Sustainable Environment Research 26 (2016) 168–176

Contents lists available at ScienceDirect

Sustainable Environment Research

journal homepage: www.journals.elsevier.com/sustainable-environment-research/

Original research article

Modeling of the residue transport of lambda cyhalothrin, cypermethrin, malathion and endosulfan in three different environmental compartments in the Philippines

Delia B. Senoro [a, b, *], Sharon L. Maravillas [a, b], Nima Ghafari [b, c], Clarissa C. Rivera [b, d], Erwin C. Quiambao [b, e], Maria Carmina M. Lorenzo [b, f]

[a] Sustainable Development Research Office, Mapua Institute of Technology, Manila City 1002, Philippines
[b] School of Civil, Environmental and Geological Engineering, Mapua Institute of Technology, Manila City 1002, Philippines
[c] Department of Civil Engineering, Laval University, Quebec G1V 0A6, Canada
[d] Department of Science and Technology, Taguig City 1631, Philippines
[e] City Engineer's Office, City of San Fernando 2000, Philippines
[f] Mariano Marcos State University, Ilocos Norte 2918, Philippines

ARTICLE INFO

Article history:
Received 19 June 2015
Received in revised form
26 March 2016
Accepted 12 April 2016
Available online 22 April 2016

Keywords:
Fate and transport
Modeling
Pesticides

ABSTRACT

This study aims to determine the environmental transport and fate of the residue of four Philippines priority chemicals; i.e., lambda cyhalothrin (L-cyhalothrin), cypermethrin, endosulfan and malathion, in three different environmental compartments (air, water and soil). In the Philippines, pesticide application is the most common method of controlling pests and weeds in rice and vegetable farming. This practice aided the agricultural industry to minimize losses and increase yield. However, indiscriminate use of pesticides resulted to adverse effects to public health and environment. Studies showed that 95% of the applied pesticides went to non-target species. Data from previous studies in Pagsanjan Laguna, Philippines were used as input data. Dispersion, Gaussian plume, and regression equations were employed to simulate the behavior of L-cyhalothrin, cypermethrin, endosulfan and malathion in air, water and soil. Substance decay was calculated using first order reaction. This study showed how L-cyhalothrin, cypermethrin, endosulfan, and malathion behaved in the environment after release from nozzle spray, and its possible duration of stay in the environment. It will also show a tool in determining the percolation depth through soil by endosulfan. This tool can be utilized in determining the depth of contaminated soil during remediation strategic planning and project implementation of similar environmental condition.

1. Introduction

In the Philippines, pesticides play a vital role in the increase and sustainability of food production. Pesticide manifests greater productivity that alleviates crop production problems such as pest infestation and poor product yield. Total pesticides usage in the Philippines increased from 3.74 kt in 1977 to 10.8 kt in 1991 [1] in Ref. [2]. This is an increase pesticide usage of 0.5 kt per year during 14 yr span. Considering the country's increase in population growth with constant rate of pesticide usage, the probable amount of pesticide usage in the Philippines may reach to 22.8 kt by 2015.

Pesticide transport and fate are significantly affected by climate and the environmental condition of the Philippines. It has two pronounced seasons; i.e., the wet and dry. Rice farmers around Pagsanjan-Lumban catchment (Fig. 1) applied pesticides three times per season. Vegetable growers in Lucban and Laguna area applied pyrethroid based insecticide such as L-cyhalothrin and cypermethrin five times throughout the cropping season. Other insecticides such as malathion and endosulfan were applied two to four times within the cropping season [2]. Depending on the types

* Corresponding author. Sustainable Development Research Office, Mapua Institute of Technology, Manila City 1002, Philippines.
E-mail address: dbsenoro@mapua.edu.ph (D.B. Senoro).
Peer review under responsibility of Chinese Institute of Environmental Engineering.

http://dx.doi.org/10.1016/j.serj.2016.04.010

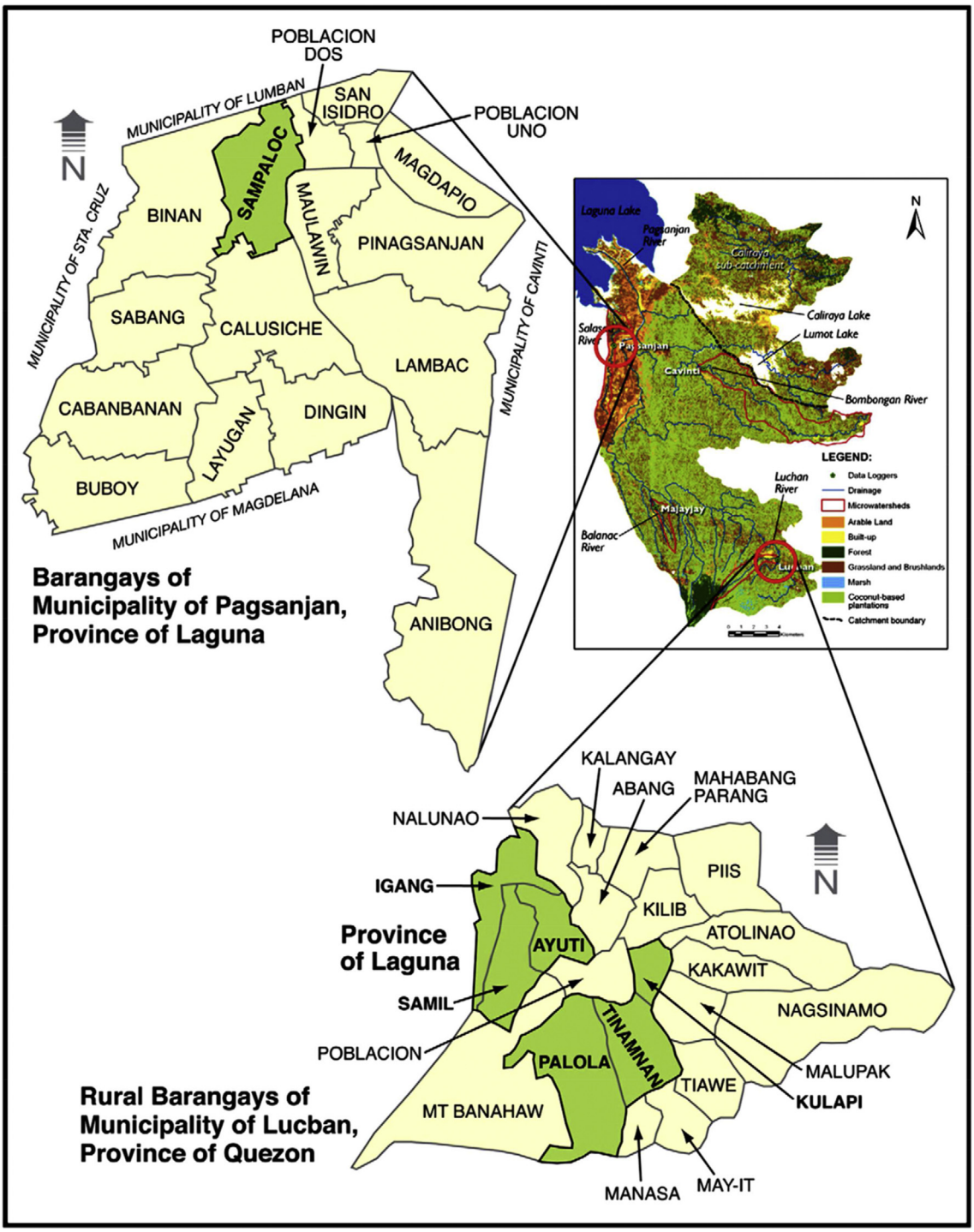

Fig. 1. Map of the Pagsanjan-Lumban catchment [2].

of vegetables, the cropping period ranges from two to six months. Farmers in the Philippines commonly applied pesticides to crops by spraying an aqueous emulsion and/or suspension using backpack knapsack sprayer. Backpack knapsack sprayer is a compressed air sprayer with a harness that allows it to be carried on the operator's back. Another type of backpack sprayer has a hand-operated hydraulic pump that forces liquid pesticide through a hose and one or more nozzles. Both types of sprayer have nozzle.

Cypermethrin [$C_{22}H_{19}O_3NCl_2$] has low solubility in water (K_w = 0.009 mg L^{-1} at 20 °C) and has higher affinity to soil and sediment particles (Koc = 6.1 × 10^4 mL g^{-1}). The field dissipation, aerobic, and anaerobic half-life are 4–12, 6–20, and < 14 d, respectively [3]. Cypermethrin is immobile in soil, however, its degradates (i.e., phenoxybenzoic acid and dichlorovinyl acid) are mobile in soil. Endosulfan in river system is stable at pH 5 with increasing disappearance at pH 7 and 9 by chemical hydrolysis [4]. L-cyhalothrin has low water solubility, not volatile, stable in water at pH < 8 with half-life greater than 3 wk under natural irradiation [5]. Malathion is non-persistent, degrades quickly in soil (3 d) compared with water (11 d). However, when malathion is absorbed