Study on Accumulation and Distribution of Cu, Ni, Cr and Cd in Polluted Soils by Rice

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Abstract: The absorption and distribution of Cu, Ni, Cr and Cd in polluted soils by rice were investigated by the pot-cultivation test on single pollution condition.The study show that the content distribution of Cu, Ni, Cr and Cd in different parts of the rice plant was uneven.The accumulation of heavy metals on organa of metabolic vigorous are much bigger than on organa of nourishment storage such as grain and fruit. Under the same treating condition, the distribution of Cu and Ni were root>leaf >stem>husk> grain and Cd was root >stem> grain>husk>leaf.

Key words: Cu; Ni; Cr; Cd; rice; accumulation; distribution

1 Introduction

China is the one of the biggest rice production nation whose grain production was 1.87 hundred millions per year on average and occupied 35% of the total production in the world. Now the total production, plant area and single production was the nomber 1,2 and 7 in the world,respectively. [1-4] In recent years, with the rapid development of industy and vast application of agricultural chemicla, pollution of the heavy metals was more severe than ever. According to imperfection staistic report, the area of heavy mental polluted farm field was about 1000 ten thousand hm^2[5]. The pollution of heavy mental will not only hinder the growth of rice, lead to the falling of production, damage the coesystem of farm field, but also dargerous to people and animals since toxic heavy metals can accumulate in the grains and transport to people and animals through the food chain. In order to reduce the absorption of the heavy metals in the grain and inhibit them enter the food chain, it is vital to study the absorption and distribution characteristics of rice to soil heavy metals.

Guangxi Zhuang Autonomous Region locate in west south karst area of China.There is abundant nonferrous mineral resources in Guangxi. Several factors such as exploitation of nonferrous mineral, the wastewater discharge from the nonferrous metallurgic industry and irrigation of wastewater caused the accumulation of toxic heavy metals and the falling of farming product quality. Therefore, it is significant to the safe production of farming product to study the absorption and distribution of heavy metals in polluted soils by rice combined with practical situation of Guangxi.

The financial supports from the Special Project of the National Water Pollution Control and Management of China (No.2008ZX07317-02-06E); Program to Sponsor Teams for Innovation in the Construction of Talent Highlands in Guangxi Institutions of Higher Learning; The Guangxi Key Laboratory of Environmental Engineering, Protection and Assessment;Guangxi Science Foundation(0542009)

The absorption and distribution characteristics of rice to soil heavy metals Cu, Ni, Cr and Cd was studid by the pot incubation test on single pollution conditions in this paper.

2 Experimental Materials and Methods

2.1 Experimental Materials

The tested metal ion Cu^{2+} was provided by $CuSO_4$, Ni^{2+} was provided by $NiCl_2$, Cr^{3+} was provided by $CrCl_3$ and Cd^{2+} was provided by $CdCl_2$; The tested rice was provided by Guilin Institute of Agricultural Science.

2.2 Pot-cultivation Test

2.2.1 The Preparation of Tested Soil

Select the pollution-free soil from rice plant area, screen from 2mm screen after soil air dred. Fit 10kg prepared soil to every pot and mix the soil well after adding in prepared heavy metal solutions. Soak with water for three days and then soil can be ready for use.

2.2.2 Cultivate Methods

The same complex fertilizer was applied for every pot as ground fertilizer with a proportion of 8g complex fertilizer per 1g soil. The rice shoots were thansplanted to the prepared pot for 3 hole per pot and 1 strain per hole after cultivating in the pollution-free soils for 30 days. 2 or 3cm water level were maintained during the whole growing season.

2.2.3 The Design of Heavy Metals Concentration on Single Pollution Conditon

Four pollution levels were designed for Cu, Ni, Cr and Cd. The treating concentrations were as follows:

Cu: 0、50、150、300mg/kg；**Ni:** 0、40、120、240mg/kg; **Cr:** 0、100、300、500mg/kg；**Cd:** 0、0.5、1、3mg/kg.

Three parallel samples were planted for every treating level.

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2.3 Samples Collection and Pre-treatment

The rice samples were collected during the mature period and first cleaned with tap water and then rinsed with de-ionized water. The cleaned plants was divided into different organa such as roots,stems,grains,husks and leaves. All the samples were dried for 30 minutes at about 105℃ and then dried for 24 hours at 80℃.

2.4 Samples Degradation and Analyses

The plant samples were break up by a non-corrosive steel crasher and 2g samples were weighed to a cone bottle. 20ml hydrogen nitrate and 5ml perchloric acid were added to the bottle and the samples were heat up to degradate. When the sample volume reduced to 2 or 5ml, the samples were transferred to a 50ml colorimetric cylinder after continuing to heat 10 or 15 minutes. After the samples cooled down, added 0.2%(m/v) hydrogen nitrate to scale and shaked the mixture well, then the content of heavy metals were measured by Air-Ethyne Flame atomic absorption spectrometry(AFAAS).

2.5 Working Conditions of Measurement Equipment

The working conditions of AAS was shown in Table 1. The content of heavy metals were measured by Air-Ethyne Flame AAS. Graphite furnace atomic absorption spectrometry（GFAAS）were used when the the heavy metals content of samples were under the detectability of AFAAS.

Table 1 The working conditions of AAS

El	W-l (nm)	L-c (mA)	Slit (nm)	A-E ratio	L-s
Cu	324.8	15	0.7	17:2	Hollow cathode lamp
Ni	232.0	25	0.2	17:2	
Cr	357.9	8	0.7	14.5:2.5	
Cd	228.8	8	0.7	17:2	

El: Elements; W-l: Wavelength; L-c:Lamp current; A-E: Air-Ethyne ratio; L-s: Light source

3 Experimental Results

3.1 The Absorption and Distribution of Cu

The content of Cu in the different positions of rice at the different treating concentrations were shown in the Table 2, Figure 1 and Figure 2.

It was shown in the Table 2, **Figure1** and **Figure** 2 that the distribution of Cu in different parts of the rice plant was uneven. Cu was accumulated mainly in the the root,

Table 2 The content of Cu in the different organas of rice at the different treating concentrations（mg/kg）

R-o / T-C	Root	Stem	Leaf	Husk	Grain
Control sample	30.675	30.433	432.500	2.639	3.793
50mg/kg	166.092	57.225	35.212	5.794	8.754
150mg/kg	248.351	70.492	37.197	7.300	9.648
300mg/kg	354.136	88.698	132.445	6.544	10.132

R-o: Rice organas; T-c: Treating concentration

stem and leaf of rice and the content of Cu in this organas were much higher than that of the other organas such as husk and grain. In general, the content of Cu in each organa increased as the treating content increasing and the accumulation abilities of each organa varied greatly. The distribution of Cu were root >stem>leaf > grain > husk.

3.2 The Absorption and Distribution of Ni

The content of Ni in the different positions of rice at the different treating concentrations were shown in the Table 3, Figure 3 and Figure 4.

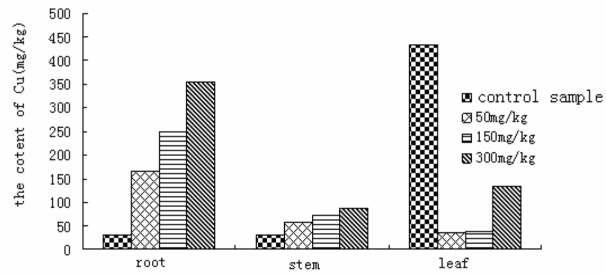

Figure1 The content of Cu in the root, stem and leaf of rice at the different treating concentrations（mg/kg）

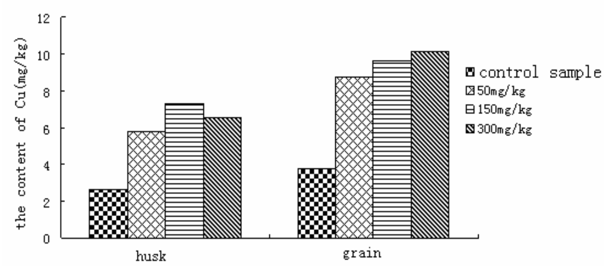

Figure 2 The content of Cu in the husk, grain of rice at the different treating concentrations（mg/kg）

Table 3 The content of Ni in the different organas of rice at the different treating concentrations（mg/kg）

R-o / T-C	Root	Stem	Leaf	Husk	Grain
Control sample	6.253	2.987	40.597	1.406	0.294
50mg/kg	25.603	3.280	3.665	2.298	2.618
150mg/kg	101.236	9.074	7.721	3.203	4.339
300mg/kg	96.143	11.104	13.701	3.823	5.578

R-o: Rice organas; T-c: Treating concentration

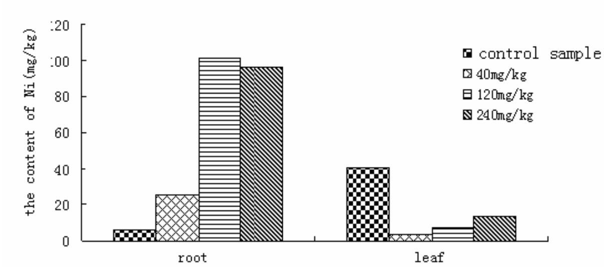

Fig 3 The content of Ni in the root, stem and leaf of rice at the different treating concentrations（mg/kg）

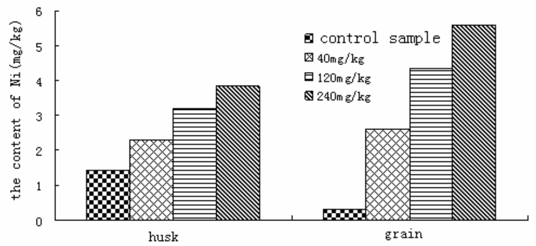

Fig4 The content of Ni in the husk and grain of rice at the different treating concentrations（mg/kg）

It was shown in the Table 3, Figure 3 and Figure 4 that the distribution of Ni in different parts of the rice plant was uneven. Ni was accumulated mainly in the the root, stem and leaf of rice and the content of Ni in this organas were much higher than that of the other organas such as husk and grain. In general, the content of Ni in each organa increased as the treating content increasing and the accumulation abilities of each organa varied greatly. The distribution of Ni were root >leaf >stem > grain >husk. When the treating concentrations of Ni increased from 120mg/kg to 240mg/kg, the accumulation ability of root decreased and the accumulation of other organas increased.

3.3 The absorption and distribution of Cr

The content of Cr in the different positions of rice at the different treating concentrations were shown in the Tab4, Fig 5 and Fig 6.

It was shown in the Table 3, Figure 5 and Figure 6 that the distribution of Cr in different parts of the rice plant was uneven. Cr was accumulated mainly in the the root and leaf of rice and the content of Cr in this organas were much higher than that of the other organas such as husk and grain. In general, the content of Cr in each organa increased as the treating content increasing and the accumulation abilities of each organa varied greatly. The distribution of Cr were root >leaf >stem > husk> grain.

3.4 The Absorption and Distribution of Cd

The content of Cd in the different positions of rice at the different treating concentrations were shown in the Tab 5 Fig7 and Fig 8.

It was shown in the Table 4, Figure 7 and Figure 8 that the distribution of Cd in different parts of the rice plant was uneven. Cd was accumulated mainly in the the

Table 4 The content of Cr in the different organas of rice at the different treating concentrations（mg/kg）

R-o / T-c	Root	Stem	Leaf	Husk	Grain
Control sample	9.331	4.360	39.932	4.431	0.652
100mg/kg	44.361	4.682	21.047	4.624	0.902
300mg/kg	97.239	6.793	28.805	3.893	0.778
500mg/kg	108.663	8.580	32.293	5.206	0.818

R-o: Rice organas; T-c: Treating concentration

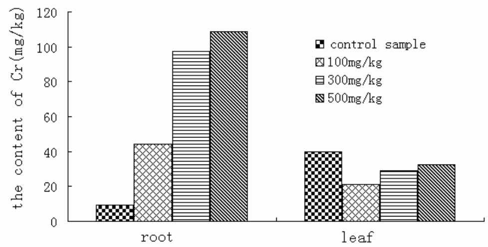

Figure 5 The content of Cr in the root and leaf of rice at the different treating concentrations（mg/kg）

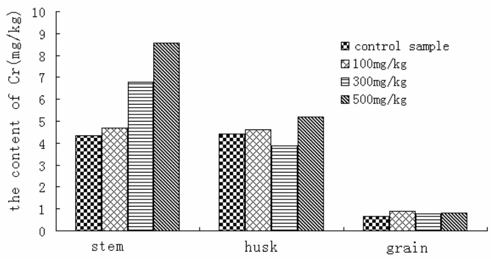

Figure 6 The content of Cr in the stem, husk and grain of rice at the different treating concentrations（mg/kg）

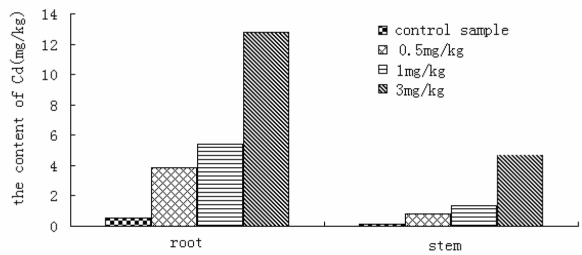

Figure 7 The content of Cd in the root and stem of rice at the different treating concentrations（mg/kg）

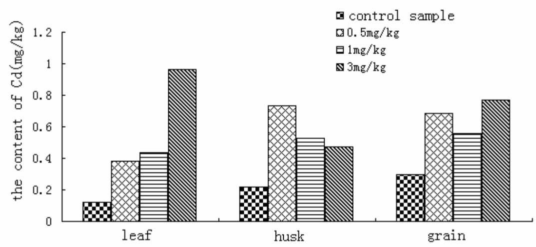

Figure 8 The content of Cd in the leaf, husk and grain of rice at the different treating concentrations（mg/kg）

Table 5 The content of Cd in the different organas of rice at the different treating concentrations（mg/kg）

R-o / T-c	Root	Stem	Leaf	Husk	Grain
Control sample	0.5670	0.1680	0.1190	0.2171	0.2978
0.5mg/kg	3.8590	0.8390	0.3810	0.7362	0.6860
1.0mg/kg	5.4210	1.3300	0.4350	0.5298	0.5597
3.0mg/kg	12.7860	7.9250	0.9640	0.4728	0.7692

R-o: Rice organas; T-c: Treating concentration

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root and stem of rice and the content of Cd in this organas were much higher than that of the other organas such as leaf, husk and grain. In general, the content of Cd in each organa increased as the treating content increasing and the accumulation abilities of each organa varied greatly. The distribution of Cd were root > stem > leaf >grain >husk. When the treating concentration of soil was 3.0 mg/kg, the content of Cd in grain reached 0.77 mg/kg and was beyond the limited standard of Cd in the rice(≤0.2mg/kg) in National Standard of China(GB2762-2005).

4. Conclusions

The study show that the content distribution of Cu, Ni, Cr and Cd in different parts of the rice plant was uneven.The accumulation of heavy metals on organa of metabolic vigorous are much bigger than on organa of nourishment storage such as grain and fruit. The main conclusions are as follows:

(1)Under the same treating condition, the distribution of Cu were root>leaf >stem>husk> grain. The content of Cu in root,stem and grain increased as the treating content increasing. The content of Cu in leaf was first decreased and then increased with the increasing treating content.

(2)Under the same treating condition, the distribution of Ni were root>leaf >stem>husk> grain. The content of Ni in root first increased and then decreased as the treating content increasing. The content of Ni in stem, husk and grain increased with the increasing treating content.

(3)Under the same treating condition, the distribution of Cr were root>leaf >stem>husk> grain. The content of Cr in root and stem increased with the increasing treating content.

(4)Under the same treating condition, the distribution of Cd were root>stem> grain >husk> leaf. The content of Cr in root and stem increased with the increasing treating content.

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