

I. Introduction to pesticides

I.1 Why are pesticides a problem?

Pesticides are widely used all over the world and are the least labour costly option in agriculture to protect and preserve crops from pests and weeds and in public health to control vector-borne diseases. However, pesticides have hazardous effects on human health and the environment if handled improperly, and are due to millions of acute poisonings each year. The World Health Organization (1990) has estimated an annual worldwide total of 3 million cases of acute, severe poisonings (including suicides) (1, 2) that cause around 300,000 deaths annually (3). It is probably an underestimation because of unreported, mild to moderate intoxications (1, 2). Studies from Bolivia and Pakistan show that more than three out of four farmers have experienced mild symptoms of intoxication in relation to a spraying session (4, 5). The majority of deaths caused by pesticide poisonings (99%) occur in middle and low income countries (3).

The demographic transition (people moving from rural areas to urban areas) has in many developing countries caused a shift in workforce with a smaller workforce available for agriculture and thus an increased need for pesticides and fertilizers to maintain an effective production (1, 6). Moreover agricultural production for export has been boosted in developing countries these years, where the use of pesticides is seen as an important means to generate income by improving food production (1).

The dilemma we face is on one hand a security of food supply and export income in middle and low-income countries, and on the other hand the risk of adverse health effects on humans and the environment due to improper handling of pesticides.

I.2 The Green Revolution

In order to secure food production new agricultural technologies were introduced into agriculture all over the world but mainly in the developed countries, the Communist countries and on big farms in developing countries from 1960 to 1990. The period is called the Green Revolution and it caused an enormous boom in agricultural productivity (7, 8). However, most farmers in developing countries never benefited from that, due to lack of agricultural extension services and a lack of money to invest in the new technologies. Pesticides were one of the major breakthroughs in the Green Revolution because they made improvements in crop yields by allowing efficient weed control and destruction of insect pests (9). At first the Green Revolution was seen as a great success, but after 1990 the widespread use of pesticides caused severe environmental damage and endangered public health. Furthermore the Green Revolution's farming systems required considerable irrigation putting a strain on the world's water resources (7).

For further reading on the Green Revolution:

- Pungali P., Raney T. From the Green Revolution to the gene revolution: how will the poor fare?: ESA Working Paper No. 05-09; 2005
- The Green Revolution: <http://www.fao.org/kids/en/revolution.html>

1.3 What is a pesticide and what is it used for?

Pesticides are widely used in agricultural production to protect crops from pests in an effort to reduce or eliminate yield losses and maintain high product quality. Pesticides are also used in public health for controlling vector-borne diseases (e.g. malaria and dengue) and in households for domestic use in order to control pests like rats and cockroaches (10).

Box 1.1: Definition by the Food and Agriculture Organization of the United Nations (FAO):

“Pesticide means any substance or mixture of substances intended for preventing, destroying or controlling any pest, including vectors of human or animal disease, unwanted species of plants or animals causing harm during or otherwise interfering with the production, processing, storage, transport or marketing of food, agricultural commodities, wood and wood products or animal feedstuffs, or substances which may be administered to animals for the control of insects, arachnids or other pests in or on their bodies (17).”

Pesticides are classified by their:

- Chemical class: Organochlorines, organophosphates, carbamates, pyrethroids, bipyridils, etc.
- Function: insecticide (insects), fungicide (fungi and moulds), herbicide (weeds) or rodenticide (rodents).
- Hazard according to toxicological classes: Ia: extremely hazardous, Ib: highly hazardous, II: moderately hazardous, III: Slightly hazardous, U: active ingredients unlikely to present any harm in normal use, and O: obsolete (11).

1.3.1 Persistent Organic Pollutants (POP's):

POP's is a group of pesticides that pose significant threats to health and the environment because 1) they are highly toxic, 2) they are persistent and last for years before degrading into less dangerous forms, 3) they evaporate and travel long distances through air and through water, and 4) they accumulate in fatty tissue (bioaccumulation) (12).

For further reading on pesticide classification and POP's:

- What is a pesticide? <http://www.who.int/topics/pesticides/en/>
- WHO. The WHO recommended classification of pesticides by hazard and guidelines to classification 2009; 2010
- Pesticide Applicator Core Tutorial: <http://psep.cce.cornell.edu/Tutorials/core-tutorial/Default.aspx>
- UNEP. Ridding the world of POPs: a guide to the Stockholm convention on persistent organic pollutants. Switzerland; 2005
- IOMC. Reducing and eliminating the use of persistent organic pesticides: Guidance on alternative strategies for sustainable pest and vector management. Geneva; 2002

I.4 Where are pesticides being used?

Seventy percent of the populations in developing countries live in rural areas, and 97% of the rural populations are engaged in agriculture (9).

In 2007 approximately 5.2 billion pounds (2.4 billion kg) of pesticides were used worldwide, of which the usage in the U.S. accounted for more than 22 % of the total amount (13). Developing countries account for approximately one third of the global pesticide use (13), however pesticides are getting more widespread, especially in developing countries in the tropical regions (1).

Herbicides accounted for the largest portion of total use worldwide in 2007 (13). Looking at developing countries alone, larger quantities of insecticides are used, given that insects create the greatest problems (1).

For further reading on the geographic use of pesticides:

- EPA. Pesticides industry sales and usage: 2006 and 2007 market estimates. Washington DC; February 2011
- Ecobichon DJ. Pesticide use in developing countries. *Toxicology*. 2001;160:27-33.

I.5 Ways of getting exposed

Exposure to pesticides is associated with severe health hazards and it is therefore essential to know how people get exposed. In principal people can get exposed intentionally or unintentionally. There are two main reasons for unintentional exposure: individuals working with pesticides (farmers and salesmen) and individuals consuming food or drinking water contaminated *with pesticide residues* (the general population).

On a world-basis the highest levels of pesticide exposure are found among farmers in developing countries, pesticide applicators and people who live adjacent to heavily treated agricultural land (10, 14). Farmers in developing countries are at great risk of pesticide poisonings because of the highly

hazardous pesticides available on the market, improper mixing and application of pesticides, inadequate storage of pesticides and not using personal protective equipment (10).

1. Non-intentional exposure (15):

- Occupational exposure seen in factory workers producing or formulating pesticides, pesticide salesmen and dealers, farmers mixing and spraying pesticides and farmers or others re-entering a newly sprayed field.
- Non-occupational exposure from contaminated water or food, and children or adults mistakenly ingesting pesticides.

2. Intentional exposure: suicide (and homicide) due to easy access to buying the most toxic pesticides in developing countries and due to pesticides being stored unlocked, so that everybody in the household has access (15).

For further reading on exposure:

- See fact sheet 2: Health effects of pesticides
- See fact sheet 3: Pesticide exposure

1.6 Health effects

Pesticides enter the human body through three routes: Oral ingestion, inhalation and through the skin. The health risk associated with pesticide exposure depends on the toxicity of the pesticide and the amount of exposure to the pesticide. The health effects of pesticide exposure can be divided into acute and chronic effects:

- Acute effects are harmful effects that occur within 48 hours of exposure to a pesticide. The most common symptoms from acute poisoning are: *headaches, dizziness, skin irritation, shortness of breath, irritation of eyes, vomiting and convulsion (5).*
- Chronic effects occur from exposure to pesticides over a longer period of time. It includes neurotoxic, reproductive, fetotoxic and carcinogenic effects. Some pesticides bioaccumulate in adipose tissue in the body of humans and animals and can therefore cause adverse effects through several generations and over large distances. For example it has been demonstrated that breast milk of Eskimo women in Greenland, where pesticides have never been used, contains DDT (16).

For further reading on health effects:

- See fact sheet 2: Health effects of pesticides
- See fact sheet 3: Pesticide exposure
- Specific chemical fact sheets: http://www.epa.gov/pesticides/factsheets/chemical_fs.htm

I.7 Environmental effects of pesticides

In addition to the negative health effects pesticide may pose on humans, pesticides also have adverse effects on the environment. Pesticides contaminate groundwater and soil, kill non-target organisms beneficial to crop, injury crop due to wrong application (timing or doses) and cause pest resistance. Pest resistance is one of the major problems in developing countries, due to the farmers extensive use of pesticides (10).

For further reading on environmental effects:

- Pesticides and the environment: <http://extension.missouri.edu/explorepdf/agguides/pests/go7520.pdf>
- Pesticides as water pollutants: <http://www.fao.org/docrep/W2598E/w2598e07.htm>
- Environmental fate: http://www.agf.gov.bc.ca/pesticides/c_2.htm
- Ecology and environmental considerations: <http://psep.cce.cornell.edu/Tutorials/core-tutorial/module06/index.aspx>

I.8 Legislation

International regulations restrict the use of the most toxic or persistent pesticides, set limits for residues in foods, regulate occupational exposure, control the trade and set standards for dumping of hazardous waste products.

The three most important regulations are:

- The Code of Conduct on the Distribution and Use of Pesticides: The Code puts an emphasis on the shared responsibility and the need for a cooperative effort to promote practices that minimize potential health and environmental risks associated with pesticides (17, 18)
- The Rotterdam Convention: provides a list of hazardous pesticides which requires that exporting countries inform and get accept from importing countries about the hazardous pesticide being exported (19).
- The Stockholm Convention: aims at eliminating the production and use of chemicals that are considered to be POP's (20).

Many countries have signed the two conventions (18). However, due to lack of law enforcement the most hazardous pesticides are still easily available in many developing countries (21).

For further reading on legislation:

- See fact sheet 4: Accessibility of pesticides

1.9 Causes of improper handling

Lack of information and proper education is a widespread problem in many developing countries and the main reason for improper handling of pesticides (4, 22-24). Pesticide practices are however shaped by larger structural influences beyond the presence or absence of accurate knowledge (25) such as: the availability of pesticides, the farmers' economy, the convenience of using preventive measures, such as PPE, peer pressure, efficiency and time consumption. These factors become essential when trying to understand the behavior of the farmer (4, 8, 22-24, 26).

For further reading on improper handling:

- See fact sheet 5: Handling of pesticides

1.10 How to prevent pesticide poisonings?

Due to the comprehensive effects pesticides have on human health and the environment it is necessary to reduce the use of pesticides in general, especially the most hazardous ones. Furthermore there is a need to enforce legislation (shorts term perspective) (8) and educate farmers to handle pesticides with precaution using personal protective equipment (PPE) and not spilling pesticides in the environment (long term perspective) (6, 10).

Three main strategies are used in the prevention of pesticide poisonings:

1. "Safe Use Concept": a concept from the pesticide industry mainly focusing on educating farmers in the use of PPE when using pesticides. This concept is however questioned when it comes to the use in developing and tropical countries, where climate, lack of knowledge and a poor economy among farmers make safe use less applicable. Regarding environmental pollution even in industrialized countries safe use can also be doubted, as we constantly see pesticide residues in food and drinking water, although the farmers handle the pesticides as prescribed by the manufacturers (25, 27).

2. Integrated Pest Management (IPM): a concept made by FAO focusing on alternative ecological strategies in pest prevention and the use of pesticides as a last resort. This method of farming has, apart from being good for health and environment, also been proven the most cost effective method for small scale farming in several tropical countries (6, 28).
3. Ecological farming where the use of pesticides is banned. There is an increased demand for this kind of farming from consumers in the industrialized world, as they have realized the dangers of pesticides and want to protect themselves and their children from these dangers. Ecological products are often more costly than conventional ones, making a good earning possible for ecological farmers (29).

For further reading on prevention:

- See fact sheet 6: Prevention of pesticide poisoning

Reference list

1. Ecobichon DJ. Pesticide use in developing countries. *Toxicology*. 2001;160:27-33.
2. WHO. *Public Health Impact of Pesticides Used in Agriculture*. Geneva: World Health Organization; 1990
3. Gunnell D, Eddleston M. Suicide by intentional ingestion of pesticides: a continuing tragedy in developing countries. *IntJEpidemiol*. 2003;32(6):902-9.
4. Jørs E, Morant RC, Aguilar GC, Huisi O, Lander F, Baelum J, et al. Occupational pesticide intoxications among farmers in Bolivia: A cross-sectional study. *Environmental Health: A Global Access Science Source*. 2006;5(10).
5. Kahn M. *Adverse health effects, risk perception and pesticide use behavior*: Federal Urdu University of Arts, Science and Technology; 2009
6. Zalom FG. *Pesticide Use Practices in Integrated Pest Management*. In: Krieger R, editor. *Hayes' Handbook of Pesticide Toxicology*. Third ed: Elsevier; 2010. p. 303-13.
7. FAO. *Green Revolution*. [cited 27.06.11]; Available from: <http://www.fao.org/kids/en/revolution.html>
8. Van Der Hoek W, Konradsen K, Athukorala K, Wanigadewa T. Pesticide poisoning: a major health problem in Sri Lanka. *SocSciMed*. 1998;46(4-5):495-504.
9. Brodesser J, Byron DH, Cannavan A, Ferris IG, Gross-Helmert K, Hendrichs J, et al. Pesticides in developing countries and the International Code of Conduct on the Distribution and the Use of Pesticides. <http://www.nawebiaeaorg/nafa/fep/public/2006-AGES-CoCpdf>. 2006;accessed 27.06.11.
10. Damalas CA, Eleftherohorinos IG. Pesticide exposure, safety issues, and risk assessment indicators. *IntJEnvironResPublic Health*. 2011;8:1402-19.
11. WHO. *The WHO recommended classification of pesticides by hazard and guidelines to classification 2009*: World Health Organization; 2010
12. UNEP. *Ridding the world of POPs: a guide to the stockholm convention on persistent organic pollutants*. Switzerland: United Nations Environment Programme; 2005
13. EPA. *Pesticides industry sales and usage: 2006 and 2007 market estimates*. Washington D C : United States Environmental Protection Agency; February 2011
14. Pimentel D, Culliney TW, Bashore T. Public health risks associated with pesticides and natural toxins in foods. In: Radcliffe EB, Hutchison WD, editors. *Radcliffe's IPM World*. University of Minnesota; 2006.
15. *Health indicators: Building blocks for health situation analysis*. Epidemiological Bulletin, Pan American Health Organization. 2001;22(4).
16. Dewailly E, Mulvad G, Pedersen HS, Ayotte P, Demers A, Weber JP, et al. Concentration of organochlorines in human brain, liver, and adipose tissue autopsy samples from Greenland. *EnvironHealth Perspect*. 1999;107(10):823-8.

17. FAO. International Code of Conduct on the distribution and use of pesticides. Rome: Food and Agriculture Organization of the United Nations; 2005
18. Jørs E. Acute pesticide poisonings among small-scale farmers in La Paz country Bolivia: University of Copenhagen; 2004.
19. The Rotterdam Convention. [cited 01.07.11]; Available from: <http://www.pic.int/>
20. The Stockholm Convention. [cited 01.07.11]; Available from: http://ec.europa.eu/environment/pops/pdf/leaflet_pop.pdf.
21. FAO. Analysis of Government Responses to the Second Questionnaire on the State of Implementation of the International Code of Conduct on the Distribution and Use of Pesticides: Food and Agriculture Organization of the United Nations; 1998
22. Palis FG, Flor RJ, Warburton H, Hossain M. Our farmers at risk: behaviour and belief system in pesticide safety. *JPubHealth*. 2006;28(1):43-8.
23. Parveen S, Nakagoshi N. An analysis of pesticide use for rice pest management in Bangladesh. *JIntDevelopCooperation*. 2001;8(1):107-26.
24. Zyoud SH, Sawalha AF, Sweileh WM, Awang R, Al-Khalil SI, Al-Jabi SW, et al. Knowledge and practices of pesticide use among farm workers in the West Bank, Palestine: safety implications. *EnvironHealth PrevMed*. 2010;15:252-61.
25. Murray DL, Taylor PL. Claim No Easy Victories: Evaluating the Pesticide Industry's Global Safe Use Campaign. *World Development*. 2000;28(10):1735-49.
26. Mekonnen Y, Agnoafir T. Pesticide sprayers' knowledge, attitude and practice of pesticide use on agricultural farms of Ethiopia. *OccupMed*. 2002;52(6):311-5.
27. Wesseling C, Ruepert C, Chaverri F. Safe use of Pesticides: a developing country's point of view. *Encyclopedia of Pest Management*. 2003;1(1):1-4.
28. FAO. IPM. [cited 27.06.11]; Available from: <http://www.fao.org/agriculture/crops/core-themes/theme/pests/ipm/en/>.
29. EPA. Organic farming. [cited 01.07.11]; Available from: <http://www.epa.gov/agriculture/torg.html>.