AVAILABILITY AND MOBILITY OF HEAVY METAL FROM SEDIMENTS IN TO LICH AND KIM NGUU RIVER SYSTEM

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Abstract: *The present study was to evaluate the availability and mobility of heavy metals in the sediments in the To Lich and Kim Nguu River system through metals concentration obtained and its percentage to total concentration. Total 12 sediment samples were collected at the To-Lich, Kim-Nguu Rivers. The results showed that the highest extracted concentration of sediment samples was in the order Zn > Cr > Cu > Pb > Ni > Cd by 0.5M HCl and Cr > Zn > Ni > Cu > Pb > Cd by 0.1M HNO_3. The extracted concentration by 0.5M HCl was higher than that of 0.1M HNO_3 for all heavy metals except for Cr.*

Keywords: Extracted heavy metals, Availability, Total, Sediments

1. INTRODUCTION

Over a long period, heavy metals along with other metals and minerals have been released from chemical compounds through industrial activities. The level of heavy metals in aquatic environment has been of much concern during the last decades due to the adverse effects of some metals on living organisms in food chains and human health.

The analysis of bottom sediments has been used to determine the extent and source of trace metal contamination in aquatic environment. Sediments have the capacity for accumulating trace metals and other contaminants over time and serve to time integrated assessment of contamination that has occurred in water body (Mark et al. 1982). Yousel et al._(1994) indicated that the transport of metals through sediments is a very slow process since the sediments possess high metal retaining capacity.

The behavior (e.g., bioavailability, mobility, toxicity and distribution) of heavy metals in sediment depends on not only on their total concentrations, but also on their mobility and reactivity with other of components of ecosystem. To predicting the availability of heavy metals to plants, the extractability of heavy metals from sediments by various chemical reagents is used. Many researchers such as Amacher (1996), Filipek and Pawlowski (1990) recommended HCl as one of the extractants used to estimate plant-available Ni, Cd, and Pb in sediment. Also, Yania et al. (1998) showed that tenth molar (0.1*M*) HCl has been widely used for the availability evaluation of heavy metals in sediments.

The physiochemical characteristics of sediment, and different acid used influenced on the amount of heavy metal extracted. In addition, the ratio of sediment to the extracting solution is one of the most importation conditions to the amount of heavy metal extracted. Many researchers used the ratio of 1/5 in the extraction of heavy metals from sediments using 0.1*M* HCl and other acids.

There are two rivers in Hanoi City, the To Lich and Kim Nguu River, which are the main source of irrigation water for suburban agricultural land and the source of fish farming pond. This area is most productive but is highly contaminated with heavy metals (Ho and Egashira, 1998), because highly polluted water from the two rivers is irrigated to the farmland (Nguyen et al. 2007).

Discharged industrial wastewater into the rivers has degraded the quality of sediments in

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the river system. This has affected not only farming and fish breeding, but also the health of general public in surrounding areas. Increasing industrialization and population growth have led to increasing fluxes of many heavy metals to soils and sediments of To Lich and Kim Nguu river system in Hanoi City, Vietnam (Ho and Egashira, 2000)

The present study was to evaluate the availability and mobility of heavy metals in the sediments in the To Lich and Kim Nguu River system through metals concentration obtained and its percentage to total concentration.

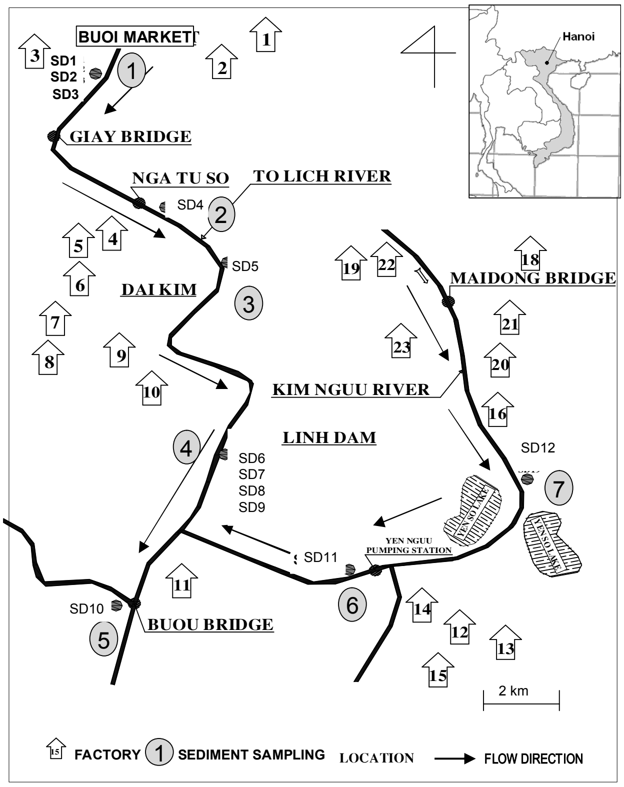

Figure 1 Sampling location

2. MATERIAL AND METHODS

Materials

Total 12 sediment samples were collected at 7 locations of To-Lich, Kim-Nguu Rivers on December 3 to 6 of 2018 (Table 1 and Fig. 1). Sediment samples (SD 4, SD5, SD6, SD 10, SD 11, SD 12) were collected from the surface zone (20 cm) of the sediment at the 6 sites submerged with water (Fig 1 and Table 1). The core samples (SD1, SD2, SD3, SD7, SD8, SD9 of 90 cm depth were also taken at 2 sites where sediment surface is exposed to the air (Fig 1 and Table 1).

Methods

Both 0.5*M* HCl and 0.1*M* HNO_3 were used to extract the heavy metals from sediments. The sediments were extracted using ratio sediment / solution of 1/5 (5g of air dry/sediments extracted with 25 ml 0.5*M* HCl or 0.1*M* HNO_3). The suspension was agitated continuously for 1h and then centrifuged at 2,500 rpm for 10 min. The supernatant was separated and analyzed for its concentration of Cd, Cr, Cu, Ni, Pb and Zn by atomic absorption spectrophotometer (AAS).

Total metal concentration, heavy metals in the sediment was digested with 1M HNO_3 at 96^0C for an hour and centrifuged, and the dissolved metals in the supernatant were analyzed by atomic absorption spectrophotometer (Committee of Soil standard methods for Analyses and Measurement, 1986).

Determinations were made in duplicated and the relative deviation of the duplicate values was usually less than 5 %.

Table 1. Sediment sample location and the type of industry

No	Depth (cm)	Location	Number in Fig.1	Type of main industry
SD 1	0-30	Buoi Market	1	
SD 2	30-60			
SD 3	60-90			
SD 4	0-20	Nga-Tu -So	2	Mechanical Construction Textile and shoes Foodstuff and tobacco
SD 5	0-20	Dai Kim	3	Mechanical

No	Depth (cm)	Location	Number in Fig.1	Type of main industry
SD 6	0-20	Linh Dam	4	
SD7	0-30			
SD8	30-60			
SD9	60-90			
SD10	0-20	Cau Buou	5	Chemistry
SD11	0-20	Yen Nguu Pumstation	6	Mechanical Construction
SD 12	0-20	Yen So Lake	7	Mechanical Construction Textile Garment

3. RESULT AND DISCUSSION

Concentration of heavy metal extracted by 0.5*M* HCl or 0.1*M* HNO_3 is shown in the table 2 and 3 along with the total heavy metal concentration give by Huong et al. (2008). In general, the highest extracted concentration was in the order Zn > Cr > Cu > Pb > Ni > Cd by 0.5*M* HCl and Cr > Zn > Ni > Cu > Pb > Cd by 0.1*M* HNO_3.

The concentration of Cd extracted by 0.5*M* HCl and 0.1*M* HNO_3 was in extremely wide range between 1.4 and 39.9 mg/kg; and 1.2 and 25.8 mg/kg. In general, the extracted of Cd for 0.5*M* HCl was slightly higher than that for 0.1*M* HNO_3. The extracted of Cd of samples SD 4, 5 and 11 were extremely higher comparing to other samples, over 50% of the total concentration, and a significant and positive correlation coefficient was obtained between extractable and total Cd for every samples for both acids. The higher extracted heavy metal concentration as SD 4, 5 and 11 was resulted in higher total heavy metal concentration due to related with type of industrial discharge (Table 1). In general, mobility and extractability of Cd in the sediment was very high.

The concentration of Cr extracted by 0.5*M* HCl and 0.1*M* HNO_3 was in range of 101 to 137 mg/kg and 132 to 181 mg/kg, around 15-20% of total heavy metal concentration. In general, the extracted of Cd for 0.5 *M* HCl was slightly smaller than that for 0.1*M* HNO_3. The concentration of available heavy metal was not much difference in sample to sample. The correlation between extractable and total concentration was not significant for both of extracted solution.

Extractable Cu concentration ranged from 37-105 mg/kg for 0.5*M* HCl (around 10-30% of total concentration) and 3-28 mg/kg (around 1-10% of total concentration) for 0.1*M* HNO_3. The extractable Cu concentration by 0.5*M* HCl was 5-10 times that of by 0.1*M* HNO_3. The concentration of available heavy metal was much difference in sample to sample due to the different in total heavy metal concentration. The correlation between extractable and total concentration was not significant for both of extracted solution.

As shown in table 3, the concentration and percentage of extractable Ni were similar between 0.1*M* HNO_3 and 0.5*M* HCl, ranged between 10-50 mg/kg (around 20-50% of total concentration). The correlation between extractable and total concentration was significant and positive for both of extracted solution. The sample contained higher total heavy metal concentrations was higher in extracted heavy metal concentration as SD 4, 5, 11, 12.

The Pb available concentration was big difference in sample to sample and also for extracted solutions. The extractable Pb concentration by 0.5*M* HCl was 10 times than that of 0.1*M* HNO_3. Extractable Pb concentration ranged from 28-212 mg/kg for 0.5*M* HCl (around 10-20% of total concentration) and 1-12 mg/kg (around 1-5% of total concentration) for 0.1N HNO_3. The correlation between extractable and total concentration was significant and positive for 0.5*M* HCl but not for 0.1*M* HNO_3.

The concentration of extractable Zn extracted by 0.5*M* HCl and 0.1*M* HNO_3, along with total Zn concentration, is given table 2, with relatively large amount of extracted Zn by 0.5*M* HCl (ranged from 83-262 mg/kg), and smaller amount of that by 0.1*M* HNO_3 (ranged from 17-207 mg/kg). Also, the extracted concentration was much difference between samples to sample.

Table 2. Total and extracted Cd, Cr and Cu concentrations of sediment samples (mg/kg)

No	Depth	Cd			Cr			Cu		
		Total	0.5*M* HCl	0.1*M* HNO_3	Total	0.5*M* HCl	0.1*M* HNO_3	Total	0.5*M* HCl	0.1*M* HNO_3
SD 1	0-30	4.4	1.4	1.2	260	115	160	250	77	5
SD 2	30-60	5.3	3.0	2.4	320	120	181	441	64	3
SD 3	60-90	5.2	2.5	2.1	345	111	146	345	37	9
SD 4	0-20	20	10.1	12.6	472	112	143	478	105	6
SD 5	0-20	40	29.9	25.8	445	101	132	490	96	5
SD 6	0-20	2.7	2.8	2.2	357	121	158	422	64	9
SD 7	0-30	2.5	1.5	1.2	340	137	155	395	37	4
SD 8	30-60	3.7	2.6	1.7	220	131	152	370	48	21
SD 9	60-90	2.7	1.8	1.6	240	112	147	325	50	27
SD 10	0-20	8.5	5.5	3.6	401	115	159	324	52	28
SD 11	0-20	17	11.4	11.1	415	103	135	535	101	5
SD 12	0-20	3.5	2.4	1.9	475	105	141	520	114	5

Table 3. Total and extracted Cd, Cr and Cu concentrations of sediment samples (mg/kg)

No	Depth	Ni			Pb			Zn		
		Total	0.5*M* HCl	0.1*M* HNO_3	Total	0.5*M* HCl	0.1*M* HNO_3	Total	0.5*M* HCl	0.1*M* HNO_3
SD 1	0-30	65	24	17	368	58	6	250	201	26
SD 2	30-60	63	22	15	395	46	1	441	187	21
SD 3	60-90	48	15	10	425	42	2	345	173	18
SD 4	0-20	165	58	31	490	101	3	478	262	17
SD 5	0-20	108	44	25	450	46	3	490	223	31
SD 6	0-20	57	31	19	348	42	3	422	203	171
SD 7	0-30	52	14	15	280	28	1	395	83	98
SD 8	30-60	58	18	10	260	45	12	370	117	64
SD 9	60-90	50	19	11	370	52	12	325	106	55
SD 10	0-20	64	30	19	435	45	6	324	149	131
SD 11	0-20	142	44	32	430	212	1	535	241	207
SD 12	0-20	151	45	32	665	37	1	520	225	197

4. CONCLUSION

The concentration of extracted heavy metals from river sediments was depended on the extracting solutions and different metal to metal.

The highest extracted concentration of sediment samples was in the order Zn > Cr > Cu > Pb > Ni > Cd by 0.5*M* HCl and Cr > Zn > Ni > Cu > Pb > Cd by 0.1*M* HNO_3.

The extracted concentration by 0.5*M* HCl was higher than that of 0.1*M* HNO_3 for all heavy metals except for Cr.

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Tóm tắt:

TÍNH LINH ĐỘNG VÀ DỄ TIÊU CỦA KIM LOẠI NẶNG TRONG TRẦM TÍCH TRÊN HỆ THỐNG SÔNG TÔ LỊCH VÀ KIM NGƯU

Nghiên cứu đánh giá tính linh động và dễ tiêu của các kim loại nặng trong trầm tích trên hệ thống sống Tô Lich và Kim Ngưu thông qua hàm lượng kim loại nặng dễ tiêu và phần trăm so với hàm lượng số. Tổng 12 mẫu trầm tích đã được lấy tại sông Tô Lịch và Kim Ngưu. Kết quả chỉ ra rằng nồng độ kim loại chiết xuất cao nhất từ các mẫu trầm tích theo thứ tự sau Zn > Cr > Cu > Pb > Ni > Cd khi tách triết bằng 0.5M HCl và theo thứ tự Cr > Zn > Ni > Cu > Pb > Cd khi tách triết bằng 0.1M HNO_3. Nồng độ các kim loại tách triết bằng 0.5M HCl cao hơn khi tách triết bằng 0.1M HNO_3 trừ Cr.

Từ khóa: Tách chiết kim loại, Dễ tiêu, Tổng số, Trầm tích

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