**HISTORY OF PESTICIDE USE**

In recent years, (basically post-World War II) chemical pesticides have become the most important consciously-applied form of pest management. This is a generalization of course; for some crops in some areas, alternative forms of pest control are still used heavily, such as the burning of the grass fields that we experience in late summer and fall in the Willamette Valley.

The "first generation" pesticides were largely highly toxic compounds, such as arsenic and hydrogen cyanide. Their use was largely abandoned because they were either too ineffective or too toxic.

The "second generation" pesticides largely included synthetic organic compounds. ('Synthetic' here means made by humans -- not naturally occurring, while 'organic' means carbon containing, not to be confused with the popular use of "organic" as in "organic farming".)

**DDT CASE STUDY:**

The first important synthetic organic pesticide was a chlorinated hydrocarboon (or organochlorine): dichlorodiphenyltrichloroethane or DDT. DDT was discovered in 1939 by a Swiss chemist Paul Muller. In its early days, it was hailed as a miracle for a number of reasons:

BI390000.gif It was toxic to wide range of insect pests (**"broad spectrum"**) yet appeared to have low toxicity to mammals.

BI390000.gif It was **persistent** (didn't break down rapidly in the environment) so that it didn't have to be reapplied often.

BI390000.gif It was not water soluble (**insoluble**), so didn't get washed off by rains.

BI390000.gif It was inexpensive and easy to apply

It was so effective at killing pests and thus boosting crop yields and was so inexpensive to make that its use quickly spread over the globe. In 1948, Muller was awarded the Nobel Prize in Mecine or Physiology for its discovery. It was used for many non-agricultural applications as well. For example, it was used to delouse soldiers in WWII, and, until the 1960's to control mosquitoes in residential areas of the US. I can remember as a child, in a small town in Minnesota, the excitingly eerie sight and sound of the "mosquito truck" driving up and down the streets at night, producing a gentle mist behind it....We would often go out and play to be near it!

The magic of DDT seemed to spread. Yields increased on treated crops, diseases such as malaria were brought under control as never before...(incidentally, malaria is now is on the increase again as the vectoring insects develop [resistance](http://people.oregonstate.edu/~muirp/resistan.htm) to chemical pesticides). It all seemed so wonderful -- people could cheaply and easily control so many pests!

Then, things began to temper the enthusiasm for pesticides. Notable among these was the publication of Rachel Carson's best selling book "**Silent Spring,**" which was published in 1962. She (a scientist) issued grave warnings about pesticides, and predicted massive destruction of the planet's fragile ecosystems unless more was done to halt what she called the "**rain of chemicals.**" In retrospect, this book really launched the environmental movement.

She was focusing on the chlorinated hydrocarbons, such as DDT, and pointed to evidence linking them to death of **non-target** creatures (organisms other than those that the pesticide is intended to kill), such as birds. She argued that the death of nontargets occurred via two basic ways:

**(1) Direct toxicity.**It was discovered that DDT was toxic to fish (especially juveniles) and crabs, not only to insects.

**(2) Indirect toxicity, related to its persistence.**(It's persistence came in part from its insolubility, from the fact that it was a synthetic, recently introduced compound that microconsumers, such as bacteria, lacked enzymes capable of degrading -- basically they hadn't evolved to use it as an energy source, as well as from other features of its chemistry.)

She reported that insect and worm eating birds were dying in areas where pesticides had been aerially applied (hence her title, "**Silent Spring."**

The pesticide manufacturers said that the minute amounts found in the environment couldn't possibly be killing them. However, some experimental work demonstrated that even small amounts of some of the pesticides could affect the survival and reproduction of some species. More important, research demonstrated that, although concentrations were very low in the soil, atmosphere and water, concentrations were higher in plants, higher still in herbivores, and still higher as one moved up the food chain.

The**indirect toxicity** related to two principles :

**(1) Bioconcentration** – the tendency for a compound to accumulate in an organisms's tissues (especially in fatty tissues for fat soluble organochlorines such as DDT) and

**(2) Biomagnification**. – an increase in concentration up the food chain.

(These terms are sloppily used; sometimes "**bioaccumulation**" is also used to mean either of these, and people often use all of these terms interchangeably.)

Because DDT was (is) persistent, there was abundant opportunity for it to be taken up from the environment by organisms. For example, in the estuarine ecosystem next to Long Island Sound, the following concentrations of DDT were found:

BI390000.gif In **water**= 3 ppt (**0.000003 ppm**)

BI390000.gif In **zooplankton** = **0.04 ppm** (bioconcentration and biomagnification from eating plants)

BI390000.gif In **minnows** = **0.5 ppm** (bioconcentration + biomagnification) (Because of the inefficiency of energy transfer, each minnow has to eat lots of zooplankton, and so acquires quite a burden from them.)

BI390000.gif In **large fish** = **2.0 ppm**

BI390000.gif In **ospreys** (fish eating birds) = **25.0 ppm**

Thus, concentrations had increased 10 million times up this progression, largely because of biomagnification (differential uptake and secretion may also be involved). These concentrations were not always directly lethal to the highest order carnivores, but did impair their reproduction. DDT (actually, its breakdown product DDE) reduced the deposition of calcium in eggshells. The birds thus produced thinner shell that cracked more readily during incubation.

The populations of many predatory populations (the highest order carnivores), such as bald eagles and brown pelicans were nearly eliminated. The peregrine falcon disappeared in the eastern US as a result of reproductive failures by the 1960's.

DDT (and DDE, a breakdown products from DDT) also appeared in the fatty tissues of seals and Eskimos, far from any area of use, indicating that, because of its persistence, it was being **transported for long distances** in the atmosphere and by marine mammals and fishes. It also showed up in human breast milk at remarkably high concentrations -- so high that the milk couldn't legally be sold through interstate commerce if it were cow's milk! DDE is one of the most widespread contaminants in human milk around the world (usually 10-20 times higher than in cow milk).

These concerns, and the resulting public outcry prompted the US Environmental Protection Agency (EPA) to cancel the registration of DDT in the US in 1972. (All pesticides used in the US must be registered with the federal government, so this cancellation effectively pulled DDT off of the US market.) (Its use is still allowed in special cases, as in controlling vectors of human diseases.) Manufacture of DDT in the US did continue for export until the late 1970's. Currently there is no manufacturing of DDT in the US.

DDT is still, however, widely used in less developed countries. And, ironically, (but all too typically), when the last DDT manufacturing plant in the US was dismantled in 1983, it was sold to Indonesia, where it continued to manufacture DDT till 2009.

**NEW PESTICIDES:**

The chemical industry responded to the concern over DDT and its relatives with new classes of pesticides, which are **less persistent** than DDT and the other organochlorines, but which are generally **more water soluble** (with consequent potential for contaminating surface and ground water) and are often also **more acutely toxic.**

Their acute toxicity is demonstrated in the minute amounts of them that are effective:

In 1945, DDT was typically applied at a rate of **2 kg/ha**

Today, similar levels of control are obtained with aldicarb and pyrethroids at 0.1 and 0.05 kg/ha (**50 g/ha!**) respectively. That is, they are over 10 times more effective (or toxic), and as much as 40 times more so!

**A solution to one problem can create new problems – we will see this over and over!**

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