DIOXIN CONTAMINATION IN BIEN HOA AIRBASE AND ITS VICINITIES: ENVIRTONMENTAL LEVELS AND IMPLICATION OF SOURCES

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Introduction

Bien Hoa city is located in the west of Dong Nai province and about 35 km north of the centre of Ho Chi Minh City (HCMC). Bien Hoa city covers an area of 155 km^2 with population of 550,000 people. In 2006, GDP of Bien Hoa consisted of 70.1% contribution from industry and construction; 28.7% from agriculture, forestry and aquatic culture; and 1.2% from other services.

Located within the city, Bien Hoa airbase has received attention from national and international environmentalist for quite long time due to high contamination of dioxin caused by Agent Orange spraying in the Ranch Hand mission of US army and suspected off-site migration of dioxin from inside of the airbase. During the wartime, approximately 159,000 barrels of herbicides, including 98,000 barrels of Agent Orange, 45,000 barrels of Agent White and 16,000 barrels of Agent Blue were transported by US army to Bien Hoa airbase for the Ranch Hand mission[1]. In order to load herbicides conveniently, onto aircraft for air spraying, they were firstly pumped into large 28,000 litter tanks. It was documented that four spills of Agent Orange and Agent White from 28,000 liter tanks occurred between December 1969 and March 1970. As a consequence, large amount of herbicides containing dioxin was spilled on the land, causing considerable contamination of dioxin in the airbase and vicinities. Schecter et al.[2] found elevated dioxins levels in blood samples (8.59 – 294 ppt TEQ) of residents living near the airbase and Bien Hung Lake. Importantly, most of sample showed high contribution of 2,3,7,8-TCDD, suggesting Agent Orange as a notable source. Besides, limited soil samples from the airbase and sediment samples from Bien Hung Lake also had elevated dioxins concentration with high contribution of 2,3,7,8-TCDD to TEQ. In a later publication, Schecter et al.[3] pointed out that the major exposure pathway to dioxin in Bien Hoa was consumption of contaminated foods, especially aquatic products harvested in Bien Hung Lake.

Concerning adverse impacts of dioxin to local environment, human health and social condition, in 2006 the government of Vietnam allocated a limited budget of about US$ 5 millions for three years to implement facilities for containment of dioxin-contaminated soil in the former storage and loading area for Agent Orange by reinforced landfill technique. This budget only allows soil excavated from four hectares of the most contaminated area being isolated in continuous concrete basins. Four other contaminated sites including two ponds which have slightly lower contamination levels are under assessment for next remediation/containment.

In this study, we only present the most recent data to give a picture on dioxin contamination in this area with regards to magnification, extent and vertical movement of the contamination. Moreover, samples from industrial areas and industrial potential sources of dioxins and furans (PCDD/Fs) were also collected for determining their concentration. These results are expected to provide understanding on magnification of dioxin contamination from relevant industrial activities and on characteristic of various potential sources of PCDD/Fs in Bien Hoa area.

Materials and methods

Surface soil samples (Table 1) were collected from 0-20 cm within the contaminated area. Excavated soil was homogenized and a fraction about 100g was placed in clean glass jar. The sediment samples (0-5cm) were collected by Erkman dredge in drainage ditch running from paper factory, chemical factory, metal smelting factory and a

general drainage ditch which collect sewage from several other factories in Bien Hoa industry zone I. After taken from the dredge, sediment was well mixed in an aluminum tray and a portion about 200-300 g was put in a glass jar. Besides, soot samples in scrubber and bottom ash were also collected in stack and stove of municipal waste incinerators and wood processing factory. All samples were preserved in ice for transport and kept at -20^{0}C once arrived at laboratory. All soil and sediment samples were air-dried, ground, sieved for particulates with diameter below 2 mm which will be used for chemical analysis.

Soil and sediment samples were analyzed following EPA method 8280A with slight modifications. Briefly, 80g of each sample is extracted by Soxhlet apparatus using toluene solvent for 24 hours. The sample extract is concentrated, re-dissolved in hexane and cleaned up by concentrated H_2SO_4 acid and solutions of NaCl 5%, KOH 20%, dried by Na_2SO_4. The liquor is then further cleaned up by multilayer column which contains silica, silica impregnated in 40% of concentrated H_2SO_4, silica impregnated in 20% of KOH and Na_2SO_4. PCDDs/PCDFs fraction is separated from the AX21 activated carbon and the neutral Al_2O_3 columns. Verification of this analytical procedure was done by UNEF inter-laboratory program[4]. Concentration of dioxins is the total concentrations of seventeen congeners using WHO-TEF.

Results and discussion

Congener concentration and TEQ of dioxins and furans

Seventeen samples including soil from contaminated sites within Bien Hoa airbase, bottom ash of municipal waste incinerator, bottom ash of wood processing factory, samples in sewage systems in Bien Hoa industrial zone I (Table 1) were collected in January – February 2008. Individual concentration and TEQ of seventeen dioxins and furans with TEF listed in WHO report were given in Table 1. TEQ concentration of dioxins in soil within the airbase were recorded in a wide range (39 – 5x10^6 ppt TEQ). Sample BH-S5 showed the highest concentration ever found in Bien Hoa. In fact, this sample was excavated from an underground concrete basin, probably used for collection run-off water from the Ranch Hand operation sites. During the Ranch Hand operation, some residues of Agent Orange was washed away form the sites and accumulated in the basin. However, it is still not sure if this is the only basin within the airport. This fact again highlights complexity of dioxin contamination status in Bien Hoa airbase. Soil samples collected from south to north along boundary of a concrete path nearby the former loading area (BH-S1, -S2, -S3) showed relatively lower dioxin levels (39-190 ppt TEQ). On the other hand samples collected in the middle area showed high dioxin levels (1,600 – 77,000 ppt TEQ). It is noteworthy that soil samples collected at different layers of a soil column in the area where Agent Orange spill occurred previously, showed high level of dioxin (920 ppt TEQ) at 3.0m of depth.

In general, the result suggested elevated and complex contamination of dioxin within Bien Hoa airbase. With regard to this issue, a project has been recently funded by UNDP-Vietnam to carry out supplemental assessment for dioxin contamination in Bien Hoa and Phu Cat airbase and propose an overall plan for remediation of dioxin-contaminated soil. Under this project, 200 samples were collected from the two airbases and it is expected that comprehensive data from this project will sufficiently clarify the contamination picture and propose adequate methodology for environmental remediation at somewhat scale.

Municipal solid waste incinerator (SWI) is considered as a source of dioxin in the world. However, in Vietnam, such solid waste is commonly dumped in open dumping sites without prior incineration (Minh et al., 2003). Only recently, few facilities at small scale were established in Bien Hoa City for incineration of certain solid wastes. Such incinerators must pass strict environmental standards of Vietnam to minimize emission of dioxin to the environment. All the investigated incinerators in this study have scrubber which condense and remove most of dioxin in emission. Samples of ash/soot trapped in scrubber and bottom ash of incinerators (BH-CN3, -CN4, -CN5) had TEQ of 878, 438 and 173 ppt TEQ, respectively, which are comparable to incinerators in other contries[5]. Besides, sample of ash from oven of a wood processing factory had concentration of 4.6 ppt TEQ. Samples of sewage from other industrial

activities of concern such as paper mill and chemical factory (BH-CN1 and BH-CN6) were also analyzed and the results showed that sewage sample from paper mill had 2.0 ppt TEQ while those from chemical factory has 3.1 ppt TEQ. In order to have an overall evaluation, a sample of sewage from general drainage ditch within the industrial zone was also analyzed and showed concentration of 13 ppt TEQ. In general, samples in potential industrial sources showed much lower dioxin levels compared to those in Bien Hoa airbase which was contaminated by dioxin from herbicides such as Agent Orange, White Agent and Blue Agent.

Congener profile of dioxins and furans

In order to understand characteristic of dioxins and furans from all collected samples, congener profiles are plotted basing on percentage contribution of seventeen congeners. Comparisons were also made accordingly among those profiles. Figure 1 showed congener profile of soil samples from Bien Hoa airbase (A); bottom ash from incinerator in Bien Hoa city (B); soot in scrubber of MSWI in Bien Hoa (C), sewage from drainage ditch of Bien Hoa industry zone I (D); average emission from incinerators in The United States[6] (E) and bottom ash from wood processing factory (F)

It is recognized that even with calculation basing on absolute concentration (i.e. without conversion to TEQ), the congener profile of seven soil samples in Bien Hoa airbase is characterized by dominant contribution of 2378-TCDD. On the other hand, profile of sewage has dominant contribution of OCDD and 1234678-HpCDD; those of bottom ash in incinerator in Bien Hoa is contributed relatively equally by furans and high chlorination dioxins. While congener profile of incinerator in Bien Hoa reflects pattern of those in US, it is quite different with soil from Bien Hoa airbase. Congener profiles from other industrial activities also demonstrate different pattern with soil samples in Bien Hoa airbase (data not showed). The results again support the conclusion that Agent Orange has remained as primary source of dioxin in Bien Hoa and provide an useful tool to classify sources of dioxins and furans in Bien Hoa.

References

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Table 1: Concentration (ng/kg dry wt.) and WHO-TEQ (ppt) of dioxins and furans in samples from Bien Hoa

Sample name	Source of sample	TCDD	ΣPeCDD	ΣHxCDD	ΣHpCDD	OCDD	TCDF	ΣPeCDF	ΣHxCDF	ΣHpCDF	OCDF	WHO-TEQ[(b)]
Soil in Bien Hoa airbase												
BH-S1	surface soil	39.00	n.d	n.d	12.93	168.31	n.d	n.d	n.d	1.95	2.26	39
BH-S2	surface soil	159.00	n.d	n.d	44.56	500.76	n.d	n.d	n.d	8.39	10.33	159
BH-S3	surface soil	181.00	9.12	n.d	6.32	33.70	5.30	n.d	n.d	n.d	n.d	190
BH-S4	at 3.3m depth	281.00	n.d	n.d	7.10	46.43	n.d	n.d	n.d	n.d	n.d	281
BH-S5	in a broken basin	5072992	32529	64179	187335	302225	127713	4375	4836	13256	17509	5129000
BH-S6	surface soil [(a)]	75767.55	1210.99	476.56	1181.08	2996.31	1376.73	70.02	70.51	152.58	134.71	77200
BH-S7	at 2.5m [(a)]	2252.12	24.94	23.30	68.14	154.30	42.24	1.75	0.00	4.92	2.83	2290
BH-S8	at 3.0m [(a)]	872.84	46.27	13.13	32.30	93.97	19.71	n.d	n.d	n.d	n.d	922
BH-S9	surface soil	1851.69	7.76	n.d	6.57	26.77	31.01	11.53	2.53	n.d	n.d	1860
BH-S10	surface soil	24074.08	93.65	74.82	33.73	181.79	423.38	49.73	26.87	46.42	43.79	24230
BH-S11	surface soil	1513.38	99.82	12.21	99.56	945.12	23.10	2.40	4.72	10.60	11.60	1620
Samples from other sources												
BH-CN1	sewage paper mill	n.d	n.d	12.60	26.80	271.60	n.d	n.d	2.70	13.30	15.60	1.95
BH-CN2	drainage ditch	n.d	n.d	52.20	563.00	14909.00	n.d	n.d	n.d	78.80	301.60	13
BH-CN3	soot of incinerator	127.40	252.30	366.20	267.80	121.60	510.90	1144.90	1002.60	525.70	40.90	878
BH-CN4	soot of incinerator	171.50	202.67	232.00	139.60	211.80	695.20	734.30	742.50	283.70	22.50	438
BH-CN5	bottom ash	6.80	17.00	35.50	51.90	49.20	82.40	254.00	413.00	396.50	72.80	173
BH-CN6	sewage chemical fact.	n.d	n.d	5.40	19.40	167.50	n.d	2.60	8.60	13.30	8.30	3.04
BH-CN7	bottom ash/wood proces	2.10	n.d	4.80	115.50	3690.00	n.d	n.d	2.70	25.90	97.00	4.64

n.d: not detected (lower than detection limit); zero is used for calculated TEQ

(a): samples from same soil column; (b): WHO-TEQ is canculated by sum-up of all individual concen. multiplied with an appropriate TEF

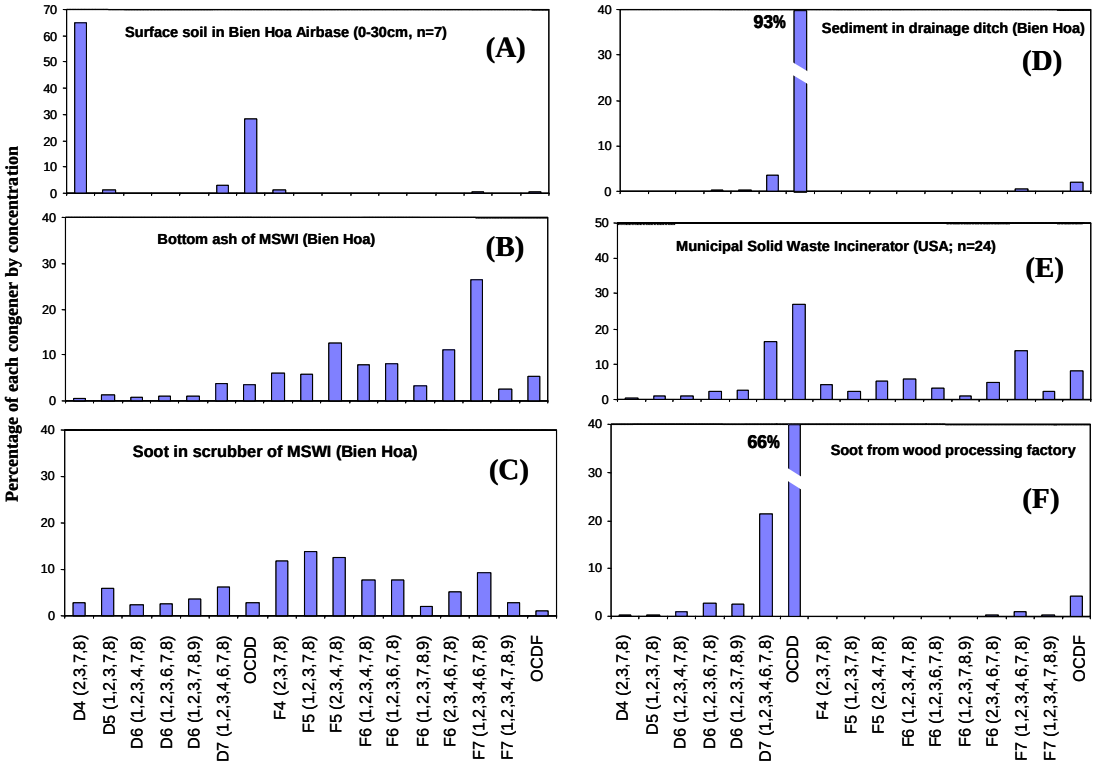

Fig. 1: Congener profiles of samples collected in Bien Hoa & comparison with references