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TYPES OF PESTICIDES AND THEIR TOXICITY LEVELS: A STUDY IN AGRICULTURAL AREAS OF BREBES REGENCY

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ABSTRACT

Introduction: A previous study found that children living in agricultural areas were exposed to organophosphate pesticides, but other types of pesticides in the community have not been identified yet. Hence, this study aimed to identify types of pesticides in the agricultural area and their toxicity levels that might cause potential health problems. **Methods:** The study population was 1,017 households living in two villages in the agricultural area of Brebes Regency, Indonesia. A cross-sectional design was used to conduct data collection among 166 respondents through a questionnaire to determine the respondent's characteristics and through observations to determine the pesticide, pesticide packaging, and pesticide residue in the respondents' houses. Pesticide toxicity levels were identified based on the pesticide toxicity classification recommended by the World Health Organization. Potential health problems of pesticides were then identified based on literature review. **Results and Discussion:** Results found that 30.7% of respondents had organophosphate, carbamate, and pyrethroid pesticides. The toxicity levels of the pesticides ranged from highly hazardous (Ib) to unlikely to present acute hazards (U). Potential health problems caused by pesticides vary from poisoning symptoms and signs to genetic disorders and polymorphisms. **Conclusion:** Three major pesticides in the community in an agricultural area with toxicity levels ranged from highly hazardous to unlikely to present an acute hazard.

Keywords: *pesticides, active ingredients, toxicity, health effects, agriculture.*

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INTRODUCTION

Using pesticides for agricultural purposes also contributes to an increased risk of pesticide exposure in rural areas (1). A previous study in the farm area of Brebes Regency has revealed that 28,9% of children had the organophosphate pesticides metabolites in the urine. The organophosphate pesticide metabolites had concentrations between 0 parts per million (ppm) to 0.223 ppm (2). Pesticides may interfere with endocrine functions (3). As a result of pesticide exposure, organophosphate pesticide is likely associated with thyroid hormone disorders (TSH,

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FT4 (4). Children can be exposed to pesticides in various ways, such as consuming food and drinks contaminated with pesticides, behavior (involvement in agricultural activities), and other factors (5). Children living in agricultural areas may be exposed to pesticides through dust from pesticide spraying or through the evaporation of pesticides from farmlands. Parents may also bring pesticide contaminants into their homes after they contract with pesticide spraying (6). A previous study has also found that most school children exposed to pesticides have lived in agricultural areas since birth and 23% of children got exposure from onion farming activities (4). Suspected pesticide sources include agricultural lands, homes, and neighborhood areas. However, previous research has only revealed one type of pesticide, organophosphate pesticides, and even the farmers use many pesticides to protect their crops, especially shallots (2). Little information is found related to the types and toxicity levels of pesticides used by the community in the agricultural area of Brebes Regency. Hence, this study investigated these aspects further.

METHODS

This observational study was conducted on people who live in agricultural areas of two villages in Brebes Regency. The agriculture areas in question are onion farming which uses a lot of pesticides. The population is the parents of elementary school students identified in the previous study (2). Data were collected through a questionnaire and observation inside and outside the respondents' houses. The questionnaires were employed to determine the respondents' characteristics. Identification of pesticides was determined by observing residual pesticides, pesticide packages or packages, and equipment used to spray or apply pesticides. The pesticide product brand, types, groups, active ingredient, and formulation are identified by reading the pesticide packages. If the containers are not legible, the respondents gave the trademark and the active ingredient traced from the manufacturers or brands through their company websites. Furthermore, to identify pesticide toxicity levels, the active ingredients are compared with those in the classification of pesticide toxicity recommended by the World Health Organization (7). Potential health effects caused by pesticides are studied based on a literature review. The Health

Research Ethics Commission of the Faculty of Public Health, Diponegoro University, approved the ethics of this study with the number 91/EC/FKM/2016.

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RESULTS

Brebes Regency is located 1–500 meters above sea level. The area of Brebes Regency is 166,296 km² with 1,781,379 people. About 70% of the population work in the agricultural sector, and 40% are farmers and farm laborers. The harvested area of shallots stretches to 30,954 ha, producing 3,759,742 quintals with an average production of 121.46 quintals per ha. The output of shallots contributes to the gross income of the Brebes Regency by 58%. The largest shallot crop centers are spread over 11 sub-districts, there are Larangan, Wanasari, Bulakamba, Brebes, Tonjong, Losari, Kersana, Ketanggungan, Songgom, Jatibarang, and Banjarharjo. The Bulakamba sub-district is in third place after Larangan and Wanasari sub-districts. Shallot farming contributes to the demand for shallot production in Central Java and Indonesia by 72.39% and 30.62%. The average age of the respondents is classified as productive at 42.1 years (see Table 1).

Tabel 1.

Based on the age category, most of the population is 36-45 years old. The majority of them are elementary school graduates and most work as small traders. This study also found pesticides in 30.7% of the respondents' houses. More clearly stated, Table 2 shows types, class, and active ingredients of pesticide.

Table 2.

Commonly used pesticides include insecticides and fungicides. Insecticides kill insects, while fungicides remove fungi from shallots and onion bulbs. Based on types, organophosphates, carbamates, and pyrethroids are the most used. Organophosphate pesticides have common active ingredients such as chlorpyrifos, dimethoate, glyphosate, and profenofos. Moreover, carbamate pesticides mostly contain mancozeb, propineb, BPMC, and carbosulfan. The active ingredients in pyrethroid pesticides include cypermethrin, permethrin, emamectin, deltamethrin, and beta-cyfluthrin. Meanwhile, most pesticides are usually liquid, which helps emulsify parts of the pesticide formulation while the rest is suspended and dispersed.

DISCUSSION

Pesticides that farmers spray to control the pests of shallot plants will spread to the soil, air, water, and residue in shallot plants and affect farmers. Pesticides can distribute in the environment through various ways, including runoff, leaching, volatilization, dust drift, and biological magnification (8,9). When pesticides are applied to land, runoff can run off into nearby water bodies, contaminating surface water and potentially affecting aquatic life. Leaching pesticides can penetrate the soil and contaminate groundwater if not bound to the soil particles. Volatilization, some pesticides can evaporate and become airborne, leading to contamination of air and potential exposure for humans and animals. Dust drift, during the application, pesticide particles can become airborne and be carried by the wind, potentially affecting non-target areas and organisms. In biological magnification, pesticides can move up the food chain when they are ingested by small organisms and then consumed by larger organisms. Pesticides in the ground, air, and water will undergo a process of degradation in a short to a long time, depending on the medium's physical, chemical, and biological conditions (10).

Sometimes the farmers bring some pesticide packs and leftover pesticides to the house, and pesticide packs also see in shallot farming areas. In addition, pesticides that stick to the clothes or the farmer's body will carry to the house. Based on the observations at the respondent's house, it was found that there were various types of pesticides with different active ingredients. We found that there were more than three types of pesticides in one house. Storage of pesticides or pesticides leftover is carried out in the kitchen together with storage of pesticide spray equipment. Based on various groups and types, insecticides and fungicides are the most found in shallots and onion bulbs as farmers choose pesticides that can kill the most attacking pests, i.e., insects and fungi. Previous research also has found the same types and groups of pesticides (11,12).

The high number of pest organisms may lead to crop failure, especially when fungal attacks increase significantly in the rainy season. Based on previous research, the most common types of fungus in the shallot farming areas of Brebes Regency are Alternaria porri, Colletotrichum gloeosporioides, Porenospora destructor, and Fusarium oxysporum. These insects and fungi grow well in the tropics. Besides these examples, Fusarium oxysporum and Colletotrichum sp are also found in shallots in other areas such as Kalimantan (13). In addition, insecticides used to control onion pests include Spodoptera exigua, Spodoptera litura, and Thrips tabaci (12). Both male and female farmers handling the shallot start from the shallot planting to post-harvest. The farmers planted shallots with bare hands and only wore long sleeves, trousers, and hats. They do not use complete personal protective equipment for handling the shallot, such as boots, gloves, face or respiratory protection, and eye protection.

The average of the volume of insecticide solution applied ranges from 13.29 to 15.17 liters per ha (14). The farmers sprayed regularly every 3–4 days per week, and they sprayed 15-20 times in the growing season. The insecticide volume used in the agricultural area of 30,954 ha is around 13.29–15.17 liters per ha and it is estimated 411,378.66–469,572.18 liters per ha in the growing season. The use of pesticides in Brebes Regency is usually to prevent onion plant pests and preserve shallot bulbs stored in the house. Pesticides are applied by spraying the shallot plants and sprinkling pesticide powder on the shallot bulbs, including for planting the shallot bulbs. Spraying pesticides on shallot plants is usually from 6 to 9 AM and 3 to 5 PM. Farmers apply more than three types of pesticides, even up to seven. Likewise, the dosage of pesticides exceeds of recommended dosage on the label on the package. It may need to educate them to comply with the recommendation for pesticide application, including wearing personal protection equipment.

The use of pesticides to control shallot plant pests; usually, there are pesticides left. The rest of the pesticides bring to the home, and some are left in the shallot farming land. Pesticide leftovers, packages, and containers were found in 51 houses. The form of pesticides that are left and taken to the house can be in solid forms such as powder and liquid. Types of materials for making pesticide containers are diverse, including plastic, cardboard, cans, and glass bottles. These containers also store in the kitchen and outside the house. The respondents usually stored the pesticides and pesticide leftovers in the kitchen, hanged them on the wall, on the edge of the siding, on the terrace, or in certain places outside the house.

White pesticide powder as preservatives was also found to protect shallot bulbs stored on wooden racks and placed in the kitchen. The floors of the respondent's house are made of earth and cement or ceramics. Pesticides (dust drift) that fall on the floor will mix or stick to the dust; cleaning the floors makes the pesticides that adhere to the dust will spread throughout the house. In addition to pesticides, the respondents also used some equipment such as sprayers, buckets for pesticide formulation, and clothes used for pesticide spraying. Previous research similarly confirms pesticide storing inside and outside the house. For example, 38.4% of farmers in Ethiopia (15) and 44.4–55.0% of farmers (16) kept pesticides in their kitchen or houses, and 59.5% of farmers in Pakistan stored them in separate rooms in the house (17). Another example is that 44% of farmers in Ghana sored pesticides in their bedrooms (18) and in Ethiopia, 30.5% under their beds (19). For outdoor storage, 96% of farmers store pesticides in separate places outside their houses, and 1% of farmers in Vietnam (20) and 9% of farmers (19) keep pesticides in their kitchens 6.6% (15).

Pesticide exposure occurs in a direct and indirect ways. Pesticides may contaminate people through the skin, inhalation, and ingestion of solid, liquid, or gas substances (21). Farming activities potentially expose the individuals around to dust pesticide from the pesticide storage or through the air, thereby letting the pesticide enter the respiratory tract or the skin. Moreover, dust and pesticide may also contaminate the food or drink the farmers consume. Besides direct exposure to pesticides, storage of pesticides in the house also has the potential to contaminate food and drink in the home. Thus, storing pesticides in the house has the potential to cause contamination of food and drinks in the place, especially if pesticides, pesticide residues, or pesticide packs are stored near a food processing area, such as the kitchen. Pesticides have volatile properties in liquid and powder forms, so they quickly transfer them. If pesticides are stored in the kitchen, pesticide vapors and drift can spread in the kitchen and contaminate food or drink, including the food and drinking utensils. Research reveals that pesticides were found around the houses in agricultural areas (22,23).

Storing pesticides in and around the house poses a risk of exposure to people living there. Pesticides have volatile properties and drift to reach spaces in the house. Usually infants, children under five years, and pregnant women spend much time at home, including the elderly. The potential for pesticides to expose these people is more significant than for those outside the home. A study confirmed that pesticide exposure in farming areas is likely higher in children and is associated with indoor pesticide storage (24). Furthermore, older children and teenagers play more outdoors. Locations for playing outdoors include on the terrace, in the yard, with the neighbors, and in the shallot farming area. Pesticides can be in the house of non-spraying farmers because pesticides can transport through dust, wind, or other objects (25). Although some people store shallot bulbs which may contain pesticide residues in the terraces and yards. Children are also involved in farming activities at this farm location besides playing (2).

Several activities cause people to be exposed to pesticides, starting to formulate pesticides, spraying, storing, living in houses with pesticides, playing outside the house in agricultural areas, and in indoor through house dust. Figueiredo (2022) created a model for the journey of pesticides from the farm to the house by considering several aspects. These aspects include the application of pesticides in agriculture, drift models, volatilization models, dispersion models, ventilation models, and sorption to dust models for indoor dust. Moreover, pesticides applied to agricultural land can spread around the agricultural area, even reaching settlements due to weather (26,27). pesticide levels at home in agricultural areas vary depending on the distance from the farming area and the sparying season (28). Previous research found, the concentration of pesticides in the dust overall was higher during the application period, and concentrations were higher in houses closer to the fields (<250 m) than in homes further away (26). Exposure to pesticides causes health problems ranging from mild health problems to serious health problems, the exposure levels of the pesticide depends the dose of exposure, the duration of exposure, and the frequency of exposure to pesticides (29).

WHO has made a classification of pesticide toxicity based on hazard. The level of toxicity of pesticides varies widely, ranging from harmless to extremely hazardous. three common approaches of pesticides classes encompass: (i) the chemical structure of the pesticide, (ii) the entry mode, and (iii) the action of pesticide and the organisms they kill (8). Table 2 shows pesticide toxicity levels from very dangerous (Ib) to unlikely cause acute danger in normal use (U). Pesticide toxicity is classified as oral and dermal toxicity tested on rats following the standard toxicology procedures. In implementing toxicity levels of pesticides, most pesticides are at a lethal dose of

50 (LD_{50}) by acute oral exposure (mg/kg body weight). However, dermal toxicity should be considered the most because most of the exposures come through the skin. Dermal exposure is considered high risk if the dermal LD_{50} value indicates a more significant hazard than the oral LD_{50} value (8). The impact of pesticide toxicity on human health ranges from mild to severe, with acute and chronic exposure. Some symptoms and signs of pesticide poisoning include body weakness, perspiration, poor appetite and depression, irritation, and acetylcholinesterase level below the limit value (30). Pesticide toxicity found in humans includes genotoxicity (31), haematotoxicity (32), hepatotoxicity (33), neurotoxicity (34), nephrotoxicity (35), and carcinogenicity (36,37). Several mechanisms of action of pesticides include oxidative stress, enzyme inhibition, DNA damage, gene expression, and adventitious bind mimicry (9).

Both acute and chronic exposure to various pesticide groups has health effects (21). Organophosphates (OPs) are pesticide groups with a central phosphorus atom with a double bond. The double bind is either sulfur or oxygen, R1 and R2 groups, ethyl or methyl in structure, and a loose group specific to the organophosphate. Where, R2 is an aromatic or aliphatic moiety and R1 is a methyl group (38). Clinical manifestations of contact with organophosphate compounds included muscarinic effects, nicotinic effects, and the central nervous system. Muscarinic effects include sweating, excessive salivation, lacrimation, bronchospasm, dyspnea, miosis, gastrointestinal symptoms, and blurred vision. Nicotinic effects include hypertension, muscle fasciculations, muscle cramps, motor weakness, tachycardia, and paralysis. Central nervous system effects include anxiety, dizziness, insomnia, nightmares, headaches, tremors, confusion, ataxia, and comma (39). Organophosphate pesticides likely inhibit cholinesterase enzymes and disrupt the endocrine (3,40,41). Organophosphate exposure has the potential to cause arrhythmias, coronary artery disease, congestive heart failure, metabolomic disorders, insulin resistance, cancer, and gene expression changes (37,42–45). Exposure to organophosphate affects insulin resistance, neurobehavioral function, blood profile, oxidative stress, metabolism of carbohydrates, fats, and proteins in the cytoplasm/ mitochondria/peroxisomes (46–51). In terms of nephrotoxicity of OPs, three molecular mechanisms are of most interest in the interaction of these compounds with serum albumin (SA): i) Binding of OPs by albumin; ii) Transport/interaction of OP-SA complexes and metabolites with kidney tissues and cells; iii) Protective effects of albumin against OPs (52). Chronic organophosphate exposure had higher insulin secretion from pancreatic islet cells and associated pancreatic hypertrophy. Insulin is vital in activating glucose transporter 9-mediated glucose transport into cells. Therefore, regulating insulin secretion is essential in mediating the plasma concentration of glucose. Acetylcholinesterase lies within the pancreas, either within acinar cells or insulin-secreting beta cells. Then acetylcholine binds to the muscarinic receptors of beta cells. After that, the cytosolic calcium concentration increases, enhancing the efficiency of calcium-mediated exocytosis, which activates insulin-secreting activity. Acetylcholinesterase also occurs within the alpha cells of the pancreas. Alpha cells stimulate insulin secretion in a paracrine manner within the pancreas (53).

Carbamates are pesticide groups with a central carbon atom with a double bond. The double bind is oxygen, R1 and R2 groups. The three main classes of carbamate pesticides are known: carbamate insecticides, where R1 is a methyl group; carbamate herbicides, where R1 is an aromatic moiety; and carbamate fungicides, where R1 is a benzimidazole moiety (38). Carbamate's potential health effects include unconsciousness, vomiting, convulsions, cyanosis (54), and cholinesterase inhibition. In addition, pesticides in this group interfere with endocrine function, impaired child development and IQ (55), decreased lung function (56), and central nervous system tumor (57). Among pesticide suicide, patients usually experience sudden respiratory and cardiac arrest (58). The pesticide group also triggers oxidative stress (48), impairing the enzymatic pathways involved in carbohydrates, fats, and protein metabolism within cytoplasm, mitochondria, and peroxisomes (49).

Pyrethroids are a group of manufactured pesticides similar to the natural pyrethrum produced by chrysanthemum flowers. The pyrethroid group possibly causes health effects, including paranesthesia and respiratory tract, eyes, and skin irritations. Increased risk of deaths in general and deaths because of cardiovascular disease (51) affects anti-Mullerian hormone levels, follicle-stimulating hormone, and antral follicle count (59). Pyrethroid also causes nephrotoxic, hepatotoxic, cardiotoxic, immunotoxin, neurotoxic, and behavioral effects and generates oxidative stress that causes changes in DNA, RNA, protein, fat, and carbohydrate molecules (60). The effects of pyrethroids on the HPG axis-related reproductive outcomes (61). Toxicological testing on pyrethroids indicates a weak, if any, effect on the incidence of tumors. There is evidence for an increased incidence of liver and lung tumors in permethrin, cypermethrin, and bifenthrin. However, at the highest doses tested, only detected tumors, which is many orders of magnitude higher than any human exposure (62).

Neonicotinoid pesticides are used to coat the seeds to prevent pest infestation (63) A previous study found neonicotinoids (NEOs) ubiquitous in the environment, drinking water, and food, with low-level exposure below acceptable daily intake standards. Moreover, neonicotinoids pesticides may cause health effects, including adverse developmental or neurological outcomes, autism spectrum disorder, memory loss, and finger tremors. Exposure to these pesticides also may lead to acute respiratory, cardiovascular, and neurological symptoms, oxidative genetic damage, and congenital disabilities (64). Thiacloprid and thiamethoxam at relatively low concentrations induce PII and I.3-mediated CYP19 expression and aromatase activity (65). They also cause changes the structure and stability of DNA (66). Acetamiprid induces DNA damage in all concentrations tested dose-dependent (67). Present studies indicated potential health risks associated with NEO exposure. Some early health changes such as disturbed insulin and glucose homeostasis among non-diabetic adults, decreased sperm progressive motility among healthy men, and increased levels of serum lipid molecules in the general population, urinary steroid hormones in reproductive-age males and urinary oxidative stress markers in healthy individuals were positively correlated with internal NEOs levels (68).

Furthermore, Chlorfenapyr, a pesticide of the pyrrole group, may trigger health problems. A previous case report mentions neurological complications, included body weakness, dizziness, delirious with visual hallucinations at 114 h and 122 h post-ingestion. At 156 h post-exposure, a brief tonic seizure followed by cardiac asystole developed and the patient died 157 h (6.5 days) postingestion (69). Chlorfenapyr intoxication causing dermal manifestation may be harmful. For example, a 49-year-old patient died five days after exposure to this pesticide (70). Another study revealed clinical feature of chlorfenapyr-induced toxic leukoencephalopathy to the 71-year-old male patient (71). The risk for pancreatic cancer is higher exposure in the dinitroaniline group, e.g., Pendimethalin (37). Another research revealed that Chlorfenapyr induced cellular toxicity in human liver cells (HepG2 cells) and induced mitochondrial damage associated with reactive oxygen species (ROS) accumulation and mitochondrial calcium overload, ultimately leading to apoptosis and autophagy in HepG2 cells (72).

Potential health effects from exposure to various pesticides may occur, especially among house residents. These effects are harmful, especially for vulnerable groups such as pregnant women and children, considering the high maternal and child mortality in this agricultural area.

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CONCLUSION

This current study revealed three major groups of pesticides in the agricultural communities: organophosphates, carbamates, and pyrethroids. In addition, insecticides, fungicides, and herbicides are the most common types of pesticides used in the areas. The pesticides stored indoors are usually placed in the kitchen, on the wooden rack, while the outdoor storage of the pesticides is on the terrace and outside the house. Pesticides stored around the house harm people who breathe the pesticide dust, consume contaminated food or drink, or contract with it on the skin. The pesticide toxicity levels found in the respondents' houses range from very dangerous (Ib) to unlikely to cause acute danger under normal use (U). Potential health problems caused by pesticides vary from poisoning symptoms and signs to genetic disorders and polymorphisms. Further research is needed to prove the health problems as a result of exposure to pesticides in agricultural communities.

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Table 1 Respondents' Characteristics and Identification of Pesticides

Characteristics of respondents	Total	Percent (%)
Age (year)		
26-35	39	23.5
36-45	78	47
46-55	39	23.5
56-65	8	4.8
>65	2	1.2
Level of education		
Not attended schools	1	0.6
Not completed elementary school	23	13.9
Completed elementary school	112	67.5
Completed junior high school	18	10.8
Completed senior high school	9	5.4
Competed higher education	3	1.8
Type of occupation		
Unemployed	1	0.6
Farmer and farm worker	62	37.3
Trader of pesticides	1	0.6
Small trader	83	50
Others (construction laborers, private workers, civil servants)	19	11.4
Identification of pesticides at home		
Presence	51	30.7
Absence	115	69.3

Table 2 Types, active ingredients, and toxicity levels of pesticides in the respondents' houses

Brands	Types	Groups	Active ingredients	Pesticide toxicity class	LD_{50} (mg/kg)
Starban 585EC	Insecticide	Organophosphates	Chlorpyrifos 530 g/l	II	135
Dursban 200 EC	Insecticide	Organophosphates	Chlorpyrifos 200 g/l	II	135
Sidajos 430 EC	Insecticide	Organophosphates	Dimethoate 430 g/l	II	c150
Destan 400 EC	Insecticide	Organophosphates	Dimethoate 400 g/l	II	c150
Roundup 486 SL	Herbicide	Organophosphates	Glyphosate 486 g/l	III	4,230
Indocron 500 EC	Insecticide	Organophosphates	Profenofos 500 g/l	II	352
Vondozeb 80 WP	Fungicide	Carbamate	Mancozeb 80%	U	>8,000
Dithane M-45	Fungicide	Carbamate	Mancozeb 80 %	U	>8,000
Colanta 70 WP	Fungicide	Carbamate	Propineb 70%	U	8,500

Antracol 70 WP	Fungicide	Carbamate	Propineb 70%	U	8,500
Emcindo 500 EC	Insecticide	Carbamate	BPMC/ butylphenyl methylcarbamate 500 g/l	-	
Baycarb 500 EC	Insecticide	Carbamate	Fenobucarb; BPMC 500 g/l	II	620
Benhur 500 EC	Insecticide	Carbamate	BPMC 500 g/l	-	
Naga 50 EC	Insecticide	Carbamate	BPMC 50 g/l	-	
Marshall 200 EC	Insecticide	Carbamate	Carbosulfan 200,11 gr/l	II	250
Buldok 25 EC	Insecticide	Pyrethroid	Beta Cyfluthrin 25 g/l	I b	c11
Prado 25EC	Insecticide	Pyrethroid	Beta Cyfluthrin	I b	c11
BM Cyperkil 50 EC	Insecticide	Pyrethroid	Cypermethrin 50 g/l	II	c250
Pounce 20 EC	Insecticide	Pyrethroid	Permethrin 20 g/l	II	c220
Decis 25 EC	Insecticide	Pyrethroid	Deltamethrin 25 g/l	II	c135
Anta 50 EC	Insecticide	Pyrethroid	Emamectin Benzoate 50 g/l	III	53-237
Prothol 10 EC	Insecticide	Pyrethroid	Emamectin Benzoate 10 g/l	III	53-237
Abenz 22 EC	Insecticide	Pyrethroid	Emamectin Benzoate 22g/l	III	53-237
Bosmex 25 EC	Insecticide	Pyrethroid	Abamectin 25 g/l	I b	8.7
Confidor 5 WP	Insecticide	Neonicotinoid	Imidacloprid 5 g/l	II	450
Besvidor 25 WP	Insecticide	Neonicotinoid	Imidacloprid 25 g/l	II	450
Tumagon 100 EC	Insecticide	Pyrol	Chlorfenapyr 100g/l	II	441
Arjuna 200 EC	Insecticide	Pyrol	Chlorfenapyr200g/l	II	441
Prowl 330 EC	Herbicides	Dinitroaniline	Pendimethalin 336 g/l	II	1,050
Amistar top 325 SC	Fungicide	Azoxystrobin	Azoxystrobin 200 g/l and Difenoconazole 125 g/l	U	>5,000 1,453
Rovral 50 WP	Fungicide	Iprodione	Iprodione 50%	III	3,500
Rapid 20 WG	Herbicide	Metsulfuron methyl	Metsulfuron methyl 20 %	U	>5,000
Prevathon 50 SC	Insecticide	Chlorantraniliprole	Chlorantraniliprole 50 g/l	U	>5,000

Classification of active pesticide ingredients: Ia = Extremely hazardous (oral < 5, dermal < 50); Ib = Highly hazardous (oral 5-50, dermal 50-200); II = Moderately hazardous (oral 50-2000, dermal 200-2000); III = Slightly hazardous (oral > 2000, dermal > 2000); U = Unlikely to present acute hazard in normal use (5000 or higher).

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TYPES OF PESTICIDES AND THEIR TOXICITY LEVELS: A STUDY IN AGRICULTURAL AREAS OF BREBES REGENCY

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ABSTRACT

Introduction: A previous study found that children living in agricultural areas were exposed to organophosphate pesticides, but other types of pesticides in the community have not been identified yet. Hence, this study aimed to identify types of pesticides in the agricultural area and their toxicity levels that might cause potential health problems. **Methods:** The study population was 1,017 households living in two villages in the agricultural area of Brebes Regency, Indonesia. A cross-sectional design was used to conduct data collection among 166 respondents through a questionnaire to determine the respondent's characteristics and through observations to determine the pesticide, pesticide packaging, and pesticide residue in the respondents' houses. Pesticide toxicity levels were identified based on the pesticide toxicity classification recommended by the World Health Organization. Potential health problems of pesticides were then identified based on literature review. **Results and Discussion:** Results found that 30.7% of respondents had organophosphate, carbamate, and pyrethroid pesticides. The toxicity levels of the pesticides ranged from highly hazardous (Ib) to unlikely to present acute hazards (U). Potential health problems caused by pesticides vary from poisoning symptoms and signs to genetic disorders and polymorphisms. **Conclusion:** Three major pesticides in the community in an agricultural area with toxicity levels ranged from highly hazardous to unlikely to present an acute hazard.

Keywords: *pesticides, active ingredients, toxicity, health effects, agriculture*.

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INTRODUCTION

Using pesticides for agricultural purposes also contributes to an increased risk of pesticide exposure in rural areas (1). A previous study in the farm area of Brebes Regency has revealed that 28,9% of children had the organophosphate pesticides metabolites in the urine. The organophosphate pesticide metabolites had concentrations between 0 parts per million (ppm) to 0.223 ppm (2). Pesticides may interfere with endocrine functions (3). As a result of pesticide exposure, organophosphate pesticide is likely associated with thyroid hormone disorders (TSH,

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FT4) (4). Children can be exposed to pesticides in various ways, such as consuming food and drinks contaminated with pesticides, behavior (involvement in agricultural activities), and other factors (5). Children living in agricultural areas may be exposed to pesticides through dust from pesticide spraying or through the evaporation of pesticides from farmlands. Parents may also bring pesticide contaminants into their homes after they contract with pesticide spraying (6). A previous study has also found that most school children exposed to pesticides have lived in agricultural areas since birth and 23% of children got exposure from onion farming activities (4). Suspected pesticide sources include agricultural lands, homes, and neighborhood areas. However, previous research has only revealed one type of pesticide, organophosphate pesticides, and even the farmers use many pesticides to protect their crops, especially shallots (2). Little information is found related to the types and toxicity levels of pesticides used by the community in the agricultural area of Brebes Regency. Hence, this study investigated these aspects further.

METHODS

This observational study was conducted on people who live in agricultural areas of two villages in Brebes Regency. The agriculture areas in question are onion farming which uses a lot of pesticides. The population is the parents of elementary school students identified in the previous study (2). Data were collected through a questionnaire and observation inside and outside the respondents' houses. The questionnaires were employed to determine the respondents' characteristics. Identification of pesticides was determined by observing residual pesticides, pesticide packages or packages, and equipment used to spray or apply pesticides. The pesticide product brand, types, groups, active ingredient, and formulation are identified by reading the pesticide packages. If the containers are not legible, the respondents gave the trademark and the active ingredient traced from the manufacturers or brands through their company websites. Furthermore, to identify pesticide toxicity levels, the active ingredients are compared with those in the classification of pesticide toxicity recommended by the World Health Organization (7). Potential health effects caused by pesticides are studied based on a literature review. The Health

Research Ethics Commission of the Faculty of Public Health, Diponegoro University, approved the ethics of this study with the number 91/EC/FKM/2016.

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Yes, it is

RESULTS

Brebes Regency is located 1–500 meters above sea level. The area of Brebes Regency is 166,296 km² with 1,781,379 people. About 70% of the population work in the agricultural sector, and 40% are farmers and farm laborers. The harvested area of shallots stretches to 30,954 ha, producing 3,759,742 quintals with an average production of 121.46 quintals per ha. The output of shallots contributes to the gross income of the Brebes Regency by 58%. The largest shallot crop centers are spread over 11 sub-districts, there are Larangan, Wanasari, Bulakamba, Brebes, Tonjong, Losari, Kersana, Ketanggungan, Songgom, Jatibarang, and Banjarharjo. The Bulakamba sub-district is in third place after Larangan and Wanasari sub-districts. Shallot farming contributes to the demand for shallot production in Central Java and Indonesia by 72.39% and 30.62%. The average age of the respondents is classified as productive at 42.1 years (see Table 1).

Tabel 1.

Based on the age category, most of the population is 36-45 years old. The majority of them are elementary school graduates and most work as small traders. This study also found pesticides in 30.7% of the respondents' houses. More clearly stated, Table 2 shows types, class, and active ingredients of pesticide.

Table 2.

Commonly used pesticides include insecticides and fungicides. Insecticides kill insects, while fungicides remove fungi from shallots and onion bulbs. Based on types, organophosphates, carbamates, and pyrethroids are the most used. Organophosphate pesticides have common active ingredients such as chlorpyrifos, dimethoate, glyphosate, and profenofos. Moreover, carbamate pesticides mostly contain mancozeb, propineb, BPMC, and carbosulfan. The active ingredients in pyrethroid pesticides include cypermethrin, permethrin, emamectin, deltamethrin, and beta-cyfluthrin. Meanwhile, most pesticides are usually liquid, which helps emulsify parts of the pesticide formulation while the rest is suspended and dispersed.

DISCUSSION

Pesticides that farmers spray to control the pests of shallot plants will spread to the soil, air, water, and residue in shallot plants and affect farmers. Pesticides can distribute in the environment through various ways, including runoff, leaching, volatilization, dust drift, and biological magnification (8,9). When pesticides are applied to land, runoff can run off into nearby water bodies, contaminating surface water and potentially affecting aquatic life. Leaching pesticides can penetrate the soil and contaminate groundwater if not bound to the soil particles. Volatilization, some pesticides can evaporate and become airborne, leading to contamination of air and potential exposure for humans and animals. Dust drift, during the application, pesticide particles can become airborne and be carried by the wind, potentially affecting non-target areas and organisms. In biological magnification, pesticides can move up the food chain when they are ingested by small organisms and then consumed by larger organisms. Pesticides in the ground, air, and water will undergo a process of degradation in a short to a long time, depending on the medium's physical, chemical, and biological conditions (10).

Sometimes the farmers bring some pesticide packs and leftover pesticides to the house, and pesticide packs also see in shallot farming areas. In addition, pesticides that stick to the clothes or the farmer's body will carry to the house. Based on the observations at the respondent's house, it was found that there were various types of pesticides with different active ingredients. We found that there were more than three types of pesticides in one house. Storage of pesticides or pesticides leftover is carried out in the kitchen together with storage of pesticide spray equipment. Based on various groups and types, insecticides and fungicides are the most found in shallots and onion bulbs as farmers choose pesticides that can kill the most attacking pests, i.e., insects and fungi. Previous research also has found the same types and groups of pesticides (11,12).

The high number of pest organisms may lead to crop failure, especially when fungal attacks increase significantly in the rainy season. Based on previous research, the most common types of fungus in the shallot farming areas of Brebes Regency are Alternaria porri, Colletotrichum gloeosporioides, Porenospora destructor, and Fusarium oxysporum. These insects and fungi grow well in the tropics. Besides these examples, Fusarium oxysporum and Colletotrichum sp are also found in shallots in other areas such as Kalimantan (13). In addition, insecticides used to control onion pests include Spodoptera exigua, Spodoptera litura, and Thrips tabaci (12). Both male and female farmers handling the shallot start from the shallot planting to post-harvest. The farmers planted shallots with bare hands and only wore long sleeves, trousers, and hats. They do not use complete personal protective equipment for handling the shallot, such as boots, gloves, face or respiratory protection, and eye protection.

The average of the volume of insecticide solution applied ranges from 13.29 to 15.17 liters per ha (14). The farmers sprayed regularly every 3–4 days per week, and they sprayed 15-20 times in the growing season. The insecticide volume used in the agricultural area of 30,954 ha is around 13.29–15.17 liters per ha and it is estimated 411,378.66–469,572.18 liters per ha in the growing season. The use of pesticides in Brebes Regency is usually to prevent onion plant pests and preserve shallot bulbs stored in the house. Pesticides are applied by spraying the shallot plants and sprinkling pesticide powder on the shallot bulbs, including for planting the shallot bulbs. Spraying pesticides on shallot plants is usually from 6 to 9 AM and 3 to 5 PM. Farmers apply more than three types of pesticides, even up to seven. Likewise, the dosage of pesticides exceeds of recommended dosage on the label on the package. It may need to educate them to comply with the recommendation for pesticide application, including wearing personal protection equipment.

The use of pesticides to control shallot plant pests; usually, there are pesticides left. The rest of the pesticides bring to the home, and some are left in the shallot farming land. Pesticide leftovers, packages, and containers were found in 51 houses. The form of pesticides that are left and taken to the house can be in solid forms such as powder and liquid. Types of materials for making pesticide containers are diverse, including plastic, cardboard, cans, and glass bottles. These containers also store in the kitchen and outside the house. The respondents usually stored the pesticides and pesticide leftovers in the kitchen, hanged them on the wall, on the edge of the siding, on the terrace, or in certain places outside the house.

White pesticide powder as preservatives was also found to protect shallot bulbs stored on wooden racks and placed in the kitchen. The floors of the respondent's house are made of earth and cement or ceramics. Pesticides (dust drift) that fall on the floor will mix or stick to the dust; cleaning the floors makes the pesticides that adhere to the dust will spread throughout the house. In addition to pesticides, the respondents also used some equipment such as sprayers, buckets for pesticide formulation, and clothes used for pesticide spraying. Previous research similarly confirms pesticide storing inside and outside the house. For example, 38.4% of farmers in Ethiopia (15) and 44.4–55.0% of farmers (16) kept pesticides in their kitchen or houses, and 59.5% of farmers in Pakistan stored them in separate rooms in the house (17). Another example is that 44% of farmers in Ghana sored pesticides in their bedrooms (18) and in Ethiopia, 30.5% under their beds (19). For outdoor storage, 96% of farmers store pesticides in separate places outside their houses, and 1% of farmers in Vietnam (20) and 9% of farmers (19) keep pesticides in their kitchens 6.6% (15).

Pesticide exposure occurs in a direct and indirect ways. Pesticides may contaminate people through the skin, inhalation, and ingestion of solid, liquid, or gas substances (21). Farming activities potentially expose the individuals around to dust pesticide from the pesticide storage or through the air, thereby letting the pesticide enter the respiratory tract or the skin. Moreover, dust and pesticide may also contaminate the food or drink the farmers consume. Besides direct exposure to pesticides, storage of pesticides in the house also has the potential to contaminate food and drink in the home. Thus, storing pesticides in the house has the potential to cause contamination of food and drinks in the place, especially if pesticides, pesticide residues, or pesticide packs are stored near a food processing area, such as the kitchen. Pesticides have volatile properties in liquid and powder forms, so they quickly transfer them. If pesticides are stored in the kitchen, pesticide vapors and drift can spread in the kitchen and contaminate food or drink, including the food and drinking utensils. Research reveals that pesticides were found around the houses in agricultural areas (22,23).

Storing pesticides in and around the house poses a risk of exposure to people living there. Pesticides have volatile properties and drift to reach spaces in the house. Usually infants, children under five years, and pregnant women spend much time at home, including the elderly. The potential for pesticides to expose these people is more significant than for those outside the home. A study confirmed that pesticide exposure in farming areas is likely higher in children and is associated with indoor pesticide storage (24). Furthermore, older children and teenagers play more outdoors. Locations for playing outdoors include on the terrace, in the yard, with the neighbors, and in the shallot farming area. Pesticides can be in the house of non-spraying farmers because pesticides can transport through dust, wind, or other objects (25). Although some people store shallot bulbs which may contain pesticide residues in the terraces and yards. Children are also involved in farming activities at this farm location besides playing (2).

Several activities cause people to be exposed to pesticides, starting to formulate pesticides, spraying, storing, living in houses with pesticides, playing outside the house in agricultural areas, and in indoor through house dust. Figueiredo (2022) created a model for the journey of pesticides from the farm to the house by considering several aspects. These aspects include the application of pesticides in agriculture, drift models, volatilization models, dispersion models, ventilation models, and sorption to dust models for indoor dust. Moreover, pesticides applied to agricultural land can spread around the agricultural area, even reaching settlements due to weather (26,27). pesticide levels at home in agricultural areas vary depending on the distance from the farming area and the sparying season (28). Previous research found, the concentration of pesticides in the dust overall was higher during the application period, and concentrations were higher in houses closer to the fields (<250 m) than in homes further away (27). Exposure to pesticides causes health problems ranging from mild health problems to serious health problems, the exposure levels of the pesticide depends the dose of exposure, the duration of exposure, and the frequency of exposure to pesticides (29).

WHO has made a classification of pesticide toxicity based on hazard. The level of toxicity of pesticides varies widely, ranging from harmless to extremely hazardous. three common approaches of pesticides classes encompass: (i) the chemical structure of the pesticide, (ii) the entry mode, and (iii) the action of pesticide and the organisms they kill (30). Table 2 shows pesticide toxicity levels from very dangerous (Ib) to unlikely cause acute danger in normal use (U). Pesticide toxicity is classified as oral and dermal toxicity tested on rats following the standard toxicology procedures. In implementing toxicity levels of pesticides, most pesticides are at a lethal dose of 50 (LD_{50}) by acute oral exposure (mg/kg body weight). However, dermal toxicity should be considered the most because most of the exposures come through the skin. Dermal exposure is considered high risk if the dermal LD_{50} value indicates a more significant hazard than the oral LD_{50} value (8). The impact of pesticide toxicity on human health ranges from mild to severe, with acute and chronic exposure. Some symptoms and signs of pesticide poisoning include body weakness, perspiration, poor appetite and depression, irritation, and acetylcholinesterase level below the limit value (31). Pesticide toxicity found in humans includes genotoxicity (32), haematotoxicity (33), hepatotoxicity (34), neurotoxicity (35), nephrotoxicity (36), and carcinogenicity (37,38). Several mechanisms of action of pesticides include oxidative stress, enzyme inhibition, DNA damage, gene expression, and adventitious bind mimicry (9)

Both acute and chronic exposure to various pesticide groups has health effects (21). Organophosphates (OPs) are pesticide groups with a central phosphorus atom with a double bond. The double bind is either sulfur or oxygen, R1 and R2 groups, ethyl or methyl in structure, and a loose group specific to the organophosphate. Where, R2 is an aromatic or aliphatic moiety and R1 is a methyl group (39). Clinical manifestations of contact with organophosphate compounds included muscarinic effects, nicotinic effects, and the central nervous system. Muscarinic effects include sweating, excessive salivation, lacrimation, bronchospasm, dyspnea, miosis, gastrointestinal symptoms, and blurred vision. Nicotinic effects include hypertension, muscle fasciculations, muscle cramps, motor weakness, tachycardia, and paralysis. Central nervous system effects include anxiety, dizziness, insomnia, nightmares, headaches, tremors, confusion, ataxia, and comma (40). Organophosphate pesticides likely inhibit cholinesterase enzymes and disrupt the endocrine (3,41,42). Organophosphate exposure has the potential to cause arrhythmias, coronary artery disease, congestive heart failure, metabolomic disorders, insulin resistance, cancer, and gene expression changes (38,43–46). Exposure to organophosphate affects insulin resistance, neurobehavioral function, blood profile, oxidative stress, metabolism of carbohydrates, fats, and proteins in the cytoplasm/ mitochondria/peroxisomes (47–52). In terms of nephrotoxicity of OPs, three molecular mechanisms are of most interest in the interaction of these compounds with serum albumin (SA): i) Binding of OPs by albumin; ii) Transport/interaction of OP-SA complexes and metabolites with kidney tissues and cells; iii) Protective effects of albumin against OPs (53). Chronic organophosphate exposure had higher insulin secretion from pancreatic islet cells and associated pancreatic hypertrophy. Insulin is vital in activating glucose transporter 9-mediated glucose transport into cells. Therefore, regulating insulin secretion is essential in mediating the plasma concentration of glucose. Acetylcholinesterase lies within the pancreas, either within acinar cells or insulin-secreting beta cells. Then acetylcholine binds to the muscarinic receptors of beta cells. After that, the cytosolic calcium concentration increases, enhancing the efficiency of calcium-mediated exocytosis, which activates insulin-secreting activity. Acetylcholinesterase also occurs within the alpha cells of the pancreas. Alpha cells stimulate insulin secretion in a paracrine manner within the pancreas (54).

Carbamates are pesticide groups with a central carbon atom with a double bond. The double bind is oxygen, R1 and R2 groups. The three main classes of carbamate pesticides are known: carbamate insecticides, where R1 is a methyl group; carbamate herbicides, where R1 is an aromatic moiety; and carbamate fungicides, where R1 is a benzimidazole moiety (39). Carbamate's potential health effects include unconsciousness, vomiting, convulsions, cyanosis (55), and cholinesterase inhibition. In addition, pesticides in this group interfere with endocrine function, impaired child development and IQ (56), decreased lung function (57), and central nervous system tumor (58). Among pesticide suicide, patients usually experience sudden respiratory and cardiac arrest (59). The pesticide group also triggers oxidative stress (49), impairing the enzymatic pathways involved in carbohydrates, fats, and protein metabolism within cytoplasm, mitochondria, and peroxisomes (50).

Pyrethroids are a group of manufactured pesticides similar to the natural pyrethrum produced by chrysanthemum flowers. The pyrethroid group possibly causes health effects, including paranesthesia and respiratory tract, eyes, and skin irritations. Increased risk of deaths in general and deaths because of cardiovascular disease (52) affects anti-Mullerian hormone levels, follicle-stimulating hormone, and antral follicle count (60). Pyrethroid also causes nephrotoxic, hepatotoxic, cardiotoxic, immunotoxin, neurotoxic, and behavioral effects and generates oxidative stress that causes changes in DNA, RNA, protein, fat, and carbohydrate molecules (61). The effects of pyrethroids on the HPG axis-related reproductive outcomes (62). Toxicological testing on pyrethroids indicates a weak, if any, effect on the incidence of tumors. There is evidence for an increased incidence of liver and lung tumors in permethrin, cypermethrin, and bifenthrin. However, at the highest doses tested, only detected tumors, which is many orders of magnitude higher than any human exposure (63).

Neonicotinoid pesticides are used to coat the seeds to prevent pest infestation (64) A previous study found neonicotinoids (NEOs) ubiquitous in the environment, drinking water, and food, with low-level exposure below acceptable daily intake standards. Moreover, neonicotinoids pesticides may cause health effects, including adverse developmental or neurological outcomes, autism spectrum disorder, memory loss, and finger tremors. Exposure to these pesticides also may lead to acute respiratory, cardiovascular, and neurological symptoms, oxidative genetic damage, and congenital disabilities (65). Thiacloprid and thiamethoxam at relatively low concentrations induce PII and I.3-mediated CYP19 expression and aromatase activity (66). They also cause changes the structure and stability of DNA (67). Acetamiprid induces DNA damage in all concentrations tested dose-dependent (68). Present studies indicated potential health risks associated with NEO exposure. Some early health changes such as disturbed insulin and glucose homeostasis among non-diabetic adults, decreased sperm progressive motility among healthy men, and increased levels of serum lipid molecules in the general population, urinary steroid hormones in reproductive-age males and urinary oxidative stress markers in healthy individuals were positively correlated with internal NEOs levels (69)

Furthermore, Chlorfenapyr, a pesticide of the pyrrole group, may trigger health problems. A previous case report mentions neurological complications, included body weakness, dizziness, delirious with visual hallucinations at 114 h and 122 h post-ingestion. At 156 h post-exposure, a brief tonic seizure followed by cardiac asystole developed and the patient died 157 h (6.5 days) postingestion (70). Chlorfenapyr intoxication causing dermal manifestation may be harmful. For example, a 49-year-old patient died five days after exposure to this pesticide (71). Another study revealed clinical feature of chlorfenapyr-induced toxic leukoencephalopathy to the 71-year-old male patient (72). The risk for pancreatic cancer is higher exposure in the dinitroaniline group, e.g., Pendimethalin (38). Another research revealed that Chlorfenapyr induced cellular toxicity in human liver cells (HepG2 cells) and induced mitochondrial damage associated with reactive oxygen species (ROS) accumulation and mitochondrial calcium overload, ultimately leading to apoptosis and autophagy in HepG2 cells (73)

Potential health effects from exposure to various pesticides may occur, especially among house residents. These effects are harmful, especially for vulnerable groups such as pregnant women and children, considering the high maternal and child mortality in this agricultural area.

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CONCLUSION

This current study revealed three major groups of pesticides in the agricultural communities: organophosphates, carbamates, and pyrethroids. In addition, insecticides, fungicides, and herbicides are the most common types of pesticides used in the areas. The pesticides stored indoors are usually placed in the kitchen, on the wooden rack, while the outdoor storage of the pesticides is on the terrace and outside the house. Pesticides stored around the house harm people who breathe the pesticide dust, consume contaminated food or drink, or contract with it on the skin. The pesticide toxicity levels found in the respondents' houses range from very dangerous (Ib) to unlikely to cause acute danger under normal use (U). Potential health problems caused by pesticides vary from poisoning symptoms and signs to genetic disorders and polymorphisms. Further research is needed to prove the health problems as a result of exposure to pesticides in agricultural communities.

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Publication article references must be followed with **Authors name** or organization name, Article **Title** (written in **Title case**), **Journal name**, **Volume and issue number** also **page number** of article publication (start to end number page).
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Table 1 Respondents' Characteristics and Identification of Pesticides

Characteristics of respondents	Total	Percent (%)
Age (year)		
26-35	39	23.5
36-45	78	47
46-55	39	23.5
56-65	8	4.8
>65	2	1.2
Level of education		
Not attended schools	1	0.6
Not completed elementary school	23	13.9
Completed elementary school	112	67.5
Completed junior high school	18	10.8
Completed senior high school	9	5.4
Competed higher education	3	1.8
Type of occupation		
Unemployed	1	0.6
Farmer and farm worker	62	37.3
Trader of pesticides	1	0.6
Small trader	83	50
Others (construction laborers, private workers, civil servants)	19	11.4
Identification of pesticides at home		
Presence	51	30.7
Absence	115	69.3

Table 2 Types, active ingredients, and toxicity levels of pesticides in the respondents' houses

Brands	Types	Groups	Active ingredients	Pesticide toxicity class	LD_{50} (mg/kg)
Starban 585EC	Insecticide	Organophosphates	Chlorpyrifos 530 g/l	II	135
Dursban 200 EC	Insecticide	Organophosphates	Chlorpyrifos 200 g/l	II	135
Sidajos 430 EC	Insecticide	Organophosphates	Dimethoate 430 g/l	II	c150
Destan 400 EC	Insecticide	Organophosphates	Dimethoate 400 g/l	II	c150
Roundup 486 SL	Herbicide	Organophosphates	Glyphosate 486 g/l	III	4,230
Indocron 500 EC	Insecticide	Organophosphates	Profenofos 500 g/l	II	352
Vondozeb 80 WP	Fungicide	Carbamate	Mancozeb 80%	U	>8,000
Dithane M-45	Fungicide	Carbamate	Mancozeb 80 %	U	>8,000
Colanta 70 WP	Fungicide	Carbamate	Propineb 70%	U	8,500
Antracol 70 WP	Fungicide	Carbamate	Propineb 70%	U	8,500
Emcindo 500 EC	Insecticide	Carbamate	BPMC/ butylphenyl methylcarbamate 500 g/l	-	
Baycarb 500 EC	Insecticide	Carbamate	Fenobucarb; BPMC 500 g/l	II	620
Benhur 500 EC	Insecticide	Carbamate	BPMC 500 g/l	-	
Naga 50 EC	Insecticide	Carbamate	BPMC 50 g/l	-	
Marshall 200 EC	Insecticide	Carbamate	Carbosulfan 200,11 gr/l	II	250
Buldok 25 EC	Insecticide	Pyrethroid	Beta Cyfluthrin 25 g/l	I b	c11
Prado 25EC	Insecticide	Pyrethroid	Beta Cyfluthrin	I b	c11

BM Cyperkil 50 EC	Insecticide	Pyrethroid	Cypermethrin 50 g/l	II	c250
Pounce 20 EC	Insecticide	Pyrethroid	Permethrin 20 g/l	II	c220
Decis 25 EC	Insecticide	Pyrethroid	Deltamethrin 25 g/l	II	c135
Anta 50 EC	Insecticide	Pyrethroid	Emamectin Benzoate 50 g/l	III	53-237
Prothol 10 EC	Insecticide	Pyrethroid	Emamectin Benzoate 10 g/l	III	53-237
Abenz 22 EC	Insecticide	Pyrethroid	Emamectin Benzoate 22g/l	III	53-237
Bosmex 25 EC	Insecticide	Pyrethroid	Abamectin 25 g/l	I b	8.7
Confidor 5 WP	Insecticide	Neonicotinoid	Imidacloprid 5 g/l	II	450
Besvidor 25 WP	Insecticide	Neonicotinoid	Imidacloprid 25 g/l	II	450
Tumagon 100 EC	Insecticide	Pyrol	Chlorfenapyr 100g/l	II	441
Arjuna 200 EC	Insecticide	Pyrol	Chlorfenapyr200g/l	II	441
Prowl 330 EC	Herbicides	Dinitroaniline	Pendimethalin 336 g/l	II	1,050
Amistar top 325 SC	Fungicide	Azoxystrobin	Azoxystrobin 200 g/l and Difenoconazole 125 g/l	U	>5,000 1,453
Rovral 50 WP	Fungicide	Iprodione	Iprodione 50%	III	3,500
Rapid 20 WG	Herbicide	Metsulfuron methyl	Metsulfuron methyl 20 %	U	>5,000
Prevathon 50 SC	Insecticide	Chlorantraniliprole	Chlorantraniliprole 50 g/l	U	>5,000

Classification of active pesticide ingredients: Ia = Extremely hazardous (oral < 5, dermal < 50); Ib = Highly hazardous (oral 5-50, dermal 50-200); II = Moderately hazardous (oral 50-2000, dermal 200-2000); III = Slightly hazardous (oral > 2000, dermal > 2000); U = Unlikely to present acute hazard in normal use (5000 or higher).

[JKL] New notification from JURNAL KESEHATAN LINGKUNGAN

Zida Husnina, S.KM, M.PH <zidahusninajkl@gmail.com>
Wed 3/1/2023 5:14 PM
To: Budiyono <budiyonofkm@lecturer.undip.ac.id>

You have a new notification from JURNAL KESEHATAN LINGKUNGAN :

There is new activity in the discussion titled "Guideline Based Review" regarding the submission "TYPES OF PESTICIDES AND THEIR TOXICITY LEVELS: A STUDY IN AGRICULTURAL AREAS OF BREBES REGENCY".

Link: https://e-journal.unair.ac.id/JKL/authorDashboard/submission/42704

Aditya Sukma Pawitra, S.KM, M.KL.
jkesling@fkm.unair.ac.id____ Jurnal Kesehatan Lingkungan https://e-journal.unair.ac.id/JKL

TYPES OF PESTICIDES AND THEIR TOXICITY LEVELS: A STUDY IN AGRICULTURAL AREAS OF BREBES REGENCY

Commented [F1]: Please attach the scan of ethical clearance certificate or research permission letter

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TYPES OF PESTICIDES AND THEIR TOXICITY LEVELS: A STUDY IN AGRICULTURAL AREAS OF BREBES REGENCY

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ABSTRACT

Introduction: A previous study found that children living in agricultural areas were exposed to organophosphate pesticides, but other types of pesticides in the community have not been identified yet. Hence, this study aimed to identify types of pesticides in the agricultural area and their toxicity levels that might cause potential health problems. **Methods:** The study population was 1,017 households living in two villages in the agricultural area of Brebes Regency, Indonesia. A cross-sectional design was used to conduct data collection among 166 respondents through a questionnaire to determine the respondent's characteristics and through observations to determine the pesticide, pesticide packaging, and pesticide residue in the respondents' houses. Pesticide toxicity levels were identified based on the pesticide toxicity classification recommended by the World Health Organization. Potential health problems of pesticides were then identified based on literature review. **Results and Discussion:** Results found that 30.7% of respondents had organophosphate, carbamate, and pyrethroid pesticides. The toxicity levels of the pesticides ranged from highly hazardous (Ib) to unlikely to present acute hazards (U). Potential health problems caused by pesticides vary from poisoning symptoms and signs to genetic disorders and polymorphisms. **Conclusion:** Three major pesticides in the community in an agricultural area with toxicity levels ranged from highly hazardous to unlikely to present an acute hazard.

Keywords: *pesticides, active ingredients, toxicity, health effects, agriculture*.

INTRODUCTION

Using pesticides for agricultural purposes also contributes to an increased risk of pesticide exposure in rural areas(1). A previous study in the farm area of Brebes Regency has revealed that 51.2% of children had the organophosphate pesticides metabolites in the urine. The organophosphate pesticide metabolites had concentrations between 0.001 to 0.14 ppm (2). Pesticides may interfere with endocrine functions (3). As a result of pesticide exposure, organophosphate pesticide is likely associated with thyroid hormone disorders (TSH, FT4) (4).

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Children can be exposed to pesticides in various ways, such as consuming food and drinks contaminated with pesticides, behavior (involvement in agricultural activities), and other factors (5). Children living in agricultural areas may be exposed to pesticides through dust from pesticide spraying or through the evaporation of pesticides from farmlands. Parents may also bring pesticide contaminants into their homes after they contract with pesticide spraying (6). A previous study has also found that most school children exposed to pesticides have lived in agricultural areas since birth (97.6%), and 65.5% of children got exposure from onion farming activities. Suspected pesticide sources include agricultural lands, homes, and neighborhood areas. However, previous research has only revealed one type of pesticide, organophosphate pesticides, and even the farmers use many pesticides to protect their crops, especially shallots (2). Little information is found related to the types and toxicity levels of pesticides used by the community in the agricultural area of Brebes Regency. Hence, this study investigated these aspects further.

METHODS

This observational study was conducted on people who live in agricultural areas of two villages in Brebes Regency. The agriculture areas in question are onion farming which uses a lot of pesticides. The population is the parents of elementary school students identified in the previous study (7). Data were collected through a questionnaire and observation inside and outside the respondents' houses. The questionnaires were employed to determine the respondents' characteristics. Identification of pesticides was determined by observing residual pesticides, pesticide packages or packages, and equipment used to spray or apply pesticides. The pesticide product brand, types, groups, active ingredient, and formulation are identified by reading the pesticide packages. If the containers are not legible, the respondents gave the trademark and the active ingredient traced from the manufacturers or brands through their company websites. Furthermore, to identify pesticide toxicity levels, the active ingredients are compared with those in the classification of pesticide toxicity recommended by the World Health Organization (8). Potential health effects caused by pesticides are studied based on a literature review. The Health

Research Ethics Commission of the Faculty of Public Health, Diponegoro University, approved the ethics of this study with the number 91/EC/FKM/2016.

RESULTS

Brebes Regency is located 1–500 meters above sea level. The area of Brebes Regency is 166,296 km² with 1,781,379 people. About 70% of the population work in the agricultural sector, and 40% are farmers and farm laborers. The harvested area of shallots stretches to 30,954 ha, producing 3,759,742 quintals with an average production of 121.46 quintals per ha. The output of shallots contributes to the gross income of the Brebes Regency by 58%. The largest shallot crop centers are spread over 11 sub-districts, and the Bulakamba sub-district is in third place after Larangan and Wanasari sub-districts. Shallot farming contributes to the demand for shallot production in Central Java and Indonesia by 72.39% and 30.62%. The average age of the respondents is classified as productive at 42.1 years (see Table 1).

Tabel 1.

Based on the age category, most of the population is 36-45 years old. The majority of them are elementary school graduates and most work as small traders. This study also found pesticides in 30.7% of the respondents' houses. More clearly stated, Table 2 shows types, class, and active ingredients of pesticide.

Table 2.

Commonly used pesticides include insecticides and fungicides. Insecticides kill insects, while fungicides remove fungi from shallots and onion bulbs. Based on types, organophosphates, carbamates, and pyrethroids are the most used. Organophosphate pesticides have common active ingredients such as chlorpyrifos, dimethoate, glyphosate, and profenofos. Moreover, carbamate pesticides mostly contain mancozeb, propineb, BPMC, and carbosulfan. The active ingredients in pyrethroid pesticides include cypermethrin, permethrin, emamectin, deltamethrin, and beta-cyfluthrin. Meanwhile, most pesticides are usually liquid, which helps emulsify parts of the pesticide formulation while the rest is suspended and dispersed.

DISCUSSION

Based on various groups and types, insecticides and fungicides are the most found in shallots and onion bulbs as farmers choose pesticides that can kill the most attacking pests, i.e., insects and fungi. Previous research also has found the same types and groups of pesticides (9,10). The high number of pest organisms may lead to crop failure, especially when fungal attacks increase significantly in the rainy season. Based on previous research, the most common types of fungus in the shallot farming areas of Brebes Regency are Alternaria porri, Colletotrichum gloeosporioides, Porenospora destructor, and Fusarium oxysporum. These insects and fungi grow well in the tropics. Besides these examples, Fusarium oxysporum and Colletotrichum sp are also found in shallots in other areas such as Kalimantan (11). In addition, insecticides used to control onion pests include Spodoptera exigua, Spodoptera litura, and Thrips tabaci (10).

The average of the volume of insecticide solution applied ranges from 13.29 to 15.17 liters per ha (12). The farmers sprayed regularly every 3-4 days per week, and they sprayed 15-20 times in the growing season. The insecticide volume used in the agricultural area of 30,954 ha is around 13.29–15.17 liters per ha and it is estimated 411,378.66–469,572.18 liters per ha in the growing season.

Pesticide leftovers, packages, and containers were found in 51 houses. The respondents usually stored the pesticides in the kitchen, hanged them on the wall, on the edge of the siding, on the terrace, or in certain places outside the house. White pesticide powder as preservatives was also found to protect shallot bulbs stored on racks (wooden racks) and placed in the kitchen. In addition to pesticides, the respondents also used some equipment such as sprayers, buckets for pesticide formulation, and clothes used for pesticide spraying. Previous research similarly confirms pesticide storing inside and outside the house. For example, 38.4% of farmers in Ethiopia (13) and 44.4–55.0% of farmers (14) kept pesticides in their kitchen or houses, and 59.5% of farmers in Pakistan stored them in separate rooms in the house (15). Another example is that 44% of farmers in Ghana sored pesticides in their bedrooms (16) and in Ethiopia, 30.5% under their beds (17). For outdoor storage, 96% of farmers store pesticides in separate places outside their houses, and 1% of farmers in Vietnam (18) and 9% of farmers (17) keep pesticides in their kitchens 6.6% (13).

Pesticides may contaminate people through the skin, inhalation, and ingestion of solid, liquid, or gas substances (19). Farming activities potentially expose the individuals around to dust pesticide from the pesticide storage or through the air, thereby letting the pesticide enter the respiratory tract or the skin. Moreover, dust and pesticide may also contaminate the food or drink the farmers consume. Research reveals that pesticides were found around the houses in agricultural areas (20,21). Pesticide exposure in farming areas is likely higher in children, and it is associated with indoor pesticide storage (22).

Table 2 shows pesticide toxicity levels from very dangerous (Ib) to unlikely cause acute danger in normal use (U). Pesticide toxicity is classified as oral and dermal toxicity tested on rats following the standard toxicology procedures. In implementing toxicity levels of pesticides, most pesticides are at a lethal dose of 50 (LD50) by acute oral exposure (mg/kg body weight). However, dermal toxicity should be considered the most because most of the exposures come through the skin. Dermal exposure is considered high risk if the dermal LD50 value indicates a more significant hazard than the oral LD50 value (8). Pesticide toxicity found in humans includes genotoxicity (23), haematotoxicity (24), hepatotoxicity (25), neurotoxicity (26), nephrotoxicity (27), and carcinogenicity (28,29).

Both acute and chronic exposure to various pesticide groups has health effects (30). Organophosphate pesticides likely inhibit cholinesterase enzymes and disrupt the endocrine (3,31,32). Organophosphate exposure has the potential to cause arrhythmias, coronary artery disease, congestive heart failure, metabolomic disorders, insulin resistance, cancer, and gene expression changes (33–36). Exposure to organophosphate affects insulin resistance, neurobehavioral function, blood profile, oxidative stress, metabolism of carbohydrates, fats, and proteins in the cytoplasm/ mitochondria/peroxisomes (37–41).

Carbamate's potential health effects include unconsciousness, vomiting, convulsions, cyanosis (42), and cholinesterase inhibition. In addition, pesticides in this group interfere with endocrine function, impaired child development and IQ (43), decreased lung function (44), and central nervous system tumor (45). Among pesticide suicide, patients usually experience sudden respiratory and cardiac arrest (46). The pesticide group also triggers oxidative stress (40), impairing the enzymatic pathways involved in carbohydrates, fats, and protein metabolism within cytoplasm, mitochondria, and peroxisomes (41).

The pyrethroid group possibly causes health effects, including paranesthesia and respiratory tract, eyes, and skin irritations (47). Increased risk of deaths in general and deaths because of cardiovascular disease (48) affects anti-Mullerian hormone levels, follicle-stimulating hormone, and antral follicle count (49). Pyrethroid also causes nephrotoxic, hepatotoxic, cardiotoxic, immunotoxin, neurotoxic, and behavioral effects and generates oxidative stress that causes changes in DNA, RNA, protein, fat, and carbohydrate molecules (50,51). The effects of pyrethroids on the HPG axis-related reproductive outcomes (52).

Moreover, neonicotinoid pesticides may cause health effects, including adverse developmental or neurological outcomes, autism spectrum disorder, memory loss, and finger tremors (53). Exposure to these pesticides also may lead to acute respiratory, cardiovascular, and neurological symptoms, oxidative genetic damage, and congenital disabilities (54). Thiacloprid and thiamethoxam at relatively low concentrations induce PII and I.3-mediated CYP19 expression and aromatase activity (55–57). They also cause changes the structure and stability of DNA (58). Acetamiprid induces DNA damage in all concentrations tested dose-dependent (59).

Furthermore, Chlorfenapyr, a pesticide of the pyrrole group, may trigger health problems. A previous case report mentions neurological complications, included body weakness, dizziness, delirious with visual hallucinations at 114 h and 122 h post-ingestion. At 156 h post-exposure, a brief tonic seizure followed by cardiac asystole developed and the patient died 157 h (6.5 days) postingestion (60). Chlorfenapyr intoxication causing dermal manifestation may be harmful. For example, a 49-year-old patient died five days after exposure to this pesticide (61). Chlorfenapyr-induced toxic leukoencephalopathy also happened to the 44-year-old female patient (62). The risk for pancreatic cancer is higher exposure in the dinitroaniline group, e.g., Pendimethalin (29). Potential health effects from exposure to various pesticides may occur, especially among house residents. These effects are harmful, especially for vulnerable groups such as pregnant women and children, considering the high maternal and child mortality in this agricultural area.

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CONCLUSION

This current study revealed three major groups of pesticides in the agricultural communities: organophosphates, carbamates, and pyrethroids. In addition, insecticides, fungicides, and herbicides are the most common types of pesticides used in the areas. The pesticides stored indoors are usually placed in the kitchen, on the wooden rack, while the outdoor storage of the pesticides is on the terrace and outside the house. Pesticides stored around the house harm people who breathe the pesticide dust, consume contaminated food or drink, or contract with it on the skin. The pesticide toxicity levels found in the respondents' houses range from very dangerous (Ib) to unlikely to cause acute danger under normal use (U). Potential health problems caused by pesticides vary from poisoning symptoms and signs to genetic disorders and polymorphisms. Further research is needed to prove the health problems as a result of exposure to pesticides in agricultural communities.

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Table 1 Respondents' Characteristics and Identification of Pesticides

Characteristics of respondents	Total	Percent (%)
Age (year)		
26-35	39	23.5
36-45	78	47
46-55	39	23.5
56-65	8	4.8
>65	2	1.2
Level of education		
Not attended schools	1	0.6
Not completed elementary school	23	13.9
Completed elementary school	112	67.5
Completed junior high school	18	10.8
Completed senior high school	9	5.4
Competed higher education	3	1.8
Type of occupation		
Unemployed	1	0.6
Farmer and farm worker	62	37.3
Trader of pesticides	1	0.6
Small trader	83	50
Others (construction laborers, private workers, civil servants)	19	11.4
Identification of pesticides at home		
Presence	51	30.7
Absence	115	69.3

Commented [F5]: put row line to separate each main variable

Table 2 Types, active ingredients, and toxicity levels of pesticides in the respondents' houses

Brands	Types	Groups	Active ingredients	Pesticide toxicity class	LD_{50} (mg/kg)
Starban 585EC	Insecticide	Organophosphates	Chlorpyrifos 530 g/l	II	135
Dursban 200 EC	Insecticide	Organophosphates	Chlorpyrifos 200 g/l	II	135
Sidajos 430 EC	Insecticide	Organophosphates	Dimethoate 430 g/l	II	c150
Destan 400 EC	Insecticide	Organophosphates	Dimethoate 400 g/l	II	c150
Roundup 486 SL	Herbicide	Organophosphates	Glyphosate 486 g/l	III	4,230
Indocron 500 EC	Insecticide	Organophosphates	Profenofos 500 g/l	II	352
Vondozeb 80 WP	Fungicide	Carbamate	Mancozeb 80%	U	>8,000
Dithane M-45	Fungicide	Carbamate	Mancozeb 80 %	U	>8,000
Colanta 70 WP	Fungicide	Carbamate	Propineb 70%	U	8,500
Antracol 70 WP	Fungicide	Carbamate	Propineb 70%	U	8,500
Emcindo 500 EC	Insecticide	Carbamate	BPMC/ butylphenyl methylcarbamate 500 g/l	-	
Baycarb 500 EC	Insecticide	Carbamate	Fenobucarb; BPMC 500 g/l	II	620
Benhur 500 EC	Insecticide	Carbamate	BPMC 500 g/l	-	
Naga 50 EC	Insecticide	Carbamate	BPMC 50 g/l	-	
Marshall 200 EC	Insecticide	Carbamate	Carbosulfan 200,11 gr/l	II	250
Buldok 25 EC	Insecticide	Pyrethroid	Beta Cyfluthrin 25 g/l	I b	c11
Prado 25EC	Insecticide	Pyrethroid	Beta Cyfluthrin	I b	c11

BM Cyperkil 50 EC	Insecticide	Pyrethroid	Cypermethrin 50 g/l	II	c250
Pounce 20 EC	Insecticide	Pyrethroid	Permethrin 20 g/l	II	c220
Decis 25 EC	Insecticide	Pyrethroid	Deltamethrin 25 g/l	II	c135
Anta 50 EC	Insecticide	Pyrethroid	Emamectin Benzoate 50 g/l	III	53-237
Prothol 10 EC	Insecticide	Pyrethroid	Emamectin Benzoate 10 g/l	III	53-237
Abenz 22 EC	Insecticide	Pyrethroid	Emamectin Benzoate 22g/l	III	53-237
Bosmex 25 EC	Insecticide	Pyrethroid	Abamectin 25 g/l	I b	8.7
Confidor 5 WP	Insecticide	Neonicotinoid	Imidacloprid 5 g/l	II	450
Besvidor 25 WP	Insecticide	Neonicotinoid	Imidacloprid 25 g/l	II	450
Tumagon 100 EC	Insecticide	Pyrol	Chlorfenapyr 100g/l	II	441
Arjuna 200 EC	Insecticide	Pyrol	Chlorfenapyr200g/l	II	441
Prowl 330 EC	Herbicides	Dinitroaniline	Pendimethalin 336 g/l	II	1,050
Amistar top 325 SC	Fungicide	Azoxystrobin	Azoxystrobin 200 g/l and Difenoconazole 125 g/l	U	>5,000 1,453
Rovral 50 WP	Fungicide	Iprodione	Iprodione 50%	III	3,500
Rapid 20 WG	Herbicide	Metsulfuron methyl	Metsulfuron methyl 20 %	U	>5,000
Prevathon 50 SC	Insecticide	Chlorantraniliprole	Chlorantraniliprole 50 g/l	U	>5,000

Classification of active pesticide ingredients: Ia = Extremely hazardous (oral < 5, dermal < 50); Ib = Highly hazardous (oral 5-50, dermal 50-200); II = Moderately hazardous (oral 50-2000, dermal 200-2000); III = Slightly hazardous (oral > 2000, dermal > 2000); U = Unlikely to present acute hazard in normal use (5000 or higher).

[JKL] New notification from JURNAL KESEHATAN LINGKUNGAN

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1 attachments (73 KB)
42074 Budiyono_LoA.pdf;

Dear Mr./Mrs. **Budiyono**,

We would like to inform you that the article under the title **"Types and Toxicity Levels of Pesticides: A Study of an Agricultural Area in Brebes Regency"** has received approval from 2 reviewers and the editorial team. The manuscript has passed the final plagiarism test (Turnitin) as well.

The editorial team has declared that the article is **Accepted to be Published** in Jurnal Kesehatan Lingkungan **Volume 15 No. 2 of April 2023**. We have also attached the Electronic Letter of Acceptance (e-LoA) as proof of validity.

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28 March 2023

LETTER OF ACCEPTANCE (LoA)

Number : 05/UN3.1.10/PJ/JKL/2023

To
Budiyono
Department of Environmental Health, Faculty of Public Health, Universitas Diponegoro, Semarang 50275, Indonesia

Dear Author/s
The reviewers have completed their review of your paper submitted for the Jurnal Kesehatan Lingkungan (*Journal of Environmental Health*). The final decision is made based on the peer-review reports, the scientific metric, and the relevance. We are pleased to inform you that your paper has now been accepted and will be published in the forthcoming issue

Manuscript number	JKL-2023- 42704
Author(s)	Budiyono Budiyono[1]*, Suhartono Suhartono[1], Apoina Kartini[2]
Affiliation	[1]Department of Environmental Health, Faculty of Public Health, Universitas Diponegoro, Semarang 50275, Indonesia [2]Department of Community Nutrition, Faculty of Public Health, Universitas Diponegoro, Semarang 50275, Indonesia
Tittle	Types and Toxicity Levels of Pesticides: A Study of an Agricultural Area in Brebes Regency
Corresponding author*	budiyonofkm@lecturer.undip.ac.id
Publish	Volume 15, issue 2
Article History	Submitted Article: 19 January 2023 Review Article: 1 March 2023 Accepted Article: 28 March 2023 Published Article: 31 April 2023
Available online	https://e-journal.unair.ac.id/JKL

It is further mentioned for your information that our journal is double-blind peer-reviewed. It is covered by the index SINTA (National Accredited SINTA-2), DOAJ, and many other indexes.

Yours sincerely,

Aditya Sukma Pawitra, S.KM, M.KL
Editor in Chief

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Thu 4/13/2023 5:12 PM

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Google Forms

Thanks for filling out CUSTOMER SATISFACTION SURVEY OF JKL 2023

Here's what was received.

Edit response

CUSTOMER SATISFACTION SURVEY OF JKL 2023

Hello authors! We hope you are in a good conditions during this pandemic. We would like to ask you to fill the form below to give us some evaluation for the purpose of journal service quality improvements. Also, we would like to thank you for choosing Jurnal Kesehatan Lingkungan as one of journal to publish your meaningful findings. Please take a look to our website and inform us if there is any updates or any details we need to improve.
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Email *

budiyonofkm@lecturer.undip.ac.id

Full Name *

Budiyono Budiyono

How would you rate your experience with our journal *

	1	2	3	4	5	
Very Dissatisfied	○	○	○	○	◉	Very Satisfied

How would you rate the journal information and author guideline provided in the website and social media? *

	1	2	3	4	5	
Not at all	○	○	○	○	◉	Very informative

Rate your satisfaction with our team in resolving your issue *

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How likely are you to return to our website *

	1	2	3	4	5	
Not at all	○	○	○	○	◉	Extremely Likely

How likely would you be to recommend our journal to a friend or colleague? *

	1	2	3	4	5	
Not at all	○	○	○	○	◉	Extremely likely

Do you have any additional comments or feedback for us? *

good job for the editor and supporting staffs