

## Study on Farmland Soil's Absorption Characteristics to BHC in Northeastern Industrial Polluted Area

Gao Ming<sup>1, 2</sup>, Hua Xiuyi, Dong Deming, Zhao Xingmin

Author Affiliation : Mob: +86 13504402672, Email: 3039679@qq.com

### Abstract

*This article adopts samples from farmland soil in Zhang Yi Zhan, Shenyang City, where is located in China's northeastern industrial polluted area, assisted by systematic absorption test and soil column device and measuring system, to conduct in-depth study on the transfer rule of a persistent pollutant-organochlorine pesticide (OCP) BHC in soil, by which we could obtain the spatiotemporal variation process of pollutant concentration in unsaturated soil column under certain pollution transport condition. The experiment result indicates, that by comparing the leaching curves of each soil column filled with sample soil collected from various soil layers across the district, we could find that the transfer velocity of BHC in the vadose zone of soil column No. IV (60~80cm) was faster than that in No. I (0~20cm), No. II (20~40cm) and No. III (40~60cm), while that in No. V (80~100cm) was the maximum. This was possibly due to its close to upper soil layer where high content of clay and organic matter exist, while the lower soil layer was nearly sandy with low content of organic matter. However, the proved research shows, that soil's absorptive capacity to BHC would grow with an increase of organic matter content, therefore, the soil column No. V had smaller absorptive capacity than No. IV, and much smaller than No. I, II and III, extending the transfer capacity of pollutant to a larger degree. Namely, once the water body polluted by OCP reached to the lower soil layer of vadose zone, its transfer velocity would accelerate, which could be potentially hazardous to ecological system and underground water. Thus to research on the transfer characteristics of BHC in each soil layer of vadose zone would be of great importance as it would provide theoretical basis for improvement and restoration of soil and underground water pollution.*

**Keywords:** BHC, soil, absorption, leach

### 1. Introduction

In recent years, the application and accumulation of OCP (organochlorine pesticide) have caused large-area pollution to the soil. Soil organic pollution is hidden and lagging. Once it has accumulated in water body and soil, it would be hard to be degraded. It would be absorbed by crops before it along with food chain gets into human body. It has become such a pollutant worthy our concern that could be greatly hazardous to human health. Absorption-desorption process is deemed as a major chemical reaction in controlling over persistent OCP's performance<sup>[1]</sup>. The absorption-desorption of chlorinated organic compounds mostly depends on its physical and chemical properties. As to OCP, due to its typically low aqueous solubility and high n-octanol-water partition coefficient, large portion of OCP existing in environment are distributed into organic matter of sediment or soil<sup>[2]</sup>.

Usually, OCP's soil pollution is relevant to underground water pollution. Once soil be polluted by OCP, as time goes on, OCP would be leaching via rainfall and self-loaded water, and gradually transfer into underground water, then spread out along with flowing water, leading to contamination to underground water. This article select the farmland soil

collected in China's northeastern industrial polluted area as the research object, to investigate soil's absorptive characteristics to Pb, Cd and Cr (VI). The purpose is to obtain data through soil's absorption-desorption of BHC and DDT experiment, in an effort to more comprehensively learn the performance of soil's absorption-desorption of BHC and DDT, to provide basis for soil restoration and research on mechanism of underground water pollution.

## 2. Experiments

### 2.1 Soil and Reagent for Experiment

The experimental used sample soil was obtained from Zhang Yi Zhan, Shenyang City (123°4.35'E, 41°38.05'N). The sampling site was a farmland, 400 meters away south to Xi River of Shenyang City, which had been one of severely polluted rivers in Shenyang City as it majorly received industrial waste water and sanitary waste water discharged from Shenyang City. Xin Kai River mainly received industrial waste water discharged from Changchun City, heavily polluted.

Take the sample back to laboratory. Air dried and grinded, then have it filtered by 100 mesh nylon screen. Quarterly divided into portions, and remain volume sufficient for experiment. For the elementary properties of soil please check Table I.

Each applied pure OCP product were purchased from Dr. Ehrenstorfer, a German company. The purities:  $\alpha$ -BHC 98.3%、 $\beta$ -BHC 97.5%、 $\gamma$ -BHC 98.5%、 $\delta$ -BHC 98.5%; the experimental water is de-ionized water.

For soils' elementary physical and chemical parameters and content please check Table I.

**Table I. Experimental Soil's Basic Physical and Chemical Parameters**

Serial no.	Z-1	Z-2	Z-3
Depth(cm)	20-40	20-40	40-60
pH	5.06	6.02	4.63
TOC (%)	2.199	1.802	1.933
BD(g/cm <sup>3</sup> )	1.668	1.503	1.412
EC ( $\mu$ s/cm)	88	102	128
CEC (mmol/kg)	157.99	153.24	164.83
Sandy Soil (%)	16	21	35
Powder Soil (%)	61	59	48
Clay (%)	23	20	17

Note:

TOC —total content of organic matter ;

BD —bulk density ;

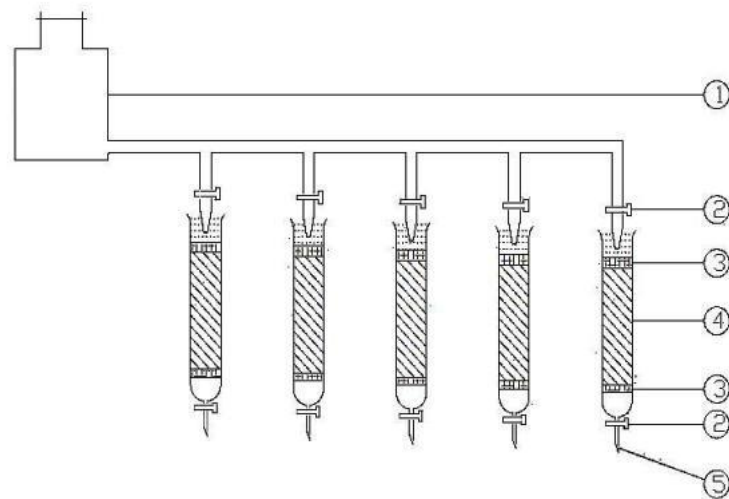
EC —electronic conductivity ;

CEC —Cation exchange capacity

### 2.2. Experimental Method

Soil column filling and leach operation: leaching soil column experimental device diagram shown as Figure 2-2. Use a specific glass tube with 3.5 cm diameter and 30 cm length as an inner wall of soil column. Fill the soil column in order of natural soil layers and bulk density. Set the height of soil column as required in experiment. Spread a thin layer of glass wool at the bottom of glass column to avoid outlet blocked by soil sample or fine sand, then fill with 1 layer of twice-rinsed and dried fine sand grains to form a 2.5 cm height screening layer. When filling with soil, every 2-3 cm should have a tamping,

then smooth the surface and proceed next time. After filling, the soil bulk density should be close to natural condition. To avoid emerging channeling on the tube wall, a 1-2 cm of coarse gravel should be added on the upper layer to avoid water flow retarding in the column as water supply last long, and for the convenience of sampling. After filling the soil column, charge in from the bottom of leach column with deionized water at steady flow rate to expel air remained in the column. The soil would get moisty by capillary rise water to reach saturated state. Once the top of soil column emerges aqueous layer, exhaust out all gravity water remained in the air gap, in order to simulate more naturally the water content of soil, and to stabilize pore structure and seepage velocity, and to avoid being blocked by air during leaching. When the moisture get to saturated state, keep balance for 48h to allow the nutrient on soil surface to dissolve into solution. Then dilute the reserving solution to  $50\mu\text{g/L}$  and use it as leaching solution. By adopting siphon principle, fill in soil column with the leaching solution. To initiate leaching at a constant speed 4-5 ml/h. When soil column all get immersed with water, decelerate to 3 ml/h (keep high water head at 3 cm). The leaching should last 24h each day and be under observation. At set intervals, take out transudate from the sampling port at the bottom of soil column, and record leaching time, and measure the content of BHC and DDT.



1 : water supply bottle 2: flow velocity valve 3 : gravel 4 :  
sample soil 5 : sampling port

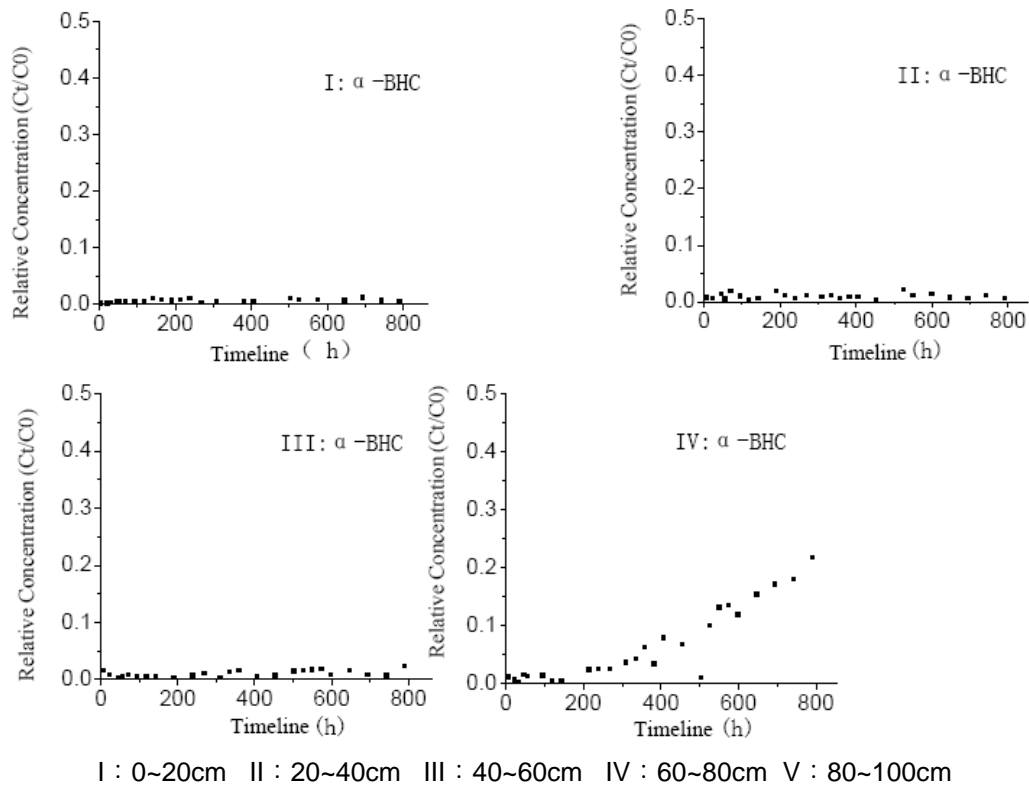
**Figure I. Soil Column Experimental System Device**

### 3. Conclusion and Discussion

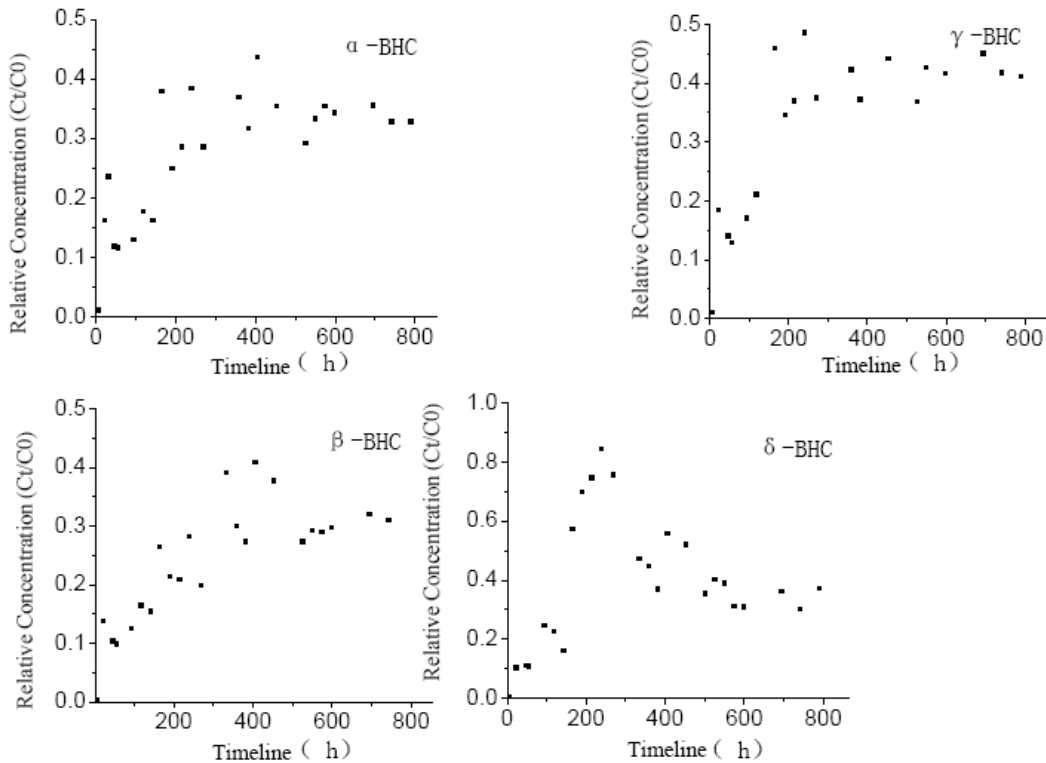
In the indoor soil column leaching simulation experiment, we can obtain a leaching curve via setting a vertical axis gauging the value of BHC's relative concentration in leachate:  $C_t/C_0$  ( $C_0$  refers to initial concentration, while  $C_t$  refers to a temporal pollutant's concentration of leachate at some moment), and setting a horizontal axis indicating the leaching time, shown as Figure II and Figure III:

From Figure II we could observe that in the soil column No. I, II and III filled with soil Z, BHC's transfer velocity appear slowly, the detected concentration of BHC were extremely low, and no noticeable breakthrough point was detected within 936h through the experiment. Take  $\alpha$ -BHC as example, when the soil layer's depth beyond 60cm, *i.e.* the soil column No. IV, breakthrough point emerged after 200h, in addition,  $\alpha$ -BHC's

concentration in water varied slowly. On 936h,  $\alpha$ -BHC's concentration in leachate out of the soil column No. IV reached to 11.5 $\mu$ g/L. Comparing to  $\alpha$ -BHC,  $\gamma$ -BHC and  $\beta$ -BHC had slower transfer velocity, as breakthrough point emerged beyond 300h of leaching time. On 936h or so, the concentrations of leachates out of the soil column No. IV reached to 10.03 and 8.27 $\mu$ g/L respectively, while  $\delta$ -BHC had no remarkable presence detected within 936h. In Figure III, in the depth of 80-100cm in the soil column No. V, BHC's transfer velocity apparently accelerated, as breakthrough point emerged in  $\alpha$ -BHC's leachate out of soil column No. V on 7h, and after leaching for 200h,  $\alpha$ -BHC's concentration reached to maximum value, then it came stabilized and edged down a bit. Meanwhile,  $\gamma$ -BHC,  $\beta$ -BHC and  $\delta$ -BHC's transfer in No. V soil column followed the same rule.



**Figure II.  $\alpha$ -BHC's Absorptive Effect in No. I, II, III, and IV Soil Column**



**Figure . III BHC's Absorption in No. V Soil Column**

In soil column No. V, BHC's migration and transfer process could be divided into 2 stages: absorptive rise stage and absorptive saturating stage. The former stage featured with strong absorptive effect, during which there were less microorganism existing within the column, with weak degradation effect. The curve came uptrend. Entering the latter stage, when its absorptive effect ran balanced gradually, as the number of microorganism were increasing within column, a degradation effect exerted by degree, and the curve ran marginally downtrend. Therefore, we could conclude from the result of dynamic absorptive experiment, that OCP's migrating and transfer process in vadose zone was the result from multiple reactions including absorption and degradation. Gao Taizhong's research on migrating and transfer of organic pollutant in vadose zone had a similar conclusion, *i.e.* COD's migrating and transfer in vadose zone was the result from multiple reactions including absorption and degradation<sup>[3]</sup>.

In comparison with leaching curves of each soil column, we could find that BHC's transfer velocity in No. IV was faster than that in No. I, II and III, while that in No. V was the top one. This is possibly due to a higher content of clay at close to upper layer and higher content of organic matter, while the lower layer was nearly sandy with low content of organic matter. However, a proved research indicates that BHC's absorptive capacity would rise as the content of organic matter increase, therefore, No. V had a smaller absorptive capacity than No. IV, and much less than No. I, II and III, leading to a larger transfer capacity of pollutants. In another word, once the OCP-polluted water reached to the lower layer of vadose zone soil, the transfer velocity would accelerate, resulting in a potential hazard to lower layer of soil and underground water. Thus, to research on BHC's vertical transfer characteristics in each layer of vadose zone soil would be of great importance, which would provide theoretical basis for soil restoration and waste water treatment.

## 4. Conclusion

Through the simulation experiment and research on vertical transfer process of OCP-BHC's each isomer by using soil column leaching device, we have a conclusion as follows:

The BHC in the soil columns No. I (0-20cm), No. II (20-40cm) and No. III (40-60cm) which filled with collected soils from various layers in Z site was slow in transfer velocity, and was extremely low in concentration detected out of leachates. While in No. IV (60-80cm), breakthrough point emerged beyond 200h of leaching time, and BHC's concentration in water was fluctuating slowly; in No. V (80-100cm), BHC's transfer velocity apparently accelerated, as breakthrough point of BHC in leachate emerged quite earlier, and after 200h or so the BHC's concentration in leachate reached to its maximum value, then went on a stable track and edged down a little bit.

In comparison with leaching curves of each soil column, we could find that BHC's transfer velocity in No. IV is faster than that in No. I, II and III, while that in No. V is the top one. This is possibly due to a higher content of clay at close to upper layer and higher content of organic matter, while the lower layer is nearly sandy with low content of organic matter. However, soil's absorptive capacity to BHC would rise as the content of organic matter increase, therefore, No. V has a smaller absorptive capacity than No. IV, and much smaller than No. I, II and III, leading to a larger transfer capacity of pollutants. Comprehensively, once the OCP-polluted water reach to the lower layer of vadose zone soil, the transfer velocity would accelerate, resulting in a potential hazard to lower layer of soil and underground water.

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## Authors



**Author's Name : Gao Ming** Author's profile : (1982- ) , female, Han race, Changchun City, Jilin Province. 1 : Jilin University ; 2 : Changchun Institute of Technology (CCIT)

