公益信託エスペック地球環境研究・技術基金
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＜研究の目的＞

ベトナムでは，経済活動の活発化にともなう産業廃棄物や都市からの一般廃棄物に関連した環境問題が年々深刻となっている．しかし，ベトナムでは，廃棄物は，一般廃棄物と産業廃棄物が分別されることなく処分場に運搬され，埋め立てられている．また，廃棄物処分場では，通常，Open Dump（廃棄物を単に地面に投棄処分する）または Control Dump（廃棄物を並べて固め，被覆する等の最低限の管理を行う）が行われ，浸出水の浸透防止や処理が不十分である場合が多い．さらに，廃棄物処分場の容量が明らかに不足していることに加え，雨期に定期的に発生する河川の氾濫・洪水によって，廃棄物処分場から汚染水が流出している可能性も高く，有害廃棄物に由来する周辺農耕地の汚染が懸念される．

そこで本研究では，ハノイにおける安全な食料生産環境の創出に寄与することを目的に，廃棄物処分場周辺の農耕地土壌および河川底質を対象に，有害元素含有量を明らかにし，廃棄物処分場を点源とする汚染分布を明らかにすることを目的とした．

＜方法＞

ハノイ近郊の Nam Son に位置する廃棄物処分場周辺の農耕地で，有害元素（As, Cd, Co, Cr, Cu, Hg, Ni, Zn）による汚染の面的広がりを把握することを目的に，廃棄物処分場から異なる距離にある水田および畑を約 500 m 間隔で選定し，聞き取りと現地調査を実施した．調査地点において，圃場の表層土壌（0-10 cm），下層土壌（20-30 cm）および灌漑に用いられている河川の底質を採取し，一般理化学性および有害元素含有量を常法に従って分析した．また，Hg については，移動性の高い画分として，2 % HCl を含む 10% エタノールで可溶化される含量を定量した．

＜成果＞

廃棄物処分場の近くを流れる Cau Lai 川の処分場よりも下流に位置する地点の表層土壌では，Cu; 98.2 mg kg^{-1}, Hg; 0.17 mg kg^{-1}, 河川底質では，Cu; 234 mg kg^{-1}, Hg; 1.21 mg kg^{-1} が検出された．これらの数値は，今回の調査地点の中で最も高い値であり，調査対象とした元素の中でも Cu と Hg の汚染程度が高いことが明らかとなった．これらの地点では，2 % HCl を含む 10% エタノールで可溶化された Hg 含量も高い傾向を示した．非汚染土壌中の水銀含量は，0.06 mg kg^{-1} と報告されていることから，これらの地域では，埋め立て処分された蛍光灯などの廃棄物に由来する Hg が，雨期の洪水等によって流出し，汚染につながっている可能性がある．Hg は，その化学形態によって毒性が異なり，特に，有機水銀（メチル水銀）は，微量であっても深刻な健康被害をもたらす可能性がある．したがって，今後，Cau Lai 川およびその川沿いの農耕地に焦点をあて，汚染分布の状況，環境中の水銀の形態別存在量等をさらに調査する必要がある．

＜成果発表＞

1) Trang BTQ, Iwasaki K, Kien CN, Noi NV: Metal contamination of agricultural soils near waste disposal facility in Hanoi, Vietnam. 日本土壌肥料学会関西支部会, 2010 年 12 月 10 日，神戸.

OUTLINE of STUDY（概要書）

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Summary
To investigate metal contaminations around Nam Son waste disposal facility, Hanoi, Vietnam, paddy soils and sediments were taken from adjacent area of the facility. Among the examined elements (As, Cd, Co, Cr, Cu, Hg, Ni, and Zn), contaminations with Cu and Hg were more marked than other elements. Total Cu and Hg in the surface soils and sediments taken along the downstream of the Cau Lai river which runs next to the disposal facility exceeded the uncontaminated levels reported by Bowen (1979). The highest values of total Cu and Hg were 234 and 1.21 mg kg^{-1} for the sediments, and 98.2 and 0.17 mg kg^{-1} for the surface soils, respectively. The total Cu exceeded the allowable limits for agricultural soils in Vietnam (TCVN 7209–2002). In addition, the amounts of "mobile and toxic" Hg were also higher for these samples than those taken from other sites around the disposal facility.

I. Introduction

Vietnam is projected to be one of the world's fastest growing countries, with expected growth rates around 7% over the next decade. However, the rapid economic development can cause unprecedented environmental problems, particularly for burgeoning urban and industrial areas. Among the environmental impacts, rapid increase of solid wastes from households, industries, commercial enterprises, and hospitals appears as a growing problem. Appropriate management of these wastes benefits to public health and the quality of life, although it is a monumental challenge because of its substantial cost. Therefore, it is important to recognize the environmental impacts and health hazards caused by waste disposal activities in order to find effective ways to solve the problem.

Among many methods of solid waste management, Vietnamese government has paid specific attention to landfill. This method is considered as the cheapest and most prevalent solution in Asia and developing countries. In Vietnam, there are 91 landfills in operation. Open and controlled dumps are the predominant form and only 17 of them are sanitary landfills (World Bank, 2004). Generally, the poor operation and the release of unqualified out-put water of the landfills have been posing health threats to the local populations.

Nam Son waste disposal facility, located in Soc Son district of Hanoi, covers an area of 83.5 ha and is the largest sanitary landfill in operation in Vietnam. The landfill receives 3,000 tons of domestic wastes per day and is planned to close in 2020 when the total volume of wastes reaches 12 million tons. According to our preliminary observation, there is a possibility that waste water from the facility affects the adjacent areas due to leaking from dumping-holes, direct release to a nearby river, and overflow during rainy time, which may pose potential risks to human and animals through water and soil contaminations. However, except for internal reports, profound researches on leachate quality of Nam Son waste disposal facility are very limited. Therefore, in this study, field survey was conducted to examine the contamination levels in the agricultural soils around Nam Son waste disposal facility.

II. Materials and Methods

1. Sample collection

Twenty paddy fields were selected in the adjacent area of Nam Son waste disposal facility, basically on a grid with approximately 0.5 km spacing (Fig. 1). The surface (0-10 cm) and sub-surface (20-30 cm) soils were taken at the center of the fields. At 9 sites among the soil sampling sites, water and sediment samples were also collected from the rivers/ponds nearby the fields. The sites 01, 02, and 03 were supposed to be more severely polluted because leachate water from the facility has been often discharged at the position between site 01 and 02 through a culvert gate.

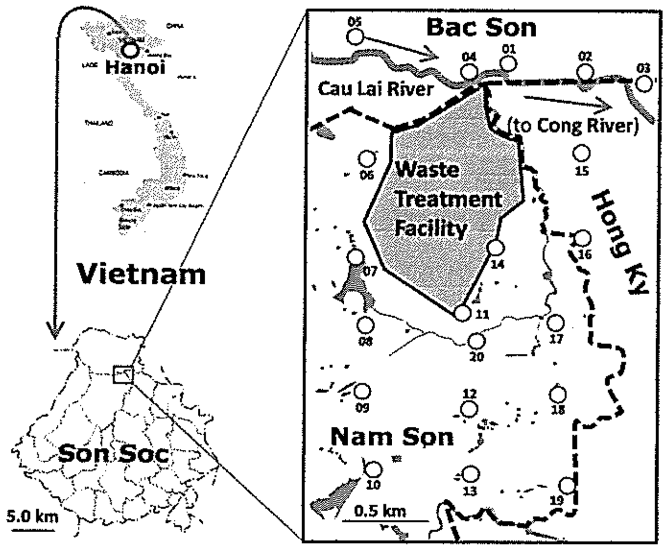

Fig 1. Map of sampling sites

2. Analytical methods

To determine total contents of As, Cd, Co, Cr, Ni, Pb and Zn in the soils and sediments, samples were digested in a mixture of HNO_3 and HF (9:1) by using a microwave digestion system (Multiwave, Perkin-Elmer, Japan). Total As was measured by using an induced coupled plasma atomic emission spectrometer equipped with hydride generation system (ICPS 1000IV and HVG-1, Shimadzu, Japan), and other elements were analyzed by flame or furnace atomic absorption spectrometry (Shimadzu, AA-6800, Japan). Total content of Hg was determined by cold vapor atomic absorption spectrometry, using 100 g L^{-1} $SnCl_2$ as a reducing regent after microwave digestion (Speed wave, Berghof, Germany) with a mixture of HNO_3 and HCl (1:3). The "mobile and toxic" Hg was extracted by 2% HCl + 10% ethanol, according to the method reported by Han *et al.* (2003), and measured by the same method as mentioned above.

III. Results and Discussion

Among the examined elements, contaminations with Cu and Hg were more marked than other elements (Fig. 2). Total contents of Cu in the surface soils at sites 01, 02, and 03 exceeded the levels for uncontaminated soil (30 mg kg^{-1}) reported by Bowen (1979) and the allowable limits for agricultural soils in Vietnam (50 mg kg^{-1}; TCVN 7209–2002). At the sites nearby the facility, Cu concentrations in the river water were higher than at farther sites. Since the farmers have been using the river water for irrigation of these fields, there is a possibility that the elevated levels of soluble Cu in the water were introduced into the surface soils. In addition to the irrigation water, the leachate water from the landfill has been often flooded into the fields under heavy rainfalls. It was supposed that the soils of fields near the facility received more Cu than that of farther ones. The highest value of total content of Cu was detected at site 01 and decreased with the distance from the facility. Different from this tendency, total contents of Cu in the sediments taken along the downstream of the river increased with the distance from the facility, and the highest value was observed at site 03.

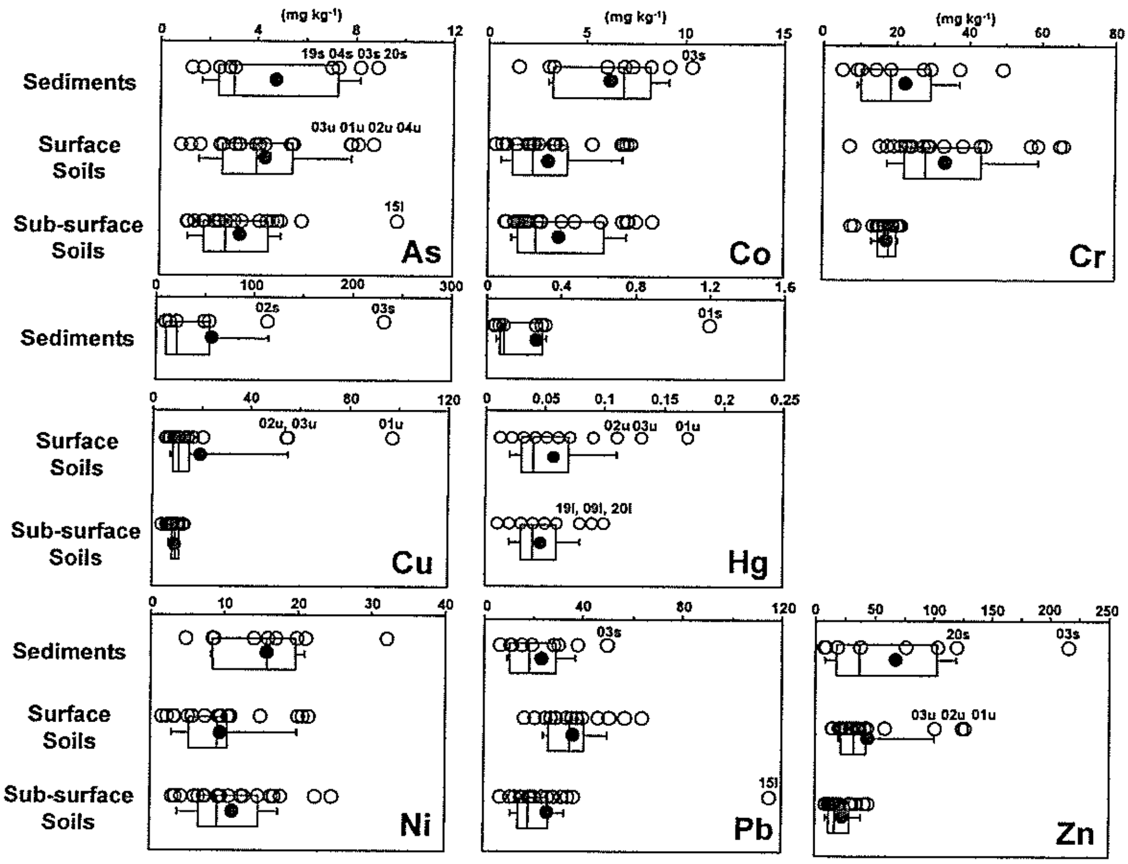

Fig. 2 Box plots of total contents of metals.
Left and right edges of a box indicate the lower and upper quartiles, respectively; the line inside the box shows the median. Horizontal lines protruding from the box (whiskers) present the 10th and 90th percentiles. Cd contents were below detection limit for all of the samples.

Total contents of Hg in some surface soils and sediments exceeded the levels for uncontaminated soil (0.06 mg kg^{-1}). Both for the surface soils and sediments, the highest value was detected at the nearest site to the facility (site 01) and tended to decrease with the increasing distance. In sub-surface soils, relatively high content of Hg was only detected at sites 09, 19 and 20. The measurement of "mobile and toxic" Hg was conducted for the samples with relatively high Hg contents (01, 02, 03, 04, and 20), aiming at estimation of the amounts of alkyl Hg species (most toxic) and soluble inorganic Hg species (most mobile). The results indicated that "mobile and toxic" Hg ranged 3.53-19.3 μg kg^{-1} in the sediments and 0.31-8.23 μg kg^{-1} in the surface soils (Table 1). Consistent with the results of total Hg, the highest amount was observed for the site 01. The percentage distribution of "mobile and toxic" Hg to the total Hg varied from 0.4 to 6.4%. Except for site 01, the sediment samples contained remarkably higher proportions of "mobile and toxic" Hg than in the case of the surface soils, despite their higher total Hg contents.

No serious contaminations of other metals (As, Cd, Co, Cr, Ni and Pb) were observed for the sediments, surface and sub-surface soils, although there was a tendency that the total contents in the surface soils were high in the samples taken along the river and the values of some samples exceeded the levels for uncontaminated soils.

Table 1 The amounts of "mobile and toxic" Hg in the selected sediments and soils.

Sample	"Mobile and toxic" Hg (μg kg^{-1})	Total Hg (mg kg^{-1})	Percentage in total Hg (%)
Sediments			
01s	19.3	1.21	1.6
02s	13.3	0.30	4.5
03s	20.1	0.32	6.4
04s	3.53	0.07	5.0
20s	10.4	0.27	3.8
Surface soils			
01u	8.23	0.17	4.8
02u	2.21	0.11	0.7
03u	2.94	0.13	0.9
04u	1.64	0.07	2.3
20u	0.31	0.05	0.4

IV. Conclusion

The overall objective of this study was to investigate the levels of toxic elements in adjacent area of Nam Son waste disposal facility, focusing on agricultural soils and river sediments. The results evidently showed the contamination with Cu and Hg, probably due to the wastewater discharged to the river, leachate leaked from the facility, and solid particles originating from the landfill. Especially, the presence of Hg contamination warns about potential influences on the ecosystem and human health, because Hg has strong toxicity, depending on the chemical species, even if it is small amounts. Therefore, further study on chemical speciation of contaminants should be carried out. It is also necessary to develop environment-friendly methods such as phytoremediation for the remediation of the contaminated soils, sediments and river water.

References

Bowen HJM: Environmental Chemistry of the Elements, pp. 237–273, Academic Press, London (1979)

Han Y, Kingston HM, Boyland HM, Rahman GMM, Shah S., Richter RC, Link DD, Bhandari S: Anal Bioanal Chem, 375, 428-436, (2003)

World Bank: Vietnam Environment Monitor (2004).