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PCBs Content Characteristics in Soil of Changchun City Suburb Vegetable Field

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***Abstract*—The content and distribution characteristics of 11 kinds of polychlorinated biphenyls (PCBs) in surface soil of Changchun city suburban vegetable field were analyzed. The results showed that the contents of PCBs in soil were in the range of 27.74~219.54 μg kg^{-1}, with the average value of 83.75 μg kg^{-1}, which were in the moderate and unpolluted level. Variation coefficients of PCBs content were larger, indicating that PCBs contents in soil were significantly affected by human activities. The distribution characteristics of PCBs in soil were mainly come from industrial production and influenced by the dominant wind direction of the region. Principal component analysis showed that PCBs in soil were mainly come from transportation, waste incineration and volatile or leakage from paint additive, insulation materials and other industrial products.**

Keywords- suburban soil; Polychlorinated biphenyls (PCBS); distribution characteristics; pollution sources

I. INTRODUCTION

PCBs (Polychlorinated biphenyls, PCBs) are the kinds of biphenyl compounds, atoms of hydrogen connected with carbon on the benzene ring are replaced by chlorine in different degrees [1]. Because of good insulation, thermal conductivity and the inertia, PCBs are widely used in electricity, plastics, chemical and printing industry, etc. Meanwhile, the molecular structure containing benzene ring and chlorine atom caused that PCBs' characteristics of low water solubility, chemical stability and biological toxicity [2], which are liable to accumulate in organisms and give rise to global environmental pollution. As a result, the production and utilization of PCBs had been prohibited in the 1970s, but PCBs in soil could still be detected in many regions, especially in the suburban relatively higher concentration of industrials [3-5]. Changchun city is an important industrial base of northeast China [6], whereas, PCBs residual characteristics in suburban vegetable field soil had not been researched deeply. Soil PCBs in Changchun city suburb vegetable field were taken as the research object to analyze the PCBs contents and sources. The research is of significance to soil pollution prevention and vegetable safety production.

II. MATERIALS AND METHODS

A. Sample Collection and Treatment

In October 2013, fifty surface soil (0~20 cm) samples were collected in Changchun city (43°17'~44°5'N, 125°3'~125°34'E) suburbs, with record of position by GPS and the around environmental situation. Each soil sample was acquired by quartering methods from the completely mixed 1.0 kg soil and then sealed in bags. One part of soil samples were stored under low temperature freezing for determination of PCBs; The other part of the soil samples were air dried at room temperature, grinded through 2 mm sieves to determine organic matter content and pH.

B. Sample Treatment and Determination

Weighed 20.0 g fresh soil (after moisture content measure) and extracted PCBs with the method of acetone/n-hexane. PCBs in the extract liquids were determined through Shimadzu GC-2010 gas chromatograph instrument with Rtx-5 (30m×0.25m×0.25μm) chromatographic column and ECD detector [7]. Interference and system error were controlled by blank sample and parallel determination during analysis, with the parallel sample standard deviation of less than 5.6% and standard sample addition recovery of 62.7%~101.2%.

III. RESULTS AND DISCUSSIONS

A. PCBs Content Characteristics

As shown in table I, PCBs in Changchun city suburb vegetable soil were detected in different degrees, with the detection rate range of 7.84%~100%, among of them, the detection rate of PCB153 was low, and those of PCB28, PCB52 and PCB180 detection rate reached 100%. Coefficients of variation (CV) of PCBs content was in the range of 44.21%~366.67%, and with the maximum value for PCB153, which indicated that its contents were significantly affected by human activities [8].

TABLE I PCBS COMPONENTS STATISTICAL CHARACTERISTIC VALUE OF CHANGCHUN CITY SUBURBAN VEGETABLE FIELD SOIL

Homologues	Components	Detective rates (%)	Minimum ($\mu g \cdot kg^{-1}$)	Average ($\mu g \cdot kg^{-1}$)	Maximum ($\mu g \cdot kg^{-1}$)	Standard deviation	CV (%)
2Cl-PCBs	PCB8	64.71	0	5.08	40.74	7.50	147.64
3Cl -PCBs	PCB28	100.00	1.37	5.22	25.93	4.76	91.19
4Cl -PCBs	PCB44	74.51	0	4.02	15.34	3.84	95.52
	PCB52	100.00	3.09	8.29	23.35	4.04	48.73
5Cl -PCBs	PCB101	72.55	0	5.63	46.71	7.61	135.17
	PCB118	58.82	0	3.60	27.16	5.14	142.78
	PCB126	31.37	0	2.99	24.51	5.48	183.28
6Cl -PCBs	PCB138	68.63	0	14.55	78.09	18.79	129.14
	PCB153	7.84	0	0.45	8.01	1.65	366.67
7Cl -PCBs	PCB180	100.00	2.29	29.88	53.67	13.21	44.21
8Cl -PCBs	PCB198	31.37	0	4.03	34.97	7.51	186.35
	∑11PCBs	100.00	27.74	83.75	219.54	41.89	50.02

PCBs contents were in the range of 27.74 ~ 219.54 $\mu g \cdot kg^{-1}$ and the average content of 83.75 $\mu g \cdot kg^{-1}$. The toxicity of PCB28, 52, 101, 118, 138, 153 and 180 is bigger than that of others, and thus Soil Environment Quality Standard (Revision) (GB15618-2008) regulated total contents standard of the above 7 kinds of indicative PCBs (∑7PCBs). ∑7PCBs contents were between the first and second level standard, and most of those closed to the first level standard with the average content of 67.63 $\mu g\ kg^{-1}$, accounted for 80.75% of total PCBs as shown in Figure 1. The above results were in accord with the research of PCBs in main industrial area soils of Jilin province by Pan (2011) [6].

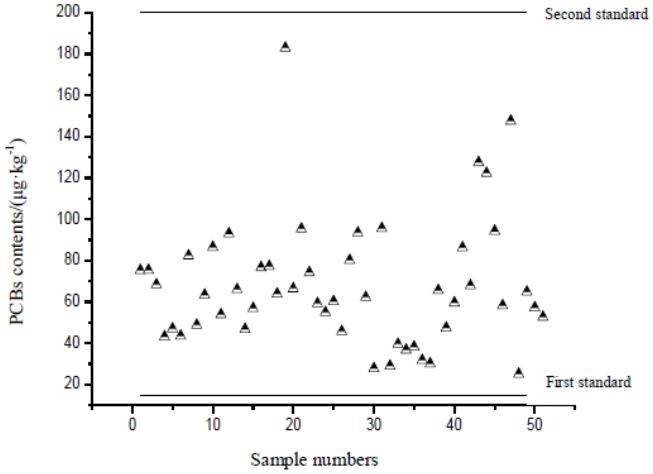

Figure 1. Content characteristic of 7 kinds of indicative PCBs.

B. *PCBs Distribution Characteristics in Soil*

The PCBs content distributions in the vegetable field soil of Changchun city suburb were shown in Figure 2. The PCBs distribution figure showed that PCBs high value areas were mainly distributed around the northeastern suburb and around Yitong river bank of southeast suburb of Changchun city, and the highest PCBs content was 219.54 $\mu g \cdot kg^{-1}$. The soil PCBs were mainly come from three aspects, which were the plasticizers volatilization, waste incineration and some industrial raw materials leakage [16]. Lots of automobile manufactures, photoelectric enterprises and steel industries distributed in Changchun city could discharge waste water, waste gas and waste residue containing PCBs, and as well as electronic waste and municipal waste incineration also could release PCBs causing soil PCBs pollution. The important reason of high PCBs areas may be that PCBs in the atmosphere could be deposited through dust and rain mostly in the northeast suburban controlled by the southwest dominated wind. Irrigation with river water may be the main reason for the higher levels of PCBs in the vegetable soil around Yitong riverbank.

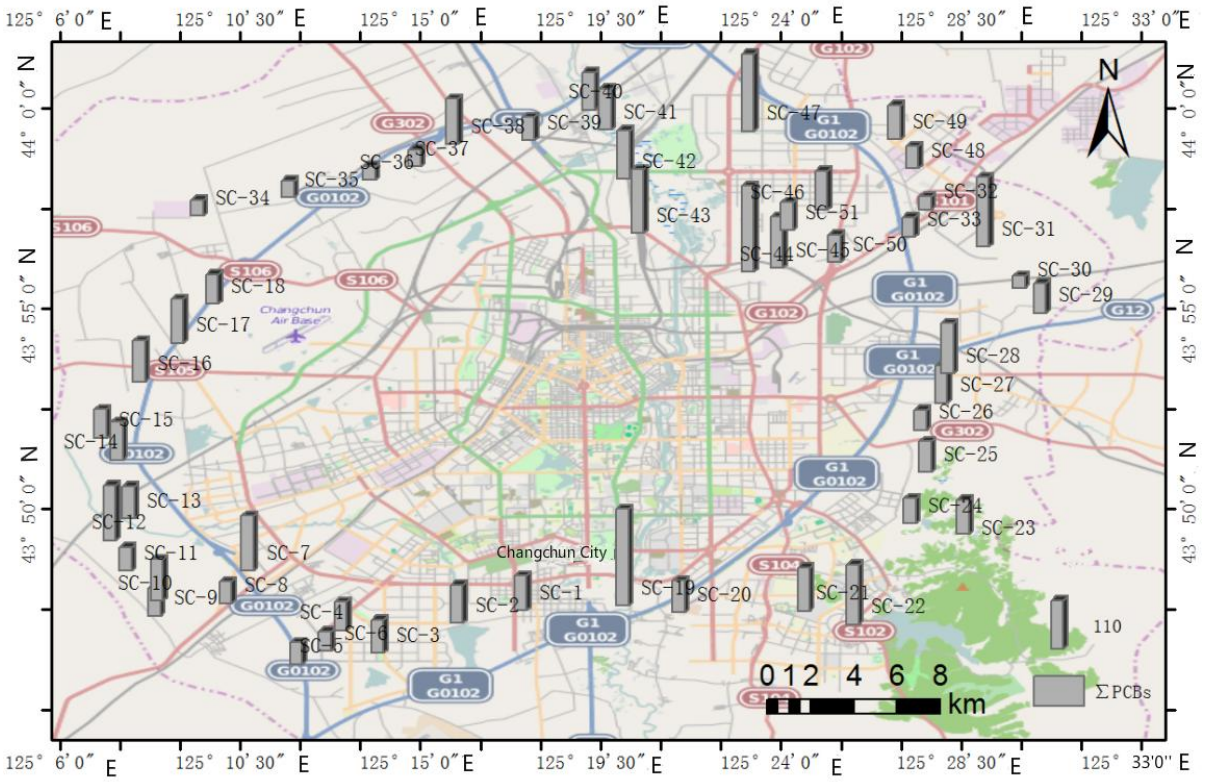

Figure 2. Distribution of PCBs contents in vegetable soils.

C. PCBs Sources Analysis

Principal component analysis (PCA) was applied to analyze the main source of vegetable field surface soil PCBs in Changchun city suburb. Factor analyses of PCBs components were conducted and 4 major principle factors were extract which characteristic values were greater than 1 (Table II). The variance contribution rates of four principal components were 35.393%, 16.755%, 13.616% and 35.393% respectively, with a total rate of 76.031%. Rotated component matrix was shown in Table III. The loads of PCB126, PCB198, PCB138, PCB44 were larger (>0.75) in the principal component F1, and were positively correlated relationship between the homologues, which were mainly come from higher temperature combustion processes (Sun et al., 2013), transportation (such as exhaust, lubricating oil leakage) and waste incineration; The loads of PCB153 and PCB118 were larger (>0.70) in the principal component F2, and were positively correlated relationship between the homologues, which were mainly come from PCBs volatile leakage from the paint additives and insulation materials and other industrial products containing Aroclor1254; The loads of PCB180, PCB52 were larger (>0.80) in the principal component F3, which were possible come from some certain enterprises, such as cement plant.

The loads of PCB28, PCB101 were larger (>0.80) in the principal component F4, which were mainly come from insulation dielectric in electronic power equipments with higher content of Aroclor1242 and Aroclor1248 containing PCBs (Chen et al., 2015)

TABLE II. TOTAL VARIANCE EXPLAINED FOR MAJOR PRINCIPAL COMPONENTS

Factors	Rotated quadratic sum loads		
	Total	Contribution rates/%	Cumulative Contribution rates /%
PC1	3.893	35.393	35.393
PC2	1.843	16.755	52.148
PC3	1.498	13.616	65.765
PC4	1.129	10.266	76.031

TABLE III. ROTATED COMPONENT MATRIX

Variances	Principal components			
	PC1	PC2	PC3	PC4
PCB8	0.404	-0.373	0.124	0.219
PCB28	-0.105	-0.127	0.042	0.875
PCB52	0.763	0.376	-0.014	0.235
PCB44	0.0500	0.254	0.833	-0.053
PCB101	0.222	0.271	0.001	0.837
PCB118	0.188	0.748	-0.106	0.124
PCB153	0.935	0.046	-0.056	-0.006
PCB138	0.814	0.496	0.024	0.069
PCB126	0.241	0.802	0.303	-0.011
PCB180	-0.182	-0.198	0.865	0.111
PCB198	0.848	0.076	-0.245	-0.113

IV. CONCLUSIONS

PCBs in Changchun city suburb vegetable soil were detected in different degrees, with the content in the range of 27.74~219.54 $\mu g \cdot kg^{-1}$ and the average content of 83.75$\mu g \cdot kg^{-1}$. The analysis results showed that the content of PCBs in vegetable soil were in the moderate and unpolluted level. The variation coefficients of PCBs content were larger, which indicated that PCBs distributions in soil were significantly affected by human activities. Principal component analysis showed that the distribution characteristics of PCBs in soil were mainly come from industrial production and influenced by the dominant wind direction of the region.

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