Journal of Rice Science

Research Article

ISSN: 2690-5183 | Volume 1

Heavy Metal Cadmium Toxic in the Land – Water of the Watershed, Sai Gon – Dong Nai River Valley and Effects on the Rice

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Received: 21 Jul 2023
Accepted: 08 Aug 2023
Published: 17 Aug 2023

Keywords:

Rice plant; Soil Biology; Cadmium toxic; Accumulation and Effect of Cd Toxic

Citation:

Huy BL, Heavy Metal Cadmium Toxic in The Land – Water of the Watershed, Sai Gon – Dong Nai River Valley and Effects on the Rice. J Rice Sci. 2023; 1(5): 1-5

1. Abstract

Applying research method of the field assessment, investigating, compensating with method of examination pilot and the field experimenting, the authors have some following results: on the soil of rice fields, are influenced by waste water from the southern Ho Chi Minh city have potential of contamination by heavy metal toxic. Because the concentration of Cd is 4.7 – 10.3 ppm, some places it is over than 2 – 3 times of the safe standard. The concentration of Cd is higher in 3 kinds of soil: the yellow-red allusion, the allusion-acid sulphate soil and the actual acid sulphate soil. When the concentration of Cd in soil is over than 25 ppm, affect on the agro-characteristic, on the field parts and disease the rice yield. However, with different rice varieties it has affected differences on the quality of the rice.

2. Introduction

The area of Ho Chi Minh city has 2.1 million kilometers and the population is near 5.4 million people, is the leading city through our country about the size and the industrial development speed and the small scale industry. In 2000, Ho Chi Minh city had 1.000 industrial companies, 28.500 small scale industries, and 12 concentrated industry areas [1]. Except for the concentrated industries were established in the recent time, most the industrial enterprises in Ho Chi Minh city have operated more than 25 years, with the backward devices and technology and without wastewater treatment systems. Wastewater from enterprises has not been treated, flows through canals, into agricultural productions directly, pollute soil environment and water resource for agriculture, specially in rice on the lowland and the aquaculture in the suburb [2-5].

There are many theses of monitoring and assessment heavy metals, such as: river water, groundwater, river silt, canals, vegetable insects, aquatic animals and plants…, however, there are a few theses about heavy metals in the rice growing soil and its effects on the rice. This thesis analyses six heavy metals: Cd, Cu, Zn, Pb, Hg, Cr in 120 points in the rice farming soil areas contaminated by industrial wastewater and domestic wastewater in the suburb of Ho Chi Minh city, include 14 communes, wards and towns of 5 districts: Nha Be, Binh Chanh, District 2, Dictrict 7 and Thu Duc. To find out the element that can pollute the rice farming soil, then study its effects on rice and vegetables to comment on planting rice status of the areas affected by wastewater in Ho Chi Minh city.

3. Materials and Methods

This thesis studies, selects and takes a sample by UNESCAP and CCME. The soil samples are taken in rice soil, the soil floor is from 3 to 15 centimeters, in the rice flowering – ripening stage. Soil samples are stored and treated in the laboratory. We analysis heavy metals in soil by analysing spectrum method and by neutron activation method in rice. After analysing six heavy metals: Cd, Cu, Zn, Pb, Hg, Cr, we detected Cd with the high risk of soil pollution in survey areas, this thesis conducts experiments, contaminates artificial pollution Cd (in the form $CdCl_2.5H_2O$) in the lab-

oratory, in the greenhouse combine with the field to assess effects of Cd in soil on rice and accumulation of Cd in all parts of rice [7].

Determine effects of Cadmium in soil on rice, vegetables: grow six plants /pot, contain 4.5kg dry soil in the surveyed areas, polluted Cd with concentrations: 0; 5; 10; 15; 20; 25; 30; 35; 40 mg/kg dry soil, water distilled water for rice. Do experimenting repeat 3 times, the rice VND 95-20, planted in the greenhouse achieved standard about humidity, temperature and light. Monitor the growth, development and accumulation of Cd in rice. Review results in the laboratory, the greenhouse and analysis Cd content in rice and do experimenting artificial pollution in fields for two popular rice seeds in Ho Chi Minh city, is VND 95-20 (high-yield rice) and VD 20 (aromatic rice). Do sampling in Nha Be, polluted by Cd with 5 doses: 0; 15; 20; 25; 30 mg/kg dry soil, put into wood frame (100x100x30 cm) with nylon at the bottom, put in the field, plant 30 rices/ treated soil tray [8-10]. We do experiments follow split- plot with 4 times. We analysis data by ANOVA, use MSTATC software and IRSTAT 4.01.

4. Result and Discussion

The analysing results of six heavy metals: Cd, Cu, Zn, Pb, Hg, Cr in 126 points in the rice growing soil of the areas contaminated by wastewater in Ho Chi Minh, Table III.1 shows that Cr and Pb starts to pollute to soil, but the two heavy metals are beyond higher than the lower limit compare with standard of some European countries. Hg and Cu is on the safe limit, the concentration of these elements in soil is lower than the lower limit of allowed standard. Zn has high concentration in some rice fields near industrial estates, but this element polluted in some areas near industrial estates, not popular in rice fields. Notably, Cd accumulated in soil with the high concentration is from 9.9 – 10.3 mg/kg, over than 2 – 3 times of the safe standard, specially in Nha Be and Binh Chanh.

Table 1: Concentration of heavy metals (mg/kg) in rice fields in wastewater polluted areas in Ho Chi Minh city

Locations	Quantity of sample	Cd	Cu	Zn	Pb	Hg	Cr
Nha Be	88	9,9	28,6	110	61,7	0,09	125,3
7 district	4	4,7	22,7	233	39,0	0,05	115,4
Binh Chanh	10	10,3	31,0	197	58,0	0,21	119,0
2 district	10	5,5	33,1	435	43,6	0,34	44,8
9 district	6	4,9	29,5	568	40,5	0,03	54,3
Thu Duc	8	6,8	30,0	282	44,3	0,20	84,3
The safe standard to agricultural soil in some countries:							
Netherlands		1-5*	50-100	200-500*	50-150*	0,5-2	100-250*
England		3-Jan	140	280	35	0 –1	0-100
Germany		3+	100+	300+	50+	2+	100+

(*). Value need to be studied

The rice fields receive waste water from 3 canals: Tan Hoa – Lo Gom, Kenh Te – Kenh Doi, and Tau Hu – Ben Nghe. These canal systems have been enumerated in black list in Ho Chi Minh city, include Tan Hoa – Lo Gom in considered "a dead canal" and "Ron heavy metals", these three canal systems receives wastewater from many wastewater sources in Ho Chi Minh city, such as: domestic wastewater, industrial wastewater, especially wastewater from textile dyeing factories, galvanizing, casting, welding in the trade villages in district 5, 6, 11 and Tan Binh district [11]. These wastewater sources are not treated, flow directly in rice – fields, lead concentration of Cd and other elements contaminate into rice fields. This result is suitable with the analysing result in the areas related to surveyed regions, such as: Cd in sludge in Nhieu Loc – Thi Nghe is from 28 to 35 mg/kg (concentration of analysing laboratory, 1996), the average Cd in water spinach in Vinh Loc, Binh Chanh is 5.09 mg/l (Bui Cach Tuyen and colleagues, 1994). Cd is one of eight elements polluted sludge in Tan Hoa – Lo Gom (Ngo Quang Huy and colleagues, 1999).

In term land in studing areas, Nha Be district has characteristics for rice fields of the southern Ho Chi Minh city, includes eight types of land (Table III.2) [12]. Considering the points are taken in Nha Be, shows that Zn and Cd concentrated highly in three types of soil: the yellow – red allusion soil (PEM), the allsion – acid soil (PPM) and the actual acid sulphate soil (SJ2M). From the type 4th soil onwards, Cd and Zn decreases follow the distance radius from the discharge source (Kuo, S., Heilman, P.E and Baker, 1983).

Table 2: The distribution of heavy metals in a main land in the survey area (mg/kg)

Order	Types of soil	Cd	Cu	Zn	Pb	Hg	Cr
1	The yellow – red allusion soil *(Pfm)*	16.7	27.5	130	78.1	0.19	133.1
2	The potentially allusion – acid soil *(Ppm)*	14	29.4	102.4	63.8	0.07	136.5
3	The actual acid sulphate soil *(Sj_2m)*	14.5	28.7	102.1	66.8	0.15	133.8
4	The actual acid sulphate soil, with the red floor *(Sj_2Rm)*	7.6	23.6	83.8	70.2	0.12	124.3
5	The actual acid sulphate soil, the deep sulphate soil *(Sp_2m)*	12.4	27.7	92.7	59.4	0.12	129.7
6	The actual acid sulphate soil, many organic residues *(Sp_2hm)*	7.8	18.6	97.2	67.1	0.11	121.3
7	The potential acid sulphate soil, the hollow sulphate soil *(Sp_1m)*	8	30	99	76.3	0.09	140.5
8	The potential acid sulphate soil, many organic compounds *(Sp_1hm)*	8	23.2	87.7	71.2	0.08	120.5

Note: *These eight types of soil were contaminated by salt in the dry season*

Table 3: Effects of Cd in soil on characteristics

Cd (mg/Kg)	Sowing of rice)(days)	The high of rice (cm)	Dried materials (g/pot)(*)
0	108	82,8	17.7
5	107	84,0	17.4
10	107	80,2	17.2
15	106	79.7	16.5
20	108	76,2	15.6
25	110	70,8	14.4
30	113	61,2	13.6
35	115	60,7	13.3
40	116	60,0	11.7
Cv (%)	-	2,48	10.02
$LSD_{0,01}$	-	4,85	419

(*) quantity of dried materials in 64 days after farming

Table III.3 shows that concentration of Cd in soil is more than 35 mg/kg of dry land, will lengthen the growth cycle of rice from 5 to 8 days. This phenomenon is due to Cd in soil with high dose, the roots are contaminated by Cd, so continue to form secondary roots, lead to lengthen ripeness time of rice. When Cd in soil is more than 20mg/kg, will inhibit the growth of rice, such as: decrease the high of rice, lead to decrease forming living mass capacity, as a result, quantity of dry matter is decreasing.

Table III.4 shows that: when concentration of Cd in soil is more than 20mg/kg, it will decrease quantity of rice ears/pot. When Cd in soil is more than 30mg/kg, it will decrease more than 40% of rice ears and increase the rate of flat-grained, 1.000 grains and grain productivity. Table III.4 shows that: if Cd in soil is from 25 to 30 mg/kg dry soil, it will decrease rice productivity from 31.6 to 32% and if contaminated Cd in soil is from 40.1 to 53.8%. As a result of the analysing in the greenhouse, with 9 levels of Cd in soil (0–40 mg/kg) of the rice VND 95-20, shows that when Cd in soil is more than 20mg/kg dry soil, it can affect to characteristics of soil [13]. To complement these results in monitoring effects of Cd on rice and others, the thesis carried out an experiment by contaminated Cd in rice fields with 5 levels: 0; 15; 20; 25; 30 mg/kg dry soil and examined effects of Cd on the rice VND 95-20 (high-yield rice) and the rice VD 20 (aromatic rice).

Table 4: Effects of Cd in soil on productivity and rice productivity

Cd (mg/kg)	ears /pot	1.000 grains (g)	Flat-grained (%)	Grain productivity (g/pot)	% comparion
0	17,0	23,6	29,2	29,6	100
5	16,0	23,2	30,2	30,6	103,6
10	15,0	22,8	29,5	27,1	91,6
15	13,7	22,8	31,7	24,0	81,2
20	11,7	21,7	35,3	23,7	80,3
25	11,7	20,5	35,8	20,1	67,9
30	11,0	20,5	42,2	20,2	68,4
35	9,7	19,9	50,2	17,7	59,9
40	9,0	19,4	44,4	13,6	46,2
Cv(%)	12,26	8,56	8,01	5,49	-
LSD0,01	4,28	2,83	8,01	3,47	-

Table 5: Effects of Cd in soil on the aromatic rice VD20 and the rice high-yield rice VND 95-20

Cd (mg/kg)	ears /m2		Firm grain /ear		Productivity (tons/ha)	
	VND 95-20	*VD 20*	*VND 95-20*	*VD 20*	*VND 95-20*	*VD 20*
0	225	214	99	129	5,31	4,51
15	203	182	101	132	4,90	4,53
20	200	168	100	122	4,68	4,35
25	217	171	77	136	3,90	3,13
30	202	165	73	104	3,58	3,77
CV(%)	7,10		8,98		8,33	
$LSD_{0,05}$	22,13		15,40		5,82	

A result of Table III.5 shows that quantity of rice ears/VND 95-20 seed decrease from 15mg Cd/kg, affects not worth considering to the rice VND 95-20. If concentration of Cd in soil is more than 25mg/kg, it will decrease quantity of plumping grains/rice ears of the rice VND 95-20 seed and when concentration of Cd is more than 30mg/kg, decrease quantity of plumping grains/rice ears of the rice VN 20. To the grain productivity, when Cd in soil is more than 20mg/kg dry soil for the rice VND 95-20, will decrease from 630 to 1730 kg/ha, for the rice VND 20 will decrease productivity when Cd in soil is 30mg/kg dry soil.

Table III.6 shows that effects of Cd in soil on rice seed with different of concentration of protein and amylose in rice. When Cd in soil is from 15 to 30mg/kg, will increase protein with the rice VD 20 and decrease with the rice VND 95-20, but amylose alters unclearly.

Table III.7 shows that concentration of Cd accumulated in rice is directly proportional to Cd accumulated in land. Cd accumulated in roots, about 20–30 times in leaf and 100–200 times in grains [14,15]. We can arrange the rate of Cd in soil: Cd in leaf: Cd in husked rice is 10: 200: 10: 1. Cd accumulated in husked rice increase with increasing Cd in soil and reaches 30mg/kg in land. Table III.7 shows that with the same level Cd in soil, the accumulation Cd of husked rice in fields is lower than in pots (only 10-20%). The reason is that experiments carried out in fields and flooded with water, oxidation electric potential reduced, so lead Cd in soil in sulfate form moves in insoluble sunfite, it is difficult to rice absorb (Iimura, 1973; Ito and Iimura, 1975). This also explains satisfaction data in Table III.8, although Cd in soil in Binh Chanh is from 7.6 to 14.5 mg/kg of dry land, but Cd in husked rice is only from 0.38 to 0.56mg/kg of dry land. This confirmed: although rice in areas contaminated by wastewater in Ho Chi Minh, increase accumulated Cd, but it still is lower than permitted standard (Figure 1).

Table 6: Effects of Cd in soil on Protein and Amylose concentration in the white rice of two seeds VND95-20 and VD 20

Cd (mg/kg)	Protein (%)		Amylose (%)	
	VD20	VND95-20	VD20	VND95-20
0	6,95	8,58	12,92	17,90
15	6,56	8,43	11,80	15,70
20	6,94	8,28	11,63	17,77
25	7,13	8,08	12,75	14,66
30	7,37	7,94	12,92	16,82

Table 7: The comparison between Cd in soil and Cd accumulated in rice

Cd in soil (mg/kg)	Cd in rice (mg/kg vật chất khô)			
	Root	Leaf	Husked rice	
			The greenhouse	The fields
0	39	3.57	0.35	0.32
5	205	10.89	1.08	-
10	323	27.4	2.66	-
15	376	38.21	4.21	0.54
20	652	44.8	5.77	1.17
25	756	45.2	8.23	2.02
30	814	46.8	9.65	2.21
35	1275	57.22	9.56	-
40	1402	56.54	9.3	-

Table 8: The concentration of Cd in rice, husked rice in the fields in Binh Chanh, Ho Chi Minh city

Order	Soil samples	Cd in soil (mg/kg)	Trunk, leaf (mg/kg)	Husked rice (mg/kg)
1	BC3	7.6	1.26	0.38
2	BC5	9.8	2.03	0.52
3	BC9	14.5	2.37	0.55
4	BC12	10.3	2.09	0.56
5	BC13	9.6	1.96	0.55
6	BC14	9.9	1.28	0.41
7	BC32	10,3	2.33	0.48
8	Standard		-	≤ 1

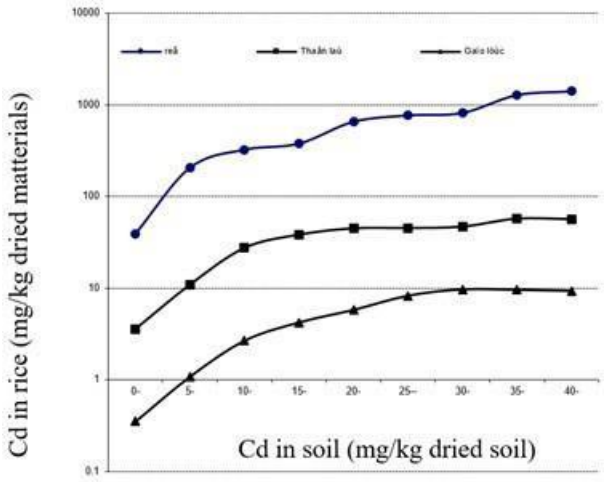

Figure 1: The interrelationship between Cd in soil and accumulation in rice

5. Conclusion and Comments

5.1. Conclusion:

The rice fields that affected by wastewater from the southern Ho Chi Minh city are at risk contaminated by Cd, Cd in soil is on the average from 4.7 – 10.3 mg/kg, some points reach over permitted standard from 2 to 3 times. Cd concentrates in 3 types of soil: the yellow – red allusion soil, the allusion – acid sulfate soil and the actual acid sulfate soil.

Cd in soil is from 25 mg/kg or more, affects to the agronomic characteristics, productivity factors and decrease rice productivity. However, effect levels of Cd on productivity and quality of rice are different with different rice seeds.

When concentration of Cd contaminated in soil increase, Cd in rice will increase, the distribution of Cd is: Cd in soil: Cd in leaf: Cd in husked soil is 10: 200: 10:1. Cd accumulated in husked rice in fields is very low (10–20%) compare with experiments in pots.

The rice producted in areas contaminated Cd in the southern Ho Chi Minh express increasing Cd accumulation but still remained below permitted limit.

5.2. Comments:

Continue to analysis Cd in rice with the numbers of samples are more than in high –yield rice, affected by industrial waste water and domestic waste water in Ho Chi Minh city.

References:

1. Le Huy Ba, Environmental Toxicology Base, 2000, Part 1, Ho Chi Minh city National University Publishing House, Reprinted in 2002, 2006,
2. Le Huy Ba, Environmental Toxicology Monograph, Part 2, Ho Chi Minh city National University Publishing House,
3. Ngo Quang Huy and colleagues, 1999, "Research contamination of toxic elements and heavy metals from industrial waste sludge

caused for Ho Chi Minh city", reported in 1998 – 1999, Page 12 – 18,

4. Ito H. and Limura K. 1976, Characteristics of Cadmium absorption by rice plant, Science of rice plant, Vol.2, 1033 – 1034 (1976),
5. Ito, H. and Limura K. The absorption and trans location of Cadmium in rice plants and its influence on their growth, in comparion with zinc studies on heavy metals pollution of soils (part 1), Bull. Hokuriku Nat. 1 Agric. Exp. Stn. 1976; 19: 71-139.
6. Kuo S, Heilman PE, Baker S. Distribution and forms of copper, zinc, cadmium, ion and manganese in soil near a copper smelter, Soil Science. 1983; 135: 101-9.
7. Martincie D, Kwookal Z, Stoppler M, Cranica M. "Distribution of Zinc, Lead". 1990.
8. Muramoto S. Heavy metals tolerance of rice plants (Oryza sativa L.) to some metal oxides at the critical levels, J Environ Sci Hlth, B. 1989; 24: 559-68.
9. Nguyen Ngoc Quynh, Nguyen Dang Nghia and colleagues, "Measures of treatment the paddy land polluted oil in the coastal Ho Chi Minh city".
10. Ho Chi Minh city Department of Science Technology and Environment, 2002, Environmental activity report in Ho Chi Minh, in December. 2000.
11. Researching soil and fertilizer center – Institute for Soil Science and Agricultural Viet Nam, Research effects of industrial wastee in Phuoc Long to soil environment and plants, Report, in June 1997, 12.Analysing experiment service center, 1986, Report on results of sediment quality assessment system of urban drainage canal in Ho Chi Minh city,
12. Lam Minh Triet and colleagues, Study of environmental protection measures in dredging operations, transports and flow canals in Ho Chi Minh city, Synthesis report Vo.1, in December 2000, Institute of Natural Resources and Environment–Ho Chi Minh city National University,
13. Bui Cach Tuyen and colleagues. Heavy metal content in agricultural products, soil, water in some local suburbs in Ho Chi Minh city, Agricultural Magazine and Rural Development. 1994; 30-2.
14. Le Van Tu, Le Van Thuong, Cong Doan Sat. Report about Edaphylogy map Ho Chi Minh city with the ratio 1/25.000 1986.
15. Williams DE, Vlamis J, Pukite AH, Lorey JE. Trace element accumulation, movement, and distribution in the soil profile from nassive applications of sewage sludge, Soil Sci.. 1980; 120: 119-32.