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Fate of BHC in the terrestrial ecosystem

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Abstract—The fate of BHC in the terrestrial ecosystem was investigated under both laboratory and field conditions. The uptake, accumulation and degradation of BHC in earthworms and corn plants were studied. Earthworms could absorb and accumulate BHC residues from soil. Statistically, significant correlation existed between the amounts of BHC in soil and in earthworms. Different species of earthworms appeared to concentrate BHC in their bodies to different extents. In a terrestrial ecosystem, the uptake, accumulation of BHC residues by soil animals and plants had an effect on each other.

Keywords: BHC; terrestrial ecosystem; absorption; accumulation.

INTRODUCTION

Soil animals, plants and birds are three main elements in the terrestrial ecosystem. Soil as beginning of terrestrial food chain, provides direct of indirect energy and habitat for terrestrial lives including mankind. Ecologists at home and abroad have been paying much attention to the research (Edwards, 1973; Yao, 1987) on the transfer of pesticides from soil to terrestrial ecosystem and the accumulation, degradation of them by living being. But, the knowledge for that is in shortage.

In order to know the transfer and accumulation of BHC in food chains, experiments were carried out under both laboratory and field conditions using earthworms as a model substance.

MATERIALS AND METHOD

Materials

The corn (Jin Huang 113) was obtained from the Academy of Agricultural Science. The soil was loam soil sampled from Tianjin Vegetable Farm Soil cultivating earthworms was mixed with decomposed horse dung and paper pulp. 12kg of soil was placed in a China pot (id 25cm, h 32cm) for planting corn. 2.5kg of soil was placed in a China pot (id 15cm, h 25 cm) for cultivating earthworms. The contents of four isomers, $\alpha, \beta, \gamma, \sigma$–BHC are 67.3%, 11.9%, 13.9%, 6.68%, respectively. After being grounded, the soil was passed through a 0.45 mm sieve, and then fortified at a rate of 1.0mg BHC/kg soil for cultivating corn. The experiment of earthworms absorbing BHC was divided into two groups, in one group 0.6mg BHC was added to 1kg soil, and in the another 2mg BHC was added to 1kg soil.

In the correlation experiments, the soil was fortified at rate of 0.30, 0.45, 0.90, 1.05, 1.20, 1.65, 1.95, 2.40 and 2.70mg BHC/kg soil, respectively. For each experiment, BHC was first dissolved in acetone and then added to soil (Chapman, 1986).

Earthworms (*Pheretima guillelmi* and *Allolobophora calignosa*), were collected from Xinan County, Henan Province; Earthworms (*Eisenia foetida*), aged 3 months, were obtained from Tianjin Earthworm Farm.

Quails (*Coturmix coturmix*) were obtained from Tianjin Quail Form, aged 50 days.

Methods

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Using previously described methods (Huang, 1983; 1984; 1985), we conducted on earthworms absorption and accumulation of BHC in soil, its effect on the absorption of BHC by corns, and the transfer and accumulation of BHC in food chains.

Chemical analysis were made according to the methods reported (Fan, 1982; Edwards, 1974; Kaphalia, 1981).

RESULTS AND ANALYSIS

Uptake and accumulation of BHC in soil by earthworms

The results of two–year–experiment are shown in Fig.1.

The curves shown that *E. foetida* and *P. guillelmi* absorbed and accumulated BHC similarly, namely, during the first 7 days the BHC was absorbed very fast, and then the absorption rate slowed down near the peak. After 28 days the rate dropped sharply and approached to balance after the 42th day. The result conformed to that reported by Yadav (1976). Figure 1 also shows that different species of earthworms appeared to concentrate BHC in their bodies to different extents. Diversity analysis of the data in the Expt. No. 4 in Table 1 shows that difference was extremely significant ($P<0.01$). The difference may be attributed to the different activities of enzymes in earthworms.

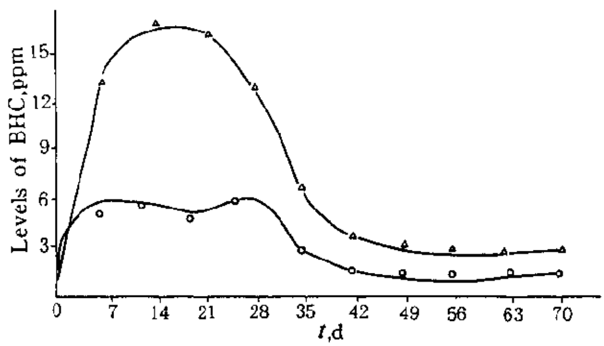

Fig. 1 Uptake and accumulation of soil BHC by *E. foetida* (A) and *P.guillelmi* (B)

Table 1 BHC residues in soil and in earthworms, and BHC accumulation coefficient in earthworms

Experiment number	Levels of BHC in soil, ppm	*Allolobophora caliginosa*		*Eisenia foetida*		*Pheretima guillelmi*	
		Level of BHC in body, ppm	Accumulation coefficient	Levels of BHC in body, ppm	accumulation coefficient	Levels of BHC in body, ppm	Accumulation coefficient
1	0.271	1.154	4.258	0.976	3.602	0.509	1.873
2	0.417	1.469	3.522	1.278	3.064	0.644	1.544
3	0.812	3.337	4.109	2.854	3.515	0.965	1.188
4	0.959	4.565	4.758	3.041	3.171	1.201	1.251
5	1.113	7.041	6.302	4.265	3.832	2.558	2.298
6	1.628	10.616	6.621	5.227	3.211	4.123	2.533
7	1.893	12.973	6.853	8.798	4.647	4.170	2.202
8	2.344	13.554	5.807	9.475	4.059	4.060	1.740
9	2.555	16.230	6.352	10.852	4.248	4.452	1.742

The accumulation of BHC in earthworms varied with the content of BHC in soil (Table 1). Figure 2 shows that the contents of BHC in three kinds of earthworms were directly correlation to that in soil.

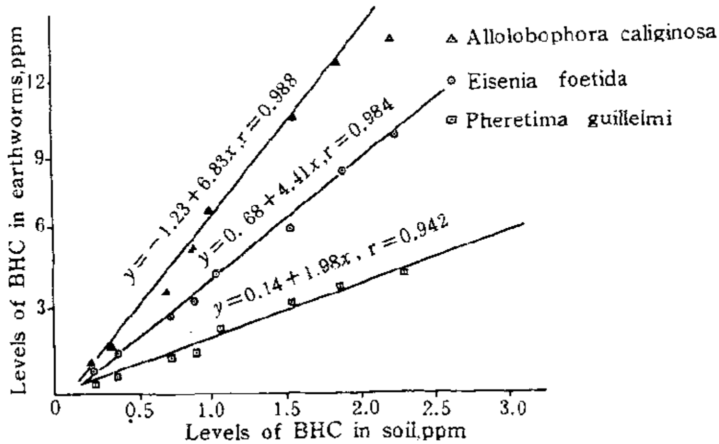

Fig. 2 Correlation between amounts of BHC in soil and in earthworms

The effect of earthworms on the absorption and accumulation of BHC in soil by corns.

Table 2 lists residue levels of different BHC isomers in soil (soil without earthworms and soil with earthworms) and in different parts of corn. Table 3 is the percentages of different isomers of BHC accumulated in soil and corn. Table 2 and 3 show that:

The accumulation of BHC in soil by different parts of corn reduced rapidly with the increase of transfer distances, namely roots > stem and leaves > seeds. This conformed to the results reported by beestman, 1969a; Beestman, 1971.

The contents of BHC in different parts of treated corns were higher than those in controlled ones.

α-isomer and γ-isomer of BHC were the main residues accumulated in seeds. The reasons why the BHC levels in corns were higher than those in controlled ones were that:

Table 2 Residue levels of BHC isomers in soil and corn

Sample	α-BHC		β-BHC		γ-BHC		δ-BHC		Σ-BHC		Accumulation coefficient	
	Cont.*	Cont.**	Cont.	Cont.	Cont.	Cont.	Cont.	Cont.	Cont.	Cont.	Cont.	Cont.
	ppm		ppm		ppm		ppm		ppm			
Soil	0.040	0.075	0.071	0.066	0.033	0.039	0.030	0.036	0.174	0.216	-	-
Roots	0.147	0.399	0.633	0.628	0.068	0.135	0.083	0.171	0.931	1.387	5.35	6.421
Leaves Stem	0.121	0.302	0.233	0.301	0.036	0.060	0.056	0.093	0.446	0.760	2.58	3.520
Seeds	0.008	0.013	0.001	0.001	0.006	0.007	0.002	0.002	0.017	0.023	0.098	0.110

* control without earthworms in soil;

** soil with earthworms (61.2g) in a pot.

Table 3 Percentage of BHC isomers in soil and corn

Sample	α-BHC		β-BHC		γ-BHC		δ-BHC coefficient	
	Cont.*	Cont.**	Cont.	Cont.	Cont.	Cont.	Cont.	Cont.
soil	23.00	34.60	41.00	30.50	19.00	18.00	17.00	16.60
roots	15.75	28.76	68.10	49.17	7.25	9.73	8.90	12.33
leaves, stem	27.00	39.73	52.13	39.60	8.05	7.89	12.52	12.23
seeds	47.06	56.52	5.88	4.35	35.29	30.43	11.76	8.69

* ** Same as in Table 2.

(A) The movement of earthworms promotes aggregation of soil and increases the porosity of soil, so that some of soil capillary were broken off; thus volatilization of BHC from soil to the air was greatly reduced (Edwards, 1972); (B) The increase of soil colloid played some part in reducing volatilization of BHC form soil to the air; (C) The movement of earthworms, which ameliorated the condition of soil ventilation and water preservation, improved the absorption ability of corns, therefore, more BHC was take up. Because of the existence of earthworms in soil, the disappearance of BHC became slower although the absorption ability of corn was improved.

Table 4 Amount of BHC in food chain and its distribution in quail bodies

pesti-cide	Levels in soil, ppm	Levels in earthworms or corn, ppm	Levels in muscle, muscle, ppm		Levels in liver, ppm		Levels in brain, ppm		Levels in blood, ppm		Levels in fat, ppm	
			10[c]	20[c]	10	20	10	20	10	20	10	20
β-BHC[a]	0.367	0.374	0.048 (0.018)[d]	0.027	0.051 (0.021)[d]	0.081	0.038 (0.012)	0.074	0.047 (0.015)	0.037	0.206 (0.432)	1.212
Σ-BHC[a]	0.507	1.628	0.071 (0.036)	0.041	0.079 (0.040)	0.094	0.301 (0.227)	0.335	0.062 (0.032)	0.059	2.359 (0.688)	1.402
β-BHC[b]		0.009	0.006				0.048		0.026		0.333	
Σ-BHC[b]		0.0094	0.018				0.145		0.045		0.521	

a. earthworms fed to birds; b. corn fed to birds; c. days;

d. figures in parentheses represent background values.

Table 5 Ratio of BHC isomers in food chains

Sample	α-BHC Levels, ppm	Ratio, %	β-BHC Levels, ppm	Ratio, %	γ-BHC Levels, ppm	Ratio, %	δ-BHC Levels, ppm	Ratio, %	Σ-BHC Levels, ppm	Accumulation coefficient
BHC		67.39		11.96		13.91		6.68		
Soil	0.80	15.70	0.367	72.39	0.037	7.30	0.024	4.73	0.507	
Earth-worms	0.392	24.07	0.734	45.09	0.175	10.75	0.327	20.09	1.628	3.211
Fat of earthworms	0.093	3.94	2.206	93.52	0.036	1.52	0.024	1.02	2.359	1.450

The transfer and accumulation of BHC in a terrestrial ecosystem

BHC residues concentrated at each step in a terrestrial food chain (from earthworms or corns to quails) are shown in Table 4 and 5. Table 4 shows that after 45 days culture, 0.507 ppm BHC residue in soil resulted in 1.628 ppm BHC in earthworms. Quails fed by these earthworms for 10 days led to 2.36 ppm BHC in their fats. The accumulation coefficient of BHC from soil to quail fat was 4.65. β–BHC was the main residue in quail fat, α–BHC ranks the second, γ–BHC the third.

The accumulation of BHC in quail eggs varied with time (Fig.3 and 4). Before experiment, 30 hen quails were fed on mixed forage containing 0.083 ppm BHC. BHC in eggs was 0.018 ppm. After the beginning of the experiment, the quails were fed on earthworms containing 2.18ppm BHC (10g/day) and mixed forage (20g/day). Each quail took in 21.8 μg BHC/day from earthworms, which was 93% of the total intake. Figure 3 shows that the accumulation of BHC in quail eggs increased at first and then gradually got to balance. Figure 4 shows that BHC residues could be quickly excreted out of the body after the diet of treated earthworms was stopped.

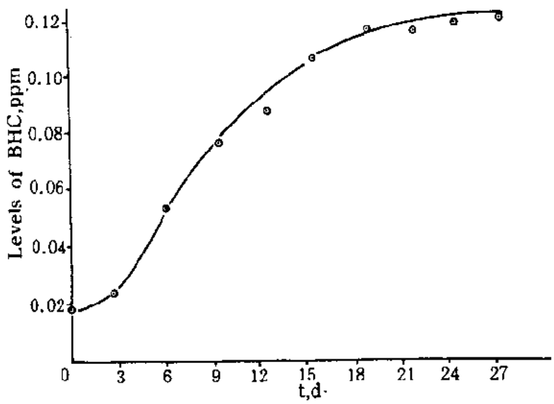

Fig. 3 Accumulation of BHC in quail eggs

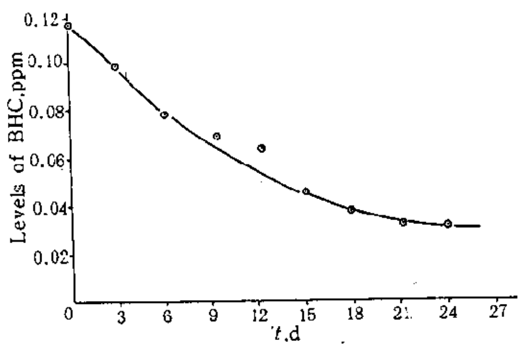

Fig. 4 Excretion of BHC from quail eggs

SUMMARY

In soil polluted by BHC, earthworms could absorb and accumulate BHC residue. Correlation between amounts of BHC in soil and in earthworms was significant. Different species of earthworms appeared to concentrate BHC to different extents.

The accumulation of BHC residues by soil animals and plants in terrestrial ecosystem had an effect on each other. Earthworms in soil could promote the absorbing ability of corns.

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