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Distribution and Dissipation of Phenthoate Insecticide Following Aerial Application

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Phenthoate (O,O-dimethyl S-(-ethoxycarbony-lbenzel)-phosphorodithioate is an organophosphorus insecticide with some acaricidal activity, having oral LD_{50} for rat 400 mg/kg, mouse 350-400 mg/kg, guinea-pig 377 mg/kg and rabbit 210 mg/kg, while the dermal LD_{50} for rat is >4000 mg/kg (WHO/FAO,2002). Inhalation LC_{50} could reach 0.8 mg/L. In the environment, the major route of dissipation seems to be through evaporation(Spencer,1984;Ritcey,1981, Burgoyne et al., 1993), however hydrolysis had also been documented, with products being, phenthoate acid, demethyl-phenthoate, and demethyl-phenthoate oxon) (PSD, 2001). Phenthoate shows moderate mobility in soil, the majority of the residue was reported in the upper 15 cm of soil profile. Thus contamination of lower soil layers or underground waters is considerably low due to the high degradability and slow leaching properties of this compound (NCA, undated). In the atmosphere it could undergo photochemical degradation yielding hydroxyl radicals with an estimated half-life of about 5 hours. Particulate-phase phenthoate may also be removed from air by wet and dry deposition. The estimated time of disappearance from treated plants ranges between 4-10 weeks, the loss is mostly attributed to volatilization (Khan,1980). Nevertheless according to PSD (2001) the calculated half-lives of the insecticide on citrus, lemon, and orange crops were found to be 1.9, 1.5 and 3.1 days, respectively. WHO supervised spraying villages and reported no symptoms among population for 15 days observation, neither did inhibition of whole blood cholinesterase occur (WHO/FAO, 2002)

This work was carried out to estimate the distribution of phenthoate insecticide in air, water, soil and plant materials, and the time of dissipation under local climatic conditions in Baghdad after aerial spraying.

MATERIALS AND METHODS

The study was carried out in the suburbs of Baghdad, the sampling area lying on the eastern bank of Tigris River, the area contains many citrus and date palm orchards . Monitoring and follow-up investigation were done in a single orchard where nine stations were selected for sampling of water and soil (Fig-1) with an approxiamte 50 meter distance between adjacent stations. Phenthoate (cidial),

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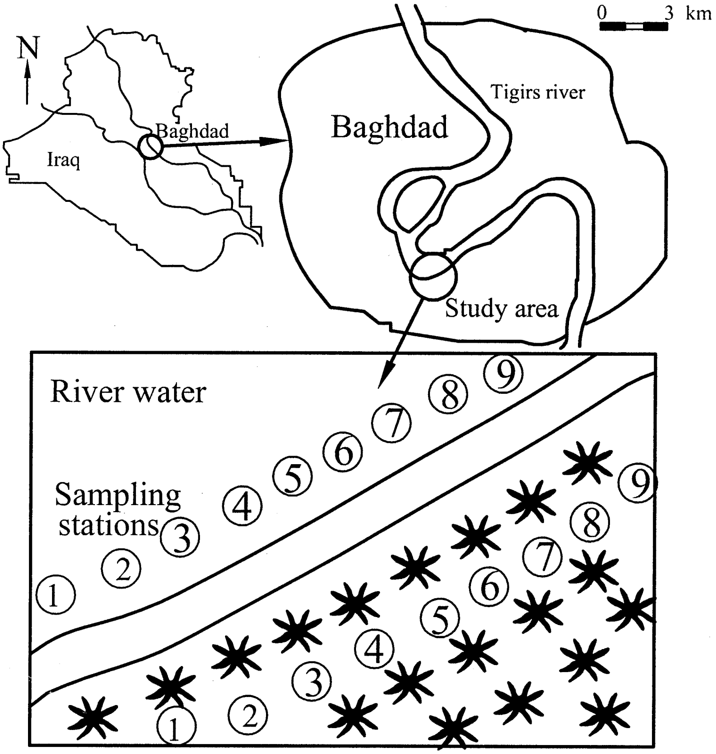

Figure 1. sampling area

(ESAGRO, ITALY) was aerially sprayed on this area on 30th April 2001, the spraying was repeated in the next day. The insecticide was ejected, from micronnair spraying devices mounted on a helicopter, at a rate of 0.5 liter per acre. The flying velocity of the plane was 90 km/hr at an altitude of 3 to 5 m above the top of date palms (i.e. 5-10 meter above ground level). The helicopter flew repeatedly over the area, in a zigzag pattern forming multiple swath tracks 22 m in width.

All types of environmental samples were taken at zero-time (half an hour after application), 3, 6, 24, 48, 72, 360, 720 hours after application (in addition to a sample one day before spraying to serve as a control). At each time of sampling 9 soil samples (1 kg each) and 9 water samples (1L each), were collected and transferred to the laboratory and processed immediately. Temperature, humidity and wind speed at the time of sampling were reported using thermometer, psychrometer and portable anemometer (other data were obtained from Iraqi Meteorological Board). Air samples were collected using a dry scrubber packed with silica gel and placed 2.5 meter above ground level, the scrubber tube was changed every 3 hours. Air was drawn at a rate of 1.17 L/min. Scrubber tubes were transferred to the laboratory and kept in the refrigerator until analysis. A sufficient quantity of leaves was randomly collected at each sampling period.

Agrochemical/Egypt (NCA, undated) estimated the time necessary for 50% disappearance of phenthoate as 10 days on silty clay. No residue was detected in soil samples taken prior to application. Table-1 shows the actual concentrations of phenthoate in the nine stations at 0, 3, 6, 24, 48, 72, 360, 720 hours as well as average values and the standard deviation.

Table 1. Concentration of phenthoate in soil with time.

Stations	Concentration in soil (mg/kg) with respect to time*						
	0	3-hr	6-hr	24-hr	48-hr	72-hr	360-hr
1	22.03	13.71	14.50	20.22	15.16	10.11	5.05
2	22.36	12.43	10.82	18.07	13.14	9.77	2.04
3	21.70	15.03	14.21	15.38	11.58	8.28	3.02
4	21.78	19.34	18.81	7.33	6.15	5.61	2.48
5	21.37	16.36	13.92	14.21	10.58	7.22	2.79
6	21.44	15.55	14.89	11.20	7.98	5.04	0.98
7	21.01	17.68	13.62	13.04	9.58	6.17	2.56
8	21.45	18.10	11.15	12.93	10.19	8.41	2.81
9	25.16	19.00	13.33	15.52	10.60	4.41	3.35
Average ±S.D.	22.03 ±1.24	16.36 ±2.39	13.92 ±2.32	14.21 ±3.77	10.58 ±2.68	7.22 ±2.05	2.79 ±1.09

*No residue was detected at day 30.

Fifty percent of the phenthoate disappeared from the soil in 2 days, and as the soil was mostly dry, the rapid reduction in concentration must be attributed to evaporation rather than any other abiotic chemical degradation, This, in turn, may be attributed to the relatively high ambient temperature in the study area which was ranging between 19.5 to 36.5° C and the relatively high wind speed (4.06 m/sec).

Loss rate of pesticides in soil is also dependent on some other conditions and soil properties which could slightly hinder evaporation, among such factors are adsorption of the insecticides on soil particles which is affected by soil texture and humus contents (Burkhard and Guth,1981, Spencer, et al., 1984). The soil texture in this study was silt-loam (16% sand, 72.5% silt and 11.2% clay), and the dissolved organic matter ranged from 6.7-12.8% while the humidity was considerably low. In spite of these properties loss rate by evaporation was not greatly affected. In a similar work, Getzin (1968) demonstrated that nonbiological degradative mechanisms were primarily responsible for the breakdown of diazinon in the silt loam soil, and the rate of degradation increases as the soil moisture is increased.

The initial concentration of phenthoate in river water at zero time (half an hour after application) was 15.45 ± 6.46 mg/L which was reduced to 9.60 ± 1.89 mg/L and 2.45 ± 1.4 mg/L after 3 and 6 hours respectively. However, after a second spraying operation, in the next day (24 hours) there was a slight increase, reaching to an average of 3.40 ± 5.02 mg/L, dropping to 1.31± 1.04 mg/L after 48 hours. Concentration was found to be 0.8 ±0.23 mg/L after 72 hours. No residue was detected after 15 and 30 days, which could be attributed to water currents as well as the liability of phenthoate (an organophosphorus compound) to rapid degradation by hydrolysis. Nevertheless, such reaction could not be followed up in running water. On the other hand, no residue was detected in the Tigris River water samples taken prior to application.

Actual concentration of phenthoate in the nine stations at 0, 3, 6, 24, 48, 72, 360, 720 hours, as well as average values for each station and the standard deviation are shown in Table –2. Figure-2 shows the general trends of phenthoate average concentrations in soil as well as in water, with respect to time.

Table 2. Concentration of phenthoate in river water with time.

Station	Concentration in water (mg/L) with respect to time* (hours)					
	0	3	6	24	48	72
1	9.12	7.83	4.50	3.41	1.31	0.80
2	11.66	7.83	3.99	1.71	0.73	0.55
3	10.10	8.71	3.48	0.24	0.47	0.71
4	14.70	9.15	2.96	2.89	1.33	0.55
5	10.17	9.60	2.45	0.41	0.81	1.22
6	13.44	10.04	1.94	1.78	0.77	0.61
7	19.15	10.48	1.42	3.41	1.31	0.80
8	27.15	14.03	0.91	16.36	3.96	0.88
9	23.67	8.71	0.40	0.47	1.10	1.07
Average ± S.D.	15.45 ±6.40	9.60 ±1.89	2.45 ±1.40	3.40 ±5.02	1.31 ±1.04	0.80 ±0.23

*No residue was detected after 15 and 30 days.

Some exceptionally high values could be noticed, e.g. stations 7, 8, 9 at 24 hours and station 3 and 5 at 48 hours (Table-2). On the other hand slight fluctuations in concentration could also be noticed. Such variation in concentration is always expected in residue analysis due to the large number of environmental as well as technical factors interfering in this problem. In spite of that the average concentrations of the nine stations show a general trend of decrease, starting from (15.45±6.40) mg/L immediately after spraying reaching 0.80±0.23 mg/L after 72 hrs. The slight increase after 24 hrs (3.40±5.02) mg/L is due to the second spraying of the insecticide No studies on the degradation of OP pesticides in running water could be found, yet in a simulated aquatic environment (in static water), there is evidence of the contribution of light and suspended particulates, to degradation. Massoud (1980) reported that non-persistent pesticides (e.g. some OP pesticides) are very unlikely to contaminate

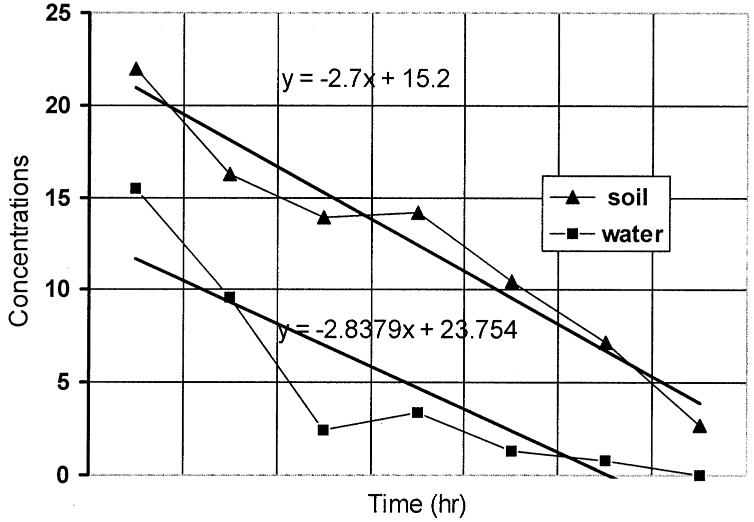

Figure 2. General trend of average concentrations of phenthoate in soil and water with respect to time.

the aquatic environment to any large extent, since they will be degraded immediately when reaching water bodies. While in a study comparing the persistence of 5 insecticides (ethion, leptophos, mevinphos, diazinon, parathion) in four types of waters: (natural, distilled, sterilized natural and sterilized distilled water), Sharom et al. (1980) reported that degradation of insecticides in aqueous systems may be due to other chemical or biological processes or both. Chemical degradation appeared to play a major part in the dissipation process in water of most of the OP insecticides.

As was demonstrated in Fig-2, Table-3 shows the percentages of reduction of phenthoate concentration in soil and water at different sampling periods. The percentages of reduction vary greatly, from the highest percentage of reduction (85%) noticed in soil concentrations within 3-6 hours, to the lowest (10.2%) after 24 hours. This conclusion is applicable to water, where the highest percentage of reduction (62%) was noticed within the first three hours as well as after three days (48-72 hr) while the lowest percentage in water concentrations (26%) was noticed in 3-6 hour intervals.

Phenthoate residues in plant materials (leaves) collected at 0, 3, 6, 24, 48, 72 hours and 15, 30 days were found to be 9.1, 1.9, 1.7, 1.6, 0.48, 0.47, 0.18 and 0.05 mg/kg (wet weight) respectively. No residue was detected in plant materials prior to application. From the above mentioned levels it could be noticed that the highest reduction in phenthoate concentration was in the first three hours, dropping from 9.1 to 1.9 mg/kg. Such reduction is also due to the rapid volatilization of the insecticide. This fact had also been mentioned by other workers (Nigg et al., 1981; Ritcey et al.,1981)

Table 3. Percentage reduction of phenthoate concentration in soil and water in different sampling period.

Sampling period	% reduction with respect to time	
	Soil	water
0-3	74	62
3-6	85	26
6-24	10.2	39
24-48	74	33
48-72	68	62
72-360	39	-

Type of crop and foliage density play a role in the process of contamination during aerial spraying of insecticide (Uk and Courshee,1981). Nigg et al.(1981) studied different OP insecticides and measured the role of evaporation from plant leaves in the disappearance of the insecticide. That result was consistent with an evaporative disappearance mechanism.

It can be concluded that phenthoate insecticide does not persist for more than few days under local climatic conditions, and evaporation appears to be the major process by which dissipation of the insecticide occur. In spite of this short half life, it is recommended shifting to more selective and less persistent insecticides, such as those of the pyrethroid group.

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