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Accumulation in Rice Kernels of Different Rice Varieties, Grownin Soil Contaminated with Cadmium

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1. Abstract

The southern paddy soils area of Ho Chi Minh City (HCMC) belong to the final downstream area of Sai Gon-Dong Nai river Watershed before flowing into the sea. It was polluted by domestic, industrial waste waters and sediments of the urban waste water drainage canals from HCMC and neighboring provinces. This land has also been identified as potentially contaminated by Cadmium (Cd). The study Cd accumulated in parts of rice was very important for food safety controls and rice production development for environmental problem areas. The subject studied Cd accumulation of two rice cultivars included one traditional rice variety (Mahsuri) and one high-yielding rice variety (VND95-20). Pots of experimental soils were infected by Cd at nine different levels from 0 to 40 mg Cd kg-1 (cry weight). All pot experiments carried out in the field of southern HCMC. The result showed that Cd accumulated ability of rice plants depends on each part of rice, various varieties and concentration of Cd in soils. At experimental condition, distribution of Cd in roots, straws and brown rice as almost equivalent ratio 1000:100:1, and Cd accumulation of brown rice correlate positive as Cd concentration of soils. Cd accumulated ability in brown rice of Mahsuri traditional rice variety is much lower than than VND95-20 high-yielding variety.

2. Place The Problem

The rice growing area south of Ho Chi Minh City (HCMC) belongs to the last basin of the Saigon-Dong Nai river system before being discharged into the sea. This is a land of alum, salinity in the dry season, affecting the semi-diurnal tide regime. This land is polluted by many waste discharges such as industrial wastewater, domestic wastewater, rainwater and sedimentation from the urban drainage canals of Ho Chi Minh City and the provinces on the territory of the Saigon-Dong river system. Deer. This area is at risk of heavy metal cadmium contamination [1](Nguyen Ngoc Quynh and Le Huy Ba, 2002). The Mahsuri season rice variety and the high-yield rice variety VND95-20 are two popular rice varieties grown in the southern area of HCMC. Research on the accumulation and fecal capacity of Cd in rice plant parts grown in contaminated soil is essential for soil pollution control, rice safety warning and contributing to development. rice production in areas with environmental problems along the current urban areas.

3. Materials and Methods

Two rice varieties represent two groups of rice varieties that are popularly growing in the southern region of HCMC, including Mahsuri (seasonal rice variety, growing time 115-120 days) and VND95-20 (high-yield rice variety, time). growing 90-95 days). Cd contamination experiment in soil pots with 9 concentrations: 0; 5; ten; 15; 20; 25; 30; 35 and 40 mg / kg-1 dry weight, done in the field according to the method of Liu Jain Guo et al. (2005)[2], using 10 kg of dry soil (converted to dry weight), crushing it into a pot with dimensions 27 x 35 cm (diameter x height). Causing Cd contamination in soil by dissolving CdCl2.2,5H2O in deionized water with the volume of Cd corresponding to 9 experimental treatments, using 100 ml of phase solution for each soil pot and then filling with tap water to cover. 2 cm of topsoil, after two weeks, submerge pots of soil into the field so that the ground in the pot is equal to the field ground. Experimental soil in pots collected from rice fields in areas not polluted with wastewater in BinhKhanh commune, Can Gio district, HCMC. Characteristics of the experimental soil: acid sulphate soils in dry season, influence of semi-diurnal tide; soil pHKCl 4.4; mechanical composition of soil (%) sand: meat: clay equivalent to 12.5: 57.7: 29.8. The total majority (%) N, P2O5 and K2O are 0.25, 0.01 and 0.75, respectively. Heavy metals (mg/kg-1): Cd, Zn, respectively 0.49, 127. Apply fertilizers for the experiment applied according to the local rice cultivation process in the study area, without phosphate and potassium fertilizers, only applying only one type of urea fertilizer (converted to kg N) equivalent to 90 kg N/ha for the variety VND95-20 and 60 kg N/ha for the variety Mahsuri. The experiment arranged 1m2 for 10 pots For rice, the total weight of N fertilized for 1 m2 of variety VND95-20 is 9.0 g (equivalent to 19.6 g of urea), Mahsuri is 6.0 g N (13.0 g urea). Mahsuri seedling age is 30 days, VND95-20 is 21 days, transplanted 1 seedling in the bush and transplanted 3 bushes on the pot. The experiment was arranged in a farmer's field planting the same rice variety in the experiment, in Long Thoi commune, Nha Be district, Ho Chi Minh city, crop year 2010. This is a land with environmental problems, the soil is polluted with wastewater from many sources, people grow rice with 1 crop / year in the rainy season. The experiment was arranged with RCBD type, 4 replicates, analyzed samples were taken at rice ripening stage. Samples of rice plant parts brought back, washed with tap water, dried at 1050C until constant weight. Cd analysis in parts of rice plants by neutron activation method and X-ray fluorescence method at Da Lat Nuclear Institute. Statistical processing of experimental results according to Anova's variance analysis method and comparing the mean values according to Duncan method.

4. Results and Discussion

The results in Table 1 showed that for treatment 0, the soil was not contaminated with Cd, both rice varieties still accumulated Cd in parts of the rice plant, but the concentration of Cd was very low because the rice plant partly accumulated Cd. from cultivated soil with very low concentration (0.49 mg/kg), partly from the field water environment, due to the pollution of wastewater in this area. When increasing the concentration of Cd in soil from 5 to 40 mg/kg, concentration of Cd in roots, straw and brown rice increased proportionally with concentration of Cd in the soil. This correlation occurs regardless of whether the variety is seasonal or high-yield rice. However, the accumulation of Cd in each part of rice plant and for each variety is very different. Table 1 and figure a show that the concentration of Cd in rice plant parts is very different. When the concentration of Cd in the soil increases from 5 to 40 mg/kg, the concentration of Cd in the rice root increases by 50-500 times, in straw increased from 10-110 and in brown rice increased by 8-100 times compared to rice grown on non-contaminated soil. The results in Figure a show clearly that Cd accumulates in the roots, followed by straw and finally in rice grains.

Note: The limit of allowed total Cd concentration in agricultural land is 2 mgCd kg-1 (QCVN 03: 2008 / BTNMT) and in rice is 0.2 mg Cd kg-1.

From the results in (Table 1 and Figure a), it is possible to arrange the Cd level in parts of rice plants in descending order of Cd accumulation in parts of rice plants as follows: roots >> straw> brown rice. This result is similar to the results of Takao Fujimoto and Yodshiya Uchida (1979)[3] who determined that rice plants in Cd-contaminated hydroponic medium, the Cd accumulation in rice in the root system was highest, then to the stem and end. the same leaves. Roongrawee and Raywadee (2011)[4] analyzed and surveyed soil and rice samples collected at soil sampling sites on heavily Cd contaminated production fields in SamutSongkhram province, Thailand, also confirmed the distribution of Cd in soil and parts of rice plants in the order: soil>roots> straw> rice> rice husks. The research results of the thesis are also consistent with the research results of Wu et al., (1999)[5], which determined the concentration of Cd in brown rice and in straw, detecting a large variation among 52 cultivated rice varieties. on Cd contaminated fields. Liu JG et al., (2006) suggested that even within the same rice grain, the Cd distribution in the hull, bran and polished rice was also very different, the most accumulated Cd was in the bran hull. The Cd uptake of rice plants in the soil environment is a complicated process, depending on many factors in the soil environment, the form of existence of Cd in the soil, Muramoto S (1989)[6] has arranged the predominance of these forms. Cd contamination in soil is related to Cd accumulation in rice as follows: CdCl2>CdO>CdS. Even on the same rice variety, grown under the same polluted environmental conditions and different growth stages, the Cd uptake is also different. Chino (1973), Kitagishi and Obata (1981) [7, 8]suggested that the rice plants had maximum Cd uptake in the dark rice stage.

(Table 1) results, when concentration of Cd contaminated in the soil is from 20-40 mg/kg, the accumulation and distribution of Cd in the parts: roots: straw: brown rice of rice varieties VND95-20 is equivalent to the rate of 1000: 10: 1. For Mahsuri rice variety, the Cd distribution in the parts of the rice plant did not follow this law. However, the interesting thing here is that Mahsuri rice has very low ability to accumulate Cd in rice, even when the Cd concentration in the soil is high, but Cd accumulation in rice of this variety is also very low (Figure a, b and c).

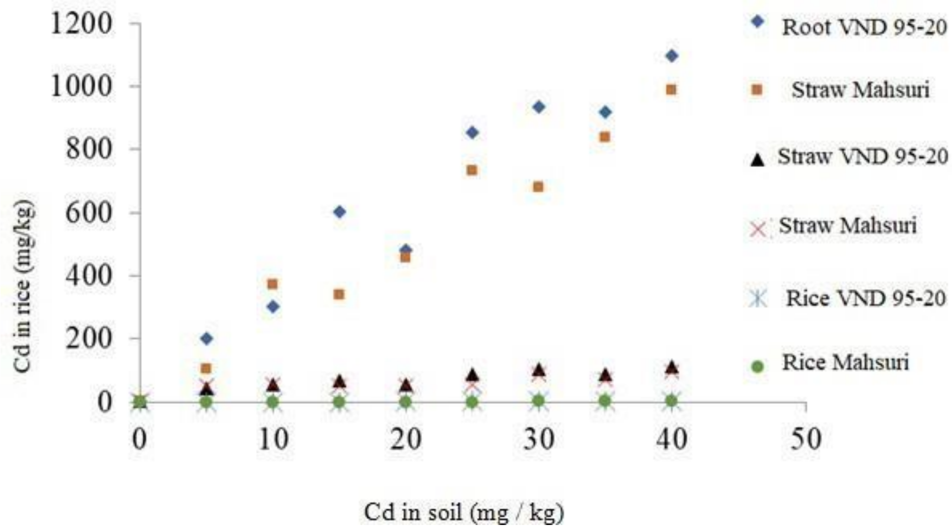

Figure A: diagram of Cd distribution in soil and parts of rice plants

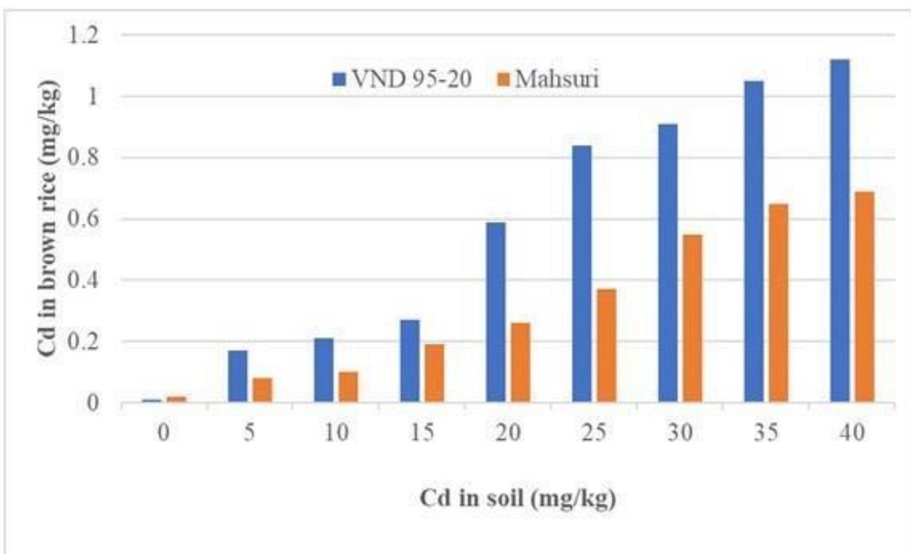

Figure b: Cd content in soil and brown rice of rice varieties

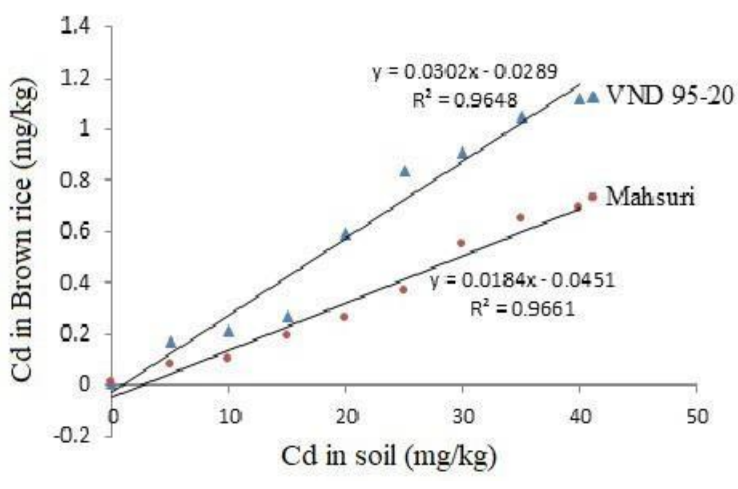

Figure c: Correlation between the Cd content in soil and brown rice of the rice varieties

Table 1: Cd content in soil and parts of rice plants

Cd	Roots (mg/kg)		Straw (mg/ kg)		Brown rice (mg/ kg)	
in the soil (mg/kg)	VND95-20	Mahsuri	VND95-20	Mahsuri	VND95-20	Mahsuri
0	2	2	1	1	0,01	0,01
5	200	105	43	52	0,17	0,08
10	301	370	55	55	0,21	0,10
15	601	338	67	52	0,27	0,19
20	480	458	57	50	0,59	0,26
25	855	732	87	56	0,84	0,37
30	934	680	105	86	0,91	0,55
35	917	838	87	70	1,05	0,65
40	1098	987	110	96	1,12	0,69

Note: The limit of allowed total Cd concentration in agricultural land is 2 mgCd kg^{-1} (QCVN 03: 2008 / BTNMT) and in rice is 0.2 mg Cd kg^{-1}.

Table 1 and figure b show that, when concentration of Cd in soil increased to 10 mg/kg, the concentration of Cd in rice of VND95-20 rice variety reached the maximum threshold of the allowable limit. Meanwhile, Mahsuri rice variety, when the Cd concentration in the soil increases from 20 mg/kg or more, the concentration of Cd in the rice will reach the limit. The increase in Cd in rice was evident in rice varieties when the concentration of Cd in the soil reached 40 mg/kg. For Mahsuri rice variety, although grown in high concentration of Cd contaminated soil, the concentration of Cd accumulated in brown rice remained stable at a very low increase of 0.1 mg/kg. While the variety VND95-20 continued to increase proportionally with the concentration of Cd in the soil. Muramoto S (1990) [9]suggested that when increasing the concentration of Cd in soil to the maximum threshold (1000 mg/kg), the possibility of Cd accumulation in non-glutinous rice was higher than that of sticky rice 1 mg/kg.

Morishita (1987) detected a very wide variation among 56 rice varieties of the species: Japonica, Indica, Javanica and hybrid rice varieties, grown in Cd contaminated fields showed very different levels of volume Cd concentration. accumulated in brown rice (from 2.1 to 73.6 mg/kg). Similarly Wu et al. (1999) also found that the difference in Cd accumulation capacity in brown rice of 20 rice varieties (including Indica and Indica hybrid) grown in South China was more than twice (0.48-1.17 mg/kg). first). He Junyu et al., (2006) [10]compared 38 rice cultivars on Cd-contaminated soil, showed that Indica-shaped rice varieties accumulate Cd in straw, brown rice and hull higher than Japonica shaped varieties and accumulation. High or low Cd accumulation in rice is mainly dependent on rice variety rather than on the region of Cd accumulation in rice. This may explain why growing under the same pollution conditions, Mahsuri rice has much lower Cd accumulation in brown rice compared to VND95-20. Because the Mahsuri variety is derived from the Japonica x Indica hybrid (Parthasarathy N, 1972)[11], so this variety is more likely to carry the gene that controls the Cd concentration in rice low from the Japonica species obtained from its parents. In contrast, VND95-20 is the rice variety causing mutation from the rice variety IR64 belonging to Indica (Do KhacThinh et al., 2000). Yu et al., (2006) [12, 13]suggested that Cd accumulation in rice was dependent on the rice genotype. Chino and Baba (1981)[14], when Cd in the medium reached the threshold toxicity to rice roots, the amount of Cd transported to the shoots was entirely dependent on the amount of Cd in the roots, not on Cd in the nutrient solution. The authors suggested that Cd was transported to the rice shoots as organic complexes when it was present in low concentrations in the root zone, but at higher concentrations of metals it was retained in the roots as inorganic.

Figures a, b and c show that, for the terrestrial parts of rice plants, Cd accumulation in brown rice is more stable than in roots and in straw. Figure c shows that the Cd accumulation in brown rice of both Mahsuri and VND95-20 rice varieties closely correlated with the Cd concentration in the soil. When the Cd contaminated soil gradually increased from 5-40 mg/kg, the Cd in brown rice of both rice varieties also increased. However, Mahsuri rice variety has very slow increase in Cd level in brown rice even because the concentration of Cd in the soil increases rapidly, so the Cd concentration in rice of this variety is very low and much lower than that of rice variety VND95-20. In fact, some rice varieties give high yield but low Cd accumulation in rice and vice versa. Hideki S et al. (2011) [15]identified two QTLs that control low Cd concentrations in rice: one on chromosome 3 (qLCdG3) and one on chromosome 11 (qLCdG11). Thus, there is a big difference in Cd concentration in the grain of rice varieties. This opens up a possibility of safe rice breeding for the Cd-contaminated rice growing areas. However, the process of transporting Cd from root-shoot-rice is a dynamic process, taking place very complicatedly. As observed by Chino and Baba (1981)[14], it is suggested that the transfer of Cd from roots to shoots is the regulatory activity of rice plants. According to Asami (1981), the maximum permissible limit of Cd in soil should be determined by concentration of Cd in rice and should not be based on total Cd concentration in soil. Because the existence of Cd in soil is affected by many factors in the soil environment. Therefore, the use of unilateral concentration of Cd in soil to determine maximum permissible concentration of Cd is very difficult and imprecise.

5. Conclusion

Cadmium accumulates in rice plants differently depending on the part of the rice plant, the variety and the concentration of Cd in the soil. Cd accumulates the most in roots, up to straw and lowest in rice.

The season Mahsuri rice variety has much lower Cd accumulation in rice compared to the high yielding rice variety VND95-20 grown under the same soil pollution conditions and the accumulation of Cd in brown rice correlates closely with the concentration of Cd in the soil.

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