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Life Cycle Analysis on Pesticide Exposure and Residues in the Environment of Brebes County Shallot Farms and Farmers

Tri Joko[1*], Sulistiyani[1], Onny Setiani[1], Mursid Rahardjo[1], Intan Sekar Arumdani[1]

[1] Department Environmental Health Office of Diponegoro University, Jl. Prof. Sudarto No.13, Tembalang, Kec. Tembalang, Semarang City, Central Java, 50275, Indonesia

* Corresponding author's email: trijoko@lecturer.undip.ac.id

ABSTRACT

Pesticides are at risk due to their toxic properties in humans as well as impact on the environment and ecosystems. Indonesia has 1,336 formulations and 402 pesticide ingredients registered to control pests in various commodity fields. The negative effects of synthetic chemical pesticides are resistance, resurgence, second pest blasting, and environmental degradation. Pesticide residues on the soil and agricultural products can cause bioaccumulation and biomagnification processes. The biomagnification process can cause exposure to pesticides that enter the human body to a greater degree than the residues found in the environment. Therefore, it is necessary to research the life cycle analysis of exposure and pesticide residues in agricultural environments. This study is an observational study with a cross-sectional design. The sample in this study was 120 respondents. This research was conducted in the Wanasari subdistrict, Brebes regency. Wanasari subdistrict is the largest shallot-producing centre in Brebes regency (26%). The shallot harvest area in Wanasari district is 6,598 ha. The life cycle analysis (LCA) results of shallot farming include five stages: soil maturation, planting seedlings, fertilizing, applying pesticides, and harvesting. The emissions in shallot farming activities come from diesel fuel, pesticides, and NPK fertilizers. Chlorpyrifos pesticide residues were found with an average level of 0.6451 ppm in 9 villages in Wanasari district.

Keywords: pesticide residues; life cycle assessment; shallot; pesticide exposure; farmer.

INTRODUCTION

Pesticides are often used to improve the productivity and quality of agricultural products. Indonesia, as an agricultural country, has a high level of pesticide consumption. About 1,336 formulations and 402 active pesticide ingredients have been registered to control pests in various commodity fields. Indonesia has an agricultural area of 8,112,103 ha, and the province of Central Java is one of the provinces with the largest agricultural area in Indonesia. The area of agricultural land in Brebes regency is 60,341 ha. Brebes regency has an area of 1,662.96 km consisting of 17 districts and 297 villages (Central Statistics Agency, 2016).

Pests may develop resistance to the use of pesticides. The pest species to be eradicated can become pesticide tolerant, resulting in an uncontrollable population. The use of pesticides aimed at eradicating specific types of pests can even lead to the appearance of other kinds of pests. The explosion of these secondary pests can occur sometime after pesticides, at the end of the growing season or even in the next growing season. After that, there can also be a resurgence, that is, if a type of pest after obtaining pesticide treatment develops to more than without pesticide treatment, then the phenomenon is called resurgence (Suhartono et al., 2010). This is a drawback of the continuous use of pesticides in the environment. Other negative impacts of synthetic chemical pesticides are resistance, resurgence, second pest blasting, environmental degradation, and so on (Diamanti K.E et al., 2009).

The use of pesticides is risky due to their toxic properties in humans as well as their impact on the environment and ecosystems. Pesticides are classified as endocrine-disrupting chemicals (EDCs), which are chemical compounds in the environment that interfere with the synthesis, secretion, transport, metabolism, binding action, and elimination of hormones in the body that function to maintain balance (homeostasis), reproduction, and growth and development processes. Some hormone functions, such as thyroid hormone, insulin, and growth hormone, IGF-1, can be disrupted due to the exposure to EDCs (Diamanti K.E et al., 2009).

The results of research in the agricultural area of Brebes district showed a significant relationship between high pesticide exposure and stunting incidence, the discovery of metabolite organophosphate from a sample of 23% of the urine of elementary school children, the prevalence of hypothyroidism in schoolchildren who were positive for organophosphate metabolites in urine by 67% (Kartini A et al., 2019). Another study showed that abnormal cholinesterase levels were a risk factor for balance disorders in peasant women. There is a relationship between cholinesterase levels in the blood and tremors (Kusumawati et al., 2015).

Research on pregnant women shows that the exposure to pesticides at the beginning of the pregnancy semester causes impaired development of the nervous system in children. Girls' speech and motor development are inversely related to pesticide exposure during pregnancy (Andersen et al., 2015). Pregnant women involved in spraying, mixing, storing, and managing pesticides and new PPE are risk factors for low birth weight (Darmawati et al., 2019).

Several organophosphate pesticide residues have been found in shallot samples from Brebes, Central Java, namely chlorpyrifos, parathion, profenofos, diazinon, fenitrothion, malathion residues, diazinon, profenofos, chlorpyrifos (Nining et al., 2019; Joko et al., 2017). The discovery of pesticide residues in the soil indicates the possibility of pesticide contamination in the soil, which is influenced by 4 factors from the soil, namely: the nature of the soil, the nature of the pesticide, the hydraulic ability of the soil and the practice of crop management (Huddleston, 1996).

The amount of pesticides used by shallot farmers in Brebes district is already very high, far exceeding the recommended doses (Hidayat et al., 1991). Pesticides can be adsorbed into soils containing high organic matter. In addition, pesticides can pollute the soil through a process of degradation by microbes, a reaction of organic matter content in the soil (Osman & Cemile, 2010). The presence of pesticide residues in the soil depends on the nature of the soil compounds and various factors, such as pH, soil moisture, and soil organic carbon (Tijana et al., 2016).

The presence of pesticide residues in the soil and agricultural products makes it a concern, because it is estimated that there have been bioaccumulation and biomagnification processes that have a health impact on humans as the highest consumers in the food chain. The biomagnification process can cause the exposure to pesticides that enter the human body to a higher degree than the residues found in the environment. Therefore, it is necessary to conduct research on the life cycle analysis of exposure and pesticide residues in the shallot farming environment in Brebes district, especially in Wanasari Brebes district.

One of the areas in Brebes Regency with a high level of pesticide use is Wanasari District. The primary agricultural commodities in the area are shallots, rice, chillies, corn, and green beans. The highest productivity is in onion crops, which is 122.2 kW/ha. Wanasari subdistrict is the largest shallot-producing centre in Brebes regency (26%). In 2015, the shallot harvest area in Wanasari District was 6,598 ha. The average shallot production in Wanasari district has increased from 2012 to 2014. In 2012, the average shallot production reached 118.84 kW/ha, rising to 131.55 kW/ha in 2013 and 144.97 kW/ha in 2014 (Regency, 2014).

The increase in shallot productivity in Wanasari district, Brebes regency, continues to occur in line with the increasing consumer needs. The use of pesticides is often applied to agricultural land to increase productivity. The long-term effects of pesticide use will seep into the soil and pollute the environment. Pesticides of the organochlorine group are persistent. OCPs can accumulate in the food chain and are toxic to non-target organisms. In addition, many studies have found that residues of OCPs can be found up to 20 years after use.

On the basis of the description above, it is known that there are several negative impacts of pesticide use, namely poisoning, environmental pollution, insects becoming more resistant, and the occurrence of pesticide residues and various health problems that arise due to pesticide exposure. This research is intended to answer the issues above regarding health and environmental impacts starting from the soil maturation process to onion harvesting, namely with the life cycle analysis (LCA) method.

METHODOLOGY

This study is an observational study with a cross-sectional design. The population is an abiotic (soil, water) and biotic (plant, human) environment in the shallot farming area of Wanasari District, Brebes Regency, Central Java. Samples were taken by purposive sampling. The soil samples were taken from the land where onions grow ± 6–12 hours after harvesting onions. At each location, 5 sampling points were determined. The soil samples were taken using an earthen shovel with a depth of 0–20 cm. The sample was composted, taken in an amount of approximately 1 kg, placed in a clean plastic bag, labeled, and transported to the laboratory. The soil samples were dried in an open space at room temperature until the moisture content was approximately 20%.

Water samples were taken from water bodies and/or dug wells in the shallot farming environment of Wanasari district, Brebes regency, Central Java. Shallot samples were harvested from a sample site by ±1000 grams, put in a clean bag, labelled, and stored at 4 °C until the time of sample extraction (Nining et al., 2019). The analysis was performed using capillary gas chromatography with a special detector after sample extraction with n-hexane and cleaning with partitions between n-hexane and acetonitrile (Joko et al., 2017).

To obtain the data on respondents' characteristics and pesticide use behaviour, a structured instrument questionnaire was used, which was distributed to 120 respondents. The data that has been collected was analyzed using descriptive analysis. In addition, risk calculation will be carried out using life cycle analysis due to exposure and pesticide residues.

RESULTS AND DISCUSSION

This research was conducted in the shallot farming centre area, namely Wanasari district, Brebes regency. Every year Wanasari subdistrict produces shallots of good quality and is distributed to other regions in Indonesia. Geographically, Wanasari sUbdistrict is located in Brebes regency and has a flat topography. Wanasari subdistrict is passed by the Pemali River, which is the source of irrigation flow of agricultural land.

The area of Wanasari district is 7,226 ha. Wanasari subdistrict consists of 20 villages, namely Tegalgandu, Jagalempeni, Glonggong, Sisalam, Lengkong, Tanjungsari, Siwungkuk, Dukuhwringin, Sigentong, Sidamulya, Wanasari, Siasem, Klampok, Pebatan, Pesantunan, Keboledan, Kupu, Dumeling, Kertabesuki, and Sawojajar. Rainfall based on the last five years ranges from 1000–2000 mm per year, with rainy days ranging from 84 days to 112 days per year with an average of 10 rainy days each month. The area that has rainfall is 7,457.4 ha or 99.3%.

Physical, chemical, and biological characteristics

Based on Table 1, laboratory tests have been carried out on groundwater samples in 5 Wanasari district, lab tests were carried out to determine the physical, chemical and biological characteristics of groundwater in the shallot agricultural land, Wanasari district, Brebes regency.

Including Tegal Gandu Village, Sidamulya Village, Siasem Village, Dukuhwaringin Village, and Wanasari Village. This test was carried out on 3 main parameters, including mandatory physical, biological, and chemical parameters. This test refers to the Environmental Health Quality Standards for Water Media for Sanitary Hygiene Purposes by the Regulation of the Minister of Health of the Republic of Indonesia Number 32 of 2017. The results showed that in the parameters of dissolved solids (Total Dissolved Solid) 2 villages exceeded the quality standards, namely Siasem Village and Wanasari Village, with a soluble solid value exceeding 1000 mg/L. The temperatures in the five villages were above the quality standard, namely at 27.0–27.5 °C. In the mandatory biological parameters, the Total Coliform in Tegal Gandu Village, Sidamulya Village, Siasem Village, and Dukuhwaringin Village exceeds the quality standard, with values above 50 CU/100 ml. The results of the E. examination showed there are 3 villages, namely Tegal Ganda Village, Sidamulya Village, and Siasem Village, which exceed the quality standard with an E. value of more than 0 CFU/100 ml.

In the mandatory chemical parameters, the hardness value ($CaCO_3$) in Wanasari Village exceeds the standard quality value of 522.22 mg/l. The manganese content in groundwater samples in Tegal Gandu Village, Sidamulya Village, Siasem Village, Dukuhwaringin

Table 1. Physical, chemical, and biological characteristics of groundwater in shallot agricultural land, Wanasari district, Brebes regency

No	Parameters	Unit	Tegal Gandu Village	Sidamulya Village	Siasem Village	Hamlet Village	Wanasari Village	Quality Standards
A	Physical							
1	Turbidity	NTU	1.5 7	3.4 9	1.7 7	2.3 8	2.0 4	25
2	Color	TCU	6.844	5.834	48.8 3	8.436	7.437	50
3	Dissolved organic matter	mg/L	662	696	1980	832	1332	1000
4	Temperature	°C	27.5	27.5	27.0	27.0	27.0	± 3 °C
5	Taste	-	Tasteless	Tasteless	Tasteless	Tasteless	Tasteless	Tasteless
6	Odour	-	Odorless	Odorless	Odorless	Odorless	Odorless	Odorless
B	Biological							
1	Total coliform	CFU/100 mL	920	1600	540	540	13	50
2	E. coli	CFU/100 mL	2,0	2,0	2,0	0	0	0
C	Chemical							
1	pH	-	8.3 2	8.3 9	8.1 4	8.3 1	8.2 4	6,5-8,5
2	Fe	mg/L	0.130	0.066	0.073	0.104	0.118	1,0
3	Fluoride	mg/L	0.163	0.192	0.408	0.230	0.209	1,5
4	($CaCO_3$)	mg/L	275,8	301,0	268,4	255,3	522,2	500
5	Mangan	mg/L	0.264	0.378	2.568	1.202	0.563	0,5
6	Nitrate	mg/L	2.028	< 0.08 0	1.934	< 0.00 1	0.039	10
7	Nitrite	mg/L	0.050	0.003	0.428	0.011	0.038	1,0
8	Cyanide	mg/L	< 0.00 1	< 0.00 1	0.005	< 0.00 1	< 0.00 1	0,1
9	Detergen	mg/L	< 0.01 0	< 0.01 0	< 0.01 0	< 0.01 0	< 0.01 0	0.0 5
10	Total pesticides	mg/L	-	-	-	-	-	0,1
11	Mercury	mg/L	< 0.00 1	< 0.00 1	< 0.00 1	< 0.00 1	< 0.00 1	0.001
12	Arsenic	mg/L	< 0.00 3	< 0.00 3	< 0.00 3	< 0.00 3	< 0.00 3	0.0 5
13	Cadmium	mg/L	< 0.00 1	< 0.00 1	< 0.00 1	< 0.00 1	< 0.00 1	0.005
14	Kromium (valence 6)	mg/L	< 0.00 1	< 0.00 1	< 0.00 1	< 0.00 1	< 0.00 1	0.0 5
15	Selenium	mg/L	< 0.00 2	< 0.00 2	< 0.00 2	< 0.00 2	< 0.00 2	0.0 1
16	Zinc	mg/L	0.032	0.022	0.029	0.019	0.022	15
17	Sulfate	mg/L	65.7 3	69.2 8	81.9 9	41.2 6	229,9	400
18	Lead	mg/L	< 0.03 0	< 0.03 0	< 0.03 0	< 0.03 0	< 0.03 0	0.0 5
19	Benzene	mg/L	-	-	-	-	-	0.0 1
20	($KMnO_4$)	mg/L	8.145	3.986	15.0 6	8.700	7.498	10

Village, and Wanasari Village exceeded the quality standard, which exceeded 0.5 mg/l. The average pH value of groundwater in the shallot farming area of Wanasari District, Brebes Regency, is 8.28 with the lowest pH value of 8.14 and the highest pH value of 8.39. At the pH of the soil, classified residual bases are found only from the active ingredient chlorpyrifos. This condition suggests pesticide residues with the active ingredient chlorpyrifos were found at pH ranging from 8.14 to 8.39.

Characteristics of pesticide residues

In this study, the pesticide residues found were from the organophosphate group. Testing of organochlorine pesticide residues shows results below the detection limit of chromatographic gas devices (LoD) so that residue measurements focus on the organophosphate pesticide group. In addition, based on information from farmers and the Wanasari district Agricultural Extension Center, organochlorine pesticides are no longer used in the area.

Table 2. Pesticide residue characteristics

No.	Location	Residual organophosphate						
		Chlorpyrifos	Fenitrothion	Diazinon	Profenofos	Metidathion	Malathion	Parathion
1.	Tegal Gandu	2.8838	<LoQ	<LoQ	<LoQ	<LoQ	<LoQ	<LoQ
2.	Sidamulya	0.2123	<LoQ	<LoQ	<LoQ	<LoQ	<LoQ	<LoQ
3.	Siasem	0.3316	<LoQ	<LoQ	<LoQ	<LoQ	<LoQ	<LoQ
4.	Wanasari	0.2318	<LoQ	<LoQ	<LoQ	<LoQ	<LoQ	<LoQ
5.	Hamlet	0.3749	<LoQ	<LoQ	<LoQ	<LoQ	<LoQ	<LoQ
6.	Jagalempeni	0.0670	<LoQ	<LoQ	<LoQ	<LoQ	<LoQ	<LoQ
7.	Sigentong	0.3021	<LoQ	<LoQ	<LoQ	<LoQ	<LoQ	<LoQ
8.	Siwungkuk	0.4876	<LoQ	<LoQ	<LoQ	<LoQ	<LoQ	<LoQ
9.	Tanjungsari	0.3133	<LoQ	<LoQ	<LoQ	<LoQ	<LoQ	<LoQ
	LOD value	0.0030	0.0150	0.0078	0.0020	0.0150	0.0123	0.0150
	LOQ value	0.0250	0.0500	0.0400	0.0500	0.0500	0.0600	0.0500

On the basis of the sampling that has been carried out the results are shown in Table 2 namely pesticide residue characteristics, there is a pattern of residual findings where in a sample, only 1 type of active ingredient was found in all villages, namely chlorpyrifos. Chlorpyrifos pesticide residues were found with different levels, including Tegal Gandu Village (2.8838 ppm), Sidamulya Village (0.2123 ppm), Siasem Village (0.3316), Wanasari Village (0.2318 ppm), Dukuhwaringin Village (0.3749 ppm), Jagalempeni Village (0.0670 ppm), Sigentong Village (0.3021 ppm), Siwungkuk Village (0.4876 ppm), and Tanjungsari Village (0.3133 ppm). The LOD limit of chlorpyrifos is 0.0030 ppm, and the LOQ limit of chlorpyrifos is 0.0250.

The quality standards for pesticide residues in the soil referred to in this study refer to the international standards Alberta Environment Site Assessment Standard or AENV. The reference to the quality standard of pesticide residues refers to the potential for polluted raw water from residues in the soil. For the group of organophosphate pesticides in this study, there are four types of quality standards, namely for the active ingredients diazinon, chlorpyrifos, malathion, and parathion. Considering the quality standards, the pesticide residues found in the onion farmland of Wanasari District still follow the quality standards, meaning there is no potential to pollute groundwater. However, pesticide residues in the soil still need to be controlled to avoid soil damage.

Chlorpyrifos residue is an active ingredient that is found in all villages. Thus, it can be said that the pesticides from the organophosphate group that are most widely used and leave residues contain the active ingredient chlorpyrifos. Chlorpyrifos has low to moderate persistence in the environment. The main mechanisms of the chlorpyrifos dissipation process (loss of residue) in the soil are volatilization, photolysis, abiotic hydrolysis, and microbial degradation. The half-life (t1/2) of chlorpyrifos in soils was reported to vary between 2–120 days, and the soil adsorption coefficient of Koc was 973–31,000 mL/g (Solomon et al., 2014). Chlorpyrifos is a slowly degraded pesticide and is not systemic. Chlorpyrifos was even persistent at low concentrations at the ground level of 0-25 mm (Akhtar et al., 2004).

Chlorpyrifos is an insecticide of the type of contact and gastric poison. When there is contact between chlorpyrifos and the organism, this insecticide immediately reacts to the target. The system of chlorpyrifos works in killing pests by attacking the nerves of the target organism. Therefore, using chlorpyrifos in case of contact with humans can result in poisoning and even death. The active ingredient chlorpyrifos is found most in comparison with other organophosphate groups. The ability of chlorpyrifos residues to survive in the soil is determined by several factors, such as volatilization, photolysis, biodegradation, hydrolysis reactions, and half-life. On the basis of its physical and chemical properties, the volatilization value of chlorpyrifos under Henry constant law shows the value of $k = 8.8 \times 10^{-2}$/day with a half-life of t1/2 = 533 hours or 22 days (Thomas, 1982).

With the slow ability of biodegradation, chlorpyrifos can be retained in the soil for a longer period. Moreover, if farmers use pesticides in relatively short intervals, for example, twice a week, the pesticides left in the soil will accumulate, and their biodegradation ability will be longer. Therefore, the appearance of pesticide residues in the soil is caused by the uncontrolled use of pesticides. Pesticides are used in large quantities and in irregular intervals of time.

Pesticide consumption patterns and Red Bawanh productivity

The use of pesticides is focused on the frequency of spraying pesticides and the large amount of pesticide mixture used by farmers in 1 (one) spraying. This study found that 77.27% of 120 respondents sprayed pesticides ≥3 times per week and as much as 22.73% of 120 respondents sprayed 1-2 times per week. As many as 68.18% of 120 respondents used ≥4 types of pesticides mixed in 1 (one) spraying, and 31.82% of respondents used a mixture of 1–3 types of pesticides.

The use of pesticides in shallot farming is one of the activities that cannot be separated from the habits of farmers. Chemical pesticides are widely used to control pest and disease attacks. Shallots are a horticultural crop that is very susceptible to pests and diseases. The results of observations and interviews with farmers showed a classification pattern of excessive pesticide use. When spraying, farmers mix at least 2–3 types of pesticides which can even be 5–7. The dosage used is 30–40 ml per type. The use of this pesticide is adapted to the attack of pests and diseases of onion crops.

Excessive pesticide application becomes uncontrollable in the event of a pest explosion. When the pest attacks less than usual, the use of insecticides is reduced. When spraying, farmers use spray tanks that have a capacity of 15 or 17 litres. For a field of 1000 m^2, it will take at least two tanks to spray once. If the farmer uses pesticides in at least 3 mixtures of 30 ml per type, then a tank of 90 ml pesticides is sprayed. For an area of 1000 m^2 there is at least 180 ml of pesticide spraying. If this amount is calculated throughout the year, it can be shown that the soil absorbs many pesticides.

Prediction of pesticide residue distribution

Semivariograms for pesticide residues were analyzed using a spherical model presented in Figure 1. The semivariogram analysis results show that the semivariogram model has a range value of 0.808, a sill of 1.667, and a nugget value of 0.559 ppm. This value indicates that data pairs with a range above 0.808 and sill of about 1.667 have a small correlation or can be said to not correlate.

Furthermore, interpolation was carried out using an ordinary kriging model to determine the distribution of pesticides in the locations that were not sampled. The predicted results of the distribution of pesticide residue values are presented in Figure 2. Predictive calculations are performed using spherical models. The map of the predicted distribution of pesticide residue values shows that the light green location is a location with a distribution of pesticide residues within safe limits, meaning that no residue is found at this location. The red location has an unsafe distribution of pesticide residues, because organophosphate pesticide residues are located in at least 1 (one) type of active ingredient at this location.

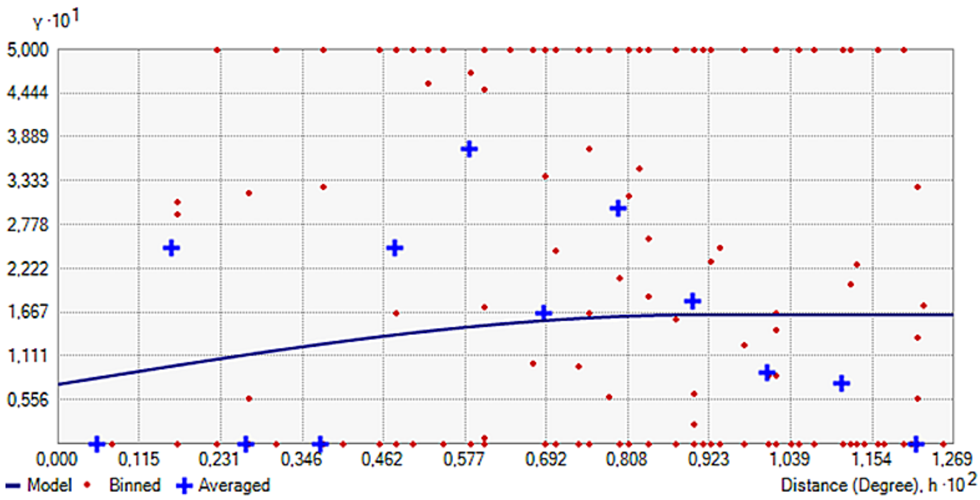

Figure 1. Semivariogram model spherical pesticide residue

The explanation above leads to the interpolation of pesticide distribution to form 2 (two) regional zones, namely the green and red zones. The green zone area is where no pesticide residues are found and the red zone area is where pesticide residues are found. The green zone includes shallot farming areas in Sawojajar Village, Kertabesuki Village, Dumeling Village, Pesantunan Village, Pebatan and Klampok Villages, Lengkong Village, Sidamulya Village, and part of Glonggong Village. The area in the red zone includes agricultural areas in Siasem, Sigentong, Tanjungsari, Dukuhwringin, Siwungkuk, Jagalempeni, Tegalgandu Villages, and parts of Klampok and Pebatan Villages. Some red locations such as Siasem, Sugentong, Tanjungsari, Dukuhwringin, Siwungkuk, Tegalgandu, and Jagalempeni villages are included in the southern region zone where the use of pesticides is relatively high with a frequency of spraying pesticides >3 times a week with the mixture used can be more than 4 kinds of pesticides.

Table 3 indicates the type of pesticide most widely used by farmers derived from insecticides and fungicides. Chlorpyrifos is one of the active ingredients of organophosphate group pesticides which are favourites of farmers as pest exterminators of onion crops.

WHO Class Information: Ib is very dangerous, II is moderately dangerous, III is slightly dangerous, U is unlikely to pose an acute danger in normal use, U = It is impossible to pose an acute danger in normal use.

Mixing pesticides that do not comply with these standards can adversely impact the environment. One of the outcomes is increasing pest resistance. When onion pests become resistant, farmers will use even more significant amounts of pesticides. Continuous exposure to large quantities of pesticides in the agricultural environment can also degrade soil quality. The soil texture becomes hard and mossy in rice fields with a high spraying intensity for growing onions. Mossy soil indicates that the soil is acidic.

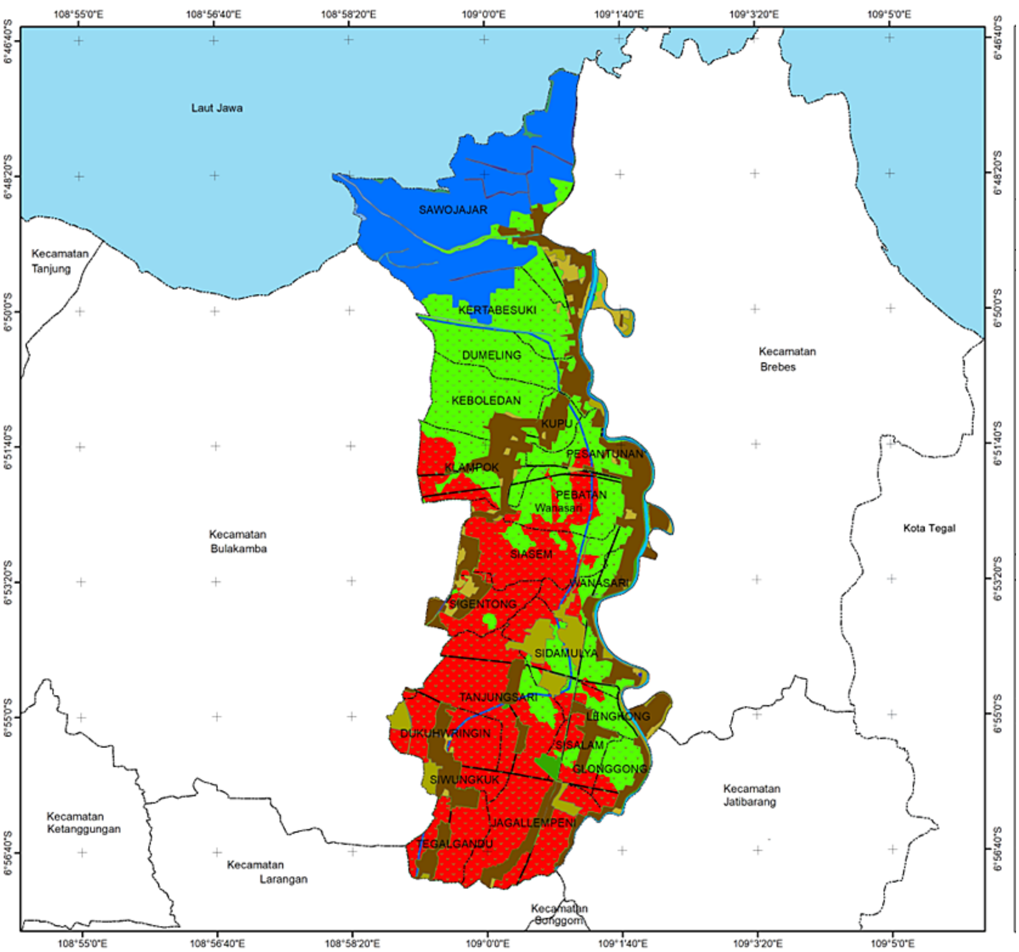

Figure 2. Pesticide residue distribution map

Table 3. Use of insecticides by shallot farmers in Wanasari district

No.	Types of pesticides	Formulation name	Active ingredients	Pesticide group	Pesticide class (WHO)
1.	Insecticide	Arjuna	Chlorfenapyr	Pirol	Ii
2.	Insecticide	Tumagon	Buprofezin	Thiadiazine	Iii
3.	Insecticide	Dursban	Chlorpyrifos	Organophosphates	Ii
4.	Insecticide	Marshal	Karbosulfan	Carbamate	Ii
5.	Insecticide	Sumo	Beta-cyfluthrin	Pyrethroid	Ib
6.	Insecticide	Trigard	Cyromazine	Urea	Iii
7.	Fungicide	Antracol	Propineb	Carbamate, organoseng	U
8.	Fungicide	Delsene	Mankozeb	Ditiocarbamat, organomangan	U
9.	Fungicide	Vondozeb	Mankozeb	Ditiocarbamat, organomangan	U
10.	Fungicide	Folycur	Tebuconazole	Triazoles	Ii

Life cycle analysis pesticide exposure and residues

Shallot farming includes 5 stages: soil ripening, planting seedlings, fertilizing, applying pesticides, harvesting and post-harvest. Post-harvest waste is left on the onion farmland shortly after the harvesting process is completed. Each stage of the onion farming process requires inputs in the form of natural resources and energy, with outputs in the form of final products, waste and emissions, as shown in Figure 3.

The onion farming process starts from the stage of soil maturation. The water requirement for soil maturation in onion cultivation is 17 litres of water /1000 m^2 of land, and 40 tons of fertilizer/ha is needed. Fossil fuels are used as inputs in the form of diesel fuel, 4.5 litres of diesel per ton of shallots, for tractor fuel and produce output in the form of emissions from burning diesel. Next is planting seedlings that require 15 tons of seedlings / ha. The stage after planting seedlings is fertilization. In this process, 60 tons of fertilizer/ha and 10 litres of water /1000 m^2 of land are needed. In terms of fertilizers used by farmers, 90% use excessive inorganic fertilizers. The continuous use of fertilizers can damage soil biota, pest and disease resistance, and can change the vitamin as well as mineral content of some vegetable and fruit commodities. This activity also provides the potential for nutrient leaching, namely the accumulation of nutrients available in the soil solution through the movement of groundwater out of the range of plant roots, so that these nutrients become unavailable to plants (Astuti, 2019).

The stage after fertilization is an effort to control pests and plant diseases by adding pesticides. Farmers mix 3–5 types of pesticides at this stage with 30–40 ml/type of pesticide. Furthermore, farmers carry out pesticide spraying on onion crops. In this process, farmers spray 3–10 times per week, with 30–40 cc per type of pesticide and 180 ml of pesticide per 1000 m^2 of land. The output produced from this stage is in the form of emissions from pesticides, both emissions to the soil, emissions into the air and emissions to nearby water bodies. Farmers will do it on farmland during mixing, which risks polluting the surrounding soil. Surface runoff from the areas treated with pesticides can pollute rivers, ponds, lakes, and wells. Pesticide residues on the water's surface can harm plants and animals and pollute groundwater. Polluted water can affect livestock and crops downstream. During the pesticide spraying, splashes can damage nearby sensitive plants or contaminate harvest-ready crops, pets, or insects. Splashes can also pollute the water of ponds, waterways and aquatic biota in it (Sirait, 2020).

The final stages in onion farming are harvesting and post-harvest. At this stage, the farmer produced 375,974 tons of shallots. Furthermore, a selection process is carried out. During this process, excellent and large shallots are produced in addition to large quantities of waste in the form of dry skin and leaves. The waste has not been utilized and is thrown away by farmers because it is considered garbage. The mountains of shallot waste that onion farmers have not managed have a negative impact on the environment. Shallot waste is included in organic waste that causes a foul odour that causes air, water and soil pollution if not managed properly

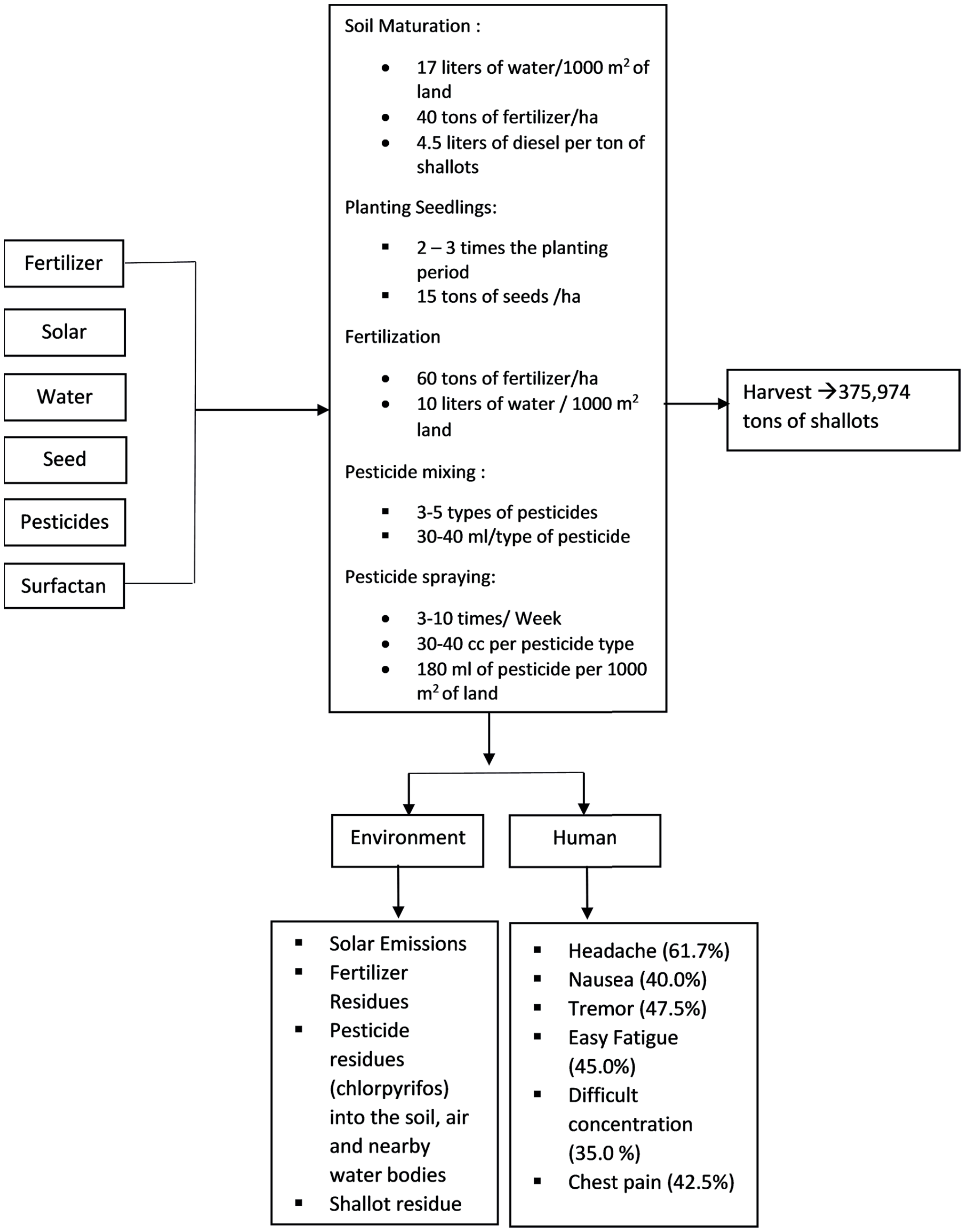

Figure 3. Life cycle analysis pesticide exposure and residues in the agricultural environment and shallot farmers of Brebes district

and reduces the aesthetic value of the environment (Hayati et al., 2022). Some farmers allow post-harvest waste left behind in agricultural areas to be burned openly (open burning). This aims to speed up cleaning the area for the following planting process. Open incineration of post-harvest waste will result in emissions of onion waste that has been burned. After the shallots are harvested, they will then be transported from the agricultural area to the factory site using transportation facilities in the form of trucks. In the transportation process, fuel (diesel) is needed, producing output in the form of transportation emissions (Sirait, 2020).

Environmental impact based on life cycle analysis

The environmental impact caused by an onion farming process has a broader influence, not only on the surrounding environment but also affecting the environment globally (Lolo et al., 2021). The emissions in shallot farming activities come from diesel fuel, pesticides, and NPK fertilizers (Hakim et al., 2014). The result of burning diesel fuel during the tillage process using a tractor has an impact on greenhouse gas emissions. Pest and disease eradication activities also can release greenhouse gases and emissions from chemicals, namely fungicides and pesticides. Fertilization activities using NPK fertilizer also remove greenhouse gas emissions because NPK fertilizer has N content that will react and produce N2O greenhouse gases (Hakim et al., 2014).

Although the use of NPK fertilizer is minimal, it can cause an enormous potential for greenhouse gases, because the radiation value of global warming NO_2 is 298 times greater than CO_2 for a radiation period of 100 years. The main factor in the occurrence of climate change is the greenhouse effect. These greenhouse gases can occur naturally, but human activities also contribute to the increase in the concentration of these gases in the atmosphere, in particular: methane or CH_4, carbon dioxide (CO_2), fluorinated gases, and nitrous oxides. Carbon dioxide (CO_2), although not the most powerful of greenhouse gases, is the most significant contributor. Another greenhouse gas emitted by human activity in smaller amounts is methane. Methane gas is one of the more potent greenhouse gases than CO_2. Nitrous oxide, like CO_2, is a long-lived greenhouse gas that accumulates in the atmosphere for decades to centuries (Rahmawati, 2022).

One of the impacts of onion farming is that it causes acidification from the deposition of inorganic substances such as sulfates, nitrates and phosphates. This deposition occurs mainly through the air and directly into the water. This is the main effect of changes in nutrient levels and acidification in the soil. Air emissions also affect aquatic ecosystems. NO_x and SO_2 increase the concentration of hydrogen ions in soils, rivers, and oceans and reduce pH. Those that cause acid deposition include ammonia (NH_3), nitrogen oxides (NO_x) and sulfur oxides (SO_x) (Rahmawati, 2022).

Pollution comes from the environment, and water comes from the chemicals caused by persistent substances that adversely affect human health and the environment, such as polychlorinated biphenyl (PCB), dioxin, some pesticides (such as DDT) and polifluoroalkil substances (PFAS). Persistent chemicals have entered the environment, and their effects will continue for a very long time (Rahmawati, 2022).

Health problems in shallot farmers

A study of 120 respondents who took part in agricultural activities shows in Table 4 the distribution of frequency of health problems in Shallot Farmers in Wanasari Village, that all respondents experienced health problems as a result of carrying out activities that were frequently exposed to pesticides.

The signs that onion farmers often feel are dizziness and headache (61.7%), nausea (40.0%), redness of the face and hands (28.3%), tremors (47.5%), pale skin (25.8%), lack and difficulty in concentration (35.0%), chest pain (42.5%), easy fatigue (45.0%), history of hypertension (28.3%), history of diabetes mellitus (25.8%), history of kidney disease (10.0%), history of spontaneous abortion (5.8%), history of giving birth to BBLR (9.1%), history of reproductive disorders (14.1%).

The ability to pose a danger depends on the dosage size and the poison's potential. The target is the nervous system. Under normal conditions, a stimulus is conveyed through the nerves to the nerves with the help of a chemical transmitter called acetylcholine. If the transmitter system is damaged, the movement becomes uncoordinated: shaking, muscle twitching, fainting and causing sudden death (Rahman et al., 2019).

The body absorbs pesticides through the skin. The skin reacts in the form of allergies to pesticides, and reactions can occur strongly even if they are only exposed to small amounts. Sunlight can exacerbate some skin diseases caused by pesticides–skin disorders such as redness, hives, scabies, blisters and loss of colour. A common symptom of pesticide poisoning is when the fingernails turn black or blue. In severe cases, the nails will come off (Rahman et al., 2019).

Local acute effects occur, affecting only those parts of the body that are in direct contact with pesticides. Local acute effects are usually irritation, dryness, redness, itching in the eyes, nose, throat and skin, watery eyes and cough. Acute poison reacts very quickly, so it is called fast poison. Symptoms of the exposure to rapid toxins are as follows: salivation, tear discharge, sweating, urination, vomiting, weak muscles, muscle spasms, trembling, convulsions, difficulty breathing, tension, restlessness, difficulty in sleeping (insomnia), headache, difficulty speaking, fainting, coma and death. Pesticides that can cause such symptoms are called acute toxins. The poisons work quickly (quick poisoning) and can kill with just a few drops. Rapid poisoning is a frequent problem in developing countries, where the information about the dangers of pesticides is difficult to obtain (Iswandari et al., 2020).

Table 4. Distribution of frequency of health problems in shallot farmers in Wanasari Village

Health disorders		f	%	Valid %	Cumulative %
Dizziness and headache	Yes Not Entire	74 46 120	74.0 46.0 120.0	74.0 46.0 120.0	61.7 100.0
Nauseous	Yes Not Entire	48 72 120	48.0 72.0 120.0	48.0 72.0 120.0	40.0 100.0
Redness of the face and hands	Yes Not Entire	34 86 120	34.0 86.0 120.0	34.0 86.0 120.0	28.3 100.0
Tremor	Yes Not Entire	57 63 120	57.0 63.0 120.0	57.0 63.0 120.0	47.5 100.0
The skin turns pale	Yes Not Entire	31 89 120	31.0 89.0 120.0	31.0 89.0 120.0	25.8 100.0
Lack and difficulty of concentration	Yes Not Entire	42 78 120	42.0 78.0 120.0	42.0 78.0 120.0	35.0 100.0
Chest pain	Yes Not Entire	51 69 120	51.0 69.0 120.0	51.0 69.0 120.0	42.5 100.0
Easy fatigue	Yes Not Entire	54 66 120	54.0 66.0 120.0	54.0 46.0 100.0	45.0 100.0
History of hypertension	Yes Not Entire	34 86 120	34.0 86.0 120.0	34.0 86.0 120.0	28.3 100.0
History of diabetes mellitus	Yes Not Entire	31 89 120	31.0 89.0 120.0	31.0 89.0 120.0	25.8 100.0
History of kidney disease	Yes Not Entire	12 108 120	12.0 108.0 120.0	12.0 108.0 120.0	10.0 100.0
History of spontaneous abortus	Yes Not Entire	7 113 120	7.0 113.0 120.0	7.0 113.0 120.0	5.8 100.0
History of BBLR childbirth	Yes Not Entire	11 109 120	11.0 109.0 120.0	11.0 109.0 120.0	9.1 100.0
History of reproductive disorders and diseases	Yes Not Entire	17 103 120	17.0 103.0 120.0	17.0 103.0 120.0	14.1 100.0

Studies showing that pesticides can be linked to children's health and development may report that exposure at the age of infection to organophosphate pesticides can decrease intelligence scores at primary school age. It was found that every tenfold increase in organophosphate size detected during a mother's pregnancy would be able to lower the point by as much as 5.5 from the overall IQ score of the child within the age of 7 years. The children exposed to high pesticides during the womb have a seven points lower intelligence standard compared to the children with low levels of pesticide exposure (Joko et al., 2017).

The fetus in the womb can also be exposed to pesticides. If a pregnant woman is exposed to pesticides continuously, it can affect the state of the fetus she contains. Pesticide exposure for 3 months before conception and during pregnancy will increase the risk of spontaneous abortion in pregnant women. As a result, the babies born are also at risk of developing leukaemia and impaired intelligence. Pesticide residues can increase the risk of specific congenital abnormalities during fetal development. During its development, the fetus cannot detoxify the toxins. Meanwhile, the brain and nervous system continue developing until the child is 12 years old (Kusumawati et al., 2015).

Table 5. Distribution of PPE frequency to shallot farmers in Wanasari Village

Specification		f	%	Valid %	Cumulative %
Mask	Yes	7	7.0	7.0	5.8
	Not	113	113.0	113.0	100.0
	Entire	120	120.0	120.0	
Eye/eyeglasses protection	Yes	11	11.0	11.0	9.1
	Not	109	109.0	109.0	100.0
	Entire	120	120.0	120.0	
Headcover/hat	Yes	117	117.0	117.0	97.5
	Not	3	3.0	3.0	100.0
	Entire	120	120.0	120.0	
Long langan shirt	Yes	116	116.0	116.0	96.7
	Not	4	4.0	4.0	100.0
	Entire	120	120.0	120.0	
Long pants	Yes	54	54.0	54.0	45.0
	Not	66	66.0	46.0	100.0
	Entire	120	120.0	100.0	
Glove	Yes	11	11.0	11.0	9.1
	Not	109	109.0	109.0	100.0
	Entire	120	120.0	120.0	
Boots	Yes	7	7.0	7.0	5.8
	Not	113	113.0	113.0	100.0
	Entire	120	120.0	120.0	

A study of 120 respondents who took part in agricultural activities shows in Table 5 the Frequency Distribution of PPE among Shallot Farmers in Wanasari Village, that all respondents (100%) were incomplete in wearing personal protective equipment, namely not wearing boots, gloves, goggles, trousers, and long sleeves altogether in each agricultural activity. Usually, farmers only use one or two types of PPE. Such as wearing only head coverings/hats (97.5%) and long-sleeved T-shirts (96.7%). Farmers do not use complete PPE, because PPE is considered to interfere with farmers' activities at work. Farmers are not free to move and have difficulty breathing.

How to spray pesticides by shallot farmers

This study shows that as many onion farmers spray poorly, 28% of pesticide spraying is not by the wind direction. Meanwhile, 72% do a good way of spraying, namely those who spray pesticides by paying attention to the wind direction. Shallot farmers do not adjust to the wind direction because, the land lane cannot be adjusted to the wind direction. They were spraying, and not following the wind direction causes pesticides to be carried away by the wind, so pesticides do not hit the soil properly.

This leads to fewer pesticides hitting the soil. Spraying at ineffective times, such as during the day at 12.00–14.00, will cause pesticides to evaporate so that the concentration of pesticides in the soil can be reduced. Djojosumarto's research in 2008 said spraying too early or too late in the evening caused the pesticides attached to plant parts to dry difficult to dry, so that plant poisoning occurred while spraying during the day caused the active ingredients of pesticides to be decomposed by sunlight so that their killing power was reduced (Djojosumarto, 2008).

Frequency of pesticide spraying carried out by shallot farmers

The frequency of spraying is the activity of onion farmers in the amount of spraying onion crops over one week and the reason for spraying onion crops. The recommended time to make contact with pesticides is a maximum of 2 times a week. The frequency of spraying carried out by shallot farmers in Wanasari Village is 24% good, namely spraying carried out regularly with 1–2 sprays in one week. Meanwhile, those who spray with an unfavourable frequency of 76% carry out spraying activities when pests attack 3–10 times a week (Suprayogi Slamet & Tommy Andryan, Widiyastuti Nurcahyati, 2013).

CONCLUSIONS

The life cycle analysis results of shallot farming include 5 stages: soil maturation, planting seedlings, fertilizing, applying pesticides, and harvesting. The emissions in shallot farming activities come from diesel fuel, pesticides, and NPK fertilizers. The result of burning diesel fuel during the tillage process using a tractor has an impact on greenhouse gas emissions. Pest and disease eradication activities also can release greenhouse gases and emissions from chemicals, namely fungicides and pesticides.

Fertilization activities using NPK fertilizer also release greenhouse gas emissions because, in NPK fertilizer, there is N content that will react and produce NO_2 greenhouse gases. Chlorpyrifos pesticide residues were found with different levels, including Tegal Gandu Village (2.8838 ppm), Sidamulya Village (0.2123 ppm), Siasem Village (0.3316), Wanasari Village (0.2318 ppm), Dukuhwaringin Village (0.3749 ppm), Jagalempeni Village (0.0670 ppm), Sigentong Village (0.3021 ppm), Siwungkuk Village (0.4876 ppm), and Tanjungsari Village (0.3133 ppm).

The results of laboratory tests showed that in the parameters of dissolved solids (Total Dissolved Solid) 2 villages exceeded the quality standards with the value of dissolved solids exceeding 1000 mg/L. Temperatures in the five villages were above the quality standards, namely at 27.0 – 27.5 °C. In the mandatory biological parameters, Total Coliform in 4 villages exceeds the quality standard, with values above 50 CU/100 ml. The results of the E. Examination showed that 3 villages exceed the quality standard with an E. value of more than 0 CFU/100 ml. In the mandatory chemical parameters, the hardness value ($CaCO_3$) in Wanasari Village exceeds the standard quality value of 522.22 mg/l. The manganese content in groundwater samples in 5 villages exceeded the quality standard, which exceeded the figure of 0.5 mg/l. The average pH value of groundwater in the shallot farming area of Wanasari District, Brebes Regency, is 8.28, with the lowest pH value of 8.14 and the highest pH value of 8.39.

A study of 120 respondents who participated in agricultural activities showed that all respondents had health problems due to carrying out the activities that were often exposed to pesticides. The signs that onion farmers often feel are dizziness and headache (61.7%), nausea (40.0%), redness of the face and hands (28.3%), tremors (47.5%), pale skin (25.8%), lack and difficulty in concentration (35.0%), chest pain (42.5%), easy fatigue (45.0%), history of hypertension (28.3%), history of diabetes mellitus (25.8%), history of kidney disease (10.0%), history of spontaneous abortion (5.8%), history of giving birth to BBLR (9.1%), history of reproductive disorders (14.1%).

A study of 120 respondents who participated in agricultural activities showed that all respondents (100%) were incomplete in wearing personal protective equipment, namely not wearing boots, gloves, goggles, trousers, and long sleeves altogether in each agricultural activity. Usually, farmers only use one or two types of PPE, such as wearing only head coverings/hats (97.5%) and long-sleeved T-shirts (96.7%).

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