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Ecological Effects of Pesticides

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1. Introduction

Pesticides which are used for preventing or destroying pest is having more negative impact on our ecological system when compared to its desired action. Pesticides are carried by wind to other areas and make them contaminate. Pesticides are also causing water pollution and some pesticides are persistent organic pollutants which contribute to soil contamination. (Rockets & Rusty, 2007).

The amount of pesticide that migrates from the intended application area is influenced by the particular chemical's properties: its propensity for binding to soil, its vapor pressure, its water solubility, and its resistance to being broken down over time (Tashkent, 1998) Some pesticides contribute to global warming and the depletion of the ozone layer.

2. Water

Pesticides were found to pollute every source of water including wells. (Gilliom et al., 2007). Pesticide residues have also been found in rain and groundwater. (Kellogg et al., 2000). Pesticide impacts on aquatic systems are often studied using a hydrology transport model to study movement and fate of chemicals in rivers and streams. Studies by the UK government showed that pesticide concentrations exceeded those allowable for drinking water in some samples of river water and groundwater. (Bingham, 2007).

The main routes through which pesticides reach the water are:

1. It may drift outside of the intended area when it is sprayed.
2. It may percolate, or leach, through the soil.
3. It may be carried to the water as runoff.
4. It may be spilled accidentally or through neglect. (States of Jersey, 2007).

They may also be carried to water by eroding soil. (Papendick et al., 1986) Factors that affect a pesticide's ability to contaminate water include its water solubility, the distance from an application site to a body of water, weather, soil type, presence of a growing crop, and the method used to apply the chemical. Maximum limits of allowable concentrations for individual pesticides in public bodies of water are set by the Environmental Protection Agency in the US (Pedersen, 1997).

3. Soil

Many of the chemicals used in pesticides are persistent soil contaminants, whose impact may endure for decades and adversely affect soil conservation (U.S. Environmental

Protection Agency,2007).The use of pesticides decreases the general biodiversity in the soil. Not using the chemicals results in higher soil quality verified needed, (Johnston,1986) with the additional effect that more organic matter in the soil allows for higher water retention.(Kellogg et al.,2000).This helps increase yields for farms in drought years, when organic farms have had yields 20-40% higher than their conventional counterparts.(Lotter et al.,2003) A smaller content of organic matter in the soil increases the amount of pesticide that will leave the area of application, because organic matter binds to and helps break down pesticides.(Kellogg et al.,2000).

4. Air

Pesticides can contribute to air pollution . Pesticide drift occurs when pesticides suspended in the air as particles are carried by wind to other areas, potentially contaminating them. (Kellogg et al.,2000). Volatile pesticides applied to crops will volatilize and are blown by winds to nearby areas posing a threat to wildlife.(Reynolds,1997). Sprayed pesticides or particles from pesticides applied as dusts may travel on the wind to other areas, or pesticides may adhere to particles that blow in the wind, such as dust particles.(National Park Service,2006). Compared to aerial spraying ground spraying produces less pesticide drift. (U.S. Environmental Protection Agency,PR,2007) Farmers can employ a buffer zone around their crop, consisting of empty land or non-crop plants such as evergreen trees to serve as windbreaks and absorb the pesticides, preventing drift into other areas.

5. Effects on biota

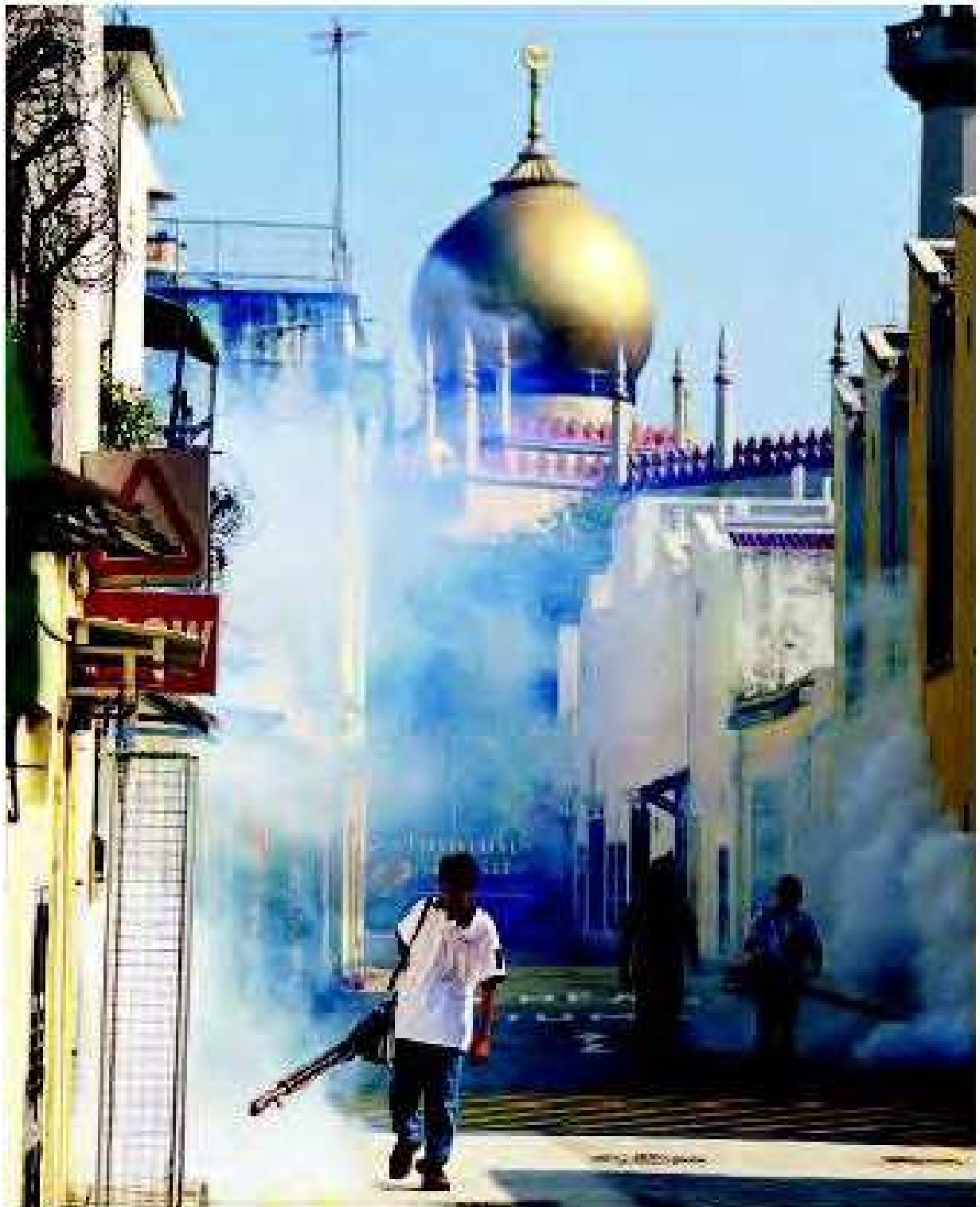
5.1 Plants

Nitrogen fixation, which is required for the growth of higher plants, is hindered by pesticides in soil. The insecticides DDT, methyl parathion, and especially pentachlorophenol have been shown to interfere with legume-rhizobium chemical signaling. Reduction of this symbiotic chemical signaling results in reduced nitrogen fixation and thus reduces crop yields(Rockets&Rusty,2007). Root nodule formation in these plants saves the world economy \$10 billion in synthetic nitrogen fertilizer every year.(Fox et al.,2007).

Pesticides can kill bees and are strongly implicated in pollinator decline, the loss of species that pollinate plants, including through the mechanism of Colony Collapse Disorder, (Wells, 2007) in which worker bees from a beehive or Western honey bee colony abruptly disappear. Application of pesticides to crops that are in bloom can kill honeybees,(Cornell University,2007) which act as pollinators. The USDA and USFWS estimate that US farmers lose at least \$200 million a year from reduced crop pollination because pesticides applied to fields eliminate about a fifth of honeybee colonies in the US and harm an additional 15%..(Rockets & Rusty,2007),

5.2 Animals

Pesticides inflict extremely widespread damage to biota, and many countries have acted to discourage pesticide usage through their Biodiversity Action Plans.Animals may be poisoned by pesticide residues that remain on food after spraying, for example when wild animals enter sprayed fields or nearby areas shortly after spraying. (Palmer et al.,2007).



Fumigators walking down a street in the Sultan Mosque area of Singapore and spraying a pesticide to rid the area of mosquitoes

Widespread application of pesticides can eliminate food sources that certain types of animals need, causing the animals to relocate, change their diet, or starve. Poisoning from pesticides can travel up the food chain; for example, birds can be harmed when they eat insects and worms that have consumed pesticides. Some pesticides can cause bioaccumulation, or build up to toxic levels in the bodies of organisms that consume them over time, a phenomenon that impacts species high on the food chain especially hard. (Cornell University, 2007).

Pesticides can affect animal reproduction directly, as evidenced by the deleterious effect of the persistent organochlorine insecticides on reproduction in raptors and other birds. Eggshell thinning due to the uptake of organochlorine insecticides that affect calcium (Ca) metabolism has been observed in predacious birds (Keith *et al.*, 1970; Newton *et al.*, 1986; Wiemeyer *et al.*, 1986; Opdam *et al.*, 1987). Fish-eating birds are more severely affected than terrestrial predatory birds, because the fish-eating birds acquire more pesticides via their food chain than the other predators (Pimentel, 1971; Littrell, 1986).

Pesticides can also affect reproduction in the invertebrates; for example, sublethal doses of DDT, dieldrin, and parathion increased egg production by the Colorado potato beetle by 50, 33 and 65 per cent, respectively, after two weeks (Abdallah, 1968). The herbicide 2,4,5-T was found to reduce the reproduction of soil-inhabiting Collembola (Eijsackers, 1978). Populations of invertebrates with high rates of increase can recover stable populations much more rapidly than those of bird and mammal populations (Pimentel and Edwards, 1982).

5.2.1 Human

Pesticides can enter the human body through inhalation of aerosols, dust and vapor that contain pesticides; through oral exposure by consuming food and water; and through dermal exposure by direct contact of pesticides with skin. (Department of Pesticide Regulation, 2008). Pesticides are sprayed onto food, especially fruits and vegetables, they secrete into soils and groundwater which can end up in drinking water, and pesticide spray can drift and pollute the air.

There is increasing anxiety about the importance of small residues of pesticides, often suspected of being carcinogens or disrupting endocrine activities, in drinking water and food. In spite of stringent regulations by international and national regulatory agencies, reports of pesticide residues in human foods, both imported and home-produced, are numerous.

Over the last fifty years many human illnesses and deaths have occurred as a result of exposure to pesticides, with up to 20,000 deaths reported annually. Some of these are suicides, but most involve some form of accidental exposure to pesticides, particularly among farmers and spray operators in developing countries, who are careless in handling pesticides or wear insufficient protective clothing and equipment. Moreover, there have been major accidents involving pesticides that have led to the death or illness of many thousands. One instance occurred in Bhopal, India, where more than 5,000 deaths resulted from exposure to accidental emissions of methyl isocyanate from a pesticide factory.

The effects of pesticides on human health are more harmful based on the toxicity of the chemical and the length and magnitude of exposure. (Lorenz & Eric, 2009). Farm workers and their families experience the greatest exposure to agricultural pesticides through direct contact with the chemicals. But every human contains a percentage of pesticides found in fat samples in their body. Children are most susceptible and sensitive to pesticides due to their small size

and underdevelopment. (Department of Pesticide Regulation,2008). The chemicals can bioaccumulation in the body over time.

Exposure to pesticides can range from mild skin irritation to birth defects, tumors, genetic changes, blood and nerve disorders, endocrine disruption, and even coma or death. (Lorenz & Eric,2009)

5.2.2 Aquatic life

A major environmental impact has been the widespread mortality of fish and marine invertebrates due to the contamination of aquatic systems by pesticides. This has resulted from the agricultural contamination of waterways through fallout, drainage, or runoff erosion, and from the discharge of industrial effluents containing pesticides into waterways. Historically, most of the fish in Europe's Rhine River were killed by the discharge of pesticides, and at one time fish populations in the Great Lakes became very low due to pesticide contamination

Fish and other aquatic biota may be harmed by pesticide-contaminated water. Pesticide surface runoff into rivers and streams can be highly lethal to aquatic life, sometimes killing all the fish in a particular stream.(Toughill,1999).

Application of herbicides to bodies of water can cause fish kills when the dead plants rot and use up the water's oxygen, suffocating the fish. Some herbicides, such as copper sulfite, that are applied to water to kill plants are toxic to fish and other water animals at concentrations similar to those used to kill the plants, Repeated exposure to sub lethal doses of some pesticides can cause physiological and behavioral changes in fish that reduce populations, such as abandonment of nests and broods, decreased immunity to disease, and increased failure to avoid predators,(Helfrich et al.,1996).

Application of herbicides to bodies of water can kill off plants on which fish depend for their habitat.(Helfrich et al.,1996).Pesticides can accumulate in bodies of water to levels that kill off zooplankton, the main source of food for young fish.(Pesticide Action Network North America,1999).Pesticides can kill off the insects on which some fish feed, causing the fish to travel farther in search of food and exposing them to greater risk from predators.The faster a given pesticide breaks down in the environment, the less threat it poses to aquatic life. Insecticides are more toxic to aquatic life than herbicides and fungicides. (Helfrich et al.,1996).

5.2.3 Birds

Pesticides had created striking effects on birds, those in the higher trophic levels of food chains, such as bald eagles, hawks, and owls. These birds are often rare, endangered, and susceptible to pesticide residues such as those occurring from the bioconcentration of organochlorine insecticides through terrestrial food chains. Pesticides will also kill grain- and plant-feeding birds, and the elimination of many rare species of ducks and geese has been reported. Populations of insect-eating birds such as partridges, grouse, and pheasants have decreased due to the loss of their insect food in agricultural fields through the use of insecticides.

Bees are extremely important in the pollination of crops and wild plants, and although pesticides are screened for toxicity to bees, and the use of pesticides toxic to bees is permitted only under stringent conditions, many bees are killed by pesticides, resulting in the considerably reduced yield of crops dependent on bee pollination.

Bald eagles are common examples of nontarget organisms that are impacted by pesticide use. Rachel Carson's landmark book *Silent Spring* dealt with the loss of bird species due to bioaccumulation of pesticides in their tissues. There is evidence that birds are continuing to be harmed by pesticide use. In the farmland of Britain, populations of ten different species of birds have declined by 10 million breeding individuals between 1979 and 1999, a phenomenon thought to have resulted from loss of plant and invertebrate species on which the birds feed. Throughout Europe, 116 species of birds are now threatened. Reductions in bird populations have been found to be associated with times and areas in which pesticides are used. (Kerbs et al., 1999) In another example, some types of fungicides used in peanut farming are only slightly toxic to birds and mammals, but may kill off earthworms, which can in turn reduce populations of the birds and mammals that feed on them. (Palmer et al., 2007).

Some pesticides come in granular form, and birds and other wildlife may eat the granules, mistaking them for grains of food. A few granules of a pesticide is enough to kill a small bird. (Palmer et al., 2007).

The herbicide *parquet*, when sprayed onto bird eggs, causes growth abnormalities in embryos and reduces the number of chicks that hatch successfully, but most herbicides do not directly cause much harm to birds. Herbicides may endanger bird populations by reducing their habitat. (U.S. Environmental Protection Agency, 2007).



A bird that died as a result of pesticide use. (U.S. EPA. Reproduced by permission.)

6. Threatening reports on hazardous effects of pesticides

Endosulfan is a harmful insecticide, it causes several health hazards in human beings. Endosulfan was aerially sprayed on cashew plantations in India, especially in northern parts of Kerala, for more than 20 years. The terrain was unsuitable for aerial spraying considering the relatively high rainfall and its geological structure. Unusual diseases and even deaths were observed in and around the region.

Endosulfan is a chlorinated hydrocarbon insecticide of the cyclodiene subgroup which acts as a contact poison in a wide variety of insects and mites. It is primarily used on food crops like tea, fruits, vegetables, and grains. Exposure to endosulfan will result from ingestion of contaminated food. It does not easily dissolve in water and transport is likely to occur if it is attached to soil particles in surface runoff. Endosulfan residues have been found in numerous food products at very low concentrations.

Endosulfan is rapidly degraded and eliminated in mammals with very little absorption in the gastrointestinal tract. In these areas, where aerial spraying was done, a lot of children who have been exposed are considered to be living martyrs.

Studies consistently show that endosulfan is highly poisonous and easily causes death and severe acute and chronic toxicity to various organ systems including mental impairment, neurologic disturbances, immunotoxicity and reproductive toxicity and most of the newborn were physically handicapped and showing epilepsy.

Classified by the US Environmental Protection Agency as highly hazardous, endosulfan was at the centre of controversy in the Philippines in the 1990's. (Nishand .P, 2006)

7. Alternative methods for eliminating pesticides

7.1 Diversified planting

A common practice among home gardeners is to plant a single crop in a straight row. This encourages pest infestation because it facilitates easy travel of an insect or disease from one host plant to another. By intermingling different types of plants and by not planting in straight rows, an insect is forced to search for a new host plant thus exposing itself to predators. Also, this approach corresponds well with companion planting. (Ann R. Waters, 2011)

7.2 Low toxicity pesticides

Formulated, biodegradable pest-control substances are commercially available. Although these products are pesticides, they have low toxicity to mammals and do not last long in the environment. The local County Extension Service can provide information on these and other pesticide products. (Ann R. Waters, 2011)

Many alternatives are available to reduce the effects pesticides have on the environment. There are a variety of alternative pesticides such as manually removing weeds and pests from plants, applying heat, covering weeds with plastic, and placing traps and lures to catch or move pests. Pests can be prevented by removing pest breeding sites, maintaining healthy soils which breed healthy plants that are resistant to pests, planting native species that are naturally more resistant to native pests, and use biocontrol agents such as birds and other pest-eating organisms. (National Audubon Society, 2003).





Photos of some victims of endosulphan tragedy

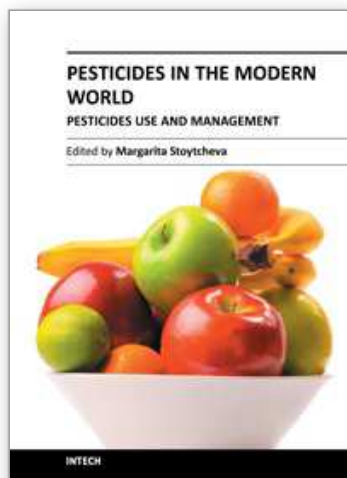
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This book brings together issues on pesticides and biopesticides use with the related subjects of pesticides management and sustainable development. It contains 24 chapters organized in three sections. The first book section supplies an overview on the current use of pesticides, on the regulatory status, on the levels of contamination, on the pesticides management options, and on some techniques of pesticides application, reporting data collected from all over the world. Second section is devoted to the advances in the evolving field of biopesticides, providing actual information on the regulation of the plant protection products from natural origin in the European Union. It reports data associated with the application of neem pesticides, wood pyrolysis liquids and bacillus-based products. The third book section covers various aspects of pesticides management practices in concert with pesticides degradation and contaminated sites remediation technologies, supporting the environmental sustainability.

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