields in another area near the city of Palembang. Rice sold in traditional markets was mostly a local product originating from agricultural land in South Sumatra, same province with Pelambang.. The location of rice cultivation in South Sumatra was mostly in Belitang, Ogan Komering Ulu. It was about 3 hours from the provincial capital, Palembang. Geographically, the west side of the province of South Sumatra is passed by a cluster of Bukit Barisan mountains. There were 61 mountains scattered in the western part of South Sumatra. Ogan komering ulu itself located on the west side of the province of South Sumatra which was known to have 8 mountains with the highest mountain being Mt. Lumut Balai (Pendaki, 2018). Such geographical conditions become potential for contamination including heavy metal contamination naturally on agricultural land.

Based on the most recent data in 2018, the number of markets in the city of Palembang was 39 markets spread throughout the city (BPS, 2018). The sample took from 3 biggest local markets in Palembang. These local markets located in left side (Ilir part), central and right side of city (Ulu part) and the biggest market in each side. From these 3 local markets, the rice took from three rice shops. These rice shop chosen by random sampling method. The criteria for selecting this shop include, among other things, that the shop sells both types of rice varieties that were commonly consumed by people in the city of Palembang. There were two varieties of white rice that easy found in local market in Palembang, These two varieties were Pandan Wangi rice and Pulen rice (IR 64). These types of white rice that were the most consumed and most easily found in the city of Palembang. Each sample used 100 grams of rice. Therefore, the total sample of rice were 6 sample. The rice sample to be analyzed took by buying rice at the local market in Palembang City. This rice sample labeled samples A and B, then sent to the Palembang laboratory for analysis. The sample sent to Palembang Laboratory Center, most large laboratory in Sumatera island own by

Ministry of Health used ICP-OES and Central Laboratory of Thailand used ICP-MS.

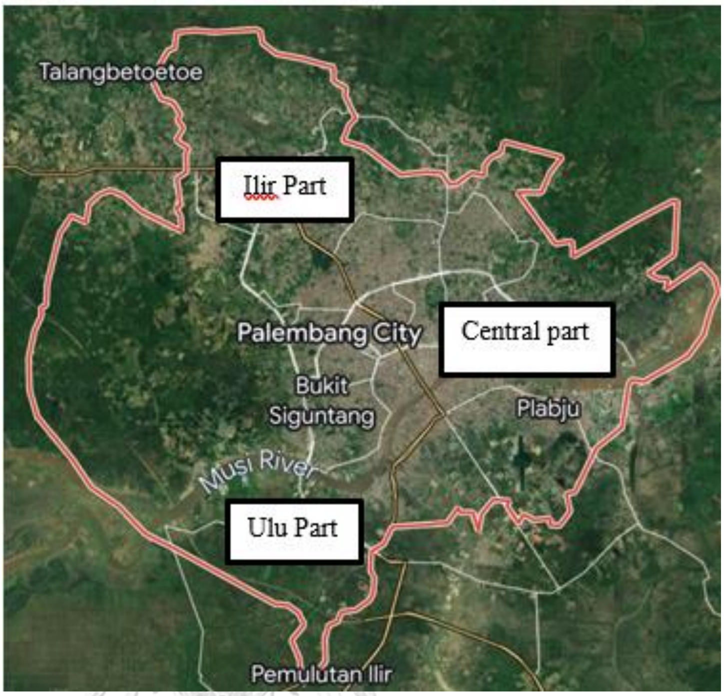


Figure 3.2 Palembang Part MAPs

(Source : Google Maps)

3.4 Sample analysis (Sample Preparation, Digestion, HMs conc. Analyze, Quality Control)

3.4.1 Sample Preparation

In this study, heavy metal analysis in rice used the Inductively Coupled Plasma (ICP) method. The initial step of the analysis was sample preparation, where at this stage the rice was converted into smaller particles by the milling method until it was shaped like flour (Pizarro et al., 2003). The rice washed using deionized water and then dry at a temperature of 70-100 C and obtained a constant weight. The next process was to grind rice into rice flour (Zhu et al., 2008). The average particle size after grinding was at least 200 and maximum 500 µm. The microwave digestion vessel with a capacity of 75 mL was cleaned and the aliquot of the sample was placed. In the recovery sample, spiking carried out without the addition of any solvent.

3.4.2 Digestion

The next step of analysis was the destruction method. The destruction method was a step in the breakdown of compounds into elements. The use of microwaves had often been used in recent years in this stage because microwaves can prevent bubbles and dumping of rice samples due to high temperatures. This was because the microwave was covered by the vessel (Chatterjee, 1999). A sample of 0.5 gram weighed into the microwave and then add a mixture of 5mL HNO3 and 1 mL HCl. The sample was absorbed according to the manufacturer's guidelines, at this stage ensure the temperature is 200 C for 15 minutes. After the digestion step, the samples were transferred to a 50mL volumetric flask and supplemented with ultrapure water (Scientific, 2021).

3.4.3 Heavy Metals Concentration Analyze

The final step of the heavy metal analysis method in rice was the inductively coupled plasma (ICP) analysis method that used magnetic and electric field induction as energy sources. The Inductively Coupled Plasma (ICP) method was a method that aimed to analyze the levels of heavy metals with special tools and gases. This aimed to improve the accuracy of the results of heavy metal analysis. This method can analyzed elements simultaneously at the rate of 1-10 ppb operating with injected argon plasma and atomized liquid samples. The element analyzed by this method must be a solution where the main principle of this method was to obtain an element that emits light that can be measured at a wavelength. Through this method, a complete multi-element analysis carried out in a relatively fast time of about 30 minutes using 0.5 mL of sample solution. Sample preparation and digestion process ICP-OES (Inductively Coupled Plasma – Optical Emission Spectroscopy) and ICP-MS (Inductively Coupled Plasma Mass Spectrometry) methods were known to be the same. ICP-MS was known to have a relatively lower detection limit than ICP-OES.

3.4.4 Quality Control

Quality control or quality assurance was a step taken to demonstrate the accuracy and precision of the monitoring results and after the analysis was carried out. Quality control aimed to maintain quality in all aspects. Quality control means preparing plans starting from documentation of procedures, volunteer training, design studies, data management, data analysis, and certain quality control measures. Quality control was carried out both internally and externally. Quality control determines whether or not the samples taken were valid and the analysis procedures to be carried out. Internal Quality control was carried out by lab staff or project volunteers. Meanwhile, external quality control was carried out by non-volunteer projects and quality control lab staff. Validation Method was a very essential method to provide accurate results in laboratory analysis. The validation method was closely related to quality control which covers a very wide range from the sampling stage to the final analysis result (Van Zoonen et al., 1999). Parameters considered in the validation method include accuracy, precision, specificity, linearity and range, limit of detection, and limit of quantitation (Harmita, 2004).

3.5 Data analysis (Descriptive, and 4 Steps of Risk Assessment)

Sociodemographic data from respondents analyzed by descriptive analysis method. Descriptive data present percentage data related to social demographic conditions, for example the number of men and women in this study. Statistical test to compare the concentration of heavy metals based on the type of rice used the u-test. Meanwhile, the statistical test used to see the association between associated factor with potential risk used Chi-square analysis. In addition, the data used as an instrument to predict the magnitude of the risk that will occur in the future due to exposure to a risk agent in humans. There were four steps to conducting an environmental health risk assessment. The following were four steps of environmental health risk assessment.

1. Hazard identification

Hazard identification was the initial step of recognizing the risks posed by exposure to risk agents. At this stage, the identification of which agents are at risk and have an impact on human health (Mukono, 2002). Hazard identification was a step to assess the effect of a substance and its impact on human health and the environment. Through this step, researchers find out which chemicals are dangerous, where was the material media in the environment and the concentration of the material and its impact on human health (Menkes, 2012).

2. Dose Response Assessment

Dose response assessment was a step to determine the quantitative value of the toxicity of a risk agent that has been determined previously at the hazard identification stage. There were several steps before determining which quantitative value used as a value for calculating risk characteristics. These stages included the following.

a. Determine the pathway of exposure to risk agents in humans. At this step, researchers can determine the use of Reference Dose (RfD) used for oral and dermal exposure pathways, while reference concentration s used for inhalation exposure pathways and Slope factor used for Cancer risk calculations.
b. Knowing changes in symptoms or effects due to increasing doses that enter the body
c. Knowing the Reference dose (RfD) or Reference concentration (RfC) and Slope factor values that will be used as an instrument to determine risk characteristics.

Table 3.1 Reference Dose and Slope Factor

Heavy Metals	Reference Dose (RfD) (mg/kg/day)	Reference	Slofe Factor (SF) (mg/kg/day)	Reference
As	3.0×10^{-4}	US EPA, 2012	1.5	US EPA, 2012
Cd	1.0×10^{-3}	US EPA, 2012	15	Zeng et al. 2015
Pb	3.5×10^{-3}	US EPA, 2012	8.5×10^{-3}	US EPA, 2012
Cu	0.37	US EPA,2012	N/A	N/A
Cr	0.003	US EPA, 2012	0.5	CALEPA, 2011
Fe	0.7	US EPA, 2012	N/A	N/A

*N/A : not available at the time of study

3. Exposure Assessment

Exposure assessment was one of the four steps of environmental health risk assessment. At this step, calculations were carried out to determine the average daily dose due to consumption of rice containing heavy metals. The formula used was the oral exposure pathway formula where ADD was used for calculating Non-cancer effects and LADD for calculating cancer effects. The following was the formula that used in this research (Song et al., 2015).

$$ADD = \frac{C\ x\ IR\ x\ ED\ x\ EF}{BW\ X\ AT}$$

Note.

ADD : Average Daily Dose (mg/kg-day)

C : Concentrations of Heavy Metals in Rice (mg/kg, ug/g)

IR : Ingestion Rate (kg)

ED : Duration of exposure (years)

EF : Frequency of exposure (days/year)

BW : Body weight of respondents (kg)

AT : Averaging times (days) (ED X 365days)

4. Risk characteristics

Risk characteristics were the final step of environmental health risk assessment. At this step, the HQ and IH values calculated as the final result of the calculation for the Non-cancer effect and Cancer risk as the result of calculating the cancer effect due to consumption of rice containing heavy metals. The following were a calculation formula for the Non-cancer effect (EPA, 2011).

$$\mathbf{HQ} = \frac{ADD}{RfD}, \mathbf{HI} = \sum HQ$$

If the results of the HQ and HI values were more than 1, it can be concluded that the consumption of rice containing heavy metals in the people of Palembang city may have a Non-cancer effect. An advanced step was needed, namely risk management for risk prevention in the future. In addition, if a risk agent can cause cancer effects in humans, it is necessary to calculate cancer risk as well. The following were a formula for calculating cancer risk (EPA, 2011).

Cancer risk = LADD x Slope Factor (SF)

If the results of cancer risk was greater than 1 x 10^{-06}, it can be conclude that may have cancer risk related to consumption rice contaminated with heavy metals. Risk management can be next step for prevent risk that may happen in the future.

3.6 Research Ethic

This study was approved by Research Ethics of Institution Review Board within University of Sriwijaya, Indonesia. The submission of an ethical review was made after the proposal examination has been carried out and the research proposal had been approved.

3.7 Methodology Flowchart

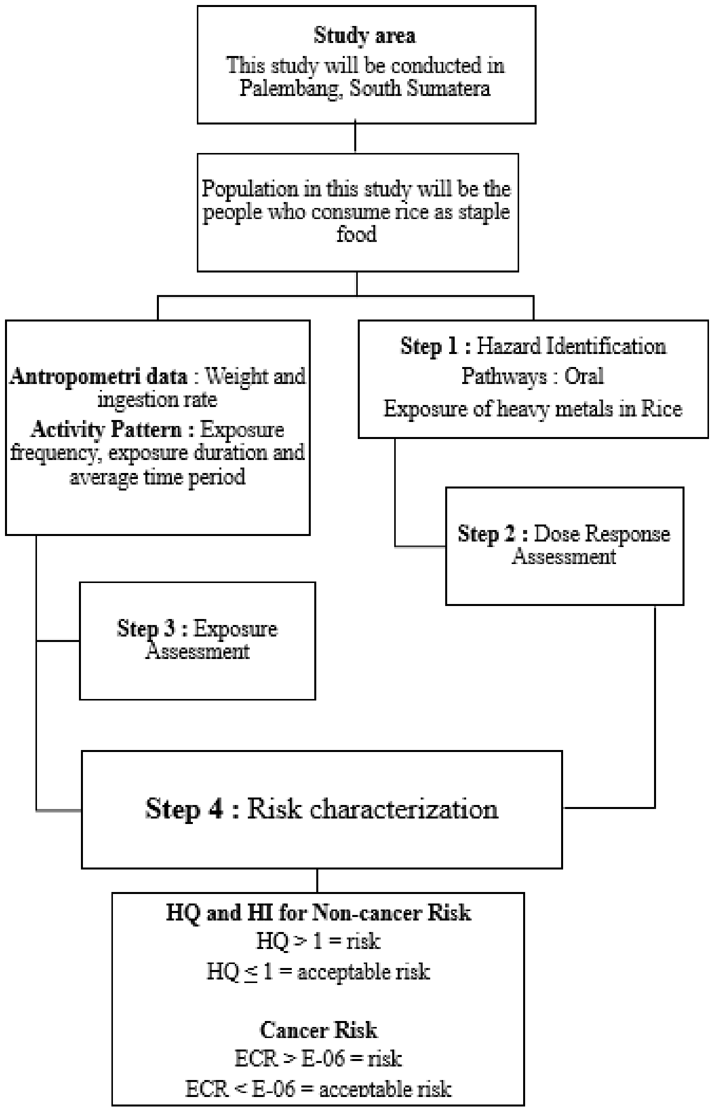


Figure 3.3 Methodology Flowchart

3.8 Research Timeline

Table 3.2 Timeline

	2021	2022										
	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Literature review												
Proposal developing												
Proposal exam												
Research ethics												
Data collection												
Data analysis												
Thesis writing												
Conference												
Final exam												

3.9 Research Budgets

Table 3.3 Budgets

No	Items	Cost (THB)
1	Data Collection	1200
2	Rice Sample	603
3	Heavy metals analysis	10.104
4	Research Asistant	3000
	Total	14.907

Chapter IV

Results

This chapter present the results of this study which are contain about characteristics of respondent, type of rice, concentration of rice, non-cancer risk, hazard index, cancer risk and total cancer risk by contamination of four heavy metals in two types of rice and associated factors.

5.1 Characteristics of Respondents

Respondents' personal data were obtained from questionnaires. The total respondents in this study were 417 people. The following was socio-demographic data consisting of age, Sex, occupation, alcohol drinking behavior, smoking behavior, source of water, underlying disease and anthropometric data consisting of weight and height.

Table 4.1 Characteristics of Respondents

Characteristics (N = 417)		
Age (years)	Mean ± SD	29.27 ± 8.88
	Median	25.00
	Min-max	18-59
Weight (kg)	Mean ± SD	59.41 ± 13.51
	Median	57
	Min-max	34-169
Height (cm)	Mean ± SD	159.85 ± 12.11
	Median	160
	Min-max	146-185
Sex	Male	39.9% (133)
	Female	68.1% (284)
Occupation	Government officer	43.6% (182)
	Enterpreneur	7.2% (30)
	Student	20.6% (86)
	Private employee	17.3% (72)
	Not work	11.3% (47)
Smoking Behaviour	Smokers	8.9% (37)
	Ex-smokers	6.0% (25)
	Never smoke	85.1% (355)
Alcohol consumption	Yes	2.4% (10)
	No	97.6% (407)
Source of drinking water	Groundwater	21.3% (89)

	River water	1.2% (5)
	Tap water	53% (221)
	Rain water	0.5% (2)
	Other	24% (100)
Source of cooking water	Groundwater	24% (100)
	River water	2.9% (12)
	Tap water	62.8% (262)
	Rain water	0.5% (2)
	Other	9.8 % (41)
Underlying disease	Yes	-
	No	100% (417)

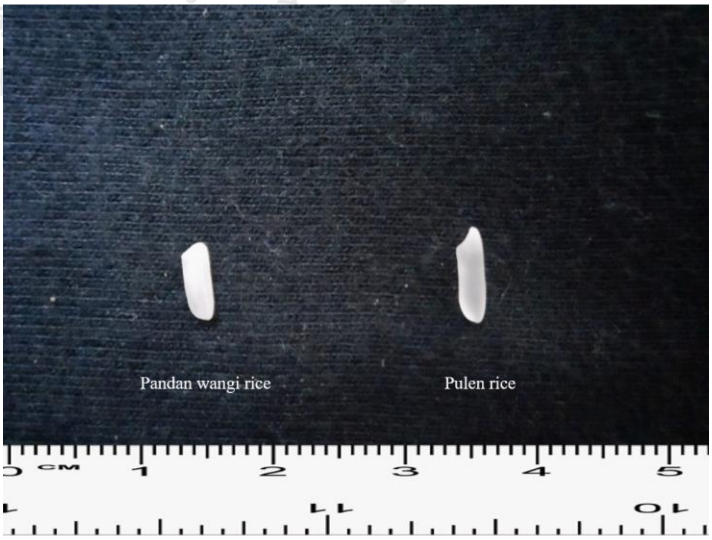
Based on the table 4.1, we can see that the average age of the respondents was 29.27 years with an average weight of 59.41 kg and height of 159.85 cm. Respondents in this study were dominated by women where the number of women was 2.1 times more than male respondents. The work of the respondents in this study was dominated by government officers as much as 43.6% or almost half of the total respondents. The second position was student as much as 20.6%, private employee as much as 17.3%, not working 11.3% and the last place was entrepreneur as much as 7.2%.

Other data were factors related to the heavy metal contaminations. Almost all respondents have never smoked with a presentation of 85.1% followed by smokers as much as 8.9% and ex-smokers as much as 6.0%. In addition, most of the respondents did not consume alcohol with a presentation of 97.6%. The source of water used by respondents for drinking was more than half of the respondents or 53% using tap water. This was also in line with the water used for cooking which also comes from tap water with a percentage of 62.8%.

5.2 Types of Rice

There were two types of rice commonly consumed by the people in the city of Palembang. This type of rice includes Pandan Wangi rice and Pulen rice. The following were the picture of Pandan Wangi rice (a), Pulen rice (b) and the comparison of these two rices (c).

(a) (b)



(c)

Figure 4.1 Types of rice

Based on the photo above, at first glance there had similar color, shape and size between these two types. Both types of rice were cylindrical and white in color. Pulen rice is known to be longer than Pandan Wangi rice. In addition, Pulen rice has a more transparent color than Pandan Wangi rice which tends to be darker in color. Pulen rice is also known to have a better quality where the rice grains are good, while in Pandan Wangi rice, crack grains are often found. The most striking difference between these two rices was when the rice was cooked. Pulen rice will increase 2.1 times more and have a fluffier texture. Meanwhile, Pandan Wangi rice was added 1.8 times more and had a distinctive pandan fragrance.

5.3 Concentration of Heavy Metals

Heavy metals contamination was found in soil, air and food. One of these contaminations was found in rice. There were four heavy metals that were commonly found in heavy metals, namely arsenic, lead, copper, and cadmium. Besides being frequent, the four metals were known to be harmful to health and three of them not only provide non-cancer effects but also cancer effects. In this study, arsenic and lead were analyzed by the ICP-MS method, while copper and cadmium were analyzed by the ICP-OES method. Following were the results of the analysis of the four heavy metals.

Table 4.2 Concentration of Heavy Metals

Code	As (mg/kg)	Pb (mg/kg)	Cu (mg/kg)	Cd (mg/kg)
A1P	0.074	0.05	0.95	<0.038
B1P	0.185	<0.025	1.23	<0.038
C1P	0.057	0.05	1.17	<0.038
Mean	**0.105**	**0.042**	**1.116**	<0.038
Median	**0.074**	**0.05**	**1.17**	<0.038
A1PW	0.081	<0.025	0.26	<0.038
B1PW	0.08	<0.025	0.79	<0.038
C1PW	0.074	<0.025	1.62	<0.038
Mean	**0.078**	**<0.025**	**0.89**	<0.038
Median	**0.08**	**<0.025**	**0.79**	<0.038
LOD	**0.05**	**0.025**	**0.1**	**0.038**

Reference Standard	0.2 (FDA, 2013)	0.2 (WHO, 2017)	20 (WHO, 2014)	0.4 (WHO, 2017)

**A1P ; Market 1 Pulen, A1PW : Market 1 Pandan Wangi*
**B1P ; Market 2 Pulen, B1PW : Market 2 Pandan Wangi*
**C1P ; Market 3 Pulen, C1PW : Market 3 Pandan Wangi*

From the table 4.2, The results of Mann-Whitney test showed, there was no significant difference between the concentration of heavy metals in Pandan Wangi rice and Pulen rice (*p-value* = .579). The table also showed that all heavy metals exposures were within safe limits. Two heavy metals, namely arsenic and lead, were analyzed using the ICP-Ms method, while copper and cadmium were analyzed using the ICP-OES method. Cadmium concentration was below the detection limit, whilst the other three heavy metals were above the detection limit of each method.

5.4 Non-cancer risk of Heavy Metals

Heavy metal contamination in foods such as rice can pose potential non-cancer and carcinogenic health risks. The risk was influenced by the concentration of heavy metals in rice, ingestion rate, length of exposure, frequency of exposure, body weight and average time. The following were the parameters used for calculating the risk of non-cancer and cancer in the two types of rice that are generally consumed by the people of Palembang.

4.3 Parameter for Risk Assessment

Parameter	Symbol	Unit	Value	Reference
Concentration	C	ug/gr	Pandan Wangi As : 105 Pb : 0.05 Cu : 1.116 Cd : 0.038 Pulen rice As : 0.078 Pb : 0.025 Cu : 0.89 Cd : 0.038	Laboratory analysis

Ingestion Rate	IR	kg/day	Pandan Wangi : 0.21 Pulen : 0.18	Questionnaire data
Exposure day	ED	years	Non-cancer : 20 Carcinogenic : 70	Questionnaire data
Exposure frequency	EF	days/year	365	Questionnaire data
Weight	Wb	Kg	57	Questionnaire data
Average time	AT	Days	Non-cancer : 7300 Carcinogenic : 25550	Questionnaire data
Reference dose	RfD	mg/kg.day	As : 3.0 x 10^{-4} Pb : 3.5 x 10^{-3} Cu : 0.37 Cd : 1.0 x 10^{-3}	US EPA, 2012 US EPA, 2012 US EPA, 2012 US EPA, 2012
Slope factor	SF	mg/kg.day^{-1}	As : 1.5 Pb : 8.5 x 10^{-3} Cu : N/A Cd : 15	US EPA, 2012 US EPA, 2012 - Zeng et al, 2015

Based on the parameters, the non-cancer risk was calculated by finding the average daily dose (ADD) with the formula ADD = C x IR x ED x EF / Wb x AT. Furthermore, the non-cancer risk was obtained through the formula HQ = ADD/RfD. The results of the calculation of non-cancer risk were as follows.

Table 4.4 Non-cancer risk of Heavy Metals from 417 Subjects

Type of rice	**HQ of Arsenic (As)**	**HQ of Lead (Pb)**	**HQ of Copper (Cu)**	**HQ of Cadmium (Cd)**

Pandan Wangi rice	Mean±SD	1.173 ± 0.597	0.032 ± 0.016	0.010 ± 0.005	0.171 ± 0.087
	Median	1.124	0.030	0.010	0.164
	Min	0.143	0.003	0.001	0.020
	Max	3.328	0.091	0.030	0.486
Pulen rice	Mean±SD	1.328 ± 0.676	0.054 ± 0.027	0.011± 0.005	0.144 ± 0.073
	Median	1.27	0.051	0.010	0.138
	Min	0.162	0.006	0.001	0.017
	Max	3.767	0.153	0.032	0.409

**HQ > 1 : risk, HQ ≤ 1 : Acceptable risk*

From the table 4.4, the results of the calculation above indicate that there may be a risk by consuming Pulen rice contaminated with arsenic. The max number of arsen in Pandan Wangi rice was 3.328 with mean 1.173 and Pulen rice was 3.767 with mean 1.328. Meanwhile, the results of other calculations show that exposure to the four heavy metals was still an acceptable risk. The different of HQ based on concentrations, exposure and body weight. The results of the total exposure to the four heavy metals for non-cancer risk were added up to produce the Hazard Index (HI) value. The following was the hazard index (HI) of the four heavy metals.

Table 4.5 Hazard Index of Heavy Metals

No	HI (PW)	HI (P)
Mean ± SD	1.38 ± 0.706	1.53 ± 0.783
Median	1.32	1.47
Max	3.93	4.36

Min	0.16	0.18
Total people with risk	276	300

**HI > 1 : risk, HI ≤ 1 : Acceptable risk*

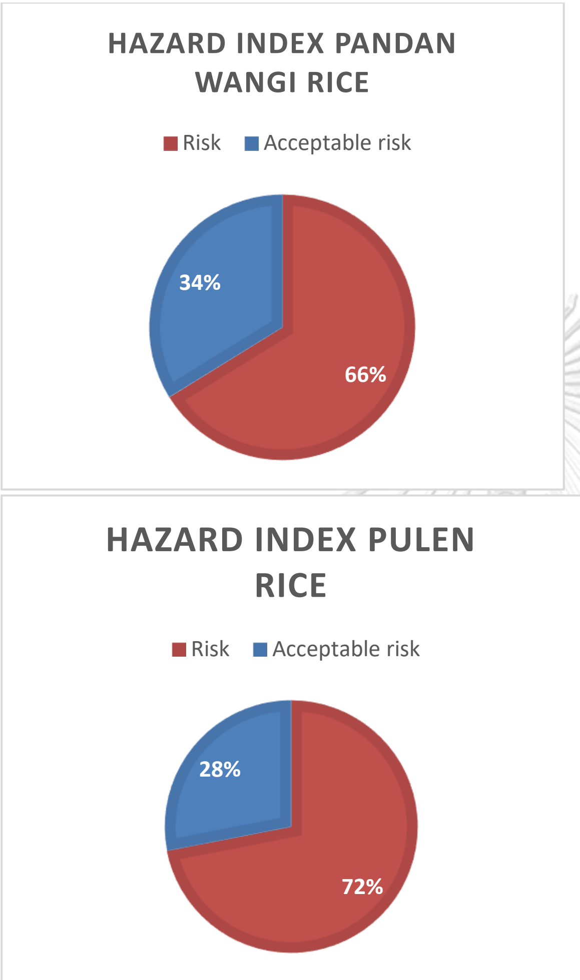


Figure 4.2 Hazard Index of Pandan Wangi Rice and Pulen rice

The total non-cancer risk or hazard index (HI) indicates that exposure to four rice metals in both types of rice had the potential to pose a non-cancer risk. In Pandan Wangi rice, the average hazard index was 1.38 with the highest HI of 3.93 and the lowest of 0.16. As many as 66.19% or 276 of respondents have the potential to have non-cancer risk health problems by consuming fragrant pandan rice. In Pulen rice, the risk posed was slightly greater with an average HI of 1.53 where the highest value was 4.36 and the lowest was 0.18. Consumption of Pulen rice may have the potential to pose a non-cancer risk to respondents with a percentage of 72% or 300 people.

5.5 Cancer risk of Heavy Metals

Heavy metal exposure in rice was known to pose a cancer risk. In this study, there were three heavy metals that have potential cancer risks, including arsenic, lead and cadmium. The cancer risk calculation used the same parameters as table 4.4. The initial calculation was to calculate the lifetime average daily dose (LADD) with the formula LADD = C x IR x ED x EF / Wb x At. Furthermore, the cancer risk was calculated by the formula CR = LADD x SF. The following was the result of calculating the cancer risk of these three heavy metals.

Table 4.6 Cancer Risk of Heavy Metals from 417 Subjects

Type of rice		**CR of Arsenic (As)**	**CR of Lead (Pb)**	**CR of Cadmium (Cd)**
Pandan Wangi rice	Mean $\pm$ SD	$5.2 \times 10^{-4} \pm 2.69 \times 10^{-4}$	$9.59 \times 10^{-7} \pm 4.88 \times 10^{-7}$	$2.57 \times 10^{-3} \pm 1.31 \times 10^{-3}$
	Median	5.06×10^{-4}	9.19×10^{-7}	2.46×10^{-3}
	Min	6.45×10^{-5}	1.17×10^{-7}	3.14×10^{-4}
	Max	1.5×10^{-3}	2.72×10^{-6}	7.30×10^{-3}
Pulen rice	Mean $\pm$ SD	$5.98 \times 10^{-4} \pm 3.04 \times 10^{-4}$	$1.61 \times 10^{-6} \pm 8.21 \times 10^{-7}$	$2.16 \times 10^{-3} \pm 1.10 \times 10^{-3}$
	Median	5.73×10^{-4}	1.55×10^{-6}	2.07×10^{-3}
	Min	7.31×10^{-5}	1.97×10^{-7}	2.64×10^{-4}
	Max	1.70×10^{-3}	4.58×10^{-6}	6.14×10^{-3}

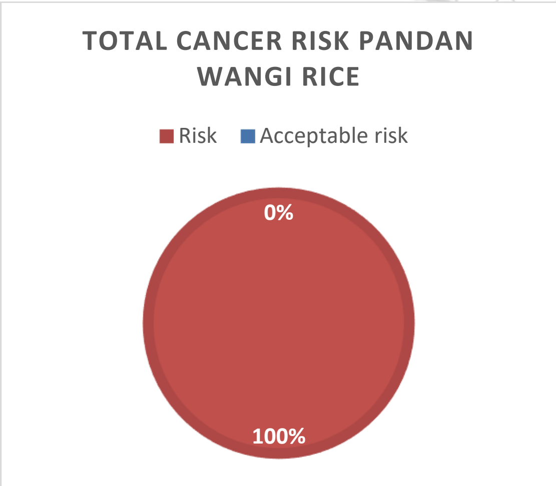
**CR> 1×10^{-6} : risk, CR $\leq 1 \times 10^{-6}$: Acceptable risk*

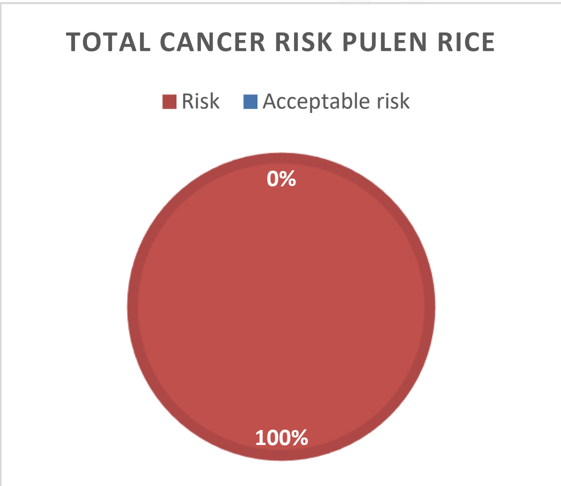
Through the table 4.6 above, we can see that the three heavy metals may have the potential to pose a risk to human health. The highest risk comes from exposure to cadmium followed by arsenic, copper and lead. These three heavy metals were added together to determine the total Cancer risk due to consumption of both types of rice exposed to these three heavy metals. The following was the total cancer risk (TCR) value of these three heavy metals.

Table 4.7 Total Cancer risk of Heavy Metals

No	TCR (PW)	TCR (P)
Mean $\pm$ SD	$3.10 \times 10^{-3} \pm 1.58 \times 10^{-3}$	$2.76 \times 10^{-3} + 1.40 \times 10^{-3}$
Median	2.97×10^{-3}	2.65×10^{-3}
Max	8.80×10^{-3}	7.84×10^{-3}
Min	3.79×10^{-4}	3.38×10^{-4}
Total people with risk	417	417

**CR> 1 x 10^{-6} : risk, CR $\leq$ 1 x 10^{-6} : Acceptable risk*





4.3 Total cancer risk of Pandan Wangi Rice and Pulen rice

Based on table 4.7, the results of the calculation of total cancer risk (TCR) above, both types of rice show a potential cancer risk in humans. In Pandan Wangi rice, the average TCR value was 3.10 x 10^{-3} or there may be 3 person will have cancer risk between 1,000 person in population with the highest value being 8.80 x 10^{-3} or there may be 9 person will have Cancer risk between 1,000 person in population and the lowest being 3.79 x 10^{-4} or there may be 3 person will have cancer risk between 10,000 person in population. It was known, 100% of respondents may have a cancer risk due to consumption of Pandan Wangi rice exposed to these three heavy metals. While in Pulen rice, the average TCR value was 2.76 x 10^{-3} there may be 3 persons will have cancer risk between 1,000 person in population with the highest value of 7.84 x 10^{-3} there may be 8 person will have cancer risk between 1,000 person in population and the lowest of 3.38 x 10^{-4} there may be 4 person will have cancer risk between 10,000 person in population. Similar to Pandan Wangi rice, 100% of respondents are known to have a potential cancer risk.

5.6 Associated factors

Health problems can come from exposure to heavy metals and people's lifestyles. In this section, we will discuss factors related to the causes of health problems other than exposure to heavy metals from rice. The independent variables in this subsection include age, BMI, occupation, sex, source of drinking water and source of water for cooking. In this section there are 14 subsections consisting of 8 non-cancer subsections and 6 cancer risk subsections.

5.6.1 Associated Factor of Non-cancer risk

The following table was the result of the analysis of the association of non-cancer risk of both types of rice included eight variables which were age, BMI, sex, occupation, smoking behaviour, alcohol consumption, source of drinking water and source of cooking water.

Table 4.8 Associated Factor of Non-cancer risk

Variable	P-value (Pandan Wangi rice)					P-value (Pulen rice)				
	As	Pb	Cu	Cd	HI	As	Pb	Cu	Cd	HI
Age	.000*	.000*	.000*	.000*	.000*	.000*	.000*	.000*	.000*	.000*
BMI	.000	.000	.000	.000	.000	.000	.000	.000	.000	.000

	*	*	*	*	*	*	*	*	*	*
Sex	.071	.283 *	.095	.071	.105	.071	.182	.099	.105	.105
Occupation	.393	.606	.332	.393	.317	.393	.288	.153	.317	.317
Smoking behaviour	.933	.984	.864	.933	.984	.933	.993	.864	.984	.984
Alcohol consumption	.459	.582	.792	.459	.728	.459	.790	.643	.728	.728
Source of drinking water	.003 *	.001 *	.001 *	.003 *	.003 *	.003 *	.004 *	.000 *	.003 *	.003 *
Source of cooking water	.123	.019 *	.052	.123	.109	.123	.141	.002 *	.109	.109

Based on the table 4.8 above, there were three variables with a p-value of less than 0.05, namely age, BMI, source of cooking water and source of drinking water. This showed that there was an association between these four variables and the non-cancer risk due to heavy metals exposure in rice. While on other variables, it was known that there was no association between sex, occupation, and drinking alcohol behavior with non-cancer risk due to exposure of heavy metals in two types of rice.

5.6.2 Associated Factor of Cancer Risk

The table below was a table of the results of the analysis between age, BMI, occupation, sex, water source, smoking behavior and drinking alcohol with cancer risk due to exposure to heavy metals contained in rice.

Table 4.9 Associated Factor of Cancer risk

Variable	P-value (Pandan Wangi rice)				P-value (Pulen rice)			
	As	**Pb**	**Cd**	**CR**	**As**	**Pb**	**Cd**	**HI**
Age	.000*	.000*	.000*	.000*	.000*	.000*	.000*	.000*
BMI	.000*	.000*	.000*	.000*	.000*	.000*	.000*	.000*

Sex	.071	.071	.071	.105	.071	.071	.071	.105
Occupation	.393	.393	.393	.317	.393	.393	.393	.317
Smoking behaviour	.933	.933	.933	.984	.933	.933	.933	.984
Alcohol consumption	.459	.459	.459	.728	.459	.459	.459	.728
Source of drinking water	.003*	.003*	.003*	.003*	.003*	.003*	.003*	.003*
Source of cooking water	.123	.123	.123	.109	.123	.123	.123	.109

From table 4.9, the results showed that age, BMI and source of drinking water in the people of Palembang had an association with cancer risk due to heavy metals exposure in two types of rice. Source of cooking water, smoking behavior, drinking alcohol, sex and occupation are known to have no association with cancer risk.

Chapter V

Discussion

This chapter present about the discussion and comparison the results of characteristics of respondents, concentration of heavy metals, non-cancer risk, hazard index, cancer risk, total cancer risk and associated factors with previous study.

5.1 Characteristics of Respondents

This research was conducted in Palembang with a total of 417 respondents. It was known that the average respondent was 29 years old. This uneven age distribution was due to the distribution of data using online questionnaires. The use of this online platform was due to the pandemic conditions when the research was conducted. The online platform itself makes it possible to reach young people rather than old people. In addition, online filling that was done independently was a factor that only a few parents became respondents in this study. Another most influential factor was that many elderly people cannot pass the questionnaire screening. In the screening section of the questionnaire, there were questions about health problems, both non-cancer and cancer. Older people have a higher ratio than young people who have health problems. This was because the immune system has decreased so it is more susceptible to disease (Mukono, 2005). Thus, residents who have health problems cannot be respondents in this study.

In this study, most of the respondents were women. Through this data, researchers can see that health risks were more common in men or women. Because most of the respondents were women, most of the respondents were known to have never smoked. Although there were female smokers, smoking behavior almost tends to be carried out by men (Sirait et al., 2002). In addition, the alcohol consumption behavior of the respondents in this study was very low. Almost all respondents were known to have never consumed alcohol. This can be influenced by the religion embraced by most of the people of Palembang. Islam was the religion followed by almost 93.116% or 1,508,046 people (Dukcapil, 2019). According to Islamic rules, drinking alcohol is prohibited, so almost all respondents do not consume alcohol (Al-Quran surah Al-Baqarah aya 219).

In addition to the above data, this study also collects data on water sources used for both drinking and cooking. In this study, both drinking water and cooking water came from tap water. This was influenced by the provision of clean water in Palembang which has been managed by the government with percentage 96.07%. In contrast to other areas where the water management system is still uneven (BPS, 2013). In Palembang, part of the distribution of clean water comes from the Regional Drinking Water Company(Suryani, 2016). Most of the water used by respondents was tap water that comes from this company. The most striking difference was the second source which was used as a means of drinking and cooking water. Where the second position both come from other sources, namely mineral water or refilled water. On other hand, the percentage between the use of other water sources for drinking tends to be higher than for cooking. Even though it was name as a drinking water company, it was not recommended to drink water directly from the tap (Suryani, 2016). It was recommended to cook it first. This was a factor that people use more other sources such as mineral water or refilled water for drinking and tap water for cooking.

5.2 Types of Rice

Rice was the staple food consumed by most people in Indonesia. Each region had a type of rice which was a local product of each place. There were two types of rice which were generally consumed by people in Palembang City. This rice product comes from other regions in the same province. This rice was Pandan Wangi rice and Pulen rice. The shape of this rice was cylindrical which was the same as the shape of rice in general. In addition, this rice was white in which Pulen rice was known to be whiter than Pandan fragrant rice. Pandan fragrant rice was known to have a distinctive aroma like pandanus. This distinctive aroma was one of the attractions of people consuming this rice. Similar to Pandan Wangi rice, jasmine rice which was a product from Thailand has a distinctive aroma such as a floral aroma (Agrawal et al., 2021). In addition, another rice that also had a distinctive aroma was basmati rice which was known as the world's leading aromatic rice. This type of rice was produced in the Punjab area located between India and Pakistan (Verma et al., 2018). The need for rice with this aroma also encourages other countries such as Indonesia, Thailand, China, Vietnam, USA to develop this type of rice. In addition to aroma, the texture of rice was also known to be one of the factors that make people interested in consuming rice (Li et al., 2015). Pulan rice was rice that has a fluffy texture. Previous study compare the texture of Indonesian rice and amylose rice and found that amylose rices was fluffier (Munawar and Sabaruddin, 2021).

5.3 Concentration of Heavy Metals

Heavy metal contamination can be found in water, soil, air and food. One source of heavy metal contamination from food was rice. Rice was a food that was generally consumed by people in Palembang. There were two types of rice that were usually consumed by people in Palembang. The first type was Pulen rice which had higher quality and more expensive price. The second type was fragrant Pandan rice, which had a fairly good quality and a cheaper selling price. Based on the results of the analysis, Pulen rice is known to have relatively higher exposure to heavy metals than Pandan Wangi rice.

There were six heavy metals that were usually found in rice. These six heavy metals include arsenic, lead, copper, iron, chromium and cadmium (Saraswati, 2018, Rasydy et al., 2021, Taghi, 2021). In this study, four heavy metals were analyzed. This was determined based on the heavy metals most commonly found in rice, namely arsenic, lead, cadmium and copper. In addition, two other heavy metals were known to be essential heavy metals while the other four heavy metals were heavy metals that were absolutely not needed by the body and dangerous if consumed even in small amounts (Bunsen, 1994). Arsenic and lead were analyzed using the ICP-MS method, while copper and cadmium were analyzed using the ICP-OES method.

The results of the analysis of arsenic, lead and copper were above the detection limit of each method, while cadmium was below the detection limit. The ICP-MS method was known to have a relatively lower detection limit than ICP-OES (Tyler and S.A.S, 1995) Cadmium analyzed by the ICP-OES method had a detection limit of 0.038 ug/gr. The high detection limit of the ICP-OES method causes the cadmium concentration to be uncertain. This also indicated that the concentration of cadmium in both types of rice was low and within the safe limits according to the standard which was 0.4 mg/kg (WHO, 2017). This contrasts with previous studies where cadmium was detected in rice even at low concentrations of 0.001-0.019 mg/kg (Hensawang and Chanpiwat, 2017). This was due to differences in the analytical methods used. In other heavy metals such as copper, it was known to have the highest average concentration but also the safest when compared to the standard, which is 20 mg/kg (WHO, 2014). This was in line with previous studies where the copper concentration in rice was only 4.13-4.76 mg/kg, which was still within the safe limit (Rasydy et al., 2021).

Arsenic analysis shows that the arsenic value was still within the safe limit even though it was close to the standard of 0.2 mg/kg (FDA, 2013). This was in line with the study in Vietnam where the average arsenic concentration was 0.115 mg/kg (Chu et al., 2021). However, other studies have shown that arsenic values exceed the safe limit, namely the study in Indonesia where arsenic findings were 0.07-3.71 mg/kg (Ginting, 2018). Lastly, lead was found in relatively low concentrations when compared to the standard 0.2 mg/kg (WHO, 2017). This was in contrast to a study in Iran, where the concentration of lead in rice was very high at 35 mg/kg (Fakhri et al., 2018).

In addition to the use of pesticides and fertilizers, the concentration of heavy metals in rice can also be affected by the location of rice planting. The rice analyzed came from an area close to the mountains. This geographical situation can affect the presence of heavy metals in the environment, especially agricultural land. Research in China found 10 heavy metals when analyzing water and soil in mountain areas. Anthropogenic sources are known to be the main source of this heavy metal contamination (Zhang et al., 2013).

5.4 Non Cancer risk of Heavy Metals

Heavy metal contamination can pose health risks, one of which was non-cancer health problems. Assessment was carried out to determine the potential risks that may occur in the future. Environmental health risk analysis was a method used to predict the potential and perceived risk due to exposure to a risk agent originating from water, soil, air and food (FDA, 2013). The risk agents in this study are heavy metals that contaminate rice as a product of agriculture. Heavy metal contamination can come from the use of pesticides, fertilizers and natural conditions of agricultural soil (SHARMA et al., 2019, Zhang et al., 2018, Wei et al., 2020).

Calculations of non-cancer health risks were calculated both individually and in aggregate. In the aggregate data, all calculation variables were tested for normality. Data that was normally distributed will use the mean as the value used for assessment, while data that was not normally distributed will use the median as the value used for assessment. After being tested for normality, the potential risk was calculated using a predetermined formula (Song et al., 2015)(ref). The assessment results show that only arsenic in Pulen rice had a non-cancer health impact. This was in contrast to the study in Poland where the hazard quotient value was still within the safe limit, namely HQ < 1 (Bielecka et al., 2020). This was due to the risk not only influenced by the arsenic concentration but also other factors such as duration of exposure, frequency of exposure, and anthropometric data of respondents (Bahar et al., 2012).

On individual data, the risk calculation was calculated using the value of each individual. Through this, it can be seen that the difference in risk between respondents was influenced by weight and data exposure. The amount of concentration, duration of exposure, frequency of exposure affect the magnitude of risk. These values are directly proportional to the risk value, where the greater these values, the greater the potential that will occur (Bahar et al., 2012). On the other hand, anthropometric values in this case weight are known to be inversely related to the magnitude of the risk. The higher the value, the lower the potential risk that occurs (Cahyana, 2019).

After calculating the risk per heavy metal or hazard quotient, the next calculation was the amount of accumulated risk of all heavy metals or the hazard index. The highest hazard index value of Pandan Wangi rice was known to be lower than Pulen rice. However, these two rices were known to have non-cancer risks for more than half of the respondents. Although the concentrations of all heavy metals were within safe limits, other data such as the ingestion rate were known to affect the magnitude of the risk (Guyton, 2011). In this study, people in Palembang consume a fairly large amount of rice per day. Rice was also known as the staple food of the people in the city of Palembang where all respondents consume rice at least once a day for a full year. This high exposure data was the factor increases the health risk for the respondents.

This potential risk can depend on the target organ of each heavy metal. For example arsenic, arsenic exposure was known to cause an irregular heartbeat (Davis, 2017). In addition, if consumed in large quantities it can be fatal to death (ATDSR, 2007). Besides arsenic, lead was a heavy metal that can have a negative impact on health (Manahan, 1992). Lead can cause encephalopathy in both adults and children leading to hypoxia (Endrinaldi, 2010). In addition, the digestive system can be disturbed by the consumption of rice containing cadmium (ATSDR, 2011b). If ingested, cadmium can cause gastroenteritis. In addition, cadmium was known to cause kidney corruption and liver problems (Davidson et al., 1988). Like cadmium, copper can cause digestive disorders such as diarrhea. In fact, if consumed in excess of the safe limit with a value large enough to cause death (Dorsey et al., 2004). These things require us to exercise control before the risk becomes the case.

5.5 Cancer risk of Heavy Metals

Heavy metal exposure is known to cause various health problems. Exposure to even small amounts of heavy metals can be hazardous due to their high toxicity (Bunsen, 1994). Heavy metals that enter the body either through the respiratory tract, oral or skin are known to cause cancer. Of the four heavy metals analyzed, three of them are known to have a Cancer risk (Saraswati, 2018, Shahriar et al., 2020, Fakhri et al., 2018). These three heavy metals include arsenic, cadmium and lead. In this study, arsenic was known to have a potential cancer risk where the cancer risk value was more than 1 x 10-6. This was in line with a study in China where arsenic was known to have a cancer risk for the community (Chen et al., 2014). Not only arsenic, in this study lead is also known to have a potential Cancer risk. This finding is similar to findings in a previous study in Iran, where the risk value exceeded the safe limit (Fakhri et al., 2018). The last heavy metal was cadmium which is also known to have potential health risks for humans who consume rice with heavy metals in it. A study in Bangladesh found that the risk of cancer from rice consumption was different in each sub-district (Shahriar et al., 2020).

The concentration of heavy metals in this study was known to be within safe limits, but the risk assessment shows a cancer risk. Consumption of rice in the amount of rice in a day was one of the factors that cause potential risks even though the concentration of heavy metals was relatively low. In addition, the people of Palembang consume rice every day with a daily frequency of at least once a day. This causes the risk value to increase with the amount of intake and frequency of exposure (Guyton, 2011). Efforts to control must be carried out as early as possible to prevent future health risks.

5.6 Associated factors

There are several factors that were thought to be associated with potential risks, both non-cancer and cancer risks. These factors included age, BMI, sex, smoking behavior, drinking alcohol, drinking water source, cooking water source and occupation. The analysis was carried out by chi square analysis. Based on the results of the overall analysis, there are 4 factors related to public health risks in the city of Palembang. These factors include age, BMI, source of drinking water and source of water for cooking.

Age was the first factor that had association with both cancer risk and non-cancer risks in both types of rice. Age was known to have a relationship with the respondent's length of exposure. In this study, the older the respondent, the longer the exposure will be. Especially for respondents who have never moved, so they always eat rice from local markets in Palembang. Therefore the higher the potential risk of both non-cancer risk and cancer risk to the respondents (Bahar et al., 2012). In addition, the older a person is, the greater the risk of experiencing health problems because the body's resistance to toxins is getting weaker (Mukono, 2005). As a person's age increases, it will affect the physiological function of the body which causes disease (Zaenurrohmah and Rachmayanti, 2017).

The second factor was Body Mass Index (BMI). BMI was calculated based on the respondent's weight (kg) and height (m). The results of the analysis showed an association between BMI and non-cancer and cancer risks due to exposure to arsenic, lead, copper and cadmium for both types of rice. This was also in line with the calculation of non-cancer and cancer risks where body weight was one of the variables that can affect the magnitude of the potential risk. The respondent's weight was inversely proportional to the magnitude of the risk value, where the lighter the respondent's weight, the higher the amount of risk that occurs (Cahyana, 2019).

The third factor was the source of community drinking water, which was mostly tap water. The tap water comes from a regional drinking water company in Palembang. However, the community first boils the water for consumption instead of consuming it directly. This factor was known to have associations with non-cancer and cancer risks due to exposure to arsenic, lead, copper and cadmium in both types of rice. While the fourth factor, which was the source of cooking water, has an association with non-cancer risk due to lead exposure in Pandan Wangi rice and copper in Pulen rice. Water itself can be a source of heavy metal contamination. Studi in Iran was found Iron, arsen, cadmium, lead and copper in source of drinking water (Maalakootian et al., 2014). Exposure to heavy metals in these water sources can cause various health problems for humans.

5.6 Limitations

This study only focused on two types of local Indonesian rice while there were so many types of rice grow in Indonesia. This study did not classify respondents according to the type of rice eaten, all respondents were considered to consume both types of rice. In addition, the subjects were not randomly collected data but collected by convenient sampling.

Chapter VI

Conclusion

This chapter present the conclusion of this study and the recommendation for individual level, government level and future study.

6.1 Conclusions

1. Local Indonesian rice that mostly were consumed were Pandan Wangi rice and Pulen rice, they were slightly differences in color, length and shape. For concentration of heavy metals found in these two rice types, all As, Cd, Pb, and Cu were lower than safety standard for food. There was no significant different of heavy metals contamination between Pandan Wangi rice and Pulen rice.
2. The average age of the respondents in this study is 29$\pm$8.88 years, most of whom are female 68.1%. The average weight of the respondents was 59.41$\pm$ 13.51 kg with a height of 159.85$\pm$ 12.11. In addition, 85.1% never smoked and 97.6% did not consume alcohol. Lastly, the respondent's source of water for drinking and cooking comes from tap water with a percentage of 53% and 63.28%, respectively.
3. For health risk assessment, non-cancer results found risk related to As contamination in both types of rice, the average As-HQ was 1.173$\pm$0.59 and ranged from 0.143 to 3.328 for Pandan Wangi rice and 1.328$\pm$0.67 and ranged from 0.162 to 3.767 for Pulen rice. The hazard index (HI) value indicates the potential non-cancer risk due to Pandan Wangi rice with the average of HI was 1.38$\pm$0.70 ranged from 0.16 to 3.93, Pulen rice consumption with average of HI 1.53$\pm$0.78 and ranged from 0.18 to 4.36.
4. Moreover, cancer risk results showed that there will be risk related to consumption of Pandan wangi rice that contaminated by arsenic and cadmium. The average As-CR was $5.2 \times 10^{-4} \pm 2.69$ x $^{10-4}$ range from 6.45×10^{-5} to 1.5×10^{-3}, and the average Cd-CR was $2.57 \times 10^{-3} \pm 1.31 \times 10^{-3}$ ranged from 3.14×10^{-4} to 7.30×10^{-3}. On other hand there will be risk related to consumption of Pulen rice by contamination of arsenic, lead and cadmium. The total cancer risk (TCR) value indicates a potential cancer risk due to consumption of rice

containing heavy metals. The average TCR was $3.10 \times 10^{-3} \pm 1.58 \times 10^{-3}$ ranged from 3.79×10^{-4} to 8.80×10^{-3}, for Pandan Wangi rice was $2.74 \times 10^{-3} \pm 1.40 \times 10^{-3}$ and ranged from 3.38×10^{-4} to 7.84×10^{-3}.

5. Age, BMI, source of drinking water, and cooking water were found association with Non-cancer and Cancer risk for both Pandan Wangi rice and Pulen rice.

6.2 Recommendation

6.2.1 Individual Level

1. For individual might reduce the daily portion of consumption of rice in one day to 160 gram/day or one plate and half portion for one day (small portion). The aging population could reduce the portion of daily consumption and change to other carbohydrates such as potatoes.
2. Use another resource of water to drink and cooking rather than use tap water. Residents in Palembang can use the filtration method to reduce the concentration of heavy metals in water.

6.2.2 Community Level

1. For community specifically for farmers should control of the use of pesticides and fertilizers during the planting process should be done to reduce heavy metal contamination in agricultural products.
2. Local government give education to farmers relating pesticides and fertilizer use during planting process.
3. Local government through public health center give health promotion related heavy metals contamination in food and water to community.

6.2.3 Government Level

1. The Government need to make clear regulation related to pesticides and fertilizers use in agricultural area.
2. The government can make a campaign related to the dangers of using pesticides and fertilizers in the rice planting process.
3. Government should set the safe limit standard of heavy metals in rice based on the number of consumption rice in one day rather than use international standard.

6.2.4 Future Study

1. Follow-up studies can classify respondents based on the type of rice they consume.
2. Research could take the sample based on respondents rather than buy from local market to analyze the specific brand which consume by respondents.
3. Future study can use biomarkers such as urine or blood to have accurate results of heavy metals contamination in human body.
4. Future study can add another type of rice to analyze.
5. Beside analyze the rice, future study can analyze others factors which have association with heavy metals contaminations such as in water, soil or air.

APPENDIX

Screening Questionnaire

This questionnaire is part of a thesis research at the College of public health sciences, Chulalongkorn University. The title of this research is "Human Health Risk Assessment Related With Heavy Metalss Contaminations In Rice : A Case Study In Palembang, South Sumatra, Indonesia" which is part of the research, Dian Islamiati. This questionnaire contains questions related to personal information and rice consumption behavior in people in the city of Palembang. Duration Filling out the questionnaire only takes 10-15 minutes. Your role is very meaningful to help this research. Thank you.

1. Do you eat rice as at least 3 days a week food?
    a. Yes
    b. No (end screening questionnaire)
2. Are you 20-60 years old?
    a. Yes
    b. No (end screening questionnaire)
3. Have you lived in Palembang for at least one year?
    a. Yes
    b. No (end screening questionnaire)
4. Do you have a history of cancer?
    a. Yes (end screening questionnaire)
    b. No
5. Do you have a history of heart disease, or kidney failure, or respiratory diseases or carbohydrate allergies?
    a. Yes (end screening questionnaire)
    b. No

Code…………..

QUESTIONNAIRE

This questionnaire is part of a thesis research at the College of public health sciences, Chulalongkorn University. The title of this research is "Human Health Risk Assessment Related With Heavy Metalss Contaminations In Rice : A Case Study In Palembang, South Sumatra, Indonesia" which is part of the research, Dian Islamiati. This questionnaire contains questions related to personal information and rice consumption behavior in people in the city of Palembang. Duration Filling out the questionnaire only takes 10-15 minutes. Your role is very meaningful to help this research. Thank you.

This questionnaire consists of 16 questions with 2 parts; Part A : Personal Information, and Part B : Rice consumption

A.PERSONAL INFORMATION

1. Age :……. Years
2. Sex : Male/Female
3. Weight……kg
4. Height……cm
5. Occupation : ……….(please specify)
6. Smoking behavior : a. Smokers/b.Ex-smoker/c.Never smoke
7. Alcohol drinking: a. Yes/b. No
8. Source of drinking Water : Groundwater / River water/ Tap water/ Rain water / other….(please specify)….
9. Source of cooking Water : Groundwater / River water/ Tap water/ Rain water / other….(please specify)….
10. Underlying disease : yes….(please specify)…. / no
11. Do you have history of cancer ? Yes/No
12. How long do you live in Palembang?…..Years

Part B Rice Consumption

13. Do you consume rice everyday?

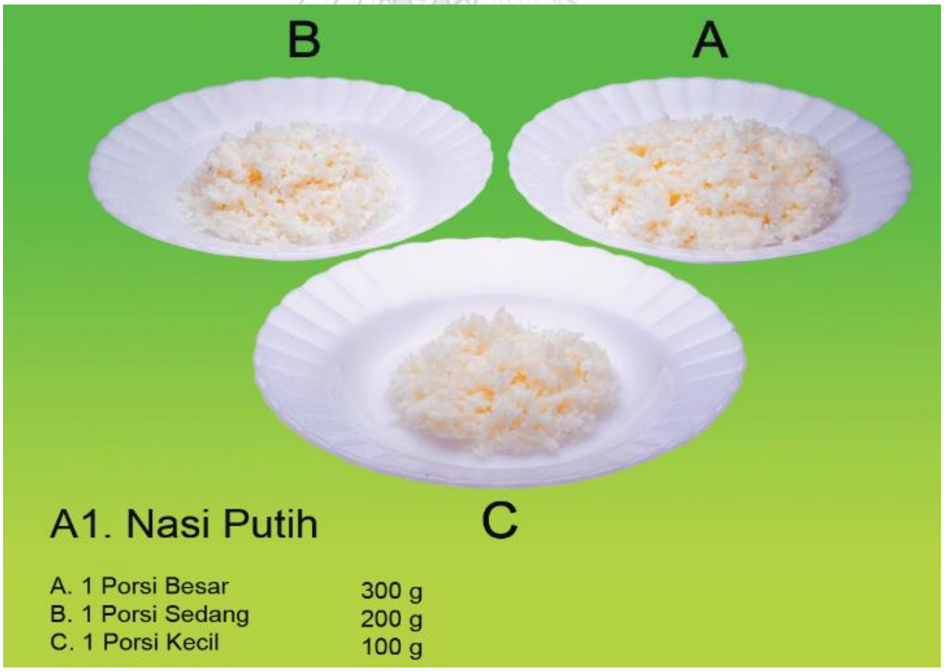
a.Yes, eat usually …….. meals per day.

b.No

14. If no, how many meal do you eat rice in a week? …….meals per week.

15. How long you have been eating rice? …..years.

16. How much you consume rice in one meal? ……gram (a. Big portion = 300 gram/b.Medium portion = 200 gram/c. Small portion = 100 gram/d. other) (Kesehatan, 2014).



KOMISI ETIK PENELITIAN KESEHATAN
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KETERANGAN LOLOS KAJI ETIK
DESCRIPTION OF ETHICAL APPROVAL
"ETHICAL APPROVAL"

Nomor : 276/UN9.FKM/TU.KKE/2022

Protokol penelitian yang diusulkan oleh :
The research protocol proposed by

Peneliti Utama : Dian Islamiati
Principal in Investigator

Nama Institusi : Chulalongkorn University, Thailand
Name of the Institution

Dengan Judul :
Tittle

"PENILAIAN RISIKO KESEHATAN MANUSIA TERKAIT DENGAN KONTAMINASI LOGAM BERAT PADA BERAS: STUDI KASUS DI PALEMBANG, SUMATERA SELATAN, INDONESIA"

"HUMAN HEALTH RISK ASSESSMENT RELATED WITH HEAVY METALS CONTAMINATION IN RICE: A CASE STUDY IN PALEMBANG, SOUTH SUMATRA, INDONESIA"

Dinyatakan laik etik sesuai 7 (tujuh) Standar WHO 2011, yaitu 1) Nilai Sosial, 2) Nilai Ilmiah, 3) Pemerataan Beban dan Manfaat, 4) Risiko, 5) Bujukan/Eksploitasi, 6) Kerahasiaan dan Privacy, dan 7) Persetujuan Setelah Penjelasan, yang merujuk pada Pedoman CIOMS 2016. Hal ini seperti yang ditunjukkan oleh terpenuhinya indikator setiap standar.

Declared to be ethically appropriate in accordance to 7 (seven) WHO 2011 Standards, 1) Social Values, 2) Scientific Values, 3) Equitable Assessment and Benefits, 4) Risks, 5) Persuasion/Exploitation, 6) Confidentiality and Privacy, and 7) Informed Concent, referring to the 2016 CIOMS Guidelines. This is as indicated by the fulfillment of the indicators of each standard.

Pernyataan Laik Etik ini berlaku selama kurun waktu tanggal 15 Juli 2022 sampai dengan tanggal 15 Juli 2023.

This declaration of ethics applies during the period July 15, 2022 until July 15, 2023.

Indralaya, 15 Juli 2022
Head of the Committee,

KOMISI ETIK PENELITIAN KESEHATAN
KEPK-FKM
FAKULTAS KESEHATAN MASYARAKAT

Dr. Rostika Flora, S.Kep., M.Kes
NIP. 197109271994032004

SPSS Output

Hazard Index for Pandan Wangi

HIPW-Smoking

Crosstab

Count

		HIPWCAT high	HIPWCAT low	Total
rokok	Perokok	17	20	37
	Mantan Perokok	11	14	25
	Tidak pernah merokok	158	197	355
Total		186	231	417

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	.032[a]	2	.984
Likelihood Ratio	.032	2	.984
N of Valid Cases	417		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 11.15.

HIPW-Alcohol cosumption

Crosstab

Count

		HIPWCAT high	HIPWCAT low	Total
alkohol	Ya	5	5	10
	Tidak	181	226	407
Total		186	231	417

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.121[a]	1	.728		
Continuity Correction[b]	.001	1	.980		
Likelihood Ratio	.120	1	.729		
Fisher's Exact Test				.757	.485
N of Valid Cases	417				

a. 1 cells (25.0%) have expected count less than 5. The minimum expected count is 4.46.

b. Computed only for a 2x2 table

HIPW-Source of drinking water

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	16.356[a]	4	.003
Likelihood Ratio	16.495	4	.002
N of Valid Cases	417		

a. 4 cells (40.0%) have expected count less than 5. The minimum expected count is .89.

Crosstab

Count

		HIPWCAT		
		high	low	Total
air_minum	Air tanah	54	35	89
	Air sungai	3	2	5
	Air Keran	96	125	221
	Air hujan	1	1	2
	Lainnya	32	68	100
Total		186	231	417

HIPW-cooking water

Crosstab

Count

		HIPWCAT high	HIPWCAT low	Total
air_masak	Air tanah	55	45	100
	Air sungai	5	7	12
	Air keran	112	150	262
	Air hujan	1	1	2
	Lainnya	13	28	41
Total		186	231	417

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	7.565[a]	4	.109
Likelihood Ratio	7.619	4	.107
N of Valid Cases	417		

a. 2 cells (20.0%) have expected count less than 5. The minimum expected count is .89.

HIPW-Sex

Crosstab

Count

		HIPWCAT high	HIPWCAT low	Total
Sex	Laki-laki	67	66	133
	Perempuan	119	165	284
Total		186	231	417

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	2.633[a]	1	.105		
Continuity Correction[b]	2.301	1	.129		
Likelihood Ratio	2.626	1	.105		

Fisher's Exact Test				.114	.065
N of Valid Cases	417				

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 59.32.

b. Computed only for a 2x2 table

HIPW-BMI

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	635.969[a]	10	.000
Likelihood Ratio	768.543	10	.000
N of Valid Cases	603		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 7.09.

HIPW-age

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	601.138[a]	4	.000
Likelihood Ratio	735.827	4	.000
N of Valid Cases	603		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 16.35.

Hazard Index for Pulen rice

HIP-Smoking

Crosstab

Count

		HIPWCAT		
		high	low	Total
rokok	Perokok	17	20	37

	Mantan Perokok	11	14	25
	Tidak pernah merokok	158	197	355
Total		186	231	417

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	.032[a]	2	.984
Likelihood Ratio	.032	2	.984
N of Valid Cases	417		

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 11.15.

HIP-Alcohol cosumption

Crosstab

Count

		HIPWCAT		
		high	low	Total
alkohol	Ya	5	5	10
	Tidak	181	226	407
Total		186	231	417

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	.121[a]	1	.728		
Continuity Correction[b]	.001	1	.980		
Likelihood Ratio	.120	1	.729		
Fisher's Exact Test				.757	.485
N of Valid Cases	417				

a. 1 cells (25.0%) have expected count less than 5. The minimum expected count is 4.46.

b. Computed only for a 2x2 table

HIP-Source of drinking water

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	16.356[a]	4	.003
Likelihood Ratio	16.495	4	.002
N of Valid Cases	417		

a. 4 cells (40.0%) have expected count less than 5. The minimum expected count is .89.

Crosstab

Count

		HIPWCAT		
		high	low	Total
air_minum	Air tanah	54	35	89
	Air sungai	3	2	5
	Air Keran	96	125	221
	Air hujan	1	1	2
	Lainnya	32	68	100
Total		186	231	417

HIP-cooking water

Crosstab

Count

		HIPWCAT		
		high	low	Total
air_masak	Air tanah	55	45	100
	Air sungai	5	7	12
	Air keran	112	150	262
	Air hujan	1	1	2
	Lainnya	13	28	41
Total		186	231	417

Chi-Square Tests

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Likelihood Ratio	7.619	4	.107
N of Valid Cases	417		

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HIP-Sex

Crosstab

Count

		HIPWCAT		
		high	low	Total
Sex	Laki-laki	67	66	133
	Perempuan	119	165	284
Total		186	231	417

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N of Valid Cases	603		

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Total Cancer risk for Pandan Wangi rice

TCRPW-Smoking

Crosstab

Count

		HIPWCAT		
		high	low	Total
Rokok	Perokok	17	20	37
	Mantan Perokok	11	14	25
	Tidak pernah merokok	158	197	355
Total		186	231	417

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
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Crosstab

Count

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Crosstab

Count

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air_minum	Air tanah	54	35	89
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TCRPW-cooking water

Crosstab

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TCRPW-Sex

Crosstab

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Sex	Laki-laki	67	66	133
	Perempuan	119	165	284
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VITA

NAME	Dian Islamiati
DATE OF BIRTH	25 January 1999
PLACE OF BIRTH	Tanjung Seteko
INSTITUTIONS ATTENDED	College of Public Health Sciences, Chulalongkorn University
HOME ADDRESS	66 Soi Phahonyothin 53 Yaek 4, Phahonyothin Rd, Anusawari, Bang Khen, Bangkok 10220
PUBLICATION	Environmental Health's Risk Analysis of Carbon Monoxide (CO) Exposure Towards Satay Traders in Palembang (https://doi.org/10.25311/keskom.Vol8.Iss1.1084)