Adsorption and Desorption of Lindane and Dieldrin by Yeast

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A major problem in the use of chlorinated hydrocarbon insecticides is their gradual accumulation in the food chain. It can be supposed that the first step in this accumulation process is the uptake of these compounds by living or dead organic material from the environment e.g. from water or soil (1).

In order to obtain some information on this we examined the adsorption and desorption of lindane and dieldrin from water solutions by a standard unicellular organism. We chose "baker's yeast" (Saccharomyces cereviciae) as sorbent because it can be accurately weighed and easily obtained in standard quality. Lindane and dieldrin were taken for their relatively high solubility in water (about 6 and 0.2 μg/ml) (2, 3) facilitating their quantitative estimation. It was possible by a simple and rapid method to obtain an impression of the degree of adsorption and desorption of these compounds by this organic material.

Materials and Methods

Analytically pure lindane and dieldrin was dissolved by boiling a small quantity of the insecticide with demineralized water for several hours. After cooling to room temperature the solution was

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carefully filtered through paper filters. After this the concentrations were found to be below the saturation values. From these solutions dilutions and mixtures were made.

The adsorption by baker's yeast was determined by putting a weighed quantity of yeast into a volumetric flask of 50 ml and shaking it with 25 ml of a solution of insecticide(s) of different concentrations for periods of 1/2, 2 and 18 hours. The quantities of yeast employed were: 250 mg for lindane, 50 mg for dieldrin and 100 mg for the mixed solution lindane/dieldrin. After the equilibration time the yeast was centrifuged down in a table centrifuge and the concentrations of the insecticides remaining in the supernatant were determined.

Dead yeast was obtained by warming the weighed yeast with 5 ml water in the volumetric flask at $96^{\circ}C$ for 3 minutes on a water bath. After cooling 20 or 25 ml insecticide solution was added and treated in the same way.

Known volumes of solution were extracted with known volumes of hexane in which the insecticide concentration was measured gas-chromatographically.

The quantity of insecticide adsorbed per gram of yeast can be calculated from the decrease of the concentration in the water.

The desorption was estimated by shaking about 250 mg living and dead yeast with a solution of lindane and dieldrin for two hours. The yeast was centrifuged down and the water-layer removed. The organic material was extracted four times with 25 ml portions of fresh water by shaking two hours each time. From these water

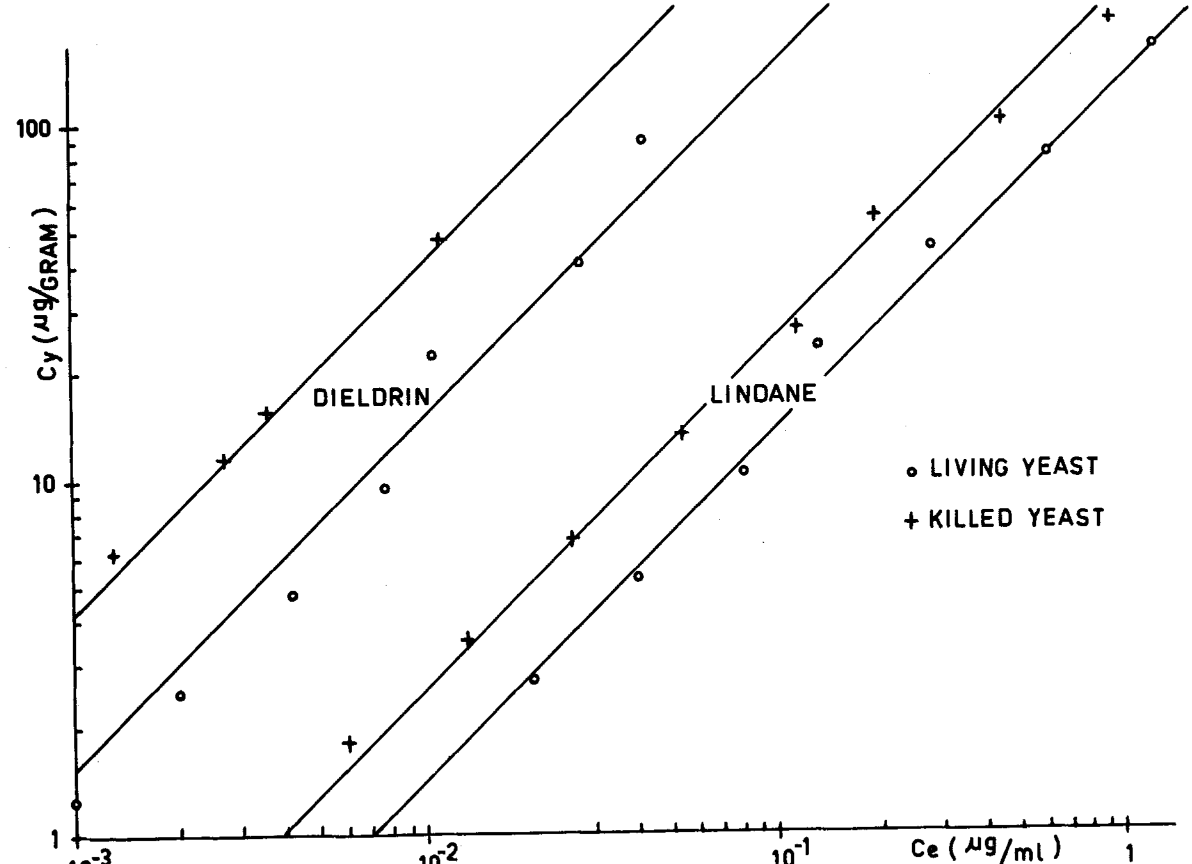

FIG. 1 ADSORPTION ISOTHERMS OF LINDANE AND DIELDRIN ON YEAST AFTER TWO HOURS OF SHAKING

extracts the concentrations of the desorbed lindane and dieldrin were determined.

All experiments were carried out at room temperature.

Results and Discussion

The equilibrium between the water phase and the organic material was very soon attained. After half an hour of shaking there was no significant increase of the adsorption of lindane or dieldrin by the yeast. In Figure 1 the logarithm of the insecticide concentration in the yeast (c_y in µg/gram) has been plotted against the logarithm of the equilibrium concentration in the water (c_e in µg/ml). The adsorption isotherms for lindane and dieldrin on living and dead yeast follow the Freundlich equation

$$c_y = kc_e^n$$

$$\text{or} \quad \log c_y = n \log c_e + \log k$$

The value of n turns out to be one (the slope of the isotherms is 45^o) and the value of k can be estimated from the graphs in each experiment. In Table 1 the values obtained for k are presented after 1/2, 2 and 18 hours of shaking.

TABLE 1

Values of k for lindane and dieldrin after different periods of time

equilibration	lindane		dieldrin	
time in hours	living yeast	dead yeast	living yeast	dead yeast
1/2	125	210	800	3900
2	145	260	1600	4300
18	145	210	1000	5100

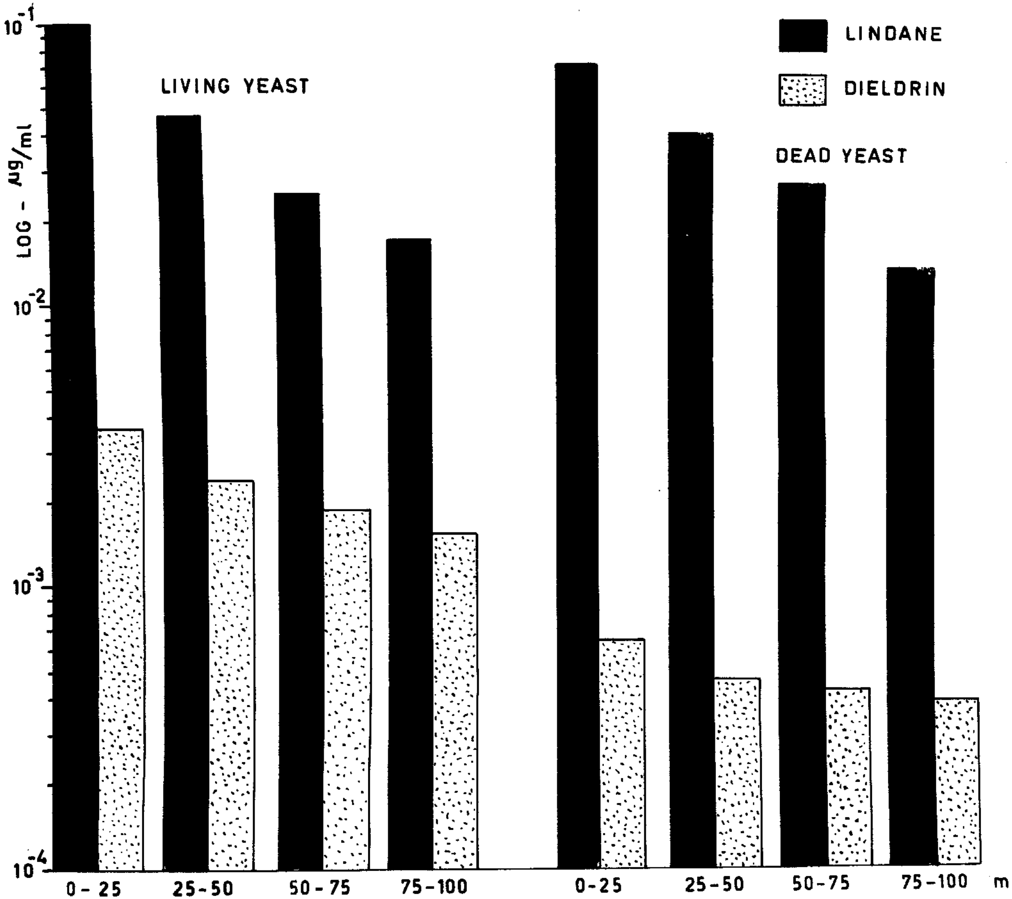

FIG. 2 DESORPTION BY WATER OF LINDANE AND DIELDRIN FROM LIVING YEAST (LEFT) AND DEAD YEAST (RIGHT)

Similar results were obtained when the adsorption was measured from a solution containing a mixture of the insecticides. There is no preference for one of the compounds as can be seen by a comparison of Tables 1 and 2. Varying the quantity of yeast did not influence our results very much.

TABLE 2

Values of k for lindane and dieldrin estimated after adsorption from a solution containing a mixture of the insecticides

equilibrium	lindane		dieldrin	
time in hours	living yeast	dead yeast	living yeast	dead yeast
1/2	150	170	1100	4800
2	150	260	730	3600
18	130	190	1200	6000

In Figure 2 the results are shown of the desorption of lindane and dieldrin from living and dead yeast. The quantities originally adsorbed were almost equal (6.0 μg and 0.7 μg on the living yeast and 5.6 and 0.6 μg on the dead, for lindane and dieldrin respectively). Dieldrin especially is washed off much more slowly from the dead material than from the living. This is in good accordance with the figures in Table 1 and Table 2.

The results and conclusions of these experiments can be summarized as follows:

1. The adsorption is a fast process being complete in less than half an hour.
2. The adsorption isotherms can be described with Freundlich's equation $c_y = k\ c_e^n$ in which n = 1.

3. Lindane is adsorbed less than dieldrin, probably because it is more water soluble than dieldrin. The distribution ratio of lindane between hexane and water is also smaller than that of dieldrin (4).

4. By killing the yeast the adsorption-capacity is increased especially for dieldrin.

5. The insecticides once adsorbed can be removed from the yeast by washing with fresh water. This means that a redistribution through the water phase remains possible.

6. Adsorption on organic material can be supposed to play an important role as a first step in the accumulation of insecticides in the food chain.

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