Proceeding of the Public Health and Well-being Conference, Vol. 1, 2022, pp. 102-110

ISSN 2659-2096
DOI: https://doi.org/10.32789/publichealth.2022.1008

Environmental Health Risk Assessment Carcinogen and Non-Carcinogen Analysis: Arsenic in Rice

Dian Islamiati[1], Dini Arista Putri[2]

[1]*Universitas Sriwijaya; dianislamiati2501@gmail.com*
[2]*Universitas Sriwijaya; dini.aristaputri@unsri.ac.id*

ENVIRONMENTAL HEALTH RISK ASSESSMENT CARCINOGEN AND NON-CARCINOGEN ANALYSIS: ARSENIC IN RICE

Abstract: Rice is the staple food of most Indonesian people. The process of planting rice using pesticides can cause contamination, one of which is arsenic contamination. Arsenic is a heavy metal that can cause various health problems such as disorders of the nervous system, respiratory system, digestive system, cardiovascular and kidney. This study aims to assess the health risks of both carcinogenic and non-carcinogenic risks due to consumption of rice containing arsenic. This research uses environmental health risk analysis method. The sample in this study amounted to 9 samples of rice which were analyzed by the Inductively Coupled Plasma (ICP) method. The sample of respondents was 96 people who were taken by purposive sampling method. Through this study, it was found that the average concentration of arsenic was 0.01 mg/kg, the respondent's body weight was 45.74 kg, the frequency of exposure was 365 days, the intake rate of 200 grams and the duration of exposure adjusted for each respondent's exposure. The final result of the calculation of the carcinogenic analysis (ECR) was 1.02 X 10^{-4} and the non-carcinogenic analysis (RQ) was 0.29. The results of these two analyzes indicate that the consumption of rice containing arsenic is still within safe limits. Continuous efforts should be made to keep arsenic concentrations within safe limits.

Keywords: pesticides, rice, Arsenic, EHRA

Introduction

The use of pesticides is now widely used in agriculture. The use of pesticides itself can indirectly increase agricultural yields (Peraturan Menteri Pertanian Republik Indonesia, 2014). The positive impact of the use of pesticides will certainly provide benefits to agriculture. However, the use of pesticides in agriculture also has a negative impact on both the environment and human health (Wahyuni, 2010). Waterlogged rice plants allow the roots to absorb the arsenic content in the soil and water due to pesticide drops. In addition, pesticides can also be absorbed by the affected plants, both in the leaves and stems of rice plants (Awasthi *et al.*, 2017).
Arsenic found in food has attracted the attention of scientists around the world. One of the foods that contain arsenic is rice. Rice is the main product obtained from milling grain from rice plants where the entire husk layer is peeled off and the bran part is partially separated (BSN, 2008). According to the Central Statistics Agency in 2017, it was noted that people's rice consumption in Indonesia reached 200-350 grams per day (BPS, 2017). Sigrist's research (2016) suggests that there is an arsenic content of 0.87-3.16 mg/kg in rice in Argentina (Sigrist *et al.*, 2016). Another study conducted by Chen et al in 2014 in China found that rice contains arsenic with a concentration of 0.21-0.3 mg/kg (Chen *et al.*, 2014). Arsenic findings in rice are not only found in foreign countries, but also in Indonesia. Through Ginting's research in 2018 it was stated that there was arsenic of 3.71 mg/kg in brown rice, 3.4 mg/kg, 0.3 mg/kg in white rice and 0.13 mg/kg in black rice (Ginting, 2018). The arsenic contained in this rice mostly exceeds the threshold, where the World Health Organization or WHO sets the maximum standard of arsenic in rice at 0.3 mg/kg.

Arsenic can cause health effects even though the exposure level is low which can cause diseases related to the liver, kidneys, blood, digestive tract and respiratory tract (Kapaj *et al.,* 2013). Toxicity of arsenic is bad for the health of the liver, eyes, blood and skin. In addition, arsenic can also cause spinal cord failure, laryngeal infection and even kidney tissue damage (Darmono, 2006). Symptoms of arsenic poisoning include muscle cramps, nausea and vomiting, abdominal pain, skin changes such as warts, heart rhythm disturbances, tingling in the fingers. hands and feet, dark urine and headaches (Davis, 2017). Therefore, an analysis was carried out to estimate the health risks of Arsenic content in rice using the Environmental Health Risk Analysis method.

Method

This research uses quantitative analysis method with descriptive research type. This study uses environmental health risk analysis with univariate analysis. Environmental Health Risk Analysis (ARKL) is a method used to calculate the estimated risk due to exposure to a biological or chemical agent in a population exposed or at risk by considering the characteristics of the agent and population. Sampling with purposive sampling method is sampling with consideration through the characteristics of the population that are already known. Before carrying out the data collection process, the researcher submitted informed consent to the respondent as a consideration for the respondent. While the rice sample was taken randomly by the method of every 11 respondents one sample was taken. Then the rice samples were analyzed at the Palembang Health Laboratory Center to determine the levels of arsenic in rice using the Inductively Coupled Plasma method. Data analysis was carried out on each variable in the form of a frequency distribution using a software program to determine the characteristics of the variables studied.

The method of calculating the environmental health risk analysis of non-carcinogenic (RQ) and carcinogenic (ECR) risk agents is to calculate the intake value first with the formula, I = $\frac{C\ X\ R\ X\ fE\ X\ Dt}{Wb\ X\ Tavg}$. After getting the Intake value, the amount of RQ and ECR risk can be calculated using the formula RQ=$\frac{I}{RfD}$ dan ECR = Ink X SF. If through the calculation of the magnitude of the risk of RQ and ECR, the calculation results in the form of a value of RQ> 1 and ECR> E-4, it can be said that the rice consumed has a risk to health that can pose a carcinogenic risk and requires control. If the risk magnitude is RQ 1 and ECR E-4, then the rice consumed by farmers is still classified as safe and no control is needed.

Results

Arsenic Concentration in Rice in Batu Ampar Village

The concentration of arsenic in rice was obtained from 9 rice samples in Batu Ampar Village and analyzed using the Inductively Coupled Plasma method at the Palembang Health Laboratory Center. The results of the analysis of the arsenic content in rice are as follows.

Table 1: Results of Statistical Analysis of Arsenic Concentration in Rice in Batu Ampar Village

Variabel	Mean	Median	SD	Min	Max
Concentration Arsenic	0.010554	0.010505	0.001067	0.009422	0.012345

Based on the results from table 1, it is known that the average concentration of arsenic in Batu Ampar Village is 0.010554 mg/kg. The average concentration is still at the safe limit set by WHO, which is 0.3 mg/kg. The highest arsenic concentration was 0.012345 mg/kg and the lowest was 0.009422 mg/kg.

Body weight, intake rate, frequency of exposure and duration of exposure of respondents

The results of the study on body weight, intake rate, frequency of exposure and duration of exposure of respondents were obtained using a questionnaire, while the intake rate used secondary data from BPS 2017.

Table 2: Results of Univariate Analysis of Body Weight

Variabel	Mean	Median	SD	Min	Max
Body Weight	45.74	49	15.68	16	83

In the table above, it can be seen that the average body weight of respondents in Batu Ampar Village, Sirah Island Padang District is 45.75 kg. The value of the intake rate is 0.2 kg, the frequency of the respondent's exposure is 365 days/year and the duration of exposure of the respondent is according to the age and length of stay of the respondent in Batu Ampar Village.

Dose Response and Slope Factor

In this study, the risk agent studied was the arsenic content in rice, where rice can cause non-carcinogenic and carcinogenic effects. So that the calculation of the RQ value uses the RfD value and the ECR calculation uses the Slope Factor value. Both of these values use the default values by IRIS at the US-EPA, where the RfD value for arsenic is 0.0001 mg/kg and the slope factor value is 1.5mg/kg.

Arsenic Exposure Intake

Calculation of intake is a calculation of the variables that have been studied either by interview in the form of measurements of body weight, duration of exposure and frequency of exposure as well as analysis of arsenic concentrations in the environment. The intake calculation is divided into two, namely the realtime intake calculation and the lifetime intake calculation. The results of the statistical calculation of realtime intake and lifetime intake of 96 respondents are as follows.

Table 3: Results of Statistical Analysis of Respondents Realtime and Lifetime Intake RQ and ECR in Batu Ampar Village

Variabel	Mean	Median	SD	Min	Max
Intake Realtime (RQ)	0.0000342	0.0000296	0.0000187	0.00000606	0.00011860
Intake Lifetime (RQ)	0.0000547	0.0000431	0.0000274	0.0000254	0.00013193
Intake Realtime (ECR)	9589.366	8284.302	5245.112	1696.983	33183.29
Intake Lifetime (ECR)	35725.66	28121.43	17896.98	16601.81	86121.88

Based on the table above, it can be seen that the average realtime RQ intake value is 0.00000342 mg/kg/day and the lifetime RQ intake is 0.0000547 mg/kg/day. While the realtime ECR intake value is 9589.366 mg/kg/day and the lifetime ECR intake value is 35725.66 mg/kg/day. Calculation of the intake value is calculated by the value of the arsenic concentration which is averaged first. Furthermore, the intake value is used to calculate the RQ and ECR values, where the median value is used because the data is not normally distributed.

Exposure Risk Characteristics (ECR and RQ Analysis)

Non-Carcinogenic Health Risk Characteristics or Risk Quotients (RQ) and carcinogenic health characteristics or Excess Cancer Risk (ECR) are the final results to determine whether or not it is safe to consume rice exposed to arsenic. RQ and ECR calculations include realtime and lifetime calculations for 96 respondents in Batu Ampar Village. The results of the statistical analysis of realtime RQ and ECR as well as lifetime RQ and ECR on respondents in Batu Ampar Village are as follows.

Table 4: Results of ECR Realtime Statistical Analysis of Respondents in Batu Ampar Village

Variabel	Mean	Median	SD	Min	Max
RQ Realtime	0.342756	0.296109	0.187478	0.060656	1.186081
RQ Lifetime	0.547266	0.43078	0.274156	0.254316	1.319264
ECR Realtime	1.44E+04	1.20E+04	7.87E+03	2.55E+03	4.98E+04
ECR Lifetime	5.36E+04	4.20E+04	26845.47	2.49E+04	1.29E+05

Based on the results of the statistical analysis above, the intake value used is the median value because the data is not normally distributed. So that the results obtained are realtime RQ values with a median value of 0.29 and a lifetime RQ value of 0.43 with an exposure duration of 30 years. While the realtime ECR value is 1.20E+04 and lifetime ECR is 4.20E+04. These two values indicate that the consumption of rice containing arsenic in Batu Ampar Village is still within safe limits.

Discussion

Arsenic Concentration

The concentration of arsenic in rice is influenced by the type and intensity of pesticide use on agricultural land. Spraying high intensity pesticides and mixing 3-5 types at once with a spraying frequency of 2-3 days can affect the levels of arsenic contamination on agricultural land (Suhartono and Dharminto, 2010). The pesticides used in Batu Ampar Village are pesticides with active ingredients including dimethyl amine, beta cyflutarin, glyphosate, dimehipo, deltamethrin, cypemethrin, fipronil, IPA glyphosate and benomyl. Identified from the active ingredient, this pesticide is a pesticide type Insecticide and herbicide which is an indicator of arsenic contamination (Ma and Hooda, 2010). White arsenic or used in herbicides that function to eradicate weeds (Purbalisa *et al.,* 2018). The low level of arsenic in rice is influenced by the intensity of pesticide spraying on farmers in Batu Village Ampar. In addition, the use of fertilizers at a certain level will affect the levels of arsenic in rice. Increasing the use of fertilizers is in line with the increase in heavy metal contamination (Raven *et al.,* 1998). The intensity of fertilizer use in Batu Ampar Village is only at the beginning of the rice planting period. So that the intensity of using fertilizer only once can affect the concentration of arsenic in rice.

Respondent's Weight

Body weight is one of the variables used in the calculation of intake, so the value of body weight affects the amount of intake. Measurement of body weight can be a determining factor in calculating risk agents

Exposure Duration

The duration of exposure was calculated from the time the respondent consumed rice from agriculture in Batu Ampar Village until his age when the study was conducted in December 2019. The shortest duration of exposure was 3 years and the longest was 59 years. Respondents are known to be mostly residents who have lived in Batu Ampar Village from birth to adulthood, although there are respondents who are residents who come from other villages and live in Batu Ampar Village now. The duration of exposure affects the health risks experienced by respondents. The longer a person is exposed to arsenic, the higher the health risks.

Exposure Intake Analysis

Calculation of intake using anthropometric data, frequency of exposure and duration of exposure of each respondent which is then calculated also the value of intake with the average value of all variables. The intake value is directly proportional to the arsenic concentration in rice, the frequency of exposure, the intake rate and the duration of exposure. This means that the greater the value of the variable, the greater the intake received by the respondent. On the other hand, the value of intake is inversely proportional to the value of body weight. The greater the value of body weight, the smaller the value of the resulting intake. Other factors that influence the intake value are gender, age, respondent's behavior such as smoking behavior or behavior in the use of personal protective equipment and a history of illness that has been suffered. Calculation of real-time intake and lifetime intake is distinguished based on the length of exposure. Realtime intake uses the duration of exposure, which is the length of time the respondent has consumed agricultural rice, while the lifetime intake uses the US-EPA default value for carcinogenic effects, which is 70 years.

Exposure Risk Characteristics

Realtime and Lifetime non-carcinogenic and carcinogenic Health Risk Characteristics are the final results used to determine whether or not risk management is necessary. Through the results of the intake calculation that has been done previously, the intake value is used to determine the value of Risk Quotient (RQ) and Excess Cancer Risk (ECR). The RQ calculation is obtained from the quotient between the intake value and RfD and the ECR value is obtained from the product of the intake value with the slope factor (SF). Through real-time and lifetime calculations, it is known that all respondents produce RQ values 1 and ECR 4. This means that the consumption of agricultural rice in Batu Ampar Village does not pose a health risk to respondents, both non-carcinogenic.

In this study, the levels of arsenic in white rice were relatively small, but the majority of Indonesian people consumed white rice. The amount of rice consumption in each country varies so that it affects the amount of carcinogenic arsenic exposure in humans. Asian countries such as Indonesia consume more rice than European and American countries, this is what causes Indonesians to be vulnerable to Arsenic contamination (Zhu *et al*, 2008). With this different amount of rice consumption, the government should set a maximum standard of arsenic in rice because the WHO standard is still too high. . The setting of this standard can be adjusted to the amount of rice consumption of the Indonesian people so that the RQ and ECR values remain within safe limits.

Conclusion

In this study, it can be seen that the analysis results show the average value of arsenic concentration in rice is 0.01 mg/kg. The real-time RQ value is 0.29 and the real-time ECR value is 1.20E+04. Thus, the RQ and ECR values indicate that the consumption of rice containing arsenic in Batu Ampar Village is still within safe limits. Even so, efforts are still needed so that the consumption of rice containing arsenic does not pose a risk to health by cooking rice using reverse osmosis water.

References

Arsenic Poisoning Symptoms, Signs & Treatment, Date of access: 27/01/22. https://www.medicinenet.com/arsenic_poisoning/davis-ca_city.htm.

Awasthi, S. *et al,* 2017, The Journey of Arsenic from Soil to Grain in Rice. *Frontiers in Plant Science*. *Frontiers,* 8, p. 1007.

Badan Pusat Statistik, 2017, *Kajian Konsumsi Bahan Pokok 2017* (Jakarta: BPS RI).

Chen, B. *et al,* 2014, Accurate Fast Screening for Total and Inorganic Arsenic in Rice Grains using Hydride Generation Atomic Fluorescence Spectrometry (HG-AFS). *Analytical methods*. *Royal Society of Chemistry*, 6(18), pp. 7554–7558.

Darmono, 2006, *Lingkungan Hidup dan Pencemaran Hubungannya dengan Toksikologi Senyawa Logam* (Jakarta: UI Press).

Ginting, E. E, 2018, *Analisis Arsen pada Berbagai Jenis Beras yang Beredar di Kota Medan dengan Spektrofotometri Serapan Atom* (Medan: Universitas Sumatera Utara).

Indonesia Congres, Badan Standardisasi NasionaL, 2008, Standar Nasional Indonesia Beras Giling, SNI 6128: 2008.

Indonedia Congres, Peraturan Menteri Pertanian Republik Indonesia, 2014, Peraturan Menteri Pertanian Republik Indonesia No.17/Permentan/SR.104/9/2014 tentang Pengawasan Pestisida.

Kapaj, S. *et al,* 2013, Human Health Effects from Chronic Arsenic Poisoning–A Review. *Journal of Environmental Science and Health, Part A*. Taylor & Francis, 41(10), pp. 2399–2428.

Ma, Y. and Hooda, P. S, 2010, Chromium, Nickel and Cobalt. *Trace Elements in Soils*. Wiley Online Library, 13, pp. 461–480.

Nukman, A. *et al,* 2012, Analisis dan Manajemen Risiko Kesehatan Pencemaran Udara: Studi Kasus di Sembilan Kota Besar Padat Transportasi. *Jurnal Ekologi Kesehatan*.

Purbalisa, W., Hidayah, A. and Sukarjo, S, 2018, Baku Mutu Arsen pada Tanah Inceptisol Grobogan dengan Tanaman Indikator Padi. *Jurnal Tanah dan Sumberdaya Lahan*, 5(1), pp. 621–627.

Raven, P, Berg, L dan Johnson, G, B 1998, *Environment* (New York: Saunder College Publishing).

Sigrist, M. *et al*, 2016, Total Arsenic in Selected Food Samples from Argentina: Estimation of Their Contribution to Inorganic Arsenic Dietary Intake. *Food chemistry*. Elsevier, 210, pp. 96–101.

Suhartono, S. and Dharminto, D, 2010, Keracunan Pestisida dan Hipotiroidisme pada Wanita Usia Subur di Daerah Pertanian. *Kesmas: Jurnal Kesehatan Masyarakat Nasional (National Public Health Journal)*, 4(5), pp. 217–222

Wahyuni, S, 2010, *Perilaku Petani Bawang Merah dalam Penggunaan dan Penanganan Pestisida serta Dampaknya terhadap Lingkungan (Studi Kasus di Desa Kemukten, Kecamatan Kersana, Kabupaten Brebes)* (Semarang: Magister Ilmu Lingkungan Universitas Diponegoro).

Zhu, Y.-G., Williams, P. N. and Meharg, A. A, 2008, Exposure to Inorganic Arsenic from Rice: A Global Health Issue. *Environmental Pollution*. Citeseer, 154(2), pp. 169–171.