Acid Rain Contribution from Pesticide Distribution to Rice Farmers in Pati Regency

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Abstract. Productivity rate of rice fields in Regency has been in a surplus condition annually. The fields have produced 7 to 8 tons per hectare, making the total annual rate of 600 tons. The regency, therefore, is considered to be capable of fulfilling its own need for rice and to contribute significantly to the rice needs in Central Java Province. Agriculture coexists with the presence of pesticides. While helping the farmers to combat the plant diseases, pesticides have still been greatly necessary by the local farmers. Distribution by means of transportation devices plays an important role for the dissemination of the pesticides from the producers to their end users. Problem arises due to emission produced during the transportation activities. Transportation emits SO_2 as the major contributor to acid rain. To make worse, application in practice by the farmers also emit the similar substance. Annual use of pesticides in Pati Regency has reached 605 tons with SO_2 emission of 13,697 kg. It is recommended that distribution management and selection of pesticides are performed by applying an integrated pest control in order to reduce the pesticide emission.

1 Introduction

Pati Regency is one of agricultural centers in Central Java Province with a total agricultural area of 150,368 hectares, comprising 58,448-hectare rice fields. Local farmers in the regency performed three harvesting times annually. Effort of pest control depends on the use of pesticides. These substances are believed to be the key to the harvest success. Whether the pests truly exist, the farmers have been get used to spraying the pesticides on their fields. The use of pesticides is usually performed by mixing 3 to 7 different types of pesticide in 5 to 9 times during the season for rice and 12 to 17 times during the season for vegetables [1]. Such condition has become the productive marketplace for the pesticide producers.

The use of pesticides often causes multi-facet impacts on ecosystem. Birkved develops a model of estimating the pesticide emission during its application towards air, surface water, and ground water according to the pesticide types and time of application, vegetation species and stage of development, geological and meteorological condition, local application, characteristics of active materials contained by the pesticide for LCA-based agricultural estimation of pesticide emission [2]. Life Cycle Impact Approach (LCIA) is a method usually applied to evaluating toxic effect of the pesticides on human health and ecosystem [3]. Juraske et al. adds that toxic effects can be found by fate, exposition, effect, and damage analysis for assessing cumulative and potential impacts [4]. Panichelli et al. assume that pesticides are totally emitted into soil compartment [5]. Margni et al. find that the distribution rate of the pesticide emission on soil, plant, and air are 85%, 5%, and 10%, respectively[3]. In addition to emission, the pesticide application also causes contamination before and during the formulation, filling sprayer tank, and after the application where the users treat the residual mixture in the sprayer, including the formulation washing [6].

Effects of pesticides on environment can be directly found from production to final cycles [7]. The LCA applies to assessing the environmental aspect and potential effects of the products by calculating eco-efficiency rate. Eco-efficiency is believed to be important towards sustainable development. Pesticide use and treatment relate to transformation process from raw materials, chemical substances, and spraying treatment by the end users. In the first stage, pesticide production provides economic benefit to the producers. However, it also pollutes in the forms of wastewater, harmful solid waste, etc. The following stages have revealed that the use of pesticides contributes to the improvement of agricultural volume. However, the negative impacts also come across in the form of ecosystem pollution by residuals and wastes the pesticides produce.

LCA applies to finding out the environmental effects, including potential course of global warming, greenhouse effect, etc. Pesticide distribution by transportation emits gases, including SO_2. The pesticide application process causes vaporation and air movement, producing gas phase pesticide in the atmosphere and

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reacting with water molecules. As it occurs, acid rain develops.

2 Research Methodology

2.1 Research Location and Time

This study was performed in Pati Regency in 2016.

2.2 Research Design

This study applied a quantitative methodology using primary and secondary data on the pesticide distribution lifecycle of the Life Cycle Assessment (LCA) approach as recommended by ISO 14044 on environmental management system.

2.3 Research Scope

The study focused on measurement of energy, materials, and wastes during the pesticide application. The pesticides selected were those popularly applied by the rice farmers in Pati Regency in one unit per ton.

2.4 Population and Samples

The research populations were rice fields with pesticide use of one ton per unit by 87 respondents.

2.5 Research Variables

Dependent variable of this study consisted of environmental effect of the pesticide distribution and use related to acid rain issue, whereas the independent variables consisted of energy needed, pesticide material distribution and use, and waste volumes from the pesticide distribution at the scale equal to SO_2 as the major substance that contributes acid rain.

2.6. Data Processing

Data collected were processed by an Eco-Indicator95 method using the LCA approach, beginning with pesticide distribution by the producer, to pesticide storage at whole sellers, to transportation and storage by retailers, and, finally, to the use and application by the farmers. The calculation also used SimaPro 7.1. application software.

3 Results

3.1. Research Location Profile

Pati is one of 35 regencies under the administrative territory of Central Java Province. It has a strategic position as it is situated between major cities of the North coast of the Java Island, from Jakarta to Semarang to Surabaya. Pati has a geographic feature of 100°15'-111°15 East and 6°25'-7°00' South with the total area of 158,368 hectares. Of these total territories, 58,448 hectares are cultivated for rice fields and 91,036 for other needs. Pati Regency is situated at the elevation of 0-1,000 meters above the sea level, experiences two seasons, dry and rainy, with the more wet than dry months. The average rainfall of the regency, as recorded in 2014, was 2,734 mm with 132 rainy days per year. The lowest and the highest temperature recorded are 23 °C and 39 °C, respectively.

Pati is the place of quite large rivers, where 93 rivers flow across the region. In general, the rivers have motives and trees, with the river mouth at Java Sea. The popular use of the rivers is for agricultural irigation. Unfortunately, during the dry season most of the rivers suffer from drought, whereas during the rainy days, they cause floods. Some of the rivers store the water source, both many of them do not. Most of the rivers have their upstreams at Mount Muria, in particular those situated in the Northern part of the regency.

3.2 Effects of pesticide distribution on acid rain

Life Cycle Assessment (LCA) (EPA, 2006) is a "cradle to grave" assessment, an approach to evaluating particular industrial system.[9] The "cradle to grave" system begins with raw material collection from nature to be converted as particular product(s), and ends at the point where all of the materials are driven back to the nature. The LCA allows the estimation of the cumulative effect on the environment caused by all stages or phases of the product life cycle.

Previous studies have revealed that LCA is a form of technological development to find out the effects of pesticides by a consistent manner to enable the comparison of impacts of other practices in agriculture. The LCA method is useful for determining the pesticide effects on human health and ecosystem. In case of human toxicity, the estimation of the pesticide residuals reveals that foods consumed have the highest toxicity exposition, approximately 103-105 higher than that of consumed by drinking or inhaled from the air [3]. To perform the LCA, one needs adequate inventories of all resources necessary for chemical substance emission calculation, including agricultural input and output inventory, such as pesticides and plant fertilizers [10].

Pesticide distribution consists of several phases, as follows: distribution from producers to distributors; unloading/loading at the distributors' yard; distribution to agricultural whole sellers and kiosks; management at the whole sellers and kiosks; distribution from kiosks to farmers; and pesticide application by end users.

The distribution begins from the producers. In this study, the national producers were located in Gresik Regency, East Java Province, as the 28% of the total respondents reported.

The pesticides were transported by trucks with the trip distance of 212 kilometers. The pesticides were then distributed to the agricultural whole sellers and kiosks using MPVs with the average trip distance of 15 kilometers. The farmers bought the products using motorcycle transportation with the trip distance of 4 kilometers from the shops to the rice fields.

The pesticide distribution causes damaging emission during the transportation from the producers to the consumers. The pesticide emits substances, energy, and components due to over-application, causing damage of particular system. Gas emission is produced by engine combustion, causing greenhouse effect and global warming. The composition of the emission produced during the pesticide distribution is carbon compounds. These compounds are found in gasoline and may cause health problems and disorders, such as eye irritation, headache, memory disorder, reflect disorder, cough, skin irritation, asthma and even lung cancer. The monoxide gas emission causes headache, and cardiac disorder, respiratory tract infection, and lung cancer. Furthermore, SO_2 (sulphuric oxide) emission causes blood formation system toxicity, leading to red blood cell development disorder, anemia, high blood pressure, kidney dysfunction, and reproductive disorder.

The SO_2 emission assessment of the pesticide distribution using eco-indicator 95 method and SimaPro 7.1 revealed that in Pati Regency, at every tone of pesticide, the emission produced was 22.638887 kg SO_2/year. Annually, the pesticide use in Pati Regency was 605 tons. Therefore, the total SO_2 emission was 13,697 kg SO_2/year.

The largest SO_2 emission was found in the pesticide application and from carbofuran pesticide, as Birkved has reported.[2] This result also illustrated the effect of the pesticide emission, assuming that pesticides are totally emitted within the soil compartment.[12, 5]. The emission was divided into 85% to the soil, 5% to the plants, and 10% to the air.[3] The LCA approach can be used for finding out the emission effects on the environment, whereas in this study the LCA revealed the SO_2 emission rate that affected the incidence of acid rain.

The pesticide distribution using transportation devices is believed to cause gas emission, including that of SO_2. The process of the pesticide application deals with evaporation and air movement, causing gas phase pesticide in the atmosphere and reaction with water molecules, where the acid rain develops.

Table 1. Assessment of SO_2 emission during pesticide distribution

No	Component	Impact category (Kg SO_2)
1	Motorbike I	0.10974424
2	Trailer diesel FAL	0.39311314
3	Transport, van <3.5t/CH S	0.20529393
4	Carbofuran, at regional storehouse/CH S	5.7990893
5	Glyphosate, at regional storehouse/CH S	3.626833
6	Tap water, at user/CH S	0.66123444
7	ABS 30% glass fibre I	0.19149345
8	Modified starch, at plant/RER S	0.20860855
9	Pyridazine-compounds, at regional storehouse/RER S	3.6666452
10	Phenoxy-compounds, at regional storehouse/RER S	2.5156454
11	Nitro-compounds, at regional storehouse/RER S	1.9707039
12	Dithiocarbamate-compounds, at regional storehouse/RER S	1.1643351
13	2,4-D, at regional storehouse/RER S	2.1021127
	Total Kg SO_2	**22.638887**

Source: Simapro 7.1

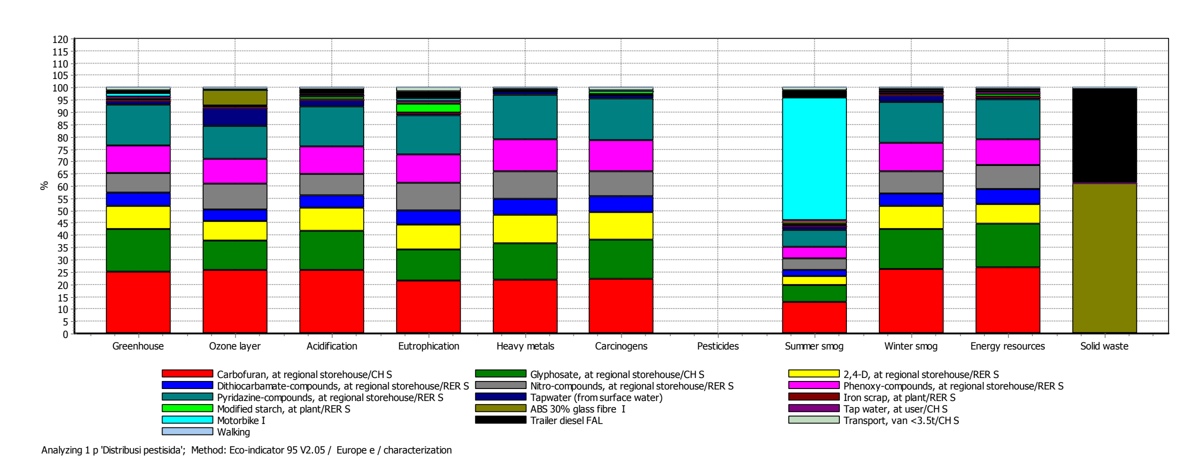

Fig. 1. Emission during pesticide distribution Source: SimaPro 7.1

The above figure presents the varied effects of the pesticide distribution, including SO_2 emission. Acid rains develop during such process. Furthermore, the below figure illustrates a flow diagram of such emission.

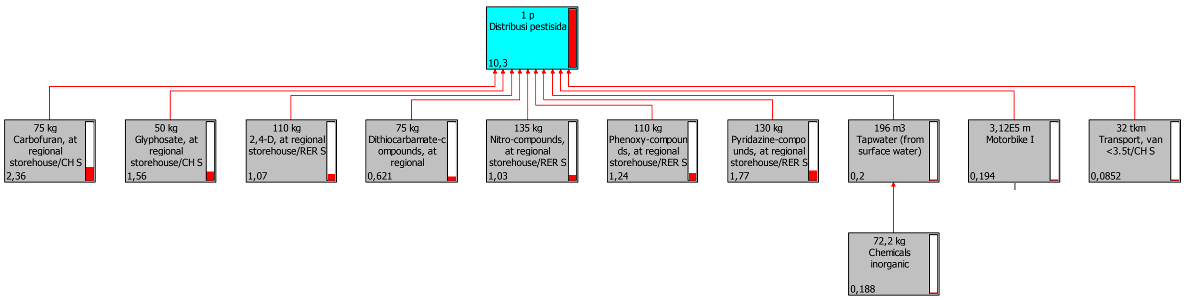

Fig. 2. Flow diagram of pesticide distribution

The study observed that of 100% composition of the pesticide effects it revealed as follows: 5% affected the target plants (the rice fields); 85% affected the nearby environment (land, air, and water contamination); and 10% vaporized

4 Conclusion

The pesticide distribution began from the producers in Gresik Regency, East Java Province and ended at the end users. Using eco-indicator 95 and SimaPro 7.1 the study found that in every tone of pesticide and 16 litres of the pesticide application, it resulted in 22.638887 kg SO_2/ton of pesticide applied by the farmers. Annually, the pesticide use in Pati.

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