A SUMMARY ON DDT

Prepared by

The Faculty and Students
of
The Hopkins Marine Station of Stanford University
Pacific Grove, California 93950

DDT - THE PROBLEM

DDT, chemically known as 1,1,1-trichloro-2,2-bis (p-chlorophenyl) ethane, was the first major synthetic insecticide. Developed by Swiss chemist Paul H. Mueller, who received a Nobel Prize in 1948 for his work, it was first used in massive amounts during World War II. Since that time it has probably saved millions of people from death by malaria, typhus, and other insect-borne diseases, and saved billions of dollars in crops from insect pests.

Praised for its beneficial effects, DDT has also been harshly criticized. Past controversy centered mainly on its acute toxic effects on a broad range of organisms. Amounts of DDT used to kill pests also kill many other animals including birds, fishes, and beneficial insects which help hold pests in check. Acute poisoning of non-target organisms still occurs, but present controversy centers mainly on a more subtle effect--the chronic poisoning of many species by the increasing levels of DDT in the environment. The main effect of chronic poisoning is reproductive failure. The visible signs of this are not as spectacular as those of acute poisoning, but the end results may be worse. Reproductive failure can lead to extinction of species, and we see this happening today.

Pollution of the environment by DDT is world wide. For years DDT has been accumulating in the oceans. The consequences are serious and soon may be disastrous. How has pollution of the oceans occurred? What is DDT doing to organisms there? And what can be done to prevent further damage?

HOW DDT GETS INTO THE OCEAN

Three properties of DDT concern us here: its stability, its ability to evaporate with water, and its tendency to cling to particles.

Stability. DDT is one of the chlorinated hydrocarbons. These are "hard" pesticides, that is, they are stable and not easily decomposed into harmless products by weathering or the activities of living things. The half-life of DDT in the environment varies greatly with conditions; it may extend for several years or even several decades.

DDT does undergo slight changes into the residues DDD and DDE. These are toxic too, and may also cause reproductive failure.

Use of DDT in the U.S. has been declining in the past 10 years, but use abroad has increased. DDT is being applied to the world faster than it is breaking down to harmless products, so concentrations are building up.

Evaporation with water. Some of the DDT applied to soils and lakes drains into streams and rivers, and is carried to the sea this way. But DDT can also evaporate along with water from both soils and lakes, so some of it enters the air.

Adherence to particles. In air and water DDT tends to cling to other particles there. In the air DDT attaches readily to dust and is transported world wide by winds. Since the sea covers nearly three quarters of the globe, it receives a major share of the dust which settles.

By runoff, rivers, and airborne dust, much DDT applied on land eventually enters the oceans and accumulates here. DDT and its toxic residues are found in Antarctic penguins and seals, and in fishes living thousands of miles out at sea.

HOW DDT GETS INTO MARINE ORGANISMS

Characteristics of DDT involved here are: its low solubility in water, its high solubility in fatty materials, and its ability to undergo "biological magnification".

Solubility. Only about 1.2 parts of DDT will dissolve in a billion parts of water. Since DDT is almost insoluble in water, filtered water always contains very low concentrations. Much more DDT may be present attached to fine particles dispersed in the water.

DDT is highly soluble in fatty or oily materials, however. For this reason it is very readily taken up by the bodies of insects and a great many other kinds of organisms, even though it may be present in the environment in very small quantities. Once it enters a body it tends to stay there, thus in any environment DDT tends to accumulate in living organisms. It is also absorbed by fatty materials in dead and decomposing organisms.

The actual concentration of DDT in the sea is very low, and is measured in parts per trillion of sea water. Even at these low levels it is quickly absorbed by living organisms. Most marine animals and plants contain sizable amounts of fats or oils, and the DDT content of this material increases during life partly as a result of direct absorption.

Biological magnification. This is another factor important in the build-up of high DDT levels in animals. In the sea, as on land, the animals are ultimately dependent on plants for food. Nearly all plants of the open sea are microscopic in size; present in immense numbers they form the plant plankton. They contain considerable oil, and readily absorb and retain DDT.

The tiny plants are eaten by many different kinds of small animals. Each small animal eats a large number of plants, and most of the DDT in the plants becomes stored in its body. Since the animal contains the DDT absorbed by many plants, the concentration of DDT in its body becomes much higher than that in the plants which it eats.

This process of concentration of DDT is called "biological magnification". Some animals are not very efficient in concentrating and storing the DDT in their food, and their levels of DDT are not very much higher than those in the things they eat. Other organisms are highly efficient concentrators, and may eventually build up levels of DDT as much as 100,000 times greater than that in their food.

Small animals are eaten by larger ones, and these in turn by still larger animals. At each successive step in such a "food chain" the DDT concentration increases. In the water it is present in a few parts per trillion; in marine plants it is many parts per trillion. In the smaller animals it is measured in parts per billion. In the larger animals levels are measured in parts per million.

At these levels we are in real trouble. Already the animals may be suffering a degree of reproductive failure from chronic poisoning. They may also be inedible by man. Food and Drug regulations prohibit marketing of fish which contain more than 5 parts per million of DDT and its residues.

The highest concentrations of DDT usually occur in the larger animals which feed on fishes, such as fish-eating birds like the pelicans and ospreys, and birds of prey like the peregrine falcon which feeds mainly on fish-eating birds. DDT levels in these birds may be between 5 and 100 times greater than the levels permitted in market fish.

Animals which die without being eaten by larger forms decompose. As this occurs, particles of organic matter and scraps of dead tissue containing DDT are eaten by a variety of small scavenging animals, which in turn are eaten by larger animals. Thus DDT in dead organisms on the bottoms of lakes and seas may enter the food chains again rather than being "lost" in bottom deposits. Since the sea is the ultimate receptacle for much of the DDT spread on land, many marine animals contain higher concentrations of DDT than do some land forms.

WHAT DDT IS DOING TO ORGANISMS

Marine plants. Laboratory experiments suggest that concentrations of DDT amounting to only a few parts per billion in water may reduce photosynthesis and growth in marine plant plankton. Such concentrations of DDT do not occur in the open sea, and are not anticipated there, but they may be approached in bays receiving agricultural drainage. No damage to plant plankton of the sea attributable to DDT has yet been reported, but we need to keep an eye on coastal waters where plant plankton supports some of man's richest fisheries.

Shellfish (shrimps, crabs, oysters, clams). For shellfish, too, man's major fisheries lie in coastal waters, often in bays which receive some runoff containing DDT as well as aerial fallout. Several cases of local damage to oysters and shrimps have been reported.

Commercial crab fisheries on both east and west coasts have declined in recent years. The causes are still unproven. However, studies carried out on DDT levels in adults, eggs, and larvae of the west coast market crab strongly suggest that DDT is an important factor. Adult crabs appear normal, with levels of DDT of less than 0.5 parts per million, and are still highly edible. But the DDT transferred to the eggs apparently kills many of the larvae, and this may be causing the population decline.

Fishes. The worst damage to fishes has occurred in inland waters and in enclosed seas like the Baltic. Carnivorous fishes in some lakes in the U.S., Sweden, and other countries contain levels of DDT above those considered safe for regular human consumption (5 parts per million). The Lake Michigan coho salmon fishery, worth millions of dollars a year, was recently closed when the catch was found to contain up to 19 ppm of DDT.

DDT levels much lower than this have been linked with reproductive failure in some fresh water fishes. DDT from the females is transferred to the eggs as these are formed. As a young fish larva grows and uses up the yolk the DDT enters its blood. In New York State, all trout eggs with more than 2.9 ppm DDT died near the end of the larval stage. The level causing larval death was even lower for trout eggs in Wyoming. Some larval mortality due to DDT occurs in the coho salmon.

DDT levels are considerably lower for most Californian marine fishes. Anchovies are mostly below 1 ppm DDT, though individual fish are sometimes higher. One batch of 44 anchovies taken off Terminal Island measured above 12 ppm DDT, more than twice the allowable level in fish sold for food. Shiner perch in San Francisco Bay contained 1-1.4 ppm DDT; hake taken off the Channel Islands averaged 1.8 ppm. The flesh of English sole, mackeral, tuna, and striped bass usually measures well below 1 ppm, though three striped bass which had been feeding on carp in inland waters averaged 111 ppm, more than 22 times the allowable limit.

A few parts per billion of DDT causes an upset in the temperature selecting and acclimating mechanism in salmon, and in some fishes low concentrations of DDT result in abnormal behavior that makes them easy prey to predators. Much more needs to be known of the effects of low concentrations of DDT on the reproduction and behavior of marine fishes. Fish that are still safe to eat may be suffering reproductive damage.

Birds. Those suffering most from chronic DDT poisoning thus far are the fish-eating birds and the raptorial birds which prey on them. These birds occupy positions on food chains several steps removed from plants, and receive the greatest effects of biological magnification.

DDT and its toxic residues are stored up in the body fat of birds at concentrations which may reach several hundred or even over 1000 parts per million. The highest levels yet found have been in the body fat of birds found dead on California beaches.

During breeding, as fat is depleted the DDT residues stored there are released to the blood. They stimulate the liver to produce enzymes that break down sex hormones which are necessary for successful breeding behavior and the formation of proper egg shells.

Birds suffering chronic DDT poisoning lay thin-shelled eggs or eggs without any hard shell. Such eggs break during incubation.

The bald eagle, osprey, brown pelican, Bermuda petrel, peregrine falcon, and numerous similar birds are all suffering degrees of reproductive failure through production of thin-shelled eggs. The effects have been catastrophic in some cases. The peregrine falcon began to lay thin-shelled eggs during the first decade of DDT use. It is now extinct as a breeding population on the east coast of the U.S. On the west coast breeding is known only in a few small groups which do not prey on fish-eating birds but instead feed on pigeons which have a much lower DDT content.

The brown pelican appears to have suffered total or almost total reproductive failure all over North America. The last known breeding ground on the west coast north of Mexico was Anacapa Island. This year all eggs laid here were either thin-shelled or shell-less, and all were broken before hatching. A recent survey extending part way down Baja California showed no successful reproduction here either. The outlook for survival of numerous seabirds is gloomy.

Man. DDT affects man in relation to both his food supply and his health.

Food. DDT still plays an important role in preserving part of man's food supply from pests, but it is rendering other parts of that supply inedible or destroying the source itself.

Permissible limits of DDT residues in foods sold on the market are established in Food and Drug regulations. Limits are set at levels low enough so that, if properly enforced, there will be no cases of acute poisoning and no cases of chronic poisoning even with continued use of the food.

Maximum permissible levels are being approached in some foods today, despite increasing restrictions on the use of DDT. The high DDT content in milk caused Arizona to place a temporary ban on the use of DDT. The Lake Michigan coho salmon fishery is closed because of high DDT levels in the fish. Pesticide levels in lake fishes and in some Baltic Sea fishes caused Sweden to ban virtually all use of DDT. DDD levels measured a decade ago in eight species of fishes inhabiting Clear Lake in California showed levels ranging from a low of 5 ppm (now the permissible limit) to 133 ppm. These levels are unusually high, for Clear Lake received large scale treatment with DDD to control gnats in 1949, 1954, and 1957; DDD was applied at the rate of 1 part to 50-70 million parts of water.

Reproductive failure in trout and other fishes at levels well below those occurring in Clear Lake show that the dangers to man lie not only in making fish inedible but in the destruction of the fishery itself. The prospect of a marked decline in reproduction of important food fishes in lakes and coastal seas at the same time that world population is increasing should be a matter of deep concern to all.

Health. People in the U.S. carry in their fatty tissues levels of DDT averaging about 12 ppm.

DDT is also present in human breast milk. In some parts of the world, and occasionally in the U.S., the DDT level in mothers milk is so high that under FDA standards it could not be sold for human consumption.

Some industrial and agricultural workers long exposed to DDT have concentrations of over 600 ppm in their body fat without suffering from any gross functional disorders.

However, little work has been done on subtle, long-term effects of DDT in man. Recent clinical research shows a strong correlation between high DDT levels and encephalomalacia, cerebral hemorrhage, portal cirrhosis, and various carcinomas. DDT and its derivatives can also induce cancer in tumor-susceptible mice.

THE SOLUTION - BAN THE USE OF DDT.

While DDT has been enormously beneficial in some respects in the past, it is now clear that it poses a very real threat to important human food resources and to other species indirectly beneficial to man.

DDT is less effective now than when it was first used, for nearly 150 species of insect pests have developed resistance to it.

Moreover, satisfactory alternatives are now available, and more are under development, for the more perceptive manufacturers of pesticides have taken note as DDT and other chlorinated hydrocarbons have been placed under increasing restrictions.

Alternative pesticides include such chemicals as the carbamates and organophosphates, which break down more easily and are not stored by living organisms. While these are more expensive than DDT at present, commercial pesticide distributors have predicted that prices will drop as sales increase, just as was the case with DDT. Meanwhile, there is hope for the development of both chemical and biological control measures which will be more selective for specific target organisms, and less destructive to beneficial species and innocent bystanders.

Even if we stopped using it today, DDT would remain with us in the environment for a long time. The number of years or decades is uncertain. Accumulation of DDT in the sea would surely continue as wind and water transferred the DDT now in soils, lakes, and the atmosphere into the ocean basins. Eventually concentrations here would reach a peak and begin to decline, but we cannot afford to wait until DDT comes close to destroying the great ocean fisheries before we call a halt to its use. If we do, the uncounted tons of DDT remaining on land and in the air could still raise the DDT concentration in the sea from a dangerous to a disastrous level. Action should be taken before there is wholesale damage to important world fisheries, and before we experience the loss of whole categories of animals that play important roles in preserving an environment favorable to man.

DDT is already banned in some areas, and its use has been restricted in other states. A "DDT trial" has just been concluded in Wisonsin, and bills to ban DDT are under consideration.

CALIFORNIA SENATE BILL 1430 - TO BAN USE OF DDT

Early in May, 1969, the California State Senate voted to consider legislation aimed at banning the use of DDT in the state. Senate Bill #1430, introduced by Senators John A. Nejedly (Contra Costa County, District 7) and Lewis F. Sherman (Alameda County, District 8) needs support if it is to pass during this session. Only a few weeks of the session remain.

Those wishing to support the bill should write to the Senator and Assemblyman from their own districts, asking support of the bill to ban DDT use in California.

Letters to your newspapers, perhaps including some information from this summary, should help awaken others to the problem and enlist their support.

While it is highly desirable that a ban on DDT should extend quickly to the nation and to other countries, control must start here at home. California manufactures and uses more DDT than any other state.

The time to ban its use is NOW.