

The Science of Chemical Safety
Essential Toxicology

DDT - A Case Study

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DDT - Origins

- Dichlorodiphenyltrichloroethane (DDT) was first synthesised in 1874 but its power as an insecticide was not reported until 1939
- It is a cheap chemical, highly toxic to insects but with extremely low toxicity to mammals and humans
 - Thus it can be applied directly to human skin to kill parasites without any harm to the people concerned

DDT - The Benefits

- Highly persistent so that it continues for months after application to kill insects such as mosquitoes that carry disease
- Used to virtually eliminate malaria, dengue fever and filariasis
- Estimated to have saved about 50 million human lives and to have prevented more than a thousand million human illnesses

DDT - the Problem

- DDT, and especially its derivative DDE, are persistent molecules which are transferred from the point of application through the air (following evaporation), through water (in spite of very low water solubility) and through food webs following bio-accumulation

DDT Bio-accumulation

- Bio-accumulation is the result of two things:
 - 1. the fat solubility of DDT and derivatives enabling them to dissolve in cell membranes and pass into cells to be stored in fatty tissue
 - 2. the chemical resistance of DDT and derivatives to biotransformation to water soluble metabolites which can be easily excreted

DDT and Pigeons

- Research was started because pigeon fanciers claimed that their birds were being killed more often by peregrine falcons than previously and thus the falcon population must be increasing
- Study showed that in fact the peregrine falcon population was decreasing rapidly
- Other birds of prey (raptors) such as eagles were decreasing in numbers too

DDT and eggshells

- The decline in numbers of raptors was associated with eggshell thinning, in turn associated with DDT and DDE levels
- Hyperactivity of affected birds on the nest probably increased egg breakage
- Other chlorinated hydrocarbons such as dieldrin and PCBs may have contributed to the effects observed.

DDT - The Lessons

- Effects may occur a long way from the point of use of DDT: direct exposure from spraying need not occur to cause food web poisoning
- Quail, pheasant and chicken - the bird species commonly used in toxicity testing are almost completely insensitive to DDT: species variability may be large
- Sublethal effects, especially on reproduction, may destroy a species

DDT, Mosquitoes, Wasps and Moths

- In Malaysia, thatched huts were sprayed by the World Health Organization with DDT to kill mosquitoes which carry the parasite causing malaria
- The DDT killed other insects as well including wasps that normally ate moth larvae that lived in the thatched roofs and ate the straw thatching

Moths, Cockroaches, and Geckos

- Many of the moths survived DDT treatment; they ate the straw in the roofs which collapsed
- In addition cockroaches in the treated huts were fairly resistant to the DDT and accumulated it in their bodies
- Geckos that lived in the huts ate the cockroaches and died of DDT poisoning

Dying Cats

- Cats that ate the geckos with DDT in their bodies also died of DDT poisoning
- Because there were no cats left in the village following the DDT treatment, rats multiplied, with the increased risk of bubonic plague carried by their fleas

Flying Cats

- The World Health Organization arranged for cats to be dropped by parachute to the remote village to replace those that had died and to eliminate the rats to prevent plague

Preventing Malaria

- The mosquito borne parasite which causes malaria is said to kill 200 children under the age of 5 every hour in developing countries and up to 2.4 million Africans every year
- Every year, up to 500 million people around the world fall ill with malaria; as a result, they may become more vulnerable to the virus that causes AIDS

Use of DDT

- The use of DDT in the 1940s and 1950s in many countries almost eliminated the mosquitos that carry the parasite that causes malaria.
- In the late 1960s and 1970s, countries that could afford alternative pesticides began to ban DDT because of its effects on predatory birds and accumulation in milk.

The DDT ban

- When DDT was banned in the wealthy countries of the world because of its effects on birds and accumulation in mother's milk, these countries began making cessation of DDT spraying a condition for granting aid

Use of Pyrethroids

- Synthetic pyrethroids were used as an alternative but mosquitoes have rapidly become resistant to these pesticides and the incidence of malaria is increasing rapidly

Malaria now

- Malaria rates in Africa are now higher than they are ever known to have been, except for Swaziland where DDT use was never stopped

DDT Now

- WHO, Greenpeace, and the Worldwide Fund for Nature (WWF) met in December 2000 in Johannesburg and WWF and Greenpeace have suspended their arguments against the use of DDT in malarial areas, provided application is limited to indoor spraying, particularly on to wall surfaces, to protect people, minimising environmental effects

Conclusions

- The harmful consequences of widespread use in quantity of any substance in the natural environment may not be predictable with our current state of knowledge
- Well planned monitoring for possible harmful effects of chemicals in use will remain essential for the foreseeable future

Conclusions

- 3. Even where environmental damage is possible or has been observed, benefits (such as elimination of disease) may be sufficient to justify careful use of a chemical