2 The fate of agro-chemicals in the land-water interface in St. Lucia and Jamaica: Environmental monitoring

This is the second of six information sheets on improving agro-chemical management in the Caribbean. This sheet aims to increase the reader's understanding of the fate of agro-chemicals reaching the environment, with particular emphasis on the land-water interface. The sheet starts with a general description of the situation and then looks in more detail at examples from St. Lucia and Jamaica. It goes on to outline a series of recommendations with particular focus on research and environmental monitoring.

1. Overview

Although developing countries use only 10-25% of the world's pesticides, they suffer up to 50% of the reported cases of acute poisoning and 73-99% of the reported fatalities among pesticide applicators. Farmers in developing countries are especially at risk because of inadequate training or the inability to read application instructions for hazardous pesticides.

In the Caribbean, it is the poor who are at greatest risk. This economic group is least able to develop cohesive strategies and coping mechanisms to mitigate the worst effects of flawed pesticide management practices. Toxic loadings need to be reduced and better health and safety practices employed to protect people and to safeguard the environment and economic resources. Problems that have been identified with respect to the use of agro-chemicals include:

- Illegal imports and their use
- Repackaging of chemicals by vendors without labelling
- Incorrect application
- Inadequate application equipment
- Failure to wear protective clothing
- A lack of long-term monitoring programmes and targeted research activities, including on bioaccumulation
- A lack of studies on agro-chemicals and their impacts
- A lack of information on the fate of agro-chemicals in the land-water interface, particularly in St. Lucia and Jamaica.

There is evidence that significant environmental pollution and impacts on human health arise from the inappropriate use of agro-chemicals. Such findings also highlight the need for long-term monitoring and additional research. Effects include harm to human health (poisoning), environmental pollution (exacerbated by lack of soil conservation measures and resulting sedimentation), as well as impacts on non-target species.

St. Lucia

In St. Lucia, bananas are cultivated under a mono-cultural production system that depletes natural nutrients, resulting in a need for fertiliser application. In addition, the majority of farms are on steep slopes, with mostly acidic and low fertility soils. This makes them prone to pest infestations and encourages high pesticide use. This frequent and intense use of pesticides, combined with inappropriate handling, storage, and disposal has contributed to environmental pollution.

The Roseau Valley, for example, has fertile alluvial soils and a high production of bananas. Nematicides applied in banana growing areas have been identified as potential water pollutants given the water solubility of their active ingredients (n.b. nematicides are not usually sprayed; they are granules). In several studies, more than 75% of water samples were found to contain pesticide residues higher than the European Community general guideline for individual pesticides in drinking water (0.1µg/l). Many of the rivers where samples have been taken are drinking water sources.

Banana cultivation on steep slopes encourages soil erosion and the movement of pesticides, such as paraquat and glyphosate, through soil transport mechanisms. Pesticide drift has been highlighted as an important additional transport mechanism, although there have been few studies on pesticide migration, movement, and persistence in St. Lucia.

The environment of the Wider Caribbean region is especially vulnerable to agro-chemical pollution for several reasons, not the least being the small size of its islands. Pollutant sources within watersheds are closely linked to the wider coastal and marine

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environment, and therefore pollutants may be found in high concentrations in coastal waters.

The Cartagena Convention (1983) and its Protocol Concerning Pollution from Land-Based Sources and Activities provides a framework to address this problem and outlines the obligations of Caribbean states in ameliorating agro-chemical pollution, including the development of national plans of action (NPAs) to address land-based pollution.

These NPAs are yet to be put in place and it is suggested that technical working groups be established to develop them. These groups should include members from a wide variety of stakeholders (Ministries of Agriculture, PCBs, national environmental agencies, and research institutes).

Given limited capacity, however, immediate emphasis should placed on reducing imports of the more toxic pesticides and controlling the administration and distribution chain. This would have the impact of reducing toxic agro-chemical loadings. At the same time, better practices should be employed in the use of agro-chemicals, and their fate should be monitored.

Jamaica

Agro-chemical contamination of the environment is likely to occur because of its thin soil cover, steep hillsides, poor agronomic practices, and the rainfall pattern of distinct rainy seasons. These factors contribute to heavy pesticide and sediment loading of the rivers and coastal waters of the country, and instances of significant soil contamination could be related to intensive farming systems, such as coffee, sugar, and banana plantations.

Some research has shown a decline in coastal water quality due to agriculture, though most studies have tended to focus on nutrient pollution including the misuse of fertilisers and disposal of animal wastes. The majority of studies have focussed on the fate of various organochlorides and organophosphates and their impact on river systems within particular watersheds or drainage basins. There has also been research conducted on the degradation of pesticides in the environment, bioaccumulation in test species, and the breakdown of pesticide residues in soil. However, few studies look at the link between agro-chemical use and their impact on coastal waters.

Environmental fate

The longer an agro-chemical stays in the environment (the persistence), the greater the potential that it will harm non-target and/or beneficial organisms. The same is true for the impacts on human health. The symptoms of acute toxicity are often fairly obvious, but chronic toxicity and its cause(s) are often not recognised.

The order of persistence of agro-chemicals in the environment, from the most to the least persistent, is as follows: organochlorides > organophosphates > carbamates > pyrethroids. Almost all chlorinated pesticides (many insecticides) are banned in Jamaica (except endosulphan) and therefore there is perhaps less urgency to monitor organochloride pollution of the environment in this island. However, there are still sites in Jamaica and elsewhere that are known to have heavy organochloride pollution loads.

Pesticides are removed from agricultural lands by running water (run-off) and adsorbed to soil particles lost in erosion processes (wash-off). Soil surface movement of pesticides is usually accelerated by steep topography, low soil permeability, considerable rainfall, strong adsorption of pesticides to soil particles, and inadequate soil conservation measures in farming practices.

Furthermore, pesticide persistence will be affected by the method of application, the method of tillage, and, finally, the formulation or mixture. Degradation products and their characteristics must also be considered when deciding what pesticides to use and where they are applied, as they may be more toxic than the active ingredients and, therefore, also more persistent in the environment. An example of this is endosulphan, which readily breaks down in soil to highly toxic endosulphan sulphate, which is readily bioaccumulated, particularly by mussels.

In terms of environmental fate, the following agro-chemicals were found to be the most persistent in soil and groundwater: imazaquin (5.5 months), endosulfan (50 days), metolachlor (97–200 days), terbutryn (180–240 days), bromacil (60–240 days), benomyl (60–360 days), ethoprophos (65–133 days), imazalil (150 days), atrazine (60-100 days), bromacil (60-240 days), and paraquat (16-384 months).

Social factors

Agro-chemical use affects the health of those that use and apply these chemicals—the consumers of farm-produce grown in pesticide-treated areas, residents including children of the communities within which agro-chemicals are used, and communities down-stream from areas of agro-chemical application.

In the Caribbean, it is the poor, less educated, socio-economically disadvantaged populations who are at greatest risk from improper pesticide use. Acute poisoning from pesticide use may include a racing of the heart, loss of feeling in the limbs, disequilibrium, choking, nausea, and death. Chronic health effects include cancer, birth defects, reduced fertility, damage to the immune system, genetic disorders, hormonal effects, damage to the nervous system, and impaired learning. A culture of denial of the ill effects of pesticides on human health among some sections of Caribbean society works in tandem with a general public ignorance about these effects.

Studies in Jamaica on human health effects have shown that 10% of poisoning cases are due to agro-chemicals. Hospital data on the incidence of poisoning reveal that 84% of such cases were among children under the age of five, and that 27% of agro-chemical poisonings are due to organophosphates and carbamates.

Extension officers advise farmers about the best pesticides to use in terms of effectiveness and environmental friendliness, but must do so on joint training days shared with pesticide salespeople with very aggressive sales techniques. The Pesticides Control Boards also have public awareness programmes for the wider community.

No systematic study of fertiliser load has been done in Jamaica, although the quantities of imports are increasing. Whereas fertilisers are not thought to be dangerous to the health of applicators, it is generally accepted that many pesticides are detrimental to human health in a dose-dependent relationship.

2. Recommendations

- Capacity and financial resources in relevant organisations should be investigated to see what further research and long term monitoring programmes are possible.
- Governments, NGOs, and chemical companies should investigate sustainable financing mechanisms to fund research institutions and laboratories and to conduct further investigations and continuous monitoring of the use of agro-chemicals on farms, including soil testing, in order that data can be used for comparison.
- Greater collaboration between Caribbean states is needed, assisted by relevant regional bodies, through (a) partnerships for collaborative research; and (b) improved mechanisms for sharing of information.
- Regionally, it may be possible to pool resources, such that research and long-term monitoring programmes could be funded through a regional agency or body like the CGPC. Research could be shared between the countries through a common regional database that is maintained by the CGPC Secretariat, UNEP, CEP, or a dedicated team.
- Evaluate the potential for locally shared reference conditions or sites relating to similar habitats throughout the Caribbean and compile data on undisturbed and less disturbed habitats to develop a regionally applicable set of reference conditions.
- There is a need to evaluate the potential for harmonisation of standards throughout the Caribbean. Jointly explore standards appropriate to the local environmental conditions, and establish national and regional standards. Regionally acceptable (or local) standards for Maximum Residue Limits should be established, in the absence of which the FAO/WHO Codex Alimentarius standards should be applied where possible.

Environmental monitoring recommendations

Environmental monitoring is an essential tool in development management planning. It is the collection of information relating to selected indicators of the condition (quality) of the environment (e.g. presence or absence of chemicals, presence or absence of certain living species). The information gathered can be compared with:

- Baseline information on local environmental quality, compared to a reference condition that may be from another environmentally similar water-body

- Standards set by governments (e.g. for water quality).

The impact of external factors (such as pollution arising from agro-chemical run-off) and the success of present and future management actions can be assessed over time using the comparisons made above.

For monitoring to be effective, a plan should be developed and placed in the context of watershed management. Factors to consider in designing such a plan include:

- Goals and objectives of the monitoring programme
- Capacity and resources available (human and financial) to deliver adequate results in a specified timeframe (and identification of the need for capacity building)
- Watershed characteristics, and use of the water-bodies to be monitored
- Assessment of pollutant threats
- Assessment of the vulnerability of a location or water-body to pollutant threats
- Adoption of scientifically robust and replicable techniques
- Selection of appropriate indicators to achieve monitoring objectives
- Sampling station specifics (i.e. where to sample along the watershed)
- Seasonality (i.e. when to sample)
- Definition of locally relevant reference conditions
- Definition of locally relevant standards (e.g. of water quality).

Research recommendations

- Further studies are required in the following areas:
  - The impact and fate of agro-chemicals (especially fertilisers) particularly in relation to steep sloped farms
  - The human health and social impacts of pesticides, in relation to human health effects and also contaminated food
  - The rate of degradation of pesticides in the environment for tropical countries
  - The transport, fate, and persistence of pesticides in the marine and terrestrial environment in both St. Lucia and Jamaica
  - The fate of agro-chemicals in the land-water interface in agricultural areas other than the Roseau Valley area in St. Lucia and near Hunt's Bay in Jamaica
  - The fate of agro-chemicals used on crops other than the banana sector in St. Lucia and the main export crops in large plantations in Jamaica.
- Additional focus is needed on the bioaccumulation of pesticides (up the food chain) and the chronic toxicity of residues to human health and to aquatic fauna during different periods of agricultural activity. Furthermore, studies on pesticide residues in terrestrial organisms are needed because past work has focussed almost exclusively on aquatic organisms.
- MAFF, RADA, PCBs, or other selected organisations should compile all nationally available research on the fate of agro-chemicals in the environment, including studies on the impacts of pesticides on drinking water, terrestrial environments, and marine and freshwater environments and share information to enhance local programmes as well as identify gaps where further research is needed.
- In St. Lucia:
  - Research needs to be updated, as many of the studies were conducted in the 1980s and 1990s and further work is specifically needed to look into pesticide residues in soil.
- In Jamaica:
  - The studies are more recent but there is a need for more consistent research over a longer monitoring period to enable comparisons to be made.
  - Most studies have focussed on organochloride and organophosphate-based pesticides and therefore further research is needed on other types of pesticides.
  - Further work is needed on the bioaccumulation rates of pesticides in aquatic fauna, as most of the studies that have been conducted in Jamaica were on test species such as cultured freshwater fish (Tilapia nilotica) and, to a lesser extent, on shrimp and mangrove fish (guppies).

- The effect of pesticides on human health should be monitored and used as a tool to encourage the use of protective clothing.

Further information

Available as downloadable files under the Land-Water Interface option in the left-hand panel at http://www.mragltd.com:

- Boodram, N., 2002. The fate of agro-chemicals in the land-water interface, with reference to St. Lucia and the Wider Caribbean. DFID NRSP Project R7668. CEHI.
- Edwards, P., 2001. The fate of agro-chemicals in the land-water interface, with reference to Jamaica and the Wider Caribbean. DFID NRSP Project R7668. Centre for Marine Studies, UWI, Mona.
- Esteban, N., C. Mees, and S. Seddon-Brown, 2003. Environmental Monitoring Options. DFID NRSP Project R7668. MRAG Ltd.
- Lewis, A. and N. Esteban, 2002. Environmental survey of agro-chemicals in the land water interface of St. Lucia. DFID NRSP Project R7668. CEHI and MRAG Ltd.
- PCA, Pesticide Control Authority, 2002. Summary Annual Report April 2001–March 2002. Paper presented to CGPC in St. John's, Antigua. June 2002.
- PCA, 2003. Summary Annual Report April 2002–March 2003. Paper presented to CGPC 8th Annual Meeting in St. Vincent & Grenadines. June 2003.
- UNEP, 2000. Land-Based Sources of Marine Pollution in the Wider Caribbean Region: A Protocol for Action. June 2000. UNEP-CAR-RCU, Kingston, Jamaica

Other information sheets in the series are:

1. Management of agro-chemicals for improved public and environmental health
3. The quantification and toxicity of agro-chemical imports into St. Lucia and Jamaica
4. The on farm use of agro-chemicals and associated soil management and farming practices in St. Lucia and Jamaica
5. Harmonisation of agro-chemical management in the Caribbean
6. Management options for the use of agro-chemicals.

This publication is an output from a project funded by DFID (UK) for the benefit of developing countries. The views expressed are not necessarily those of DFID.