Spatial Analysis of Environmental Health Aspects on Cholinesterase Levels Among Farmers Using Pesticides

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Abstract. Utilization of spatial data integrated in GIS to make efforts to solve the problem of pesticide poisoning is expected to be a solution with an accurate and easy method. Environmental aspects affect the amount of pesticides used. The aim of this study was to determine environmental aspects and level cholinesterase among horticultural farmers. A cross sectional study among 107 horticultural farmers in Gisting District, Tanggamus regency, Lampung. Data were collected from June-Augut 2022. Data collection was carried out using questionaires, spectrophotometer and spatial geospatial positioning instrument. Analysis data using chi-square test. The study showed 32 farmers (29,9%) decreased cholinesterase level, 59 respondents (55,1%) distance from land to settlement ≥ 250m, 64 farmers (59,8%) with distance from river to settlement ≥250m and farmers on low topography 79 respondent (78,3%). There were significant asssocation between topography for pesticide poiosoning among horticultural farmers (p=0,036). The data is visualized in the form of a map by arc.gis. Farmers with low topography had a risk to decreased level cholinesterase. Relevant stakeholders must educate farmers on low topography use pesticides based on guidelines for the use of pesticides that are safe for health.

Keywords: environmental health, farmers, pesticides, spatial

1 Introduction

Current technological advances have been able to utilize spatial data to be processed in the form of a Geographical Information System (GIS). This spatial analysis in public health can be used as input for decision-making processes, health interventions and strategies for preventing pesticide poisoning, as well as epidemiological analysis and public health management [1]. The research conducted the incidence of filariasis in Pekalongan City which utilizes spatial data with the incidence of filariasis in Pekalongan City [2]. Furthermore, the study examined the risk factors for the occurrence of Upper Respiratory Tract Infections (URI) with a spatial approach [3]. Utilization of spatial data by utilizing GIS in the spread of malaria has been carried out in Jombang, East Java and Central Java[4, 5].

Utilization of spatial data integrated in GIS to make efforts to solve the problem of pesticide poisoning is expected to be a solution with an accurate and easy method [1, 6]. The results of research on farmers in California found that spatial-based pesticide exposure increases the risk of developing Parkinson's disease by 70-93% [7]. Subsequent research

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identifying the contribution of GIS-based environmental factors to the incidence of Hepatocellular Carcinoma (HCC) found that the prevalence of HCC cases was higher in agricultural land areas using pesticides [8]. The results of research in Brazil found a positive correlation between the spatial distribution of agricultural land area, use of pesticides with the risk of health problems (acute, subacute and chronic poisoning)[9].

One of the districts that has a fairly large area of the agricultural sector is Tanggamus Regency. The land use area in Tanggamus Regency consists of food crops 35,085 ha, horticulture 75,021 ha, plantations 92,991 ha and forestry 27,527 ha [10]. The largest area of agricultural land in Tanggamus district is Gisting District as a horticulture center with an area of 83 ha. The majority of horticultural products produced in Tanggamus district include chilies, shallots, lettuce, cucumbers[11]. To increase agricultural productivity, the use of pesticides is still the main factor in controlling Plant Pest Organisms (OPT).

Pesticide residues in Tanggamus Regency are still quite high, such as diazinon, endosulfan, permethrin, hexachlorocyclohexanan (HCH), fenthion, and chlorpyrifos [11]. Environmental aspects affect the amount of pesticides used. The identified environmental aspects are the location of the land elevation (topography), the presence of rivers near agricultural land, the distance from land to settlements, humidity, temperature and wind speed [12]. Based on the research on farmers in Batu Raden, Malang, it was found that farmers who have land in the highlands (>600 masl) use 2 times more pesticides than farmers in the lowlands [13]. Farmers who experience an increase in cholinesterase levels with the distance from the river to the settlement < 250 m, are located in the upper reaches of the river so they tend to be more at risk of pesticide poisoning. Public health problems in the upstream area tend to be more severe than the downstream community [14]. Approximately 75% of the application of pesticides is done by spraying, thus allowing the droplets of the liquid to float, deviating from the application distance traveled by the droplets of the liquid on the grain size. Liquid granules with a radius of less than 1 micron, can be considered gases with infinite settling velocity so that farmers with a distance of < 250 m are at risk of getting greater pesticide exposure [15].

Based on the empirical data that has been stated above, we can see aspects of environmental health in the form of rivers, agricultural land, land elevations and population settlements, the use of spatial data that is integrated in the form of GIS to analyze cholinesterase levels in farmers using pesticides in Gisting District, Tanggamus.

2 Material & Methods

This study was an observational study with cross sectional design. This study was conducted in from May 2022 to August 2022. The population in this study were all horticultural farmers in Gisting District, Tanggamus Regency, Lampung Province. The sample were 107 respondents who met the inclusive and exclusive criteria. The inclusion criteria were: Horticultural farmers who are still actively working using pesticides in Gisting sub-district ;spray 1-7 days before taking blood (Rahmawati, 2014). The exclusion criteria were: Do not have a history of high blood pressure (hypertension) and or anemia; Not being treated by a doctor because of an illness.

The independent variable of pesticide poisoning (cholinesterase levels), the dependent variable the location of the land height (topography), the presence of rivers near agricultural land, the distance from land to settlements. Data were taken Questionnaire, injection syringe, thermometer, tourniquet, EDTA tube, Spectrophotometer and Geographical Positioning System (GPS) brand Garmin type 78S Map. The collected data were processed through editing, coding, scoring, entry, cleaning, and analysis. Correlation test using computer applications both univariate analysis, bivariate with Chi-Square ($\alpha = 5\%$). Mapping data on the distribution of cholinesterase levels were analyzed using the ArcView GIS program.

Ethical approval was granted by Medical Research Ethics Committee of Faculty of medicine, Lampung University. Respondents who are willing to participate in the study have signed an informed consent form.

3 Results

Table 1 showed most of the respondents with aged ≥ 40 years (80.4%), low education (59,8%), low income (57%), duration of work as farmer ≥ (94,4%).

Table 1. Respondent Characteristics

No	Characteristics	n	%
1	Age		
	a. ≥40 years	86	80,4
	b. <40 years	21	19,6
2	Education		
	a. Low	64	59,8
	b. Middle	37	34,6
	c. High	6	5,6
5	Income		
	a. Low	61	57
	b. Middle	34	31,8
	c. High	12	11,2
6	Duration of work as Farmer		
	a. ≥ 5 years	101	94,4
	b. < 5 years	6	5,6
	Total	107	100

Table 2 showed decrease cholinesterase level <4620 IU/l (29,9%), distance from land to settlement (55,1%), topography low (78,3%).

Table 2. Univariat Analysis

No	Variable	n	%
1	Cholinesterase level		
	a. <4620 IU/l	32	29,9
	b. Normal	75	70,1
2	Distance from land to settlement		
	a. <250 m	48	44,9
	b. ≥250 m	59	55,1
3	Distance from river to settlement		
	a. <250 m	43	40.2
	b. ≥250 m	64	59.8

4	Topography		
	a. High	28	26,2
	b. Low	79	73,8
	Total	107	100

Table 3 found that there were significant association between topography and cholinesterase level (p<0,05).

Table 3. Bivariat Analysis (n=107)

No	Variable	Cholinesterase Level				p
		Poisoning		Normal		
		n	%	n	%	
1	Distance from land to settlement					
	a. < 250 m	14	29,9	34	70,8	0,88
	b. ≥ 250 m	18	30,5	41	69,5	
2	Distance from river to settlement					
	a. < 250 m	10	23,3	33	76,7	0,218
	b. ≥ 250 m	22	34,4	42	45,6	
3	Topografi					
	a. high	4	14,3	24	85,7	0,036
	b. low	28	35,4	51	64,6	

Based on spatial analysis with arc.gis, most of respondent distance of land to settlement <250 m (70,8%), distance from river to settlement <250 m (76,7%), high topography (85,7%). The data were visualized in the form of a map (Figure 1,2 and 3).

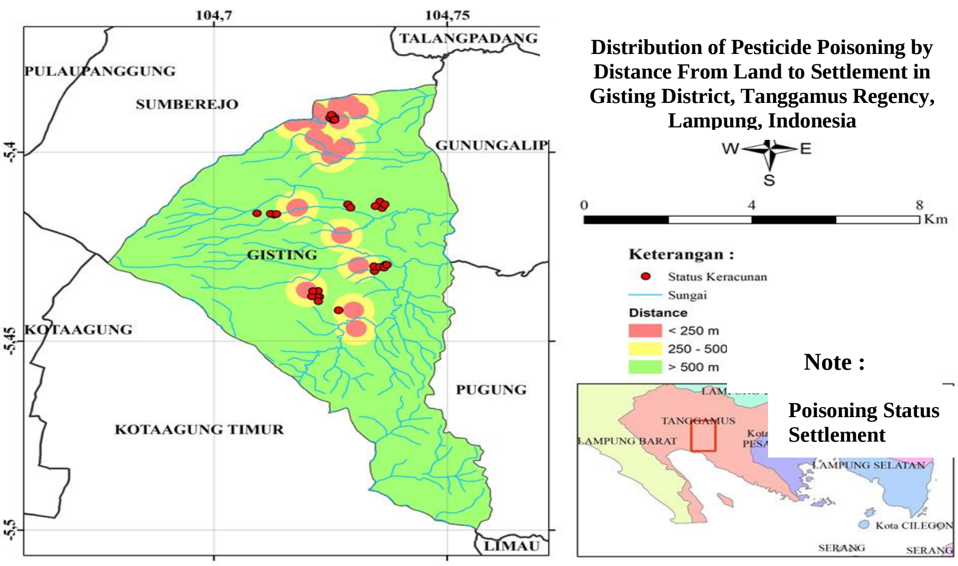

Fig. 1. Spatial Analysis Distance Land to Settelement

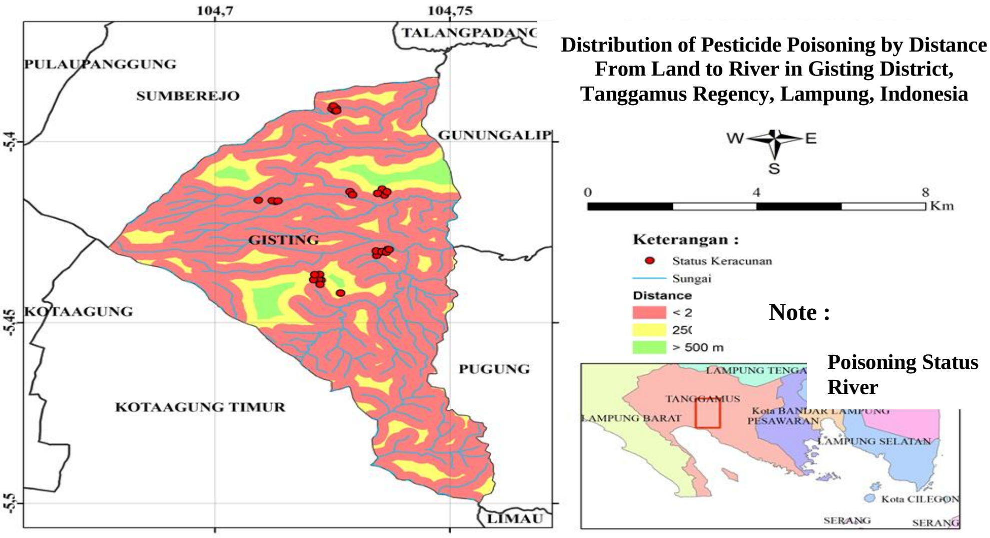

Fig. 2. Spatial Analysis Distance River to Settelement

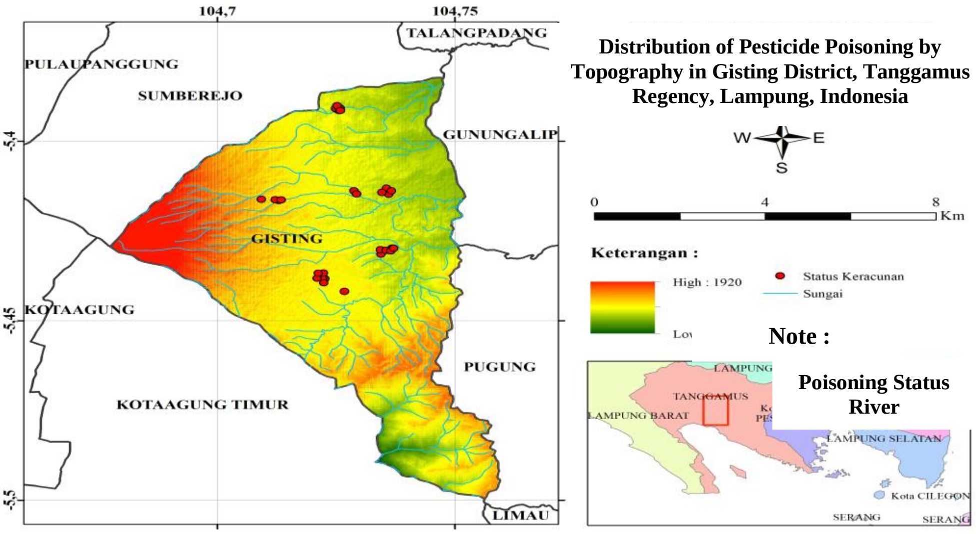

Fig. 3. Spatial Analysis Topogaphy

4 Discussion

Horticultural farmers in Gisting District about 32 farmers (29.9%) of farmers experienced pesticide poisoning with indicators of decreasing levels of cholinesterase (<4620IU/L). The same study at 2010 on farmers in Gisting, Tanggamus found that 28.6% experienced pesticide poisoning [16]. This result is slightly lower than the research on farmers in Thailand, it was found that 28.9% experienced pesticide poisoning[17].

The mechanism of action of pesticides is highly dependent on the chemical structure and toxicological characteristics of each species. It is known that the toxicity of pesticides, such as organophosphates, works by inhibiting the enzyme acetylcholinesterase (AChE) an enzyme that regulates the action of hydrolysis of acetylcholine into choline and acetic acid. Inhibition of this enzyme causes acetylcholine overload at neuronal synapses and at the neuromuscular junction resulting in overstimulation of muscarinic and nicotinic receptors [18]. There is a link between decreased levels of cholinesterase on the impact of pesticides, the mechanism explained is that one type of pesticide, namely organophosphate, enters the body through the brain barrier, causing the accumulation of acetylcholine in the neuronal system which affects cholinergic activity. AChE inhibited by organophosphate forms a stable enzyme-OP complex and is slowly hydrolyzed. This binding causes acetylcholine to be unable to bind to the enzyme, resulting in an overload of acetylcholine in the synaptic cleft. The binding of the enzyme-OP complex will permanently become inactive forever and its function can return when new enzymes are synthesized. As a result, there is damage and brain function and cholinesterase levels also decrease [19].

A meta-analysis study stated that the accumulation of acetylcholine in the synaptic system is a disturbance of AChE activity [20]. This is a sign of a decrease in cholinesterase levels, poisoning can occur [20, 21]. However, on the other hand there are factors that involve decreased cholinesterase levels including genetic and environmental factors. The individual's ability to excrete Toxins from the body are different, the ability is controlled by the mechanism of biotransformation. Genetic factors play a role in the biotransformation process of chemical pollutants, genetic polymorphisms are formed depending on the deletion of each individual's gene which eventually lacks protein, resulting in a functional decline in the activity of certain enzymes. Active substances in pesticides damage cellular integrity by releasing free radicals and ROS to become active. As a result, the chemical structure of pesticides can have a negative effect on farmers' health. In addition, environmental factors can also affect poisoning, such as the length of exposure to pesticide pollutants, wind direction in pesticide spraying, mixing of pesticide species. sticides and neglecting to use PPE can lead to pesticide poisoning [20, 22].

The results showed from table 2, about 59 farmers (55,1%) with distance from land to settlement ≥250 m. Approximately 75% of the application of pesticides is done by spraying, thus allowing the droplets of the liquid to float, deviating from the application distance traveled by the droplets of the liquid on the grain size. Liquid granules with a radius of less than 1 micron, can be considered gases with infinite settling velocity so that farmers with a distance of < 250 m are at risk of getting greater pesticide exposure [15]. Based on table 2, the proportion of farmers with a distance of land to settlements < 250 m as many as 14 respondents (29,9%) experienced pesticide poisoning compared to farmers who were 250 m as many as 18 respondents (30,5%). The results of chi-square analysis, obtained p = 0.88, meaning that there is no relationship between the distance from land to settlements and the occurrence of pesticide poisoning. It is possible that the droplets of liquid that are sprayed have a radius of more than 1 micron so that they mix with gases in the air and settle on plants or soil [15]. In addition, the wind speed factor can be considered. Wind speed data in July 2021, obtained at 7.56 km/hour [23]. The wind speed of 15 km/hour is indicated by the wind passing over the cheek [12]. So it can be concluded that the wind speed at the time the data was taken was relatively slow, so that the exposure of farmers to pesticides carried by the wind was small.

Based on Table 2, that most of the horticultural farmers in Gisting District, namely 64 farmers (59,8%) had a river distance to the settlement as far as ≥ 250 m. Based on observations, farmers use river water for daily needs (washing, bathing and other activities) and agricultural irrigation. The results of this study, showed that 10 respondents (23,3%) had pesticide poisoning with distance frm rver to settelemt <250 m, compared to 22 respondent (34,4%) with ≥250 m and decreased level of cholinesterase. The results of chi-square showed that there was no relationship between the distance from the river to the settlement and the occurrence of pesticide poisoning (p = 0.218). From the results of field observations, farmers who are poisoned by the distance from the river to the settlement < 250 m, are located in the upper reaches of the river so they tend to be more at risk of pesticide poisoning. Public health problems in the upstream area tend to be more severe than the downstream community [14]. In addition, the farther the waters/rivers are from the agricultural and plantation areas, the pesticide residues will decompose or dilution occurs on their way to the river body. In addition, the potential for erosion and landslides does not directly deliver the pesticide material to the river body, so that the concentration of pesticide residues is smaller when compared to points closer to agricultural areas [24]. The type of pesticide used also affects the presence of pesticide residues accumulated in the soil or water. The type of pesticide that is widely used by horticultural farmers in Gisting Disctrict is organosphosphate. The highest concentration of organophosphate pesticides was found in soil samples, while the concentration of organochlorine pesticides was higher in water [25].

The results showed that 79 farmers (78,3%) had land topography < 600 masl. From the results of spatial analysis, it was found that areas located in topography < 600 masl are in the villages of Campang, Kuta Dalom, Partly Gisting Bottom, Partly Gisting Upper, and Partly Gisting Permai. This low land topography is related to the area of pesticide accumulation in the river flow from higher agricultural land. The topography of high land, which is 600 - 1200 mdpl, is located in Pekon Simpang Kanan, Sidokaton, Partly Lower Gisting, Partly Upper Gisting, and Partly Permai Gisting. The high topography in this area is the highest area where land use activities and residential areas are found, so it can be referred to as the upstream of the spread of pesticide use. While the high topography area > 1200 mpdl is a mountainous and forest area. The effect of topography can also be correlated with the location of land use and residential residents, residents who live in locations with a lower topography than land have a higher potential for poisoning, this can be caused by factors such as wind direction, rainwater flow, and river water flow. In addition, pesticides can experience evaporation due to high environmental temperatures, high rainfall also causes leaching of pesticides by rainwater [13, 26].

Based on the table 3, it was found that there was a significant relationship between topography and pesticide poisoning (p=0.036). This is due to the higher ambient temperature in the topography < 600 mdpl, so that body temperature will also increase and cause vasodilation of blood vessels adjacent to the skin which allows heat to be released out through the sweating process. Sweat glands have a certain heat so that the skin pores open to maintain body temperature but on the other hand cause the entry of secondary pollutants from the air including pesticides [27].

5 Conclusion

Topography as environmental health risk factors to decreased cholinestase level. Relevant stakeholders must educate farmers on low topography use pesticides based on guidelines for the use of pesticides that are safe for health.

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