

Effect of Glyphosate Herbicide on Environmental Health

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Abstract_One of the active ingredients of herbicide is Glyphosate (N- (phosphonomethyl) glycine) which is widely used in plantation land. Herbicide residues will accumulate in agricultural products, pollution in the environment (water, air and soil), poisoning in humans both acute and chronic that have an impact on death.

Glyphosate was found in the 10-20 cm layer after 1 day of application for up to 2 weeks, glyphosate was found in the 0-10 cm layer. The quality standard of glyphosate concentration in the soil was 22 mg / kg. Water glyphosate was absorbed by particles and sediments; (half-life) is estimated to be between 2-820 years depending on sunlight and water depth, Glyphosate lost from fresh water after 36 hours by 50% and 100% after 4 weeks; in sea water lost after 24 hours by 50-70%. Glyphosate in air has a vapor pressure of 1.31×10^{-5} Pa at 25°C (98.6%), in the form of particulates and the vapor phase is partially removed from the air by rain. The glyphosate threshold value in the air is 0.5 mg / m³.

Keywords: glyphosate, health, environment

I. INTRODUCTION

The use of pesticides in agriculture and plantation areas is currently increasing, especially in developing countries, including Indonesia. At present the number of pesticides used and registered is 3,207 formulations for agriculture and plantations (1). Herbicide is a type of pesticide that is widely used in agricultural and plantation areas, its use is around 50 - 60% (2).

The use of pesticides in agricultural and plantation areas in addition to having a positive

impact that is saving the number of workers in controlling weeds, also has a negative effect if the use is not in accordance with the provisions. Negative effects are at risk for human health and can also pollute environmental media (3).

The use of herbicides in agriculture and plantations is currently increasing. One of the active ingredients of herbicide is Glyphosate (N- (phosphonomethyl) glycine) which is widely used in agriculture and plantations (4). Plantations that use glyphosate herbicides are oil palm plantations with the aim of eradicating weeds. The use of herbicides is considered to contribute greatly to increasing agricultural productivity and can save labor. In addition to having a positive impact on the use of glyphosate herbicides in the agricultural sector, it can also have a negative impact, especially on the health risks to both people and workers exposed to these active ingredients. Health effects due to glyphosate exposure are acute, sub-chronic, chronic and systemic.

Herbicides based on how they work are divided into two namely contact and systemic. The most widely used systemic herbicide is herbicide with glyphosate as an active ingredient, because it has an advantage that is quite effective in suppressing the growth of weeds and has a broad spectrum in controlling weeds. Whereas from the types of contact herbicides that have been used so far, one of them is the type of paraquat that is suitable for controlling narrow-leaf weeds, puzzles and broad-leaf weeds.

Application of herbicides in weed control besides administration alone is usually used in a mixture to increase the effectiveness of herbicides. Based on information from the Du Pont Company, the use of glyphosate mixed with methyl methulfuron is effective in controlling

broadleaf weeds, shrubs and ground cover nuts (LCC).

The use of herbicides with large doses and carried out continuously will cause several losses, including herbicide residues that will accumulate in agricultural products, pollution in the agricultural environment, decreased productivity, poisoning in animals, poisoning in humans that have a negative impact on health. Humans will experience both acute and chronic poisoning which has an impact on death (5).

II. DISCUSSION

1. Glyphosate

Glyphosate is a non-selective, systemic and post-emergent herbicide that is widely used on agricultural land (6). Glyphosate with the chemical name N- (phosphonomethyl) glycine is a weak organic acid, polar in nature so it is easily soluble in water and insoluble in non-polar solvents such as acetone, ethanol and benzene (6).

Glyphosate as an active ingredient in herbicides has a broad spectrum in controlling weeds. (7) This herbicide is effective for controlling annual weeds and deep-rooted weeds. Glyphosate killing power is slow, but spray results are easily transplanted to other parts of the plant so the killing power is more certain. Glyphosate is absorbed by plants through the leaves (cuticles), then spread to all parts of the plant. The translocation of glyphosate herbicides in the plant body is generally through simplas, so that accumulation occurs under the tissue of young leaves and meristem tissue, some plants pass apoplast translocation.

The mechanism of action of glyphosate to kill weeds is by inhibiting the activity of the EPSP (5-enolpyruvylshikimate-3-phosphate) enzyme synthase, EPSP produced from shikimate-3-phosphate or phosphoenolpyruvate in the shikimate acid pathway. EPSP enzymes play a role in the biosynthesis of the amino acids tryptofan, phenylalanine and tyrosine. The presence of glyphosate inhibits these activities resulting in the depletion of amino acids needed in protein synthesis in the synthesis pathway for growth. Symptoms of chlorosis in young leaves and growth spots followed by necrosis occur 4–7 days after the application of glyphosate herbicides (grass species have high susceptibility), and less susceptible species appear to be necrosed on days 10-20 after application of glyphosate herbicides. Certain plant species exhibit symptoms of poisoning on

the leaves to a purplish red color, while forest plant species and their annual vegetation cause the buds to become deformed, whitish and multiply shoots (8).

2. Environmental Fate in Environmental Media

2.1. Soil

Glyphosate is stable upon entering the soil and is resistant to microbial degradation under aerobic and anaerobic conditions. Glyphosate can relate easily to clays, absorption increases depending on the organic matter content in clay; sorption coefficient between 8,400 - 40,000,000 (9).

Glyphosate absorption in clay and clay soils is higher depending on soil acidity, if high pH adsorption increases (10). Experiments in the laboratory using clay have been reported that the mobility of glyphosate degradation in land is faster than in laboratory experimental soils (11). Glyphosate is found in layers 10-20 cm after 1 day of application until 2 weeks, then glyphosate is found in layers 0-10 cm (3). The glyphosate concentration standard in the soil is 22 mg / kg (12), whereas in Indonesia glyphosate quality standard has not been established.

2.2. Water

Water glyphosate is absorbed by particles and sediments; half-life is estimated to be between 2 - 820 years depending on sunlight and water depth (15). Glyphosate is more resistant (resistant) to hydrolysis (13), and is very soluble in water with a solubility of 10.5 g / L at 20 OC with a pH of 1.90 - 1.98) (99.5%) (14). Glyphosate is lost from fresh water after 36 hours by 50% and 100% after 4 weeks; in sea water lost after 24 hours by 50-70%. Mobilization of glyphosate from water follows aquatic plants, sediments and solid particles; glyphosate enters the surface of the water bound to particles due to erosion and water flow, then stored again in water bodies or lower areas due to erosion of sediment from the upstream riparian zone (16).

Studies in Thailand of glyphosate concentrations found in ground water > 18.9 µg / L (0.018) (11); in the Caribbean Santa Lucia concentrations in drinking water are found > 0.1-5.3 µg / L (0.0001 - 0.005 mg / L (17). In Indonesia, there are no standards for the quality of glyphosate concentrations in drinking water, clean water or ground water.

2.3. Air

Glyphosate has a vapor pressure of 1.31×10^{-5} Pa at 25°C (98.6%) (14); in the form of particulates and vapor phases partially removed from the air by rain, and transferred from the atmosphere in the form of dry deposition. Spraying in the form of dew (mist) is needed. This buffer zone is needed to prevent ecological effects on non-target plants with a distance of > 300 meters; for land based on application as far as 110 meters (16). The glyphosate threshold value in the air that is 0.5 mg / m³ which applies internationally is determined by ACGIH (18) and in Indonesia is determined by Permenaker (19).

3. Health effects on humans

3.1. Acute effect

Severe poisoning due to swallowing of glyphosate causes death very quickly or is delayed by only a few weeks; The main target organs of glyphosate poisoning are the eyes, skin, respiratory system, liver, heart, kidneys, gastrointestinal tract, lungs. The brain as a target for other organs is seen after injection of a single dose (20). Systemic glyphosate poisoning is characterized by mouth, throat and stomach burning (when swallowed); acute respiratory distress and multi-organ failure; likely to affect the central nervous system; adrenal gland; kidney; heart; muscles including necrosis; extubility; convulsions; lack of coordination; coma (15).

Besides symptoms such as nausea, vomiting, abdominal pain, diarrhea, weakness, headache, heat, muscle aches, burning skin, shortness of breath, rapid heart rhythm, coughing, death due to respiratory failure (21). Doses of glyphosate concentrations are very lethal at least 1 teaspoon of a solution of 20% or 17mg / kg due to swallowing (21).

Symptoms and clinical signs of glyphosate poisoning depending on the dose ingested, sub-acute poisoning at mild doses <20-30 mg / kg body weight, the symptoms caused are asymptomatic or nausea, vomiting and diarrhea; moderate acute poisoning at doses > 20-30 mg / kg body weight; at doses <40-50 mg / kg body weight, some patients survive, but most die within 2-3 weeks of lung failure; symptoms are vomiting, diarrhea, abdominal pain, mouth ulceration, and throat ulceration that occur after several hours of swallowing glyphosate. (22).

3.2. Chronic Effects

Glyphosate poisoning in the long term (long term exposure) causes pulmonary fibrosis (15);

glyphosate exposure increases oxidative stress and apoptosis. NADPH oxidation plays a role in glyphosate toxicity; in microglia cells can destroy substantia nigra, causing symptoms of Parkinson's disease (23).

Exposure to low-dose glyphosate during a critical period in childhood influences the development of brain function (15). Pathogenesis from Parkinson disease and partial dysfunction of neuron protective genes can develop progressively (24). Exposure to herbicides is related to neurodegenerative Parkinson's disease (25).

4. Exposure to Glyphosate

Glyphosate poisoning most often occurs in the workplace especially during spraying applications, a study of farmers in South Korea reported that illnesses related to work, social-demographic and seasonal factors were significantly associated with piscicide poisoning including glyphosate (26). Continuous use of glyphosate causes severe poisoning in catchments in France (27); causes seizures in patients with high glyphosate concentrations in blood and urine.

Route of glyphosate exposure at work as follows:

4.1. Dermal

The skin is the most common exposure during glyphosate spray application. Studies on spraying on Costa Rican banana plantations report that heavy poisoning is due to continuous paraquat; health complaints include: burning sensation in the hands, thighs, back, testicles and feet; reddish and hot eyes from splashes; nose bleeding (28). In addition to 11 of the applicators that diluted glyphosate, total skin exposure (in certain body areas) was 0.2 - 5.7 mg / hour.

Studies on cotton plantations in Mali on pesticide sprayers using non-leaky tanks reported that exposed body parts were: head (3.6%), body (23.7%) and legs (29.1%); in spraying with a leaky tank exposed to the head (0.76%), body (4.8%), legs (5.8%). Additionally glyphosate exposure to sprayers was reported that groups using protective equipment were 60 times more at risk; in groups not wearing personal protective equipment 100 times more at risk (29). Pesticide exposure including glyphosate was reported by 4 workers who had a history of burning skin (30). Prolonged repeated exposure to the skin causes dermatitis and nails can cause nail damage (31).

4.2. Inhalation

Exposure to the inhalation route affects lung function, a study of 126 workers exposed to glyphosate in a South African fruit plantation found pulmonary capacity of less than 10-15%. Exposure to glyphosate at high concentrations via the inhalation route and ingested in large amounts causes effects on the lungs, kidneys, liver and cardiovascular system; resulting in dysfunction and tissue lesions including bleeding and pulmonary fibrosis (30).

5. Glyphosate Toxicokinetics

5.1. Absorption

Glyphosate is more quickly absorbed through the inhalation route and through the digestive tract after the ingestion process (16). Absorption after oral intake is around 15%, whereas contact with skin is generally around 0.5% (9).

Besides glyphosate absorption causes direct damage to the stomach or intestinal tract if swallowed. Absorption through the skin increases if the skin is injured, and can cause death in humans (32).

5.2. Distribution

After glyphosate is absorbed into the body, it is then distributed to the body parts, especially the lungs, liver and kidneys, the concentration of glyphosate in plasma is relatively stable for 30 hours and in the lungs more increased and active (32).

Apart from being distributed to the glyphosate lungs, liver and kidneys, they are also distributed to the muscles, progressively toxic effects on organs determined by bioavailability and elimination; increased bioavailability is followed by increasing doses caused by intestinal and liver toxicity (33). Glyphosate concentrations are lower in muscle tissue, after exposure through the skin and slowly released into the blood (34).

5.3. Metabolism and Excretion

The process of glyphosate metabolism in the body is influenced by a number of the enzymes nicotinamide adenosine dinucleotide phosphate oxidase (NADPH), ubiquinone, cytochrome P450, nicotinamide adenosine dinucleotide hydrogen (NADH) (35). Repeated oxidation causes the formation of free radicals such as: superoxides, hydrogen peroxide, thus causing oxidative damage to fats, proteins and DNA (36).

6. Biological Monitoring

Biomonitoring is an activity of testing the presence of chemicals, and other metabolites or

biochemical changes in a person's biological material such as body tissue, blood, urine, breathing to determine how much chemical enters the body due to exposure (37).

Biological monitoring is a chemical exposure assessment method that involves analysis of blood, urine, hair or breath samples exhaled from workers, for hazardous substances or their metabolites (breakdown products in the body). There are two main objectives of biological monitoring, namely: exposure assessment and health surveillance (38).

Biological specimens used as samples for biomonitoring tests are blood and urine. Blood is a sample that is often used, but for a short half-life and volatile chemicals the use of blood samples needs to be considered, while urine is an easy-to-take sample, urine can be used 24 hours or urine for a moment, but for practicality at work generally urine is taken moment.

III. CONCLUSION

Glyphosate is a non-selective, systemic and post-emergent herbicide that is widely used on agricultural land. Activities in agriculture and plantations are applications of glyphosate spraying and other active ingredients of pesticides. Application of spraying herbicide active ingredients including glyphosate is emitted to environmental media such as soil, water and air. If the active ingredient of herbicide is exposed to workers and the surrounding community, it can be absorbed into the body and accumulated in target organs such as the lungs, kidneys, liver, other organs, causing health effects both in the form of symptoms / clinical signs, even to the point of death.

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