Agrochemical use in the Philippines and its consequences to the environment

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Contents

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Summary

Agriculture has been the traditional backbone of the Philippines' economy and farming is still by far the most common form of employment in the country. 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 the environment.

The widespread use of irrigation, agrochemicals and new seeds have largely increased agriculture production, but this model of agricultural growth is flawed because of declining crop yields and massive environmental impacts. According to the recent Food and Agriculture Organization of the United Nations (FAO) data, between 1961 and 2005 fertilizer applications in the Philippines increased by 1000%, while yields of rice and maize increased only by 200 and 280% respectively, and the yield of pulses remained about the same.

From 1977 to 1987 pesticide use increased by 325%, while rice yield increased by only 30%. Pesticide imports have continued to increase, while rice and corn yields have increased at a much smaller rate.

Poverty in rural areas is not being reduced in the Philippines, and it affects many smallholding farmers. However, farmers are still encouraged to spend heavily in seeds and agrochemical inputs (the main expenditure in farms is agrochemical inputs: 65% for fertilizer and 18.2% for pesticides). After the introduction of high yielding varieties of seeds in the 70s, indigenous rice was almost eradicated and farmers have lost ownership of the seeds they grow.

In general, the excessive and inappropriate use of chemical fertilizers in crop soils cause land degradation and losses in soil fertility worldwide. Moreover, agrochemicals cause water pollution that directly and indirectly affects human health. According to the National Economic and Development Authority (NEDA), 37% of the total water pollution originates from agricultural practices, which include animal waste and fertilizer and pesticide runoff. Water pollution from nitrates derived from fertilizer runoff is more widespread in the Philippines than previously thought. For example, a recent analysis by Greenpeace of groundwater in Benguet and Bulacan Provinces found that 30% of the tested artesian wells had nitrates levels above the World Health Organization (WHO) drinking water safety limit. Other studies have also found high levels of nitrates around sweet pepper farms in the Manguang area in Ilocos Norte. 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. Moreover, anyone drinking from a contaminated well could be vulnerable to the long-term effects of nitrates, such as various types of cancer.


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Agriculture runoff fuels large algal blooms in vulnerable areas of the ocean, especially in tropical marine ecosystems that are naturally low in nitrogen. In the Philippines, more than 120 outbreaks of red tide and other harmful algal blooms occurred in coastal waters between 1990 and 2003, most of them in Manila and Masinloc Bays. In Manila Bay, toxic blooms have been increasing since its first recorded occurrence in 1983 and 80% of blooms have occurred during the last decade. Eutrophication caused by organic and nutrient discharges from aquaculture and agriculture seems to be the major causes of algal blooms in fresh and coastal waters in the Philippines. 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 diarrheic shellfish poisoning in human consumers.

Toxic pesticide residues which can also pollute water bodies used for drinking, are toxic to fish and can accumulate in many aquatic organisms. Between 1995 and 1999, residues of the pesticides Azin and Butachlor were found in groundwater wells around farming areas in Ilocos Norte in concentrations higher than the European Union (EU) safety limits. Recently, researchers at the Benguet State University have found pesticide residues of organophosphates, organochlorines and pyrethroids in soil and vegetables grown in the Benguet municipality.

Pesticides can provoke acute and chronic toxic effects in humans. Pesticide self-poisoning is the most common form of suicide in rural Asia, accounting for 60% of all deaths. Between April 2000 and May 2001, 273 cases of pesticide poisoning cases were reported to the Philippine National Poison Control and Information Service. Around 88% of those cases were due to intentional oral contact. More than 60% of the victims were between 10 and 35 years old. Chronic effects of pesticides can deteriorate the health of people living in rural communities. However, not only farmers and rural communities are affected. The effect of pesticide application also affects other populations which consume contaminated food and water. Pesticide exposure can trigger chronic eye, skin, pulmonary, neurological, and renal problems in people who manage pesticides or are exposed to them.

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 recognize 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.


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I. Agriculture in the Philippines

Agriculture has been the traditional backbone of the Philippines' economy and farming is still by far the most common form of employment in the country. Only about one-third of the total land area in the country is classified as arable, and all of it is currently in production. Soils are generally fertile, but 30% of the agricultural land is suffering erosion. Roughly half the cultivated land is devoted to the two principal subsistence crops, palay (unhusked rice) and corn.

Agriculture in the Philippines has experienced a great transformation in the last 50 to 60 years. Agriculture productivity started to increase in the 1960s as a consequence of improved agricultural infrastructure, especially irrigation, a massive increase in the application of chemical fertilizers and pesticides, and the introduction of new crop varieties known as high-yielding varieties (HYVs) (Figure 1). The *Masagana 99* project, initiated by President Ferdinand Marcos in 1972 to promote the Green Revolution principles, produced a massive increase in agrochemical use and HYVs adoption by farmers. Ten rice HYVs were encouraged, and consequently indigenous rice was almost eradicated. As a result of this and the other industrial techniques adopted, biodiversity was severely threatened and soil started to degrade rapidly. By 1982, 93% of the irrigated lowlands were planted with HYVs (Mariano, 1999).

Current government policies still promoted massive use of pesticides and fertilizers, as well as HYV seeds. In addition, monopolistic practices by big chemical and biotechnology companies that dominate Philippine market (DuPont controls 65% of the seed market in the country) are questioned because they can exert great pressure over policy makers (Mariano, 1999).

Despite the steady increase in crop productivity that the Philippines experienced in the second half of the 20th century, the country is still far behind most Asian countries in terms of productivity or food security of crops such as rice or maize, of which Philippines is a net importer. The country remains competitive almost exclusively in corporate-grown fruits such as banana or pineapple (Pascual-Gapasin, 2006). New government plans (MTPDP, 2004-2010) focus on the development of new high-value farm crops, vegetables and fruits with much higher yields and income than corn or rice, the traditional staple crops. In the Philippines, poverty is essentially a rural phenomenon and food production within smallholders has grown less than the growth of the population.

The widespread use of irrigation, agrochemicals and new seeds have largely increased agriculture production, but this model of agricultural growth is fatally flawed because of declining crop yields and massive environmental impacts. Poverty in rural areas is not being reduced in the Philippines (NEDA, 2004a), and food security will not be achieved through outdated, expensive fixes such as ever-increasing amounts of chemical fertilizers or pesticides, or genetically-engineered crops.

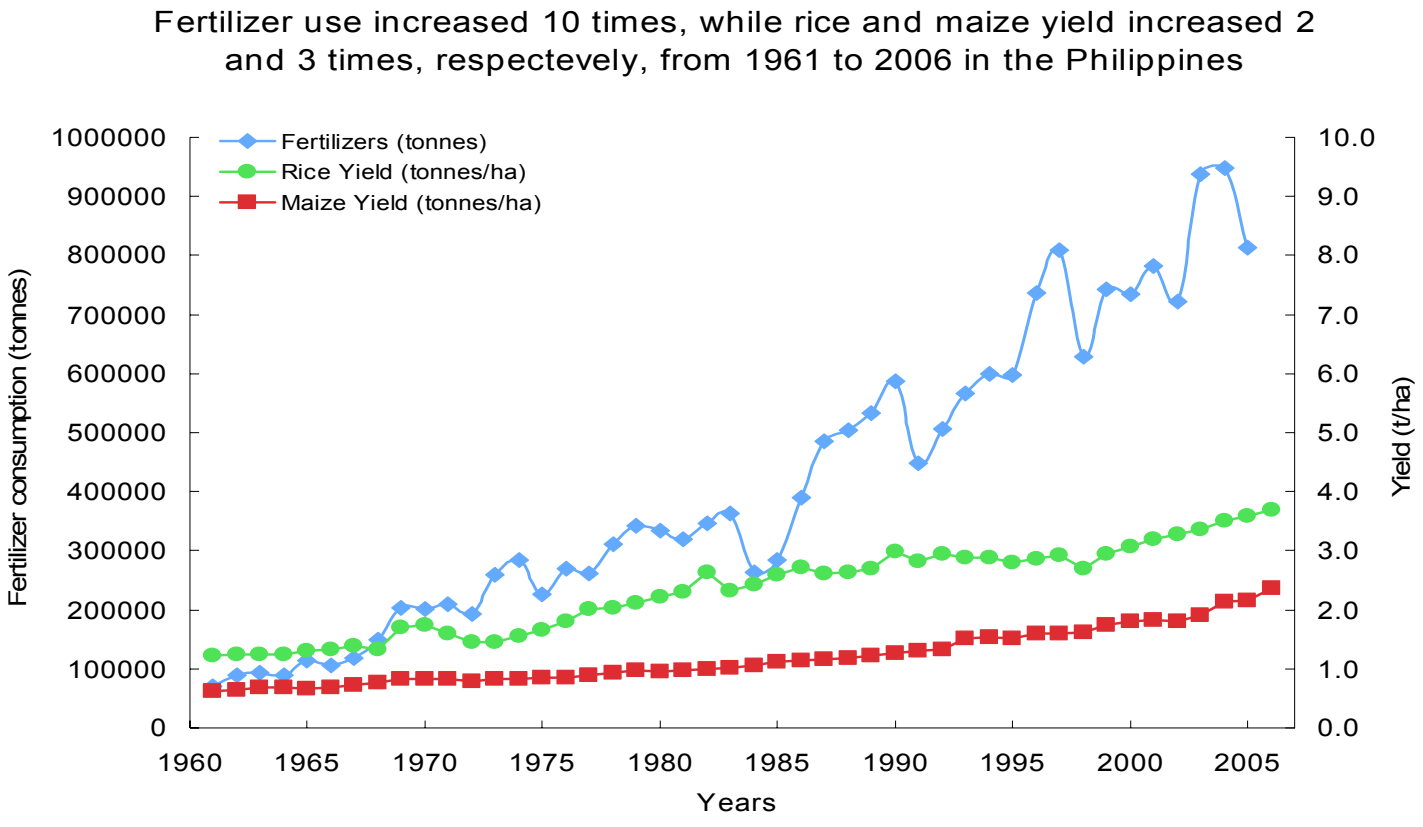
The future of farming lies in a modern type of agriculture that works with nature and with people, not against them. Millions of farms on all continents already prove that organic and sustainable agriculture can provide sufficient food, increase food security, replenish natural resources and provide a better livelihood for farmers and local communities (Badgley et al. 2007).

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.

II. Agrochemicals

The current industrial agriculture system promotes the reliance on agrochemicals, both synthetic fertilizers and pesticides, while neglecting to consider their negative effects on local communities, human health and the environment. The main expenditure in conventional farms is agrochemical inputs (65% for fertilizer and 18.2% for pesticides) (Mendoza 2004). However, 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 which can provide food for all (Pretty et al. 2003, Badgley et al. 2007).

Figure 1. Evolution of fertilizer use and rice and maize yield in the Philippines from 1961 to 2001. Source FAOSTAT, 2007.



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Fertilizer use

The use of chemical fertilizers in the Philippines started to increase exponentially in the late 1950s; between 1961 and 2005 fertilizer applications increased by 1000% (Figure 1, FAOSTAT 2007). In spite of this massive increase in chemical fertilizer use, the yield of rice and maize increased only by 200% and 280%, doubled and tripled respectively, while the yield of pulses remained about the same. This indicates a tremendous loss of fertilizers into the environment due to their imbalanced use and poor management.

While fertilizer sales almost doubled in the 1990s, the improvement in crop yield was minimal. The major reason for the low response of crops, particularly grain, is the imbalance in the use of nitrogen (N) and phosphorus (P), and also the deficiency in sulphur caused by the extensive use of urea. However, under the current model, farmers also struggle with rising costs of farm inputs and recommended technology (NEDA 2004a).

In general, the excessive and inappropriate use of chemical fertilizers in crop soils cause land degradation and losses in soil fertility worldwide. Philippine farmers are starting to see these problems. And while the government Fertilizer and Pesticide Authority (FPA) acknowledges that the need for finding the right “balance” in fertilizer application is one of the current priorities (Arboleda, 1998), fertilizer policies in the Philippines have usually aimed for the conflicting objectives of low-priced, subsidized fertilizers for farmers and incentives to fertilizer manufacturers. The FPA acknowledges that farmers are currently using too much nitrogen fertilizer, while soils are losing other nutrients like phosphate and potassium (FPA 2007, http://fpa.da.gov.ph/newdevt.html). At the same time, the FPA believes the demand for all types of fertilizers will continue growing for the next fifteen years, and thus “the fertilizer manufacturing sector of the Philippines will continue to play a vital role in sustaining agricultural productivity and stable food supply until the next millennium” (FPA 2007, web. http://fpa.da.gov.ph/newdevt.html). It is worthwhile to note past experience has shown that yields and food supply do not respond exclusively to synthetic fertilizer use and that organic materials are key to maintaining and restoring soil nutrient exchange capacity; thus, we need a modern approach that considers sustainable ways of securing future soil fertility.

Pesticide use

Insecticides are by far the most used type of pesticide in the Philippines; they represented 56% of the total pesticide trade in the country in 1996. Insecticides are generally highly toxic to fish and tend to bioaccumulate in aquatic organisms. The most widely used pesticide types are organophosphates, carbamates and pyrethroids. The three most important crops using pesticides are vegetables, banana and rice. While the largest gross amount of pesticides in the Philippines is used in rice (due to a larger production area), pesticides are

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used more intensively in vegetables (ACIAR, 2000).

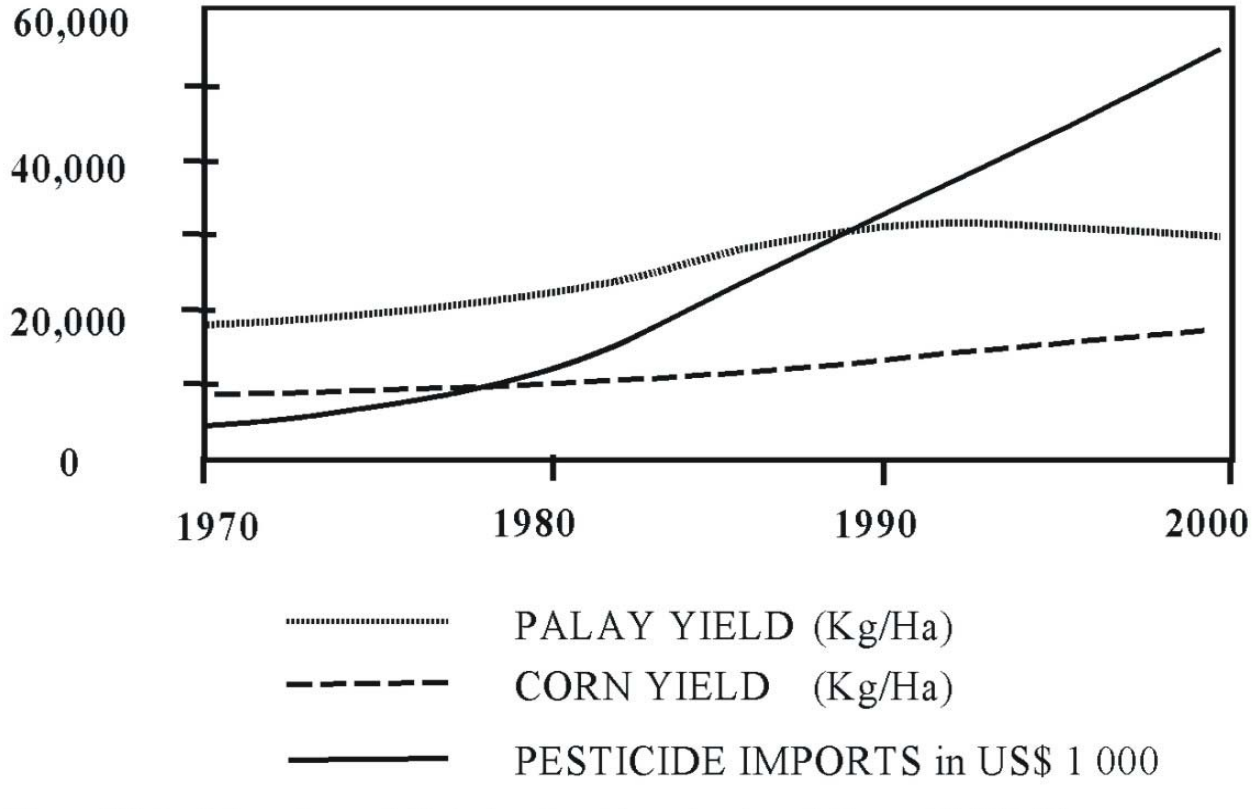
Prior to the 1970s, the use of pesticides in Philippines was mainly concentrated in plantation crops. Small farms started to use pesticides intensely in the early 1970s. During the period from 1972 to 1978 the import of pesticides in the Philippines grew some 500% (Mariano, 1999, Loevinsohn and Rola, 1998).

From 1977 to 1987 pesticide use increased by 325%, however, rice yield increased by only 30% during this time (Figure 2). Pesticide imports have continued to increase, while rice and corn yields have increased at a much smaller rate (Figure 2).

III. Water pollution

Despite high rainfall, since 2000 the Philippines has had the second lowest per capita freshwater availability in Southeast Asia. The supply of freshwater has been diminishing due mainly to overuse of groundwater, denuded forests and watersheds and water pollution. Agriculture is estimated to use around 75% of the total water demand in the Philippines (FAO, 2004). According to the Philippine 2001-2005 National Water Quality Status Report (EMB, 2006), groundwater contamination is mainly caused by salinity, fecal coliforms and nitrates. 37% of the total water pollution originates from agricultural practices, which include animal waste, and fertilizer and pesticide runoff (NEDA, 2004b).

Figure 2. Evolution of rice and maize yields and pesticide use (FAOSTAT).

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Nitrate pollution

Agriculture contributes directly to water nitrate pollution through fertilizer runoff. Often, too much nitrogen fertilizer is applied to crop soils, and the excess that is 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 harmful algal blooms in future years, since higher temperatures may increase algal growth and favor toxic algal species (Chu et al. 2007).

The Environment and Natural Accounting Resources Project (ENRAP) estimated in 1998 that the major contribution of nitrogen in Philippine waters comes from agriculture (fertilizers and livestock) at a rate of 1892 kg nitrogen per square kilometer per year. Nitrate pollution in drinking water related to fertilizer use seems to be more widespread in the Philippines than previously thought. A study monitoring groundwater wells in agriculture areas from 1995 to 1999 found nitrates levels above the World Health Organization (WHO) safety limit (50 mg l-1 NO3-) in wells around sweet pepper farms in Manguang in Ilocos Norte. Seasonal mean concentrations were around 40 mg l−1, close to the WHO limit, and maximum concentrations were two to four times the WHO safety limit (100-170 mg l−1 (Bouman et al. 2002). A different study in the same area also found that 60% of the monitored water sources in the watershed showed nitrate pollution above WHO limits (Shrestha and Ladha 2002). These high levels of nitrates in groundwater are often related to crops that are heavily fertilized with nitrogen fertilizers.

A recent survey found that groundwater wells in vegetable farming areas in Benguet, the ‘salad bowl’ of the Philippines, were also polluted with nitrates levels above WHO limits (Tirado 2007). This study showed examples of groundwater pollution with nitrates in the two provinces sampled, Benguet and Bulacan, and this pollution seems related to intensive farming areas where nitrogen fertilizers (and other agrochemicals) are applied in excess (Reyes and Laurean 2006, 2007). In 30% of the artesian wells tested, nitrates levels were above the WHO drinking water safety limit (Tirado 2007).

Agriculture runoff fuels large algal blooms in vulnerable areas of the ocean, specially in tropical marine ecosystems that are naturally low in nitrogen (Beman et al. 2005). The current trend towards agriculture intensification show that by the year 2050, 27-59% of all nitrogen fertilizer will be applied in developing


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regions located upstream of nitrogen-deficient marine ecosystems, which highlights the present and future vulnerability of these ecosystems to agricultural runoff (Beman et al. 2005). The Philippines' shores are in one of these vulnerable ocean areas, and they have experienced more than 120 outbreaks of red tide and other harmful algal blooms in coastal waters between 1990 and 2003, most of them in Manila and Masinloc Bays (Wang et al. 2008). In Manila Bay, toxic blooms have been increasing since its first recorded occurrence in 1983 (Sombrito et al. 2004), 80% of blooms have occurred during the last decade (Wang et al. 2008). In Laguna de Bay, the largest freshwater lake in the country, a regular occurrence of the toxic blue-green algae *Microcystis aeruginosa* blooms is experienced during the months of May to July or from September to November, varying from year to year (Baldia et al. 2003). Toxins produced by the blooms could endanger fish produced in aquaculture, the major economic activity in the lake. Eutrophication caused by organic and nutrient discharges from aquaculture and agriculture seems to be the major cause of algal blooms in fresh and coastal waters in the Philippines (Wang et al. 2008).

Pesticide pollution

A study by Bouman et al (2002) found residues of dangerous pesticides in the artesian wells around agriculture areas in Manguang in Ilocos Norte and in other locations in Laguna and Nueva Ecija (Luzon Island). In some wells, levels of the pesticides Azin and Butachlor were higher than the safety limit set by the European Union (0.1 µg/L), and the maximum observed levels for other pesticides (Carbofuran, DDT, Diazinon, Endosulfan, Endrin, MIPC, and Parathion) were also above the EU standard.

Recently, researchers at the Benguet State University have found pesticide residues of organophosphates, organochlorines and pyrethroids in soil and vegetables grown in the Benguet municipality (Reyes et al 2006, 2007).

IV. 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.


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Eutrophication of coastal and marine ecosystems, caused in part by intensive fertilizer use, can also impact human health through ecological changes like the worldwide increase in harmful algal blooms (Robertson and Swinton 2005). 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 diarrheic shellfish poisoning in human consumers.

Pesticides

The use of pesticides has caused health problems to the population that handles, or is exposed to, them. Both, acute and chronic toxic effects have been reported in the Philippines. Pesticide oral poisoning (mostly suicides) represents the greatest part of the acute effects. The WHO estimates that 849,000 people die globally from self-harm each year based on data from year 2001 (WHO, 2002). In fact, it has been reported that pesticide self-poisoning is the most common form of suicide in rural Asia, accounting for 60% of all deaths (Somasumdaram and Rajadurai, 1995, Phillips et al., 2002, Joseph et al., 2003). In the Philippines, an increased use of pesticides during the 1970s coincided with a 27% increase in mortality from non-traumatic causes among economically active men. Konradsen et al (1993) report that direct restrictions of highly toxic or locally popular pesticides (mainly Class I and II) can be very effective in reducing total suicide deaths. Many health-risk analyses of pesticide usage have reported poisoning cases and their relationship with increased mortality rates (Wilson and Tisdell, 2001, Pingali et al. 1994, Loevinsohn, 1987).

The great relevance of intentional exposure to pesticides was also confirmed by a study carried out by Dioquino (2002). Between April 2000 and May 2001, 273 cases of pesticide poisoning cases were reported to the Philippine National Poison Control and Information Service. Around 88% of those cases were due to intentional exposure (oral contact in 251 cases), while accidental and occupational exposures accounted for 8 and 4% respectively. More than 60% of the victims were between 10 and 35 years old.

Even though acute toxicity, either by intentional or accidental exposure, is the most immediate threat to rural communities, pesticides also have important chronic effects that affect the well-being and health of people living in rural communities. However, not only farmers and rural communities are affected. The effect of pesticide application also affects other populations who consume contaminated food and water.

Among the most common chronic effects from pesticides exposure are eye problems (mainly chronic irritation), dermatological problems, respiratory problems (mainly asthma), neurologic disorders and kidney and gastrointestinal abnormalities (Antle and Pingali 1994). In 1992, a comparative study between farmers who had been exposed to

pesticides and farmers who had not been exposed was performed in Nueva Ecija and Quezon areas. Eye, skin, pulmonary, neurological, and renal problems were clearly associated to pesticide exposure (UNEP 1996).

The Philippines made a significant effort in pesticide application reduction in the early 1990s when integrated pest management (IPM) became the national crop protection policy. Nonetheless, the strained and very limited human and financial resources and the weak institutional infrastructures jeopardize the implementation, monitoring, enforcement and improvement of pesticides laws and policies. The FPA is very limited in its enforcement capabilities to deal with pesticide control (UNEP, 1996).

References

Antle, J. M., and P. L. Pingali. 1994. Pesticides, Productivity, And Farmer Health - A Philippine Case-Study. American Journal Of Agricultural Economics **76**:418-430.

Arboleda Jr., G.J. (1998). General description of the fertilizer sector. Philippine Fertilizer and Pesticide Authority. Available at: http://fpa.da.gov.ph/home2.html

Badgley, C., J. Moghtader, E. Quintero, E. Zakem, M. J. Chappell, K. Avilés-Vázquez, A. Samulon, and I. Perfecto. 2007. Organic agriculture and the global food supply. Renewable Agriculture and Food Systems **22**:86-108.

Baldia, S. F., M. C. G. Conaco, T. Nishijima, S. Imanishi, and K.-I. Harada. 2003. Microcystin production during algal bloom occurrence in Laguna de Bay, the Philippines. Fisheries Science **69**:110-116.

Beman, J. M., K. R. Arrigo, and P. A. Matson. 2005. Agricultural runoff fuels large phytoplankton blooms in vulnerable areas of the ocean. Nature **434**:211-214.

Bouman, B. A. M., A. R. Castaneda, and S. I. Bhuiyan. 2002. Nitrate and pesticide contamination of groundwater under rice-based cropping systems: past and current evidence from the Philippines. Agriculture, Ecosystems & Environment **92**:185-199.

Chu, Z., X. Jin, N. Iwami, and Y. Inamori. 2007. The effect of temperature on growth characteristics and competitions of Microcystis aeruginosa and Oscillatoria mougeotii in a shallow, eutrophic lake simulator system. Hydrobiologia **581**:217.

Dioquino, C.C. (2002). Report on pesticide poisoning in the Philippines. National Institute of Health and Sciences. 7th GINC meeting. Tokyo, Japan. Available at: http://www.nihs.go.jp/GINC/meeting/7th/profile.html

Food and Agriculture Organization. (2004). Gateway to Land and Water Information. Country Reports: the Philippines. Available at: http://www.fao.org/ag/AGL/swlwpnr/reports/y_ta/z_ph/ph.htm

Greer, F. R., M. Shannon, Committee on Nutrition, and Committee on Environmental Health. 2005. Infant methemoglobinemia: the role of dietary nitrate in food and water. Pediatrics **116**:784-786.

Joseph, A., Abraham, S., Muliyil, J.P., George, K., Prasad, J., Minz, S., Abraham, V.J., Jacob, K.S. (2003). Evaluation of suicide rates in

rural India using verbal autopsies, 2994-9. BMJ 24: 1121-1122

Konradsen,F., van der Hoek, W., Cole, D.C., Hutchinsom, G., Daisley, H., Singh,S., Eddleston, M. (2003). Reducing acute poisoning in developing countries- options for restricting the availability of pesticides. Toxicology 192:249-261

Loevinsohn, M., Rola, A.C.(1998). Linking research and policy on natural resource management: The case of pesticides and pest management in the Philippines. In: Closing the loop: From research on natural resources to policy change. Edited by S.R. Tabor and D.C. Faber. (Policy Management Report No.8). Masstricht, European Center for Development Policy Management: 88-113

Loevinsohn,M. (1987). Insecticide use and increased mortality in rural Central Luzon, Philippines. Lancet 13:1359-1362.

Mariano, R.V. (1999). The politics of pesticides. Peasant Movement of the Philippines. Available at: http://www.mindfully.org/Pesticide/Politics-Of-Pesticides-Mariano.htm

Mendoza, T.C. (2004). Evaluating the benefits of organic farming in rice agroecosystems in Philippines. Journal of Sustainable Agriculture 24(2): 93-115

National Economic and Development Authority in the Philippines (2004a). Medium Term Philippine Development Plan. Chapter 2: Agribusiness. Available at: http://www.neda.gov.ph/

National Economic and Development Authority in the Philippines (2004b). Medium Term Philippine Development Plan. Chapter 3 Environment and Natural Resources. Available at: http://www.neda.gov.ph/

Pascual-Gapasin, D. (2006). Philippines. Rural growth and development revisited study: agricultural research, development and extension. The World Bank Publications and Documents, Report number 36684. Available at: http://www.worldbank.org/reference/

Phillips, M.R., Li, X., Zhang, Y. (2002). Suicide rates in China, 1995-99. Lancet 359: 835-840

Pingali, P. L., C. B. Marquez, and F. G. Palis. 1994. Pesticides and Philippine Rice Farmer Health: A Medical and Economic Analysis. American Journal Of Agricultural Economics **76**:587-592.

Pretty, J. N., J. I. L. Morison, and R. E. Hine. 2003. Reducing food poverty by increasing agricultural sustainability in developing countries. Agriculture, Ecosystems & Environment **95**:217-234.

Reyes, G. A., and C. P. Laurean. 2006. Pesticide residues in soil, water and vegetables from selected barangays in a Benguet municipality: assessing potential concern for human health. Saint Louis University Research Journal **37**:35-51.

Reyes, G. A., and C. P. Laurean. 2007. A comprehensive assessment of pesticide residues in two vegetable-farming municipalities in Benguet. NLR Journal **1**:39-54.

Robertson, G. P., and S. M. Swinton. 2005. Reconciling agricultural productivity and environmental integrity: a grand challenge for agriculture. Frontiers in Ecology and the Environment **3**:38-46.

Shrestha, R. K., and J. K. Ladha. 2002. Nitrate pollution in groundwater and strategies to reduce pollution. Water Science And Technology **45**:29-35.

Somasumdaram, D.J., Rajadurai, S. (1995). War and suicide in Northern Sri Lanka. Acta Psychiatr. Scand. 91: 1-4

Sombrito, E. Z., A. d. Bulos, E. J. Sta Maria, M. C. V. Honrado, R. V. Azanza, and E. F. Furio. 2004. Application of 210Pb-derived sedimentation rates and dinoflagellate cyst analyses in understanding Pyrodinium bahamense harmful algal blooms in Manila Bay and Malampaya Sound, Philippines. Journal of Environmental Radioactivity **76**:177-194.

Tirado, R. 2007. Nitrates in drinking water in the Philippines and Thailand. Greenpeace Research Laboratories Technical Note **11/2007**.

United Nations Environmental Programme: Chemicals (1996). Philippine case study: a developing country's perspective on POPS. IFCS meeting on POPs. 17-19 June, 1996. Manila, The Philippines. Available at: http://www.chem.unep.ch/pops/indxhtms/manexp7.html

Wang, S., D. Tang, F. He, Y. Fukuyo, and R. Azanza. 2008. Occurrences of harmful algal blooms (HABs) associated with ocean environments in the South China Sea. Hydrobiologia **596**:79-93.

Wilson, C., Tisdell,C. (2001). Why farmers continue to use pesticides despite environmental, health and sustainability costs. Ecological Economics 39: 449-462