Pergamon

Wat. Sci. Tech. Vol. 39, No. 3, pp. 61–66, 1999.

0273–1223/99 $19·00 + 0·00

PII: S0273-1223(99)00032-3

AGRICULTURAL DIFFUSE POLLUTION IN THAILAND

N. Tonmanee and N. Kanchanakool

Division of Soil Analysis, Department of Land Development, Chatuchak, Bangkok 10900, Thailand

ABSTRACT

Over the past two decades there have been a number of changes in Thailand, changes in the environment and quality of life for its people, changes in its communities and in the foundations of its economy. Before 1970, Thailand was a rural society in which local communities depended on the natural resources which surrounded them, and the national economy relied on the export of native crops. The sustainable use of resources was a fundamental aspect of rural life, people understood the interrelationships between the different components of their local environment and their activities which were defined by the need to protect their surrounding resources.

Agriculture is the major profession and source of income for the rural poor. Land degradation and soil depletion result in low crop yields and pollution of the environment; soil erosion and landslides are found in Thailand. Nutrient uptake by crops and loss by leaching is much greater than the nutrients applied. Hence soils become less productive and it results in more land requirement for food production. Forest land declines rapidly in hilly watershed areas.

Thailand is located in a tropical region and European countries are located in a temperate region. The climate is completely different, the temperature during summer in some European countries is probably almost the same as winter in Thailand. Not only is the climate in the two regions different, but land use and soil type are different also. These parameters have to be considered when studying the impact of agricultural diffuse pollution on the environment.

Research studies on agricultural diffuse pollution in water resources in Thailand show that nutrient loads and pesticide residues still do not exceed the standard level. However, there was a trend showing the increase of $N\text{-}NO_3$ in water resources, in short-term monitoring of nutrients in the east of Thailand between 1988-1990 and 1993-1995. The result showed the increase of $N\text{-}NO_3$ from 1.60 ppm to 2.54 ppm in the same watershed and landuse areas. If the use of fertilizers and pesticides in agriculture is increased without due consideration, Thailand will face the same problem as European countries. © 1999 IAWQ Published by Elsevier Science Ltd. All rights reserved

KEYWORDS

Diffuse pollution; nutrient; pesticide; monitoring; water resource.

INTRODUCTION

Diffuse (nonpoint source) pollution of water and groundwater is still a major problem in many countries. Thailand has begun to focus on agricultural diffuse pollution in recent years. The increasing use of chemical fertilizers, pesticides, growth regulators and feed additives in order to maximize yield, can cause pollution of water resources.

In 1990, Thailand applied 47 kg/ha of fertilizer which contained 26 kg nitrogen, 14 kg phosphorus (P_2O_5) and 7 kg potassium (K_2O) per ha. In the case of low fertility efficiency, about 40% of N was lost, 90% of P was fixed and 50% of K was fixed and leached. These elements moved into the groundwater, surface water and the sea in different amounts.

Fertilizer consumption in Thailand has increased over the last decade from 25 kg/ha (1983) to 47 kg/ha (1990) (UN, 1993), three times less than in European countries.

Thailand belongs to the twenty largest users of pesticides worldwide, and among the "developing countries" it is ranked among the five top users, after China, Brazil, Algeria and Egypt (UNIDO, 1984). Global figures state that fruit, including grapes, receives the highest amount of annual pesticide treatment, compared with other cash crops and field crops. It has been estimated that intensively cropped fruit orchards receive around eleven fungicide and ten insecticide applications per season in the tropical region (UNIDO, 1984).

Eutrophication of water bodies, lakes, rivers and coastal sea areas was a big problem earlier in certain areas. Increased awareness about environmental pollution has changed peoples attitudes considerably and people are really concerned about pollution. Crop production and fertilizer use have been identified as a main source of surplus nitrogen and phosphorus (diffuse pollution) in water, but probably untreated urban and industrial sewagecauses more pollution.

To protect natural resources, the government plan to develop an environmental pollution monitoring programme and integrated pest management (IPM) system. Agricultural production practices such as organic farming, intergrated farming and agro-forestry have been recommended to farmers.

SOIL TYPE, CLIMATE, GEOLOGY AND LAND USAGE IN THAILAND

The Kingdom of Thailand is located in Southeast Asia approximately between latitudes 5 and 21 °N and longitudes 97 and 106 °E with a total land area of 51,089 km^2.

The climate of Thailand is tropical and the average temperature in the coldest month (December) is not less than 18°C with the exception of some higher mountainous areas in Northern Thailand (2-7°C). There are two major rainfall distribution patterns. These are a monsoon type with distinct rainy and dry seasons occurring in the greater part of the country (average annual temperature 23-29°C, average annual rainfall 200-4,000 mm).

Geologically the country is made up of two parts: Northeast Thailand and the rest of the country (Beeser, 1972). The Northeast or Korat Plateau is underlain by subhorizontally bedded arenaceous rocks (clastic sediments of sand grain size) which in many places are covered by old and recent alluvial deposits. Geological structure and the alluvial cover are responsible for the predominant plateau-like character of this area.

The rocks underlying the rest of the country are folded and locally metamorphosed and include a wide variety of caustic rocks and limestones that, in many places, are intruded by igneous rocks. The dominant structural trend is approximately north-south and this has created a general topography of north-south elongated mountain and hill ranges that are separated by intervening alluvial plains, basins and valleys.

The widest lowland area is the Central plain that stretches from the Gulf of Thailand as far north as Sukothai. This plain is an area of subsidence that is filled from north to south with alluvial, brackish water and marine deposits respectively. Smaller coastal plains with old and recent marine and brackish water deposits occur in many locations along southeast and peninsular seaboards of Thailand.

Soils on steep slopes, with low fertility, and/or high salinity, present particular problems for cultivation. There are a number of land resource categories, as follows: land with severe fertility limitation (28%), constraint-free land (18.2%), arable and permanently cropped land (38.3%), steeply sloping land (34%),

shallow soil (2.9%), poorly drained with severe fertility limitation (28%). Arable land and forest occupy 57.10% and 31.41% of the total land area, respectively (Table 1). The arable land is intensively farmed, mainly with rice paddies (Table 2).

Table 1. Land use in Thailand (%)

Arable land	Forested land	Urban	Fallow	Reservoir
57.10	31.41	0.52	8.58	1.29

Table 2. Arable land in Thailand (%)

Rice	Vegetables	Fruit	Other crops
42.8	14.1	23.1	20

THE CAUSE OF AGRICULTURAL DIFFUSE POLLUTION IN THAILAND

The cause of agricultural diffuse pollution in Thailand is mainly from soil erosion, cultivation, aquaculture and irrigation return flow.

Cultivation

Thailand, due to its variety of climates and soils, low and highland areas, and due to the fact that domestic consumption and export of fruit are both steadily increasing, grows a wide variety of fruit. About 60 fruit species have been registered, 52 of them are tropical and only 4 species demand a temperate climate. Out of this wide range, only 17 species are of importance to the economy of the country: A fruit tree census carried out by the DOAE in 1987 indicated that these 17 species covered approximately 787,600 ha in total, and produced about 3.3 million tons of fruit.

On most farms, however, the use of cheap, broad-spectrum pesticides is common. The active ingredients cause various ecotoxicological effects. Canal/ditch systems are a characteristic feature of most citrus orchards in the central part of Thailand and fish raising is common in many of these systems. The use of chemicals results in toxic effects on the fish, and on the farmers because they consume fish from the canal. The consumption of pesticides varies drastically within the country and accurate data on agrochemical use for specific (fruit) crops are not easily available.

Weed control in orchards is generally done mechanically (slashing/cutting) supplemented by herbicides. This is particularly the case where there is a lack of labour because people prefer to work in industry.

Soil erosion

Deforestation, cultivation on very steep slopes (30-70%), and shifting cultivation in the northern highlands of Thailand can all cause severe erosion. Conversion of forest into farmland growing annual crops causes a drastic increase in soil erosion, from 0.6 ton/ha/annum under natural vegetation, to values as high as 100 ton/ha/annum under cultivation (Suthigoolabed and Ongprasert, 1996; Turkelboom *et al.*, 1995a). This is far above an acceptable rate, and eventually leads to soil and nutrient loss. Sediments and nutrients from the northern watersheds contribute to the improvement of soil fertility in the central plain. In order to replace the loss of soil fertility through erosion and continuous cultivation, farmers now begin to apply chemical fertilizers to ensure a good yield. Highland farmers, practising traditional shifting cultivatiion, rarely use chemicals. The application of fertilizers and pesticides (herbicides, insecticides) above the recommended levels can seriously affect the livelihood of the people downstream.

Aquaculture

Over the last decade shrimp culture has been expanded on a large scale in coastal areas of southern and eastern Thailand. The sludge and effluent from shrimp farms containing nutrients and chemicals has caused

pollution in coastal water areas, this has had a negative impact on seawater intrusion in freshwater areas and paddy fields.

Irrigation return flow

With the present population of 60 million, Thailand is among the few countries in the world that produces sufficient food for domestic consumption. The increasing global demand for food, and increasing prices of some crops, have made the farmers produce additional crops in the dry season.

Irrigation water from the highlands of northern Thailand has been used two or three times in lowland cultivation before flowing to the gulf of Thailand. These irrigation return flows contain high levels of nutrients and pesticides which can be harmful to the people in lowland areas and cause "red tides" in coastal areas.

THE SITUATION OF AGRICULTURAL DIFFUSE POLLUTION IN THAILAND

The major pollution problems in Thailand are caused by domestic and industrial untreated waste (point sources). Therefore, a monitoring programme of point sources has to have priority. In the past there were a few monitoring programmes of watersheds in Thailand to serve soil and water conservation in rural areas. Some short-term monitoring programmes of agricultural diffuse pollution in watersheds in rural areas have been conducted.

Table 3. The quantity of nitrate nitrogen and phosphorus in some watersheds in agricultural areas (ppm)

Watershed	Year	Nitrate-nitrogen (mean)	Phosphate (mean)
Ping River	1975	0.02	0.02
Wung River	1975	0.03	0.02
Tapee-Phumduag River	1979	0.09	0.28
She River	1977	0.09	0.04
Ravaeng	1990	1.60	0.24
Ravaeng	1995	2.54	0.15
Klong Thubma	1995	4.50	0.11

Sources: Ratana *et al.* (1997); Rungkarn *et al.* (1990).

Table 4. The trend of increasing nitrate nitrogen in watersheds in Thailand

Region	1978-1981	1996
	Nitrate nitrogen (mean) (ppm)	Nitrate nitrogen (mean) (ppm)
North	0.92	1.03
Northeast	0.46	1.91
East, Central	0.34	1.15
South	0.82	0.89

Source: Soil and Water Conservation Division, Land Development Department.

The amount of data from monitoring nutrients lost through water runoff is still small, but some data show the increase of nutrients in the watershed (Tables 3 and 4). Pesticide use seems to be a serious problem in Thailand, because the farmers are not aware of the toxic nature of pesticides.

Pesticides found in water in a vineyard in Ratchabury Province include: captan, copper oxychlorine, dimethoate, methamidophos, monocrotophos and mevinphos. The insecticide dimethoate was found in quantities higher than the standard level during eight months.

In 1993 Soraya *et al.* monitored the pesticides in water in the Pummelo orchard at Nakorn Pathom. Both organochlorine and organophosphate were found, but they did not exceed the standard levels.

In 1979, Prapussara *et al.* monitored pesticides in water resources at Bungboraped, Nonghan and Guanpayoa. They found the following pesticides: linden, heptachlor, aldrin, dieldrin and DDT; dieldrin occurred at the highest concentration.

PREVENTION OF AGRICULTURAL DIFFUSE POLLUTION IN THAILAND

The government introduced a fertilizer application recommendation for each upland crop on particular soil types. An integrated pest management (IPM) system has been introduced in fruit orchards in the highland and central region.

NGOs have tried very hard to push alternative agriculture as one of the national agricultural policies since the Sixth Plan. Fortunately, the government has responded to their wishes in the latest plan, the Eighth Plan (1997-2001). In this plan, reduction of agrochemical usage is mentioned and, to conserve natural and environmental resources, alternative agriculture development. The plan also states that alternative agriculture includes integrated farming, organic farming, natural farming and agro-forestry.

Organochlorine pesticides banned and/or restricted by the Minister of Agriculture include: endrin (1981), DDTc (1983), taxaphene (1983), aldrin (1988), dieldrin (1988), heptachlor (1988), and HCHs (1980).

Some programmes which should be conducted are land-use planning, soil and water conservation, reforestation, and shrimp culture management.

CONCLUSION

Agricultural diffuse pollution in Thailand is presently not severe due to low applications of fertilizer on cultivated land. However, if the trend of using fertilizers and pesticides increases, then we will face the same problems as developed countries.

We should not wait for the problem to arise, prevention must be by an integrated management approach including water resources, watershed management, farm lands and agricultural practices.

REFERENCES

Beeser, W. F. (1972). SSR No. 72A, Chapter on Geology.

Prapussra Pimpun *et al.* (1989). Bio-accumulation of pesticide residues in water through food chains. *Toxic Substances News and Reports*, **22**(2).

Ratana Jindapol *et al.* (1995). Effect of land use on suspended sediment and plant nutrients in Klong Yai watershed, Rayong province. In a research report submitted to DLD Land Development Department.

Rungkarn Krisnamra *et al.* (1990). A study of the water quality from eastern agricultural catchment areas. In a research report submitted to Land Development Department.

Sivaporn Skultiengtrong *et al.* (1993). Accumulation of pesticide in soil, water, sediment and fish in Pummelo Orchard under IPM Project; GTZ. *Toxic Substances News and Reports*, **22**(2).

Suthigoolabed, P. and Ongprasert, S. (1996). Soil Fertility Conservation on the Highlands. Proceedings of the 2nd Scientific Seminar, Maejo University, Thailand (in press).

UN (1993). Balanced Fertilizer Use. ESCAP/FAO/UNIDO/FAD/NAP. United Nations, New York.

UNIDO (1984). Global Overview of Pesticide Sub-Sector. Sectoral Working Paper United Nations Industrial Development Organization. Vienna. (unpublished).

Wipa Tungnipon *et al.* (1997). Accumulation of pesticide on soil and water in vineyard at Ratchaburi Province under the integrated pest control project. *Toxic Substances News and Reports,* 22(2).