Jurnal Kesehatan Lingkungan
Journal of Environmental Health
Vol. 14 No. 3
DOI: 10.20473/jkl.v14i3.2022.193-200
ISSN: 1829 - 7285 | E-ISSN: 2040 - 881X
Journal Home Page: https://e-journal.unair.ac.id/JKL
ORIGINAL RESEARCH Open Access

RISK ANALYSIS OF COMMUNITY WATER QUALITY IN ALAHAN PANJANG AGRICULTURAL AREA, SOLOK REGENCY, WEST SUMATERA, INDONESIA

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Article Info
Submitted : 19 February 2022
In reviewed : 16 May 2022
Accepted : 15 July 2022
Available Online : 31 July 2022

Keywords : *Agriculture, Clean water, Dug well, Pesticide, Risk Analysis*

Published by *Faculty of Public Health Universitas Airlangga*

Abstract

Introduction: *Pesticides are chemicals used by farmers to eliminate pests on plants and increase crop productivity. The intensive use of pesticides increases pesticide residues in soil and water. Pesticides can cause certain cancers such as cancer of the digestive system, stomach, esophagus, lung, intestine, bladder, and lymphoma, mutagenic, and teratogenic. The purpose of this research was to determine the risk analysis of community water quality in the agricultural area of Alahan Panjang, Solok Regency.* ***Methods:*** *The design applied in this research was a descriptive observational study conducted with a cross-sectional design and a field study approach with Environmental Health Risk Analysis (EHRA), by examining 30 dug wells in the agricultural area of Alahan Panjang and the people who consume the water taken by purposive sampling.* ***Results and Discussion:*** *The average length of use of well water by the community was 26.87 years. Based on the results of sanitation inspections, most of the well water was vulnerable to contamination, namely 90%. All well water samples exceeded the quality standard value of 0.1 mg/L. All real-time Risk Quotient (RQ) and 30 year RQ values were risky.* ***Conclusion:*** *The use of pesticides that were not in accordance with the established rules causes pollution to the water sources consumed by the community around the Alahan Panjang farm. The excessive use of pesticides can cause contamination of water sources in communities around agricultures areas.*

INTRODUCTION

Indonesia is known as an agricultural country where agricultural activities can provide economic support. However, agricultural activities can also have a negative impact on the environment. One of the pollutants produced from agricultural activities is pesticides (1). Pesticides are chemical compounds that are used to kill pests including insects, mice, and unwanted plants. Regarding in public health, pesticides are used to kill disease vectors, such as mosquitoes, while in terms of agriculture, they are defined as killers of pests that damage crops. By nature, pesticides are potentially toxic to other organisms including humans, and their use must be safe and disposed of properly. Pesticide comes from the Latin *pestis* and *caedo* which can be freely translated into poison to control intruder bodies (2-3).

The use of pesticides in their application in agriculture is not right on target. It is estimated that only 20% of pesticides reach the target while another 80% fall to the ground and contaminate groundwater (4). The general weakness found among farmers in increasing agricultural production and in tackling pests and plant diseases is their lack of knowledge about the negative impact of pesticide residues that can cause environmental pollution, killing of natural enemies, the occurrence of pest resistance and resurgence, emergence of residues in commodity products and agriculture, which is harmful to humans and the environment. Given the need and the use of pesticides, there have been many pesticide products circulating in the community, especially farmers. Each type of pesticide has a different function and toxicity. Besides being able to help humans in an effort to overcome pests and plant diseases, it turns out that the application of pesticides has a great influence on other organisms and the environment that are not targeted. Most pesticides contain chemical compounds that are highly toxic, not only toxic to pests and plants, but also have a negative impact on human health and the surrounding. Humans as the highest trophic level in the

Cite this as :
Arlinda S, Suksmerri S, Mukhlis M, Mahaza M. Risk Analysis of Community Water Quality in Alahan Panjang Agricultural Area, Solok Regency, West Sumatera, Indonesia. *Jurnal Kesehatan Lingkungan*. 2022;14(3):193–200. https://doi.org/10.20473/jkl.v14i3.2022.193-200

food chain cannot escape the adverse effects of using pesticides, either directly or indirectly (5–7). Deaths caused by pesticide poisoning are rarely reported, only a few are published mainly due to misuse (to commit suicide). Deaths caused by pesticide poisoning are rarely reported, only a few are published mainly due to misuse (to suicide). Currently, various types of pesticides have been produced in an effort to reduce side effects that can cause reduced toxicity to humans but are very toxic to insects. With the toxic and persistent nature of pesticides, uncontrolled use of pesticides is feared to burden the environment and reduce health (8).

Intensive use of pesticides increases pesticide residues in soil and water. The dose of fertilizer application that is quite high at present is 400-600 kg pesticide/ha above the government recommendation of 200-260 kg pesticide/ha. Rain or evaporation carries pesticides from farmland to rivers and lakes. Pesticides that are left or dissolved in surface runoff will be found in the soil layer and dissolved with groundwater flow. Increased concentrations of pesticides in water are caused by accidental spills or excessive discharge of chemicals on the surface of the water. Water quality is affected by pesticide content related to the presence and level of toxicity, where its ability to be transported is a function of its solubility and ability to be absorbed by soil particles (9). One of the factors for pesticide contamination in wells is the distance between the well and agricultural land. The distance between the well as a provider of clean water and agricultural land is recommended to be a minimum of 50 m, and the radius of pesticides carried by groundwater flow is 10 to 150 m depending on the amount of pesticide concentration that contaminates, type and soil position (10).

Pesticide poisoning in agricultural areas is a public health problem, especially in developing countries (11). Chronic poisoning due to pesticides is currently the most feared because the toxic effects can be carcinogenic (formation of cancer cells in the body), mutagenic (genetic damage for future generations), and teratogenic (birth of deformed children from poisoned mothers). It is estimated that 1 to 5 million cases of pesticide poisoning occur in the world each year with 220,000 deaths. Pesticide poisoning occurs due to the use of inappropriate doses and is carried out continuously. The main effects of pesticide poisoning are nervous system disorders such as headaches, dizziness, paresthesias, tremors, discoordination, and seizures; and inhibits the enzyme acetylcholinesterase which interferes with the organs of motion. The long-term effects of pesticides include anemia, anorexia, weight loss, and impaired liver function (12-13). The least number of cases of death caused by pesticide poisoning is 20,000 people per year based on data from the World Health Organization (WHO). Approximately 5,000 – 10,000 people per year are estimated to experience very fatal impacts, such as cancer, disability, infertility, and liver disease (14).

Solok Regency is one of the regencies in West Sumatra which has an area of 3,738 km^2 with a government administrative area covering 14 sub-districts and 74 *nagari*, and 403 *jorong*. Geographically, Solok district has four lakes and one mountain, namely Mount Talang. Based on this geographical location, Solok Regency is very suitable to be used as a location for farming, especially horticultural crop farming (15).

Alahan Panjang is one of four villages located in the valley sub-district of Gumanti in Solok Regency, which has an area of 88.76 km^2. The major occupations of the residents are farmers and farm laborers where well water is used as a source of clean water. Horticultural crops that are the mainstay in this area are shallots, potatoes, and tomatoes. It requires the use of fertilizers and pesticides to increase the production of cultivated horticultural crops (15). In this area, the average population uses drinking water from their dug wells. Therefore a risk analysis of pesticide exposure was carried out.

Risk analysis can be used to assess the level of risk of pesticide exposure to health. EHRA was an approach used to conduct a health risk assessment in the environment with the output was a risk characterization (expressed as risk level) which explains whether the risk agent/environmental parameter was at risk to public health or not.

METHODS

This type of research was a descriptive observational study with a cross-sectional design and an Environmental Health Risk Analysis approach. This study was conducted to determine the risk of exposure to the pesticide used on public health in agricultural areas.

The object population of this study was all dug wells in Kanagarian Alahan Panjang, while the subjects were the Kanagarian Alahan Panjang communities who used dug well water as a source of clean water. The object of the sample was a dug well that is <50 meters from the agricultural area and is used as a fountain of drinking water. While the sample of the research subject was the community that utilizes the object sample as a source of drinking water. The sampling method in this research was purposive sampling. Through this method, 30 dug wells, owned by respondents, were chosen to be examined.

The analysis carried out in this study was the univariate analysis which was used to describe the variables and present them in the form of a frequency distribution table. Environmental Health Risk Analysis is carried out through 4 stages, namely Hazard identification to identify ones that are pesticide risk agents. The second stage is dose-response analysis, which is to determine the reference dose of the pesticide. The next step is exposure analysis by calculating intake where the results of non-carcinogenic intake are by comparing the pesticide concentration (C), intake rate (R), annual exposure frequency (fE), duration of exposure (Dt) with worker body weight (Wb) and the period of exposure time (tavg). The last stage is risk characteristics by comparing the results of the calculation of chemical intake with the reference dose (RfD) (16). This data was obtained from primary data collected and calculated based on Environmental Health Risk Analysis (EHRA) formula above.

$$I = \frac{C \times R \times t_E \times f_E \times I}{W_b \times t_{avg}}$$

$$RQ = \frac{I}{Rfc}$$

RESULTS

Univariate data processing is used to see the frequency distribution of each research variable. Based on Table 1, 63.3 % of respondents (19 people) belong to the adult group which is counted as the highest number among the samples examined. Furthermore, the proportion of female respondents is 27 with a percentage of 90%. Regarding the educational background, most of the respondents are in the elementary and junior high school level with a percentage of 36.7%. In terms of occupations, the number of respondents who work as housewives is 17 with a percentage of 56.7%. Furthermore, respondents who have smoking habits are 5 people with a percentage of 16.7%. The average body weight of the respondents is 57.23 Kg with a minimum weight of 38 Kg and a maximum weight of 70 Kg where the Standard Deviation distribution is 8.207 kg.

Table 2 and Table 3 shows the length of stay of respondents from 1 to 70 years with an average of 32.40 years and a standard deviation of 19.911. The respondents use water from 1 year to 57 years with an average of 26.87 years and a standard deviation of 14.722. The depth of the water source used by the respondents is from 1 meter to 7 meters with an average depth of 4.47 meters and a standard deviation of 1.525. Meanwhile, the duration of exposure to water in a day is 2 hours to 18 hours with an average of 12.67 hours and a standard deviation of 9.234. Regarding the amount of water in a day, 3 liters up to 36 liters are used with an average of 23.27 liters and a standard deviation of 23.364. Furthermore, the water consumption in one week is 3 days to 8 days with an average of 6.87 days and a standard deviation of 0.900. The duration of water consumption in one year is 1 to 57 years with an average of 26.87 years and a standard deviation of 14.722. A lot of water consumption outside the well water used by respondents is 2 to 10 liters with an average of 4.72 liters and a standard deviation of 2.270. Based on the ownership of water sources, most of the respondents have their water sources, namely 24 respondents with a percentage of 80%. All respondents treat drinking water by cooking, namely 30 respondents with a percentage of 100%. In addition, 60% (18 people) of respondents use gallons of water to fulfill their daily needs. Most of the respondents' dug wells are vulnerable to contamination, namely 27 dug wells with a percentage of 90%.

Table 1. Characteristics of Respondents

Variable (N=30)	F	(%)
Age		
Young	1	3.4
Adult	19	63.3
Elderly	10	33.3
Total	30	100
Gender		
Man	3	10
Woman	27	90
Total	30	100
Educational Background		
Elementary School Students	11	36.7
Junior High School Students	11	36.7
Senior High School Stutdents	4	13.3
University Students	4	13.3
Total	30	100
Occupations		
Midwife	2	6.7
Housewife	17	56.7
Student	1	3.3
Farmer	10	33.3
Total	30	100
Smoking Habit		
No	25	83.3
Yes	5	16.7
Total	30	100

Weight (Kg)	Min – Max	Mean	Std. Deviation
	38 - 70	57.23	8.207

Table 2. Duration of Well Water Exposure to Respondents

Variable (N=30)	Min – Max	Mean	Std. Deviation
Length of Stay (years)	1 – 70	32.40	19.911
Length of Water Use (Years)	1 – 57	26.87	14.722

Variable (N=30)	Min – Max	Mean	Std. Deviation
Water Source Depth (meters)	1 – 7	4.47	1.525
Water Exposure in one day (hours)	2 – 18	12.67	9.234
Total Water Usage (Liters)	3 – 60	23.27	23.364
Water Consumption in one Week (Day)	3 – 8	6.87	0.900
Long water consumption (years)	1 – 57	26.87	14.722
A lot of water consumption outside the water	2 - 10	4.72	2.270

Table 3. Distribution of Well Water Exposure to Respondents

Variable (N=30)	F	(%)
Water Source		
Ownership	24	80
Shared	6	20
Total	30	100
Drinking Water Treatment		
Cooked	30	100
Total	30	100
Consumption of water outside the water		
Yes (Gallon water)	18	60
No	12	40
Total	30	100
Dug Well Inspection		
Risky	27	90
Seldom	3	10
Total	30	100

Table 4. Intensity of Respondents' Health Disorders

Health Disorders	F	(%)
Often	20	66.7
Seldom	10	33.7
Total	30	100

Based on Table 4, it can be seen that most of the respondents often have health problems with a percentage of 66.7%. The respondent's health problems are obtained through the symptoms felt by the respondent such as headaches, diarrhea, nausea, and vomiting.

Table 5 shows that the measurement of pesticide concentrations in the agricultural area of Alahan Panjang, Solok Regency exceeds the quality standard. It is in accordance with the Regulation of the Minister of Health of the Republic of Indonesia Number 32 of 2017 which states that the maximum concentration of total pesticides in clean water (sanitary water) is 0.1 mg/L (17). The calculation of pesticide levels is obtained through the gas chromatography test method.

Table 5. Pesticide Concentration in Well Water

Sample Number	Total Pesticide (PMK RI no. 32 of 2017 BOE=0.1 mg/L)	
	Sample Concentration	Information
1	6.735	Exceeding Quality Standard
2	32.201	Exceeding Quality Standard
3	51.02	Exceeding Quality Standard
4	27.484	Exceeding Quality Standard
5	30.879	Exceeding Quality Standard
6	28.815	Exceeding Quality Standard
7	43.159	Exceeding Quality Standard
8	16.441	Exceeding Quality Standard
9	29.632	Exceeding Quality Standard
10	53.492	Exceeding Quality Standard
11	50.428	Exceeding Quality Standard
12	31.081	Exceeding Quality Standard
13	31.699	Exceeding Quality Standard
14	28.517	Exceeding Quality Standard
15	42.127	Exceeding Quality Standard
16	50.332	Exceeding Quality Standard
17	34.083	Exceeding Quality Standard
18	31.061	Exceeding Quality Standard
19	40.186	Exceeding Quality Standard
20	29.033	Exceeding Quality Standard
21	19.524	Exceeding Quality Standard
22	6.985	Exceeding Quality Standard
23	30.363	Exceeding Quality Standard
24	38.911	Exceeding Quality Standard
25	32.477	Exceeding Quality Standard
26	46.056	Exceeding Quality Standard
27	29.632	Exceeding Quality Standard
28	26.478	Exceeding Quality Standard
29	29.959	Exceeding Quality Standard
30	38.414	Exceeding Quality Standard

Based on Table 6, it is known that the results for the risk characteristics (RQ) of pesticide risk agents while staying at home are 100% at risk and for the risk characteristics at 30 years are 100% at risk due to the value of effects non-carcinogenic by comparing (dividing) the non-carcinogenic intake of each risk agent with the reference dose (RFC) according to the equation that is declared vulnerable. It is necessary to carry out control efforts.

Table 6. Risk Characteristics Of Respondents

Sample Number	Exposure Time (hours)	Exposure frequency (days/year)	Exposure Duration (years	Intake (mg/Kg/ hari)	Projected 30 years Intake (mg/Kg/day)	Characteristics (RQ) of risk during water consumption	Characteristics (RQ) of risk over 30 years
1	2	350	3	0.02	0.20	1.01	10.09
2	2	350	40	2.01	1.51	100.42	75.31
3	2	350	45	2.77	1.85	138.46	92.31
4	2	350	57	2.33	1.23	116.45	61.29
5	2	350	50	1.86	1.12	93.11	55.87
6	2	350	70	2.22	0.95	111.16	47.64
7	2	350	60	2.71	1.36	135.69	67.84

Sample Number	Exposure Time (hours)	Exposure frequency (days/year)	Exposure Duration (years	Intake (mg/Kg/ hari)	Projected 30 years Intake (mg/Kg/day)	Characteristics (RQ) of risk during water consumption	Characteristics (RQ) of risk over 30 years
8	2	350	1	0.02	0.62	1.03	30.91
9	2	350	13	0.35	0.81	17.59	40.59
10	2	350	35	1.99	1.71	99.74	85.49
11	2	350	8	0.38	1.44	19.25	72.17
12	2	350	25	0.72	0.86	35.99	43.19
13	2	350	38	1.38	1.09	68.75	54.28
14	2	350	17	0.44	0.78	22.14	39.06
15	2	350	60	2.49	1.24	124.29	62.15
16	2	350	70	3.69	1.58	184.61	79.12
17	2	350	21	0.88	1.26	44.00	62.85
18	2	350	25	0.75	0.90	37.61	45.13
19	2	350	16	0.82	1.54	41.10	77.07
20	2	350	28	0.88	0.94	44.04	47.19
21	2	350	24	0.59	0.73	29.37	36.71
22	2	350	28	0.21	0.22	10.42	11.16
23	2	350	38	1.32	1.04	65.86	51.99
24	2	350	5	0.24	1.44	11.96	71.75
25	2	350	5	0.20	1.18	9.79	58.76
26	2	350	39	2.17	1.67	108.33	83.33
27	2	350	42	1.33	0.95	66.30	47.36
28	2	350	56	1.55	0.83	77.70	41.62
29	2	350	25	1.26	1.51	63.00	75.60
30	2	350	28	1.07	1.15	53.72	57.56
Average		350	32.4	1.29	1.12	64.43	56.18
Max		350	70	3.69	1.85	184.61	85.49
Min		350	5	0.02	0.20	1.01	10.09

DISCUSSION

The source of activity comes from agricultural activities that can cause disease and damage to the surrounding. From the source of this activity, the community has the potential to get some risks from agricultural activities in the form of giving synthetic pesticides to increase agricultural yields. Synthetic pesticides which come from a mixture of chemicals can quickly reduce the population of Plant Pest Organisms with a longer control period (residual). Another advantage of synthetic insecticides is that they are easy to produce on a large scale, easy to transport, and store, and relatively affordable. The consumption of synthetic pesticides can contaminate the soil and permeate the groundwater or well water around agricultural land. It happens when the consumption does not meet the rules that have been set in the procedures. The use of pesticides, especially the synthetic ones, is widespread among farmers because they are considered the fastest and most effective in overcoming pest problems. Research in 2020 ported that the use of insecticides for pest control in the world reached more than US$ 1 billion per year (18-19).

There are two negative impacts of using pesticides. Firstly, the pollutants can return to humans through food since pesticide residues are difficult to decompose. Secondly, the disruption of the ecosystem due to the death of natural enemies from the pest results in an increase in the number of pests which causes a much greater increase in the number of attacks (pest resurgence) and secondary pest attacks, as well as the death of beneficial organisms such as bees that play a role in pollination. Synthetic pesticides can be grouped based on their chemical properties, including organophosphate, carbamate, organochlorine, and pyrethroid pesticides. Many of the losses caused by the use of synthetic pesticides can have an impact on pest immunity. For instance, it can bring back pests that have been resolved, predators will become extinct, the environment quality becomes decreased, and also gives a negative impact on human health (20). Pesticide residues contained in plants when consumed by humans will cause various adverse effects for humans. At the extreme level, pesticide residues can cause death. Meanwhile, at a lower level, these pesticide residues cause stomachache and vomiting. Symptoms of acute poisoning in humans due to consumption of pesticide residues are paraesthesia, tremor, headache, fatigue, abdominal nausea, and vomiting. The effects of chronic poisoning that occur in humans due to the consumption of pesticide residues are damage to liver cells, kidneys, nervous system, immune system, and reproductive system (21-22).

The results of the measurement of the total pesticide level of agricultural well water in Alahan Panjang, Solok Regency, showed that thirty samples of well water examined exceeded the Quality Standard value. Referring to the Regulation of the Minister of Health of the Republic of Indonesia number 32 of 2017 which states that the Maximum Total Pesticide Quality Standard in clean water is 0.1 mg/L. Efforts to reduce pesticide residues in agricultural products are carried out in many ways and methods with the same goal of ensuring that agricultural products consumed by humans are free from pesticide residues. This effort has been carried out by many Indonesian and international communities since the problem of pesticide residues has become a worldwide concern. Efforts to reduce pesticide residues are carried out at various stages of planting, which are generally divided into two parts, namely pre-harvest treatment and post-harvest treatment. The removal of pesticide residues contained in agricultural products depends on various factors, such as the chemical nature of the pesticide itself, the nature of the food commodity, the application of pesticides, the processing steps from the beginning of planting to harvesting, and the length of time the pesticide compounds make contact with agricultural products. The effect of removing pesticide residues from agricultural products is also influenced by the absorption, translocation, and decay rate of the pesticide itself. In addition, processes that occur in the field such as evaporation, hydrolysis and so on also affect the pesticide residues contained in agricultural products. The processing treatment during planting also often affects the level of pesticide residues, but this is not always related to the physicochemical properties of the pesticides themselves (21).

People who often consume well water contaminated with pesticides can disturb the comfort and health of the community. Furthermore, if the well water is used continuously, it can cause acute and chronic poisoning with symptoms of digestive disorders, degenerative diseases, and even death. As for some of the effects of pesticide residues on the human body, they can interfere with steroid metabolism, damage thyroid function, disrupt the endocrine hormone system (reproductive hormones) or better known as EDP (Endocrine Disrupting Pesticides), and also stimulate the growth of cancer. Chronic pesticide poisoning can be found in the form of neurological and behavioral disorders (neurotoxic) or mutagenicity. In addition, other chronic impacts caused by the use of pesticides are pesticide poisoning in the lungs, liver, stomach, and intestines, and affecting the work of organ systems such as the nervous system, hormonal system, and immune system. Individuals exposed to pesticides may develop a cough that does not go away or feel tightness in the chest. This is a symptom manifestation of bronchitis, asthma, or other lung diseases. Long-standing lung damage can lead to lung cancer). In addition, individuals who are exposed to pesticides are more likely to develop cancer. However, it does not mean that individuals who work with pesticides will inevitably develop cancer. Hundreds of pesticides and the ingredients contained in pesticides are known to cause cancer. The most common cancer caused by pesticides is blood cancer (leukemia) (23).

Symptoms of poisoning in general related to pesticides may occur in that the person often experiences excessive fatigue, skin irritation, burning, excessive sweating, and discoloration. Meanwhile, the symptoms of pesticide poisoning in the eyes are characterized by irritation, burning, excessive tears, blurred vision, and smaller or enlarged eyes. In terms of the digestive tract, the symptoms can be identified by the signs of burning mouth and throat, excessive salivation, nausea, vomiting, stomach cramps or pain, and diarrhea. Pesticide poisoning can also cause disturbances in the nervous system characterized by symptoms of difficulty in breathing, wheezing, coughing, chest pain, or stiffness (24). Efforts can be made to prevent the occurrence of symptoms of poisoning due to exposure to pesticides on farmers who are influenced by the age factor, one of which is by increasing a person's nutritional status. Good nutritional status can increase the body's immune system, so it can increase the body's sensitivity to infection. In good nutritional conditions, the body does not experience a lack of protein so that the work of enzymes in the body can run normally. Based on research, 66.7% of respondents often experience health problems, especially digestive disorders. This happens because of the consumption of well water contaminated with pesticides that are used continuously.

Based on the results of this study 66.7% of respondents often experience health problems, especially digestive disorders. This is consistent with the effect of consuming well water contaminated by pesticides that are used continuously.

Characteristics of Health Risks Due to Pesticides

Among the 30 samples examined, the Risk Characteristics of the pesticide risk agent while staying in the house (Real Time) is 100% at risk. Meanwhile, the risk characteristic at 30 years is 100 % considered endangered. It happens because to get the value of the non-carcinogenic effect, a comparison of the non-carcinogenic intake of each risk agent with the reference dose (RFC) is carried out where declared endangered,

and it is necessary to control the pesticide risk agent for further action.

Farmers are the ones who are vulnerable to being contaminated by pesticide ingredients through the process of buying, storing, mixing, spraying, and after spraying (handling used pesticide containers). To avoid the danger of being contaminated, there are several instructions for using pesticides, starting from buying pesticides, transporting pesticides, storing pesticides, preparing pesticides, spraying pesticides, finishing spraying, and securing pesticide cans (25).

Risk characteristics are carried out to determine whether the risk agent at a certain concentration analysed in EHRA has a potential to cause health problems in the community with characteristics such as Concentration of risk agent (C) Body weight (Wb) Ingestion rate (R) Exposure time (Te) and duration of exposure (Dt) the frequency of exposure (fE) and the average time period (Tavg) by a risk agent causing interference or not. Risk characteristics were conducted by comparing (dividing) the intake with the RFC value. The variables used were intake values obtained from exposure analysis and reference concentrations from the existing literature.

CONCLUSION

Based on research that has been carried out in the agricultural area of Alahan Panjang, Solok Regency, it can be concluded that the source of activities that cause the impact of pesticide pollution comes from pesticide administration activities that are not in accordance with the rules that have been stated on the packaging. The highest pesticide concentration result is 53,492 mg/L. The results of public health problems that consume well water are (66.7%) of respondents often experience health problems, mostly digestive disorders. The risk characteristics of the community in the agricultural area of Alahan Panjang, Solok Regency from pesticide risk agents while consuming pesticide-contaminated well water realtime is 100% at risk and for the risk characteristics at the time of the 30-year projection it is 100% at risk.

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