Residues of Insecticides in Vegetation and in Soil From High Dispersed Insecticide Aerosols

V. I. Makarov, V. M. Sakharov, and K. P. Kutzenogii
Institute of Chemical Kinetics & Combustion
Siberian Branch of the Soviet Academy of Sciences
Novosibirsk, 630090, USSR

Insecticidal residues in edible vegetation are elicited through numerous investigations to be very dangerous. The residue amounts depend essentially on the amount of insecticides used, the method of their application, and the type of vegetation (MAIER-BODE, 1965).

The residue data given in literature on ground and aircraft applications enable to conclude that the residue amounts in vegetation and soil are from one ppm to tens ppm. In this connection, the aerosol insecticide method is regarded to be the most progressive one with respect both to its efficiency and contamination of the environment. This method allows to substantially reduce the residue concentrations as an aerosol application enables to make insecticide consumption 5-10 times as little as that at an aerial application, the efficiency being the same.

This paper presents data of γ-BHC and p,p'-DDT residues in grass, pine-needle, forest layers, soil, and their change vs. time after aerosol treatments with a high power aerosol generator (MAG-3) (SAKHAROV et al., 1973).

METHODS AND MATERIALS

In our field experiments Calliptamus italicus L. was subjected to an aerosol produced from 3% γ-BHC solution in diesel fuel oil at linear consumption of 50 g/m (TABLE 4). Mortality of the insects was about 80-90 percent. To control Ocneria monacha L. pine woods were treated with 7% p,p'DDT solution produced from 16% concentrated DDT solution in diesel fuel oil. The linear consumption was about 80 g/m. Mortality of Ocneria monacha L. was 62-95% (TABLES 1-3, test 1). To control Bupalus piniarius L. woods were treated with 8% p,p'-DDT solution, linear consumption being about 100 g/m, mortality being 100% (TABLE 1-3, test 2).

SOIL AND VEGETATION SAMPLING

Samples were collected both before and after treatments at distances of 20, 50, 100, 500, 1000, 2000, and 4000 m from the generator moving path in the direction of the wind. Samples were collected from the same places.

On an area of about 1 m^2 grass was cut away, and a forest or soil layer of 1-2 cm thick was removed from an area of 50 x 50 cm^2.

Bulletin of Environmental Contamination & Toxicology,
Vol. 17, No. 6 © 1977 by Springer-Verlag New York Inc.

In the same place a branch of a pine-tree of about 10 m height was cut away, and the needle was taken. Before chemical analysis the samples collected were kept in glass pots for 3-4 days at the temperature of 4-5^{o}C.

Analysis method. For analysis we took 50 g of the grass, needls, forest layer, and 100 g of the soil. To extract DDT and γ-BHC from the soil and vegetation samples the codistillation method was employed (BELONOSOV et al., 1970). The residue extraction rate of the method is not less than 85%. The samples were analyzed with a chromatograph of the "Tsvet-5" type with an electron-capture detector. The sensitivity of the method was 0.002 ppm for γ-BHC and 0.005 ppm for p,p'-DDT.

RESULTS AND DISCUSSIONS

The experimental results are adduced in tables 1-4. Residues of p,p'-DDT in grass (TABLE 1, test 1) at distances up to 100 m directly after the treatment are in the range of 0.9-1.6 ppm. But 30 days after the application p,p'-DDT residues in grass become 3-4 times as little and equal to about 0.4 ppm. However, one must not attribute the reduce of the residues to insecticide decomposition only, as alongside with it, a biomass increase in grass resulted from its growth takes place. This process contributes to the decrease in insecticidal residue concentrations. At distances of 50 m and more p,p'-DDT residues in grass change from some tenth to some hundredth of a ppm, and are in the range of the background values within the experimental errors.

The residue of p,p'-DDT in needle and in forest layers (TABLES 2,3) show that their distribution vs. distance follows the same rules as that for grass. Nevertheless, the residues in grass are 2-3 times as high as those in needle at a distance of about 100 m. It is evidently associated with the fact that the effective surface of 1 kg of grass accumulating insecticidal aerosols is 2-3 times as much as that of needle, as it follows from our data and those of the work (MAIER-BODE, 1965).

The γ-BHC residues are given in table 4. At a linear consumption of 50 g/m the residues change in the range of 0.1-4 ppm. In the experiments both with γ-BHC and p,p'-DDT the residue concentrations in soil differ greatly from those in grass.

Thus, p,p'-DDT and γ-BHC residues in vegetation and soil after high dispersed aerosol applications at distances less than 100 m from the generator path are equal to some tenth of a ppm and to about 1 ppm in grass. But at distances exceeding 500 m the residue concentrations are of the background level and equal to 0.1-0.2 ppm and less. Usually the effective working width of a MAG, i.e. the distance at which the extermination rate is sufficiently high, is 5-7 km. So, the area with the residues less than some tenth of a ppm is at least 50 times as much as that with higher concentrations. It means that applications of high dispersed aerosols contaminate

TABLE 1

p,p'-DDT residues in grass (ppm.)

Test	Time passed after treatment, days	p,p'-DDT linear consumption, g/m	Distance from the generator moving path, m						
			20	50	100	500	1000	2000	4000
1.	Background	-	0.16	0.19	0.15	0.08	0.08	0.07	0.05
	0	80	0.9	1.6	1.34	0.1	0.14	0.04	0.03
	4	-"-	1.1	0.89	0.78	0.47	0.2	0.24	0.16
	30	-"-	0.37	0.45	0.35	0.1	0.08	0.08	0.12
2.	Background	-	0.03	0.01	0.03	0.01	0.02	0.01	0.02
	42	96	0.18	0.09	0.24	0.08	0.06	0.02	0.03

TABLE 2

p,p'-DDT residues in needle (ppm.)

Test	Time passed after treatment, days	p,p'-DDT linear consumption, g/m	Distance from the generator moving path, m						
			20	50	100	500	1000	2000	4000
1.	Background	-	0.04	0.05	0.02	-	0.02	0.02	0.07
	0	80	0.1	0.23	0.95	0.7	0.02	0.02	0.06
	4	-"-	0.1	0.09	0.08	0.12	0.03	0.05	0.04
	30	-"-	0.1	0.1	0.1	0.06	0.03	0.06	0.03
2.	Background	-	-	-	0.02	0.05	-	0.005	0.006
	42	96	0.07	0.1	0.04	0.05	0.06	0.06	0.03

TABLE 3

p,p'-DDT residues in forest layers (ppm.)

Test	Time passed after treatment, days	p,p'-DDT linear consumption g/m	Distance from the generator moving path, m						
			20	50	100	500	1000	2000	4000
1.	Background	-	0.02	0.01	0.02	0.02	0.01	0.02	0.02
	0	80	0.09	0.08	0.36	0.02	0.01	0.02	0.04
	4	-"-	0.05	0.05	0.1	0.07	0.04	0.03	0.04
	30	-"-	0.2	0.13	0.08	0.04	0.04	0.02	0.03
2.	Background	-	0.01	0.01	0.16	0.01	0.02	0.03	0.01
	42	96	0.1	0.05	0.09	0.06	0.03	0.03	0.01

TABLE 4

γ-BHC residues in grass and soil (ppm.)

Distance from the generator moving path, m	γ-BHC linear consumption, g/m	γ-BHC amounts (ppm.)			
		in grass		in soil	
		Before treatment	After treatment	Before treatment	After treatment
150	50	-*)	4	-	0.3
250	-"-	-	0.1	-	0.02
900	-"-	0.4	2.2	0.02	0.06
1000	-"-	0.1	0.3	-	0.05
2000	-"-	0.07	0.8	0.003	0.03

-*) - γ-BHC amount in a sample is less than 0.002 ppm..

the nature least. The conclusion is valid both for agriculture and forestry, as the amount of insecticidal residues in field (TABLE 4) and in forest grass (TABLE 1) after the aerosol applications is nearly the same.

The DDT and BHC residue data obtained for vegetation and soil are of great importance. It is possible to consider that when aerosols of modern insecticides less persistent under the nature conditions and of an identical size distribution are used the data obtained will be close to those discussed in the present paper. As for the recovery rate, it will be much higher due to a less persistency of phosphororganic insecticides.

Special attention should be paid to the fact, that high extermination rates are obtained at extremely small amounts of insecticidal residues in vegetation and soil. For example, at a distance of 500 m and more the residue amounts are of the background level. Whereas the effective working width of an aerosol cloud with the extermination rate of 90% and more is 5 km in the experiments described and 5-7 km in other cases of treatment with a MAG (BERDENNIKOVA et al., 1970).

Thus, to reduce a population of deleterious insects to low levels considerable deposits of insecticides on vegetation are not necessary. It has been noted (DUNSKIY et al., 1959; MAKSYMJUK, 1963) that there is no simple relation between the residue concentrations and insect control. In the works mentioned the deposit density was estimated by the deposits on slides. That did not allow to make a conclusion of the minimum deposit density ensuring the necessary protection for vegetation. An appreciable mortality of insects was observed at deposits being tens and hundreds times as low as the level, corresponding to the average insecticide output per unit of the area treated at an ULV application.

In our field experiments performed on vast areas we have manged to prove a high efficiency of aerosols, in fact, all over the area treated, i.e. at distances from 0.5 km to 5 km from a generator at the amounts of the residues commensurable with the background values.

Fig. 1 shows the data of DDT residue change in various substrata vs. time. The points in the lower part of the plot denote the residue amounts after the treatment with a MAG. Dotted lines 1-5 show the level of the background concentrations in grass (1,2) needle (3), and forest layers (4,5). The fact is, that these data are referred to the period before the treatment, i.e. to the moment "0" of the plot. Curves 6, 7 describe the data on an aerial application of DDT. Curve 6 gives the decomposition rate of DDT in grass after applications of oil solutions at a rate of 2.24 kg/ha (MAIER-BODE, 1965), and curve 7 those in wood grass after treatments of oak woods with 16% oil solutions at a rate of 5 l/ha (KLISENKO, 1968).

The points referred to the aerosol treatments denote the

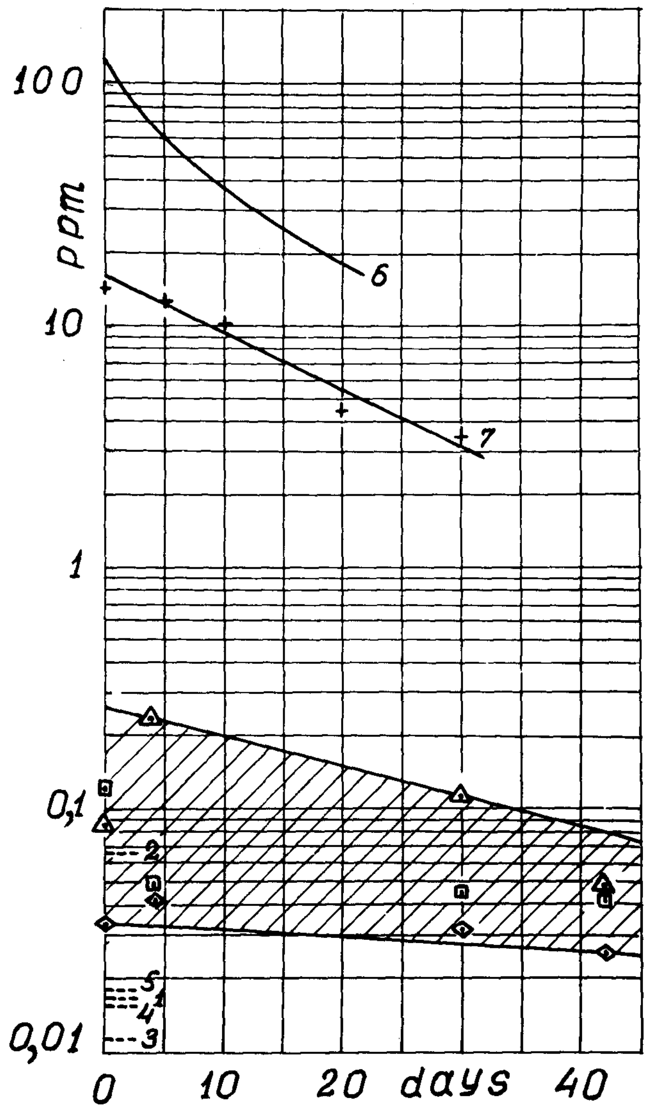

Fig. 1. Initial levels of DDT residues and rates of their disappearance after various application methods.

DDT residues after aerosol applications:
- in grass, - in needle, - in forest layers.

Curves 6 and 7 - after aircraft treatments.

average suspended values of the residue concentrations all over the working width, i.e. up to 4-5 km. The region embracing all the values is in the range of 0.03-0.4 ppm. The data for grass occupy the upper part of the region (0.08-0.4 ppm), then follow those for needle (0.05-0.12) and for forest layers (0.03-0.04). The background values are much lower, namely, in the range of 0.01-0.02 ppm, and only in test 1 they reach as high as 0.064 ppm.

So a strict division into two regions is indicative of accuracy of the data obtained. Curves 6,7, characterizing aerial treatments, are adduced for comparison. The residue data for DDT in these cases are two orders higher than those on aerosol treatments. Sometimes they reach 50-100 ppm. For example, in some compared the residue concentrations in froest grass after aerial applications were about 10 ppm, whereas those after aerosol ones were about 0.1 ppm.

REFERENCES

BELONOSOV, V. M. and V. V. ERMAKOV: Voprosy pitaniya. No. 3, 21 (1970).

BERDENNIKOVA, S. P., G. N. ZAGULYAEV, E. I. KIROV, V. M. SAKHAROV: "Primenenie khimicheskih sredstv borby s vreditelyami lesa." M., TsBNTI lesn. hosyaistva, 1970.

DUNSKI, V. F., A. M. CHURAKOV, Z. M. YUHZNYI: "Aerosoli v selskom hosyaistve." M., Selhosgiz, 1956.

KLISENKO, M. A. and Z. F. YURKOVA: "Primenenie khimicheskih sredstv borby s vreditelyami lesa." M., TsBNTI lesn. hosyaistva, 1970.

MAIER-BODE, HANS: Pflanzenschutzmittel rückstände Insecticide. Verlag Eugen Ulmer Stuttrart, 1965.

MAKSYMIUK, B.: J. Econ. Entomol., 56, No. 4, 465 (1963).

SAKHAROV, V. M., K. P. KUTZENOGII, G. N. ZAGULYAEV: "Aerosoli v selskom hosyaistve." M., "Kolos", 1973.