Agrochemicals unmasked: fertilizer and pesticide use in Thailand and its consequences to the environment

Summary

The current industrial agriculture system promotes the reliance on agrochemicals, both synthetic fertilizers and pesticides, while neglecting to consider their negative effects on the economy of local communities, the human health and the environment. The long term use of high levels of agriculture inputs to boost crop yields have made it difficult to sustain the same rate of yield growth, and yields are becoming stagnant. Moreover, increased intensity of land use has led to increasing input requirements in order to sustain current yield gains. Environmental pressures are increasing as existing land and water resources come under threat from rapid urbanization. Land is being withdrawn from agricultural production, creating additional pressures, including the reallocation of water now used in agriculture. Furthermore, the need to use large amounts of agrochemicals to control pests and weeds has raised environmental and human health concerns. Agrochemicals pose health and environmental risks: they can pollute rivers and lakes through runoff and groundwater through leaching. There are proven alternatives to this expensive agriculture system: farmers are already fertilizing soils and protecting crops with organic and sustainable techniques that work with nature, not against it, and can provide food for all.

The use of chemical fertilizers in Thailand started to increase exponentially in the 1970s; between 1961 and 2003 fertilizer use increased 94 times, an spectacular increased from 18 thousand tones in 1961 to 1700 thousand tones in 2003. The total area dedicated to cereal crops also doubled during this period, reaching almost 12000 thousand hectares in 2005. In spite of the massive increase in chemical fertilizer use, the yield of rice and maize increased barely 1 time (doubling in 45 years). This indicates a tremendous loss of fertilizers into the environment due to their imbalance use and poor management.

There are many examples of fertilizers and pesticides polluting water and risking human health of Thai people. The Gulf of Thailand is suffering from eutrophication and toxic algal blooms, caused among other factors by runoff of fertilizers. In intensive farming areas, groundwater wells used for drinking are heavily polluted with nitrates, endangering people's health, especially for children. Dangerous pesticides applied in farms find their way into rivers and groundwater, and into foods sold in Thai markets. Direct poisoning with pesticides causes severe health effects on farmers, in 2003, for example 2406 cases of pesticide poisoning were reported in Thailand.

The future of farming lies in a modern type of agriculture that works with nature and with people, not against them. Millions of farms on all continents already prove that organic and sustainable agriculture can provide sufficient food, increase food security, replenish natural resources and provide a better livelihood for farmers and local communities.

The time has come to recognise the false promise of the Green Revolution and for governments to support the real revolution in farming that meets the needs of local communities and the environment, restores the land and enables the poor to combat hunger, displacement and depletion of their resources and culture.

Agriculture in Thailand

Once a predominantly agricultural country, agriculture growth in Thailand has slowed down during the previous decades. In the last 20 years, the contribution of agriculture to the national economy has dropped from 25% to less than 10% (Reunglertpanyakul, 1993). However, farming is still by far the most common form of employment in the country (65% of labor force in 2006). Population is still mainly rural, with about 68% of the population living in rural areas and 32 % in urban areas.

The Thai government has historically recognized agriculture as the principal driving force of economic growth in Thailand. Starting in the 1960s the government economic plans aimed at developing agriculture infrastructure for irrigation, transport and agriculture credits. In the 1970s the economic plans promoted the use of inputs such as agrochemicals (fertilizers and pesticides) and farm machinery with the development of credits to help boost agriculture growth.

Thailand is a country rich in natural resources and has a long history of exporting agricultural produce. Traditionally most farmers practiced subsistence farming and were self-sufficient, depending on natural processes to build soil fertility, control pests, and supplement their diets and income with wild plants and animals from the forest. The arrival of the Green Revolution in the 1960s dramatically changed the Thai countryside. The Green Revolution promoted the use of new varieties of crops that depend agrochemicals to produce higher yields. The new varieties were often susceptible to insect and disease pests and so insecticides and fungicides had to be introduced to combat pest.

The total cereal production in Thailand increased 2 times from 1961 to 2005, and the total land under cereal production almost doubled in the same period (from 6.500 to 11.5000 thousand hectares) (FAOSTATS 2007). Thailand is presently the world's largest exporter of rice (FAO, 2004). Food availability (measured as calories available per person per day) increased from 2,200 in 1990-1992 to 2,414 in 2001-2003 (FAO, 2006).

Organic agriculture, which emphasizes conservation and rehabilitation, is part of the solution to environmental sustainability and to the sustainable use of the natural resource base; however, currently to land area devoted to organic farming is very small (0.07%). Also, as more and more consumers worldwide are demanding safer food and environmentally responsible farming, organic products have better market access opportunities. This in turn assures a fairer income for small-scale organic farming families.

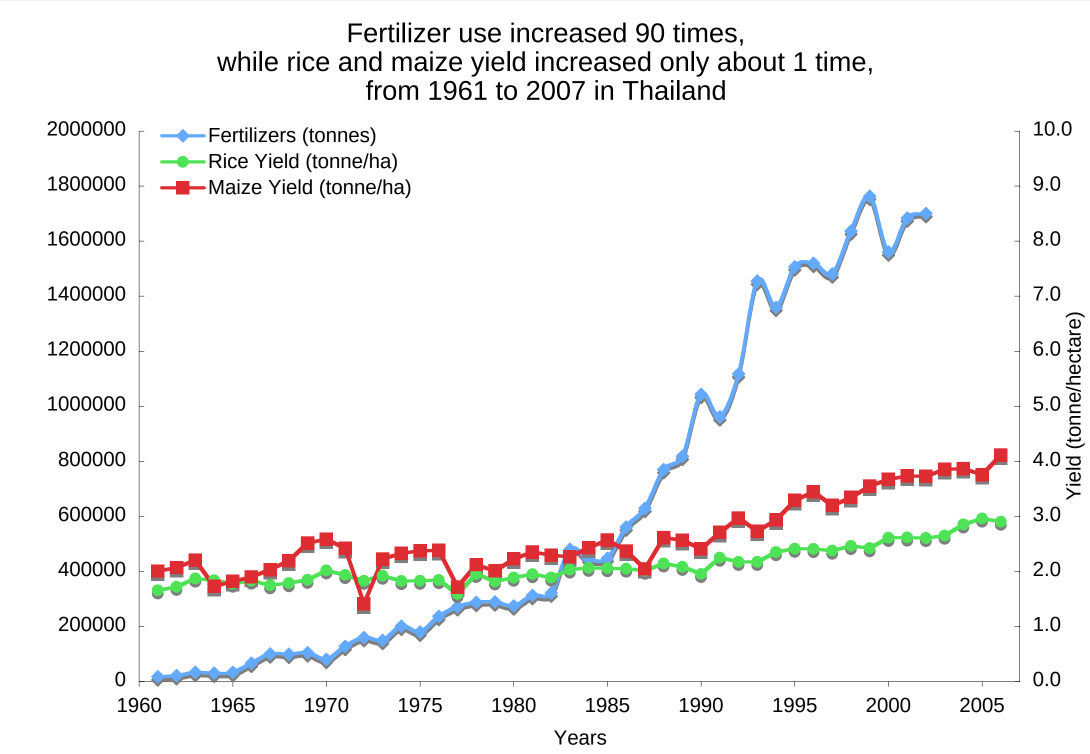

Figure 1. Fertiliser consumption (left axis) and rice and maize yield (right axis) in Thailand from 1961 to 2005. Data source FAOSTAT, 2007.

Agrochemicals

The current industrial agriculture system promotes the reliance on agrochemicals, both synthetic fertilizers and pesticides, while neglecting to consider their negative effects on the economy of local communities, human health and environment. The long term use of high levels of agriculture inputs to boost yields have made it difficult to sustain the same rate of yield growth, and yields approach the economic optimum levels. Moreover, increased intensity of land use has led to increasing input requirements in order to sustain current yield gains. Environmental pressures are increasing as existing land and water resources come under threat from rapid urbanization. Land is being withdrawn from agricultural production, creating additional pressures for the reallocation of water now used in agriculture. Furthermore, the need to use large amounts of agrochemicals to control pests and weeds has raised environmental and human health concerns. Agrochemicals pose health and environmental risks: they can pollute rivers and lakes through runoff and groundwater through leaching. There are proven alternatives to this expensive agriculture system: farmers are already fertilizing soils and protecting crops with organic and sustainable techniques that work with nature, not against it, and can provide food for all (Pretty et al. 2003, Badgley et al. 2007).

Fertilizer use

The use of chemical fertilizers in Thailand started to increase exponentially in the 1970s; between 1961 and 2003 fertilizer use increased 94 times, an spectacular increased from 18 thousand tones in 1961 to 1700 thousand tones in 2003 (Figure 1, FAOSTAT 2007). The total area dedicated to cereal crops also doubled during this period, reaching almost 12000 thousand hectares in 2005. In spite of the massive increase in chemical fertilizer use, the yield of rice and maize increased barely 1 time (doubling in 45 years) (Figure 1). This indicates a tremendous loss of fertilizers into the environment due to their imbalance use and poor management.

Production of major crops has increased considerably with the rapid expansion of planted areas over the last 30 years; however, the yield of major crops has not increased. Yields of some crops have actually decreased. Since increasing amounts of land with high fertility have been successively converted into cultivated areas, the average yields of crops have thus far not experienced drastic decreases. However, continuous cultivation with little or no recycling of plant nutrients have caused rapid productivity deterioration to most cropping areas (Chaiwanankupt, 1983).

The expansion of cultivated area has been restricted by government policy; therefore, the only means available to increase national agricultural production to meet the demand for exports and for domestic consumption is by increasing the yield per unit area. The Government has encouraged the intensification in the use of chemical fertilizers as the approach to increase crop production. However, Thai farmers are starting to increase fertilizer use at high rates without corresponding increases in yield, and there are now examples of overuse and inadequate use in Thai agricultural systems.

Pesticide use

The highest amount of pesticides used in vegetable and fruit farming, where market pressure for appearance is higher. Since pesticides were first imported into Thailand under the "Green Revolution Policy", as part of the 1st National Economic and Social Development Plan in 1966, the total amount of imported pesticides has dramatically increased year by year (Figure 2), and most pesticides used in the country are imported (Department of Pollution Control 2005). The quantities of imported agricultural pesticides have increased drastically from 1994 to 2005 (Figure 2). In 1994, most of imported pesticides were organophosphates, followed by carbonates. In 2000, organophosphates still contributed the majority of imported pesticides followed by carbonates and organochlorines (Department of Pollution Control 2002). In 2000, the entire amount of imported pesticides was about 40000 tones, which cost about 7294 million baht. Most were herbicides, followed by insecticides, disease control agents and plant growth regulators. Using WHO hazard categories, 54% of imported insecticides fell into the extremely hazardous category (Ia) and highly hazardous (Ib) categor (Pingali and Rosegrant, 1993).

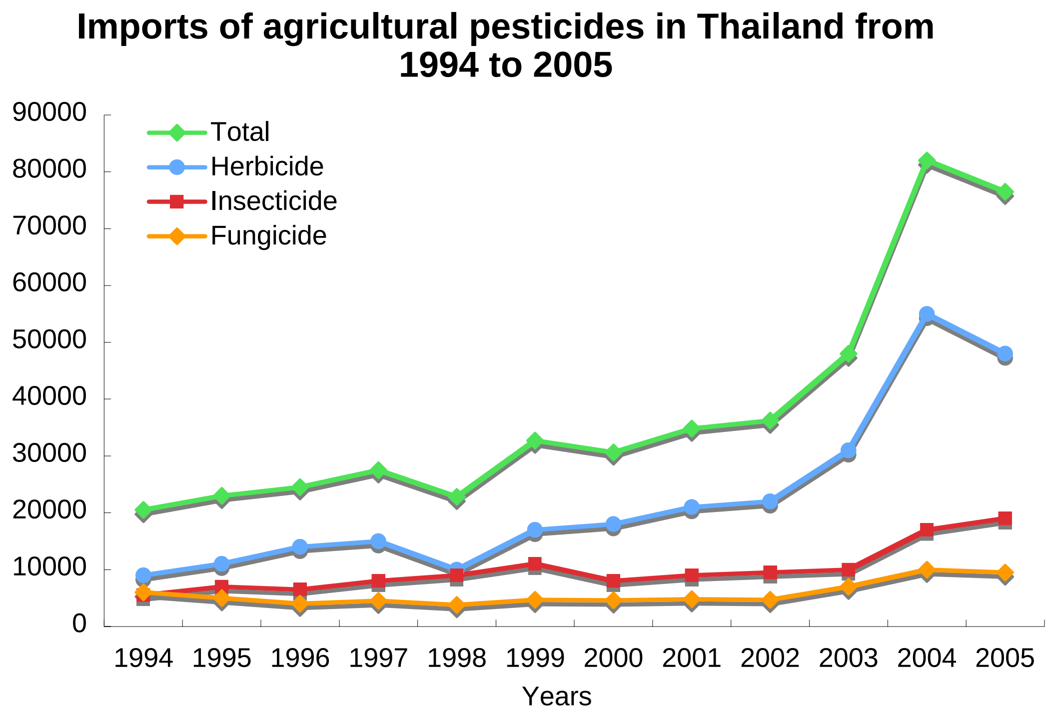

Figure 2. Tonnes of pesticide imported in Thailand between 1994 and 2005. Most pesticides used in Thailand are imported.

Initially, importation of pesticides was mostly in the form of finished products. Now there are three categories of pesticide imported in Thailand, the active ingredients, additive chemicals and separated packaging (Office of Industrial Economics, 2002). Because pesticides are often overused, Thai farmers' current use of pesticides is highly inefficient and has led to chemical poisoning. For instance, in order to save labour costs associated with spraying, farmers often mix pesticides themselves, creating a "cocktail" of several chemicals without considering their synergistic effects (Chaiwanankupt, 1983).

The rapid increase of pesticide use in Thailand may be accounted for in several ways:

- **Increase in cash crops:** Thailand's most pesticide-intensive crops, vegetables and fruits, are also its highest cash value added crops. As farmers have gradually switched from low value added to high value added crop production, the overall consumption of pesticides has naturally increased.
- **Higher application rate:** in order to raise yield, farmers have intensified pesticide use in the production of all crops. This is reflected in the increasing share of pesticide costs in total production costs.
- **Lower pesticide price:** along with an increased in the number of manufactures from 1986 to 1996, the average nominal retail price of Thai pesticides actually fell by 45 % in that decade. For example, the real price of the highly hazardous methyl-parathion fell by 23 percent (Ruhs et al 1997).
- **Farmers uncertainly in correct use:** the great gap between registered trade-names and generic names (3,058 trade-names and 247 widespread product adulteration (Sombatsiri, 1997)) have considerable increase farmers' uncertainly regarding the effectiveness of pesticides, which is widely agreed to be a major factor inducing pesticide use.
- **Government policies:** a number of public policies have encouraged pesticide use (Chaiwanankupt, 1983), and continue to do so.

Water pollution

Around 91 % of freshwater in Thailand is used for irrigation for the almost 5 million hectares of irrigated agriculture. Due to the high use of agrochemicals in Thailand in the last years, there is a high potential for pollution of water sources through irrigation runoff, return flows and infiltration. For example, the high rate of application of chemical fertilizers and pesticides in home gardens and commercial farms in the Rattaphum Catchment of Thailand in 2005 led to the accumulation of nitrates in the top-soil, and contribute to the high potential for agrochemicals contamination in the groundwater in the area (Chatupote and Panapitukkul, 2005).

In Thailand, surface water and groundwater are the water sources for tap water and drinking water for the Thai people (National Statistical Office). Water supply is available to over 98 % of the Thai population. Provision for sanitation has also reached nearly universal coverage within the country. According to WHO data, between 1970 and 2002 (2006 update), the fraction of the population with access to safe drinking water for the entire country was 85% (95 % of urban and 80% of rural). However, there appear to be still many cases of water pollution with agrochemicals throughout the country. In rural areas, which accounts for nearly 70 % of the population, there are still many problems related to water quality due to microbiological and chemical contaminations from both surface and groundwater sources.

Surface water quality

The Pollution Control Department (PCD) monitors the water quality in the major rivers and lakes in Thailand. The major causes of water pollution in the country are related to fecal coliform bacteria, high solids, organic matter and nutrients (phosphates, ammonia and nitrates) (Simachaya, 2002).

According to the Pollution Control Department, in 2003 around 60% of the water bodies surveyed were suitable for agriculture and general consumption (“good” and “moderate” quality). However, more than 40% of Thailand’s surface waters were in “poor” or “very poor” quality. No surface water was categorized as “very good” quality (extra clean water which is suitable for aquatic animals and human consumption after normal treatment), and the surface water quality appeared to be slightly worse than in previous years in terms of dissolved oxygen and total coliform bacteria indicators.

The Pollution Control Department also monitors coastal water along the coastline and islands. In 2003, 68% of the sampling stations showed “very good” or “good” quality, while 33% showed indicated “fair” or “poor” quality. Compared to previous years, coastal water quality had deteriorated, especially in the areas where the four main rivers flow.

Groundwater status

In agriculture, groundwater is mainly used to supplement surface water sources. It is also a clean water source used within households and for agriculture and livestock. Groundwater is used for public water supply for one fifth of the nation’s towns and cities and for half of the sanitary districts. It is estimated that 75% of domestic water is obtained from groundwater sources and that they service some 35 million people in villages and in urban areas. Increasing demand for water has led to a growing unsustainable reliance on groundwater. Moreover, groundwater pollution is occurring from a number of sources and urgently needs to be controlled.

Nitrates pollution

Agriculture contributes directly to water nitrate pollution through fertilizers. Often, too much nitrogen fertilizer is applied to crop soils, the excess not used by the plants runs-off polluting groundwater, rivers, and finally coastal areas. Drinking water polluted with nitrates poses health risks, especially to children. Lakes and coastal areas polluted with nitrates cause major problems by eutrophication and massive growth of harmful algae. Nutrients from agricultural and domestic waste sources have resulted in eutrophication of major water bodies worldwide. Eutrophication causes loss of productivity due to low dissolved oxygen concentrations in water, but of particular concern is the explosive growth of algae (cyanobacteria) and toxins production. Global warming may exacerbate the occurrence of algal blooms in future years.

Recent studies in Thai reservoirs have found blooms of toxin-producing algae in the water bodies (Peerapornpisal, 2006). Earlier studies in the Mae Kuang Udomtara Dam reservoir in Chiang Mai found proliferation of the blue-green algae *Microcystis aeruginosa*, which secretes the potent liver toxin microcystin. The explosive growth of this alga is related to nutrient enrichment, particularly phosphates (Peerapornpisal et al 1999). In 2001 and 2002 the toxic blue-green algae *Microcystis aeruginosa* was found in every sample taken in Mae Kuang Udomtara reservoir in Chiang Mai, although at lower concentration than the indicative of a harmful bloom (Chanttara et al 2002).

Rate of occurrences of plankton bloom has been increasing in the last decades years in the Gulf of Thailand (Singhasaneh 1995). Two species of blue-green algae (*Trichodesmium erythraeum* and *Trichodesmium thiebautii*) and *Noctiluca miliaris* were found to be the cause of sea water algal blooms. Blooms are also frequently seen in the vicinity of estuarine area as red, green, yellow, and brown tides (Singhasaneh 1995).

The Gulf of Thailand has been a major marine resource for Thai people during centuries. However, recent agricultural and industrial development has exerted considerable stress on the marine environment. Eutrophication is the most serious problem of the inner gulf of Thailand nowadays (Menasveta 2001, Cheevaporn and Menasveta 2003). The runoff from Thailand's four principal rivers ends into the Gulf causing eutrophication: the Chao Phraya is the most polluted of the four rivers, particularly in the river estuary area due to the urban and industrial expansion. The Ta Chin is becoming increasingly polluted due to accelerated agricultural and industrial development as well as urban expansion from the Bangkok area. Eutrophication can cause explosive bloom of algae, frequently in the form of red tides. In occasions, paralytic shellfish poisoning (PSP) after consuming contaminated mussels in the red tide area of Pranburi river estuary have occurred, causing even human deaths (Menasveta 2001). Anoxic conditions due to algal blooms could cause massive fish killed, in August 1991 there was a mass fish killed in the coastal area of Cholburi due to a vast red tide blooming of *Noctiluca* covering the area from Bangsan district to Pattaya (Menasveta 2001).

Other potent toxins produced by algal blooms were found in the Bang Phra Reservoir in Thailand, associated with high nutrient levels in the water body. In particular, nitrogen and phosphorus are the two major nutrients driving growth of algae in the reservoir (Wang et al. 2002).

Approximately 91% of surface water withdrawn in Thailand is used by the agricultural sector, particularly for paddy rice, which is the major crop in the country (EarthTrends Country Profiles, 2003). Water pollution resulting from discharges from paddy fields is becoming more serious, particularly in river basins where rice is the main economic crop (Tougkasame 2007). Discharges of nitrogen, phosphorus and pesticides are the main pollutants from paddy rice farming affecting water quality. Water pollution caused by rice farming also affects the populations of fish and other aquatic fauna. In Pranburi Irrigation Project area (Prachuab Khiri Khan province) the density of fish and benthic faunas in 2005 was less than half in the section downstream of the paddy irrigation area compared to that in the upstream section (away from the influence of rice farming).

A study in a pilot rice paddy field located at the Asian Institute of Technology (AIT campus, Pathumthani) showed that 20% of the nitrogen applied as fertilizers to paddy fields found its way into the river basin through surface runoff and percolation. The nitrate concentration in the groundwater increased more than 3 times after fertilization (from 1.8 mg l^{-1} to 7.2 mg l^{-1} NO_3^-). Contamination of groundwater is therefore a concern especially if these practices (like application of excess fertilizers) are continued over long time periods (Pathak et al 2006).

A recent survey found examples of water pollution with nitrates in intensive farming areas in the Central Plain (Kanchanaburi and Suphanburi) (Greenpeace 2007) In Kanchanaburi, the study found a clear example of heavy fertilizer use related to water pollution with nitrates in asparagus farms: in 6 out of 11 asparagus farms, nitrates levels in groundwater wells were above the WHO drinking water safety limit of 50 mg/l NO_3^-, in some cases 2 times higher than the safety limit, and even in the other five wells nitrate levels showed evidence of pollution. In Suphanburi, two of the five wells sampled in farms had nitrates levels higher than the WHO safety limit. These high levels of nitrates in drinking water could have serious health effects for the local population, especially for children.

Thailand has several strategies to manage and mitigate water pollution from agricultural activities. One of them is to build understanding among farmers in the appropriate uses of agrichemicals to prevent excessive and untimely uses, thus minimizing their residues in soil and water. Stringent control of import highly toxic agrichemicals is another measure. However, these measures are clearly insufficient and much more needs to be done to avoid water contamination and health risks associated with agrochemicals.

Pesticide pollution

From 1993 to 1999 the main rivers in Thailand were monitored for the presence of pesticide residues; most water samples contained insecticide and herbicide residues in levels above advisable limits, whereas less contamination was observed in sediment samples. In river water, organochlorine pesticides were detected in 40.62% of the samples (in concentration ranging from 0.01 to 1.21 µg/l), organophosphate pesticides were detected in 20.62% of samples (in concentration ranging from 0.01 to 5.74 µg/l). The safety limit established by the European Union is 0.1 µg/l for any single pesticide and 0.5 µg/l for the sum of all pesticides detected. Both organochlorine and organophosphate pesticide residues were found above those safety limits. Additional compounds, like carbamate pesticides were detected in 12.39% of samples (in concentration ranging from 0.01 to 13.67 µg/l), triazines were detected in 20.0% of samples (in concentration ranging from 0.01 to 6.63 µg/l), and paraquat was detected in 21.36% of samples (in concentration ranging from 0.14 to 87.0 µg/l) (Chulintorn, et al., 2002). An earlier study has also found residues of the pesticides DDT and dieldrin in five Thai rivers (Upper Ping, Lower Ping, Wang, Yom, Nan, Chee), in concentrations above acceptable standard levels (Sombatsiri, 1997).

The Division of Agricultural Toxic Substances in the Department of Agriculture (Ministry of Agriculture and Cooperatives) has also monitored the presence of pesticide residues in rivers and canals around agricultural areas in the country. The contamination of pesticides in water and sediments was generally low in water resources used for domestic consumption like ponds and reservoirs that have no connection to agricultural plantations. However, the water resources in certain agricultural areas, like orchid and ornamental plantations, were contaminated with organophosphate and carbamate insecticides.

From 1999 to 2001, a survey of three major rivers along paddy field areas (Thachin river in Suphanburi and Nakornpathom, the Chao Phraya river in Pathumthani and Nonthaburi, and the Bangpakong river in Chachengsao), found the highest residues of the insecticide endosulfan in the Thachin River, followed by the Chao Phraya and Bangpakong Rivers. In all cases, the levels of pesticide residues were above the safety limit set by the European Union (0.1 µg/l) (Chatsantiprapha, et.al., 2002).

In 2001, groundwater in the lower Central and the lower Northeastern region of Thailand was contaminated with pesticides residues, in many cases in concentration above the safety limit set by the EU (0.1 µg/l). In the lower Central region during the rainy season in 2001, 68% of the total groundwater samples were contaminated with endosulfan and other insecticides, in concentration ranging from 0.02 to 3.2 µg/l, and paraquat, 2,4-D, butachlor, atrazine and metribuzin herbicide residues ranging from 0.02 to 18.9 µg/l. In lower Northeastern region during the dry season in 2001, 71.2% of the total groundwater samples were contaminated with endosulfan and other insecticides, in concentrations from 0.01 to 0.33 µg/l, and atrazine and paraquat herbicide residues at the level of 0.5-4.0 µg/l (Sakultiangtrong, et.al., 2002).

In 1993, the Department of Agriculture investigated shallow groundwater wells from Rayong Province. From 160 samples collected from wells, 67% were contaminated with organochlorine and organophosphate pesticides, but in concentration below the safety limits (Pollution Control Department, 2004).

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Health risks associated with nitrates and pesticides

Nitrates

Babies and infants living around agricultural areas and who drink water from wells are the most vulnerable to health risks from nitrates. Additionally, anyone drinking from a contaminated well could be vulnerable to the long-term effects of nitrates, such as various types of cancer (Greer et al. 2005). The greatest risk of nitrate poisoning is considered to be the *blue baby syndrome* or *methemoglobinemia*, which occurs in infants given nitrate-laden water, and affects particularly babies under 4 months of age (Greer et al. 2005). Blue-baby syndrome occurs when the hemoglobin in the blood losses its capacity to carry oxygen, and this can ultimately cause asphyxia and death.

One common and well-documented effect of intensive fertilizer use, mainly through nitrates, is the eutrophication of coastal and marine ecosystems (Robertson and Swinton 2005). This can lead to ecological changes with impacts on human health. One of the consequences of eutrophication is the worldwide increase in harmful algal blooms. Algal blooms can lead to the proliferation of algal species that produce toxins. When the algae are ingested by shellfish this can result in neurological, amnesic, paralytic, and/or diarrhetic shellfish poisoning in human consumers.

Pesticides

In 1972 the government put in place the primary legislation for the control of pesticides use in Thailand, the Hazardous Substance Act (1972). While this legislation has reduced pesticide impacts, cases of pesticide poisoning of Thai farmers continue to be reported. In 2003, 131 000 tonnes of pesticides were used and 2,406 cases of pesticide poisoning were reported.

Over the past decade, pressures to sustain high crop yields have led to heavy usage of pesticides. Residues, especially organochlorine and organophosphate compounds, have been found in soil, water, and agricultural products throughout the country. Occupational exposure and suicide are the main causes of pesticide poisoning to Thailand's residents**.** Recognizing the growing problem, Thailand's government has enacted environmental laws and education programs aimed at minimizing adverse effects of pesticides (Poapongsakorn, et.al., 2004).

All of the organochlorine insecticides that were classified under the Stockholm Convention as persistent organic pollutants (POPs) were prohibited or banned from use, import, export and production in the country on different occasions: Aldrin (1988), Chlordane (2000), DDT (1983), Dieldrin (1988), Endrin (1981), Heptachlor (1988), Toxaphene (1983), Mirex (1995), and PCBs (1975).

Like in the other Asian countries, several factors contribute to the direct health risks associated with pesticides, including the mixing high potency pesticides to make toxic cocktails, increasing pesticide dosages over recommended limits, preference for strong and fast acting pesticides, improper disposal of empty containers, using inappropriate pesticides, and lack of education on handling the pesticides.

The application of pesticides adversely affects consumers indirectly through the chemical residues left in food after application. A study conducted between 1982 and 1984 by the Food and Drug Administration and the Department of Medical Sciences detected chemical residues in 52 % of the 663 food samples analyzed; including DDT in 39 %, and dieldrin in 15 % of the samples (Jungbluth 1997). Another study published in 1995 by the Division of Toxic Substances found that 37 % of the sampled vegetables were contaminated with insecticide residues.

The amount of the chemical residue left in the crop is higher when higher is the concentration of the pesticide applied and when spraying rounds are more frequent in time (Sombatsiri, 1997). As Thai farmers generally spray highly concentrated pesticides with little intervals between spraying rounds, chemical residues in food are generally high.

In 1995, the Occupational Health Department (Ministry of Public Health) found that 18 % of the farmers tested (85.140 farmers out of 463.142) had unsafe levels of pesticides in their blood, an increase over the 16 % found from similar blood testing of farmers done in 1994.

One earlier study examined the problem of pesticide poisoning in Rayong Province. Researchers assessed an agricultural community for pesticide poisoning. Of the total community, 46.2% of people had agriculture-related employment, and 42.3% handled pesticides as part of their daily work. Of those, 19.5% had experiences some type of pesticide poisoning. Data showed that pesticide poisoning was a major problem, and researchers concluded that implementation of pesticide control legislation was inadequate (Wongphanich, 1985).

A study by the Division of Toxic Substances on pesticides residues in fruit and vegetables found that around 37 % of vegetables were contaminated with organophosphate insecticide residues. About 20 % of kale and 10 % of cowpea showed residues exceeding the Maximum Residue Limits (MRL). 73 % of tangerine samples were contaminated with pesticide residues (around 10 % exceeding the MRL). Pesticide residues consisted mainly of malathion, monocrotophos and methyl parathion (Palakool, 1995).

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