

## ENVIRONMENTAL ASSESSMENT OF DIOXIN CONTAMINATION IN NEWLY SUSPECTED AGENT ORANGE SITE IN BIEN HOA AIRBASE

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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<sup>2</sup>. 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<sup>1</sup>. 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.<sup>2</sup> 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.

Concerning adverse impacts of dioxin to local environment, human health and social condition, in 2006 the government of Vietnam implemented facilities for containment of dioxin-contaminated soil in the former storage and loading area for Agent Orange by secured landfill. The remediation budget only allows soil excavated from four hectares of the most contaminated area (commonly known as Z1 site) being isolated in ten continuous secured landfill cells. Along with the cooperation between Vietnam and The United States on overcoming consequences of AO/Dioxin, more information regarding historical usage of AO/Dioxin during the wartime was recently released by US Department of Defense (US DOD). The information pointed out that few potential AO/Dioxin contaminated areas could exist in the west and the southwest of the airbase (Fig. 1; Commonly known as Pacer Ivy site). The dioxin contamination in such new sites was due to activities to revoke and destroy unused AO/Dioxin barrels after recognition of its high toxicity (the operation was carried out in 1971 and known with nickname Pacer Ivy). Because these potential AO/Dioxin sites are located in military area of Bien Hoa airbase with several difficulties for site assess, the contamination status in such sites have not been comprehensively studied. In 2011-2012, a new study was launched in order to make a comprehensive assessment of AO/Dioxin contamination in the Pacer Ivy site. The study was focused on current contamination status in the Pacer Ivy site and to investigate vertical migration of dioxin to deep soil as well as transport of dioxin to surrounding areas.

### Materials and methods

The Pacer Ivy area was divided into many sampling lots (50 x 50m); Total 55 surface and 62 coring soil and sediment samples were collected in Pacer Ivy and surrounding areas in May 2011. Surface soil sample was collected from 0-20cm of depth. In each sampling lot, a composite soil sample was made by combination of ten component samples. Excavated soil was homogenized in an aluminum tray and a representative fraction about 100g was placed in clean amber glass jar. The sediment samples (0-5cm) were collected in several ponds nearby the Pacer Ivy site using Erkman dredge; sediment samples were kept in 240ml glass jars for transportation to the laboratory. Core soil samples were collected using soil corer which is able to sample soil at 300cm of depth. Each deep soil samples were representative of segment with 30cm increments in the soil columns. All samples were preserved in ice for transport and kept at -20°C once arrived at laboratory. All soil and sediment samples were air-dried, ground, sieved for particulates below 2mm before being used for chemical analysis. Water

moisture in soil samples was determined by heating 2 grams of air-dried samples at 106<sup>0</sup>C for 6 hours. The water moisture was used for correction of concentration on dried mass basis.

Soil and sediment samples were analyzed basically following USEPA method 8290 using HRGC/HRMS (Waters, Autospec). Briefly, soil sample is extracted by speed extraction apparatus using toluene solvent for 24 hours. The sample extract is concentrated, re-dissolved in hexane and cleaned up by multi-layer columns which contain silica, silica impregnated in 40% of concentrated H<sub>2</sub>SO<sub>4</sub>, silica impregnated in 20% of KOH and Na<sub>2</sub>SO<sub>4</sub>. PCDDs/PCDFs fraction is separated in dual activated carbon columns. Verification of this analytical procedure was done by UNEF inter-laboratory program<sup>4</sup>. Concentration of dioxins is the total concentrations of seventeen congeners using WHO-TEF (2005).



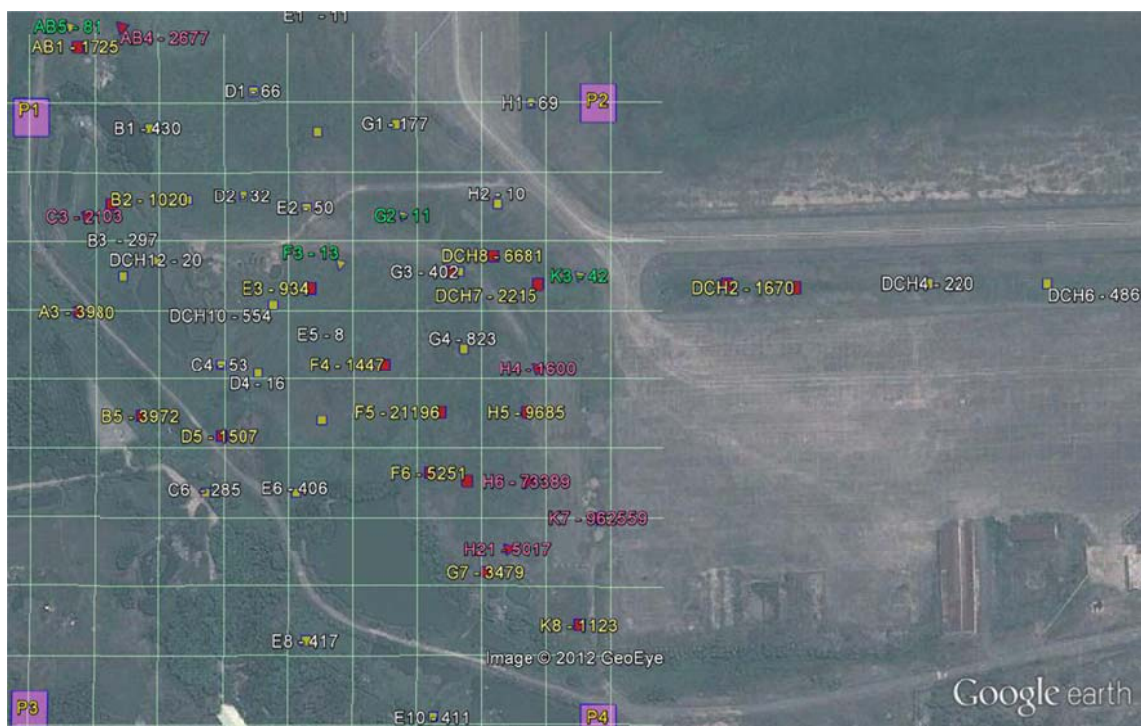
**Figure 1.** Position of contaminated sites in AO/Dioxin Hotspots of BHA (AO West site is another name of Pacer Ivy site)

## Results and discussion

### *Dioxin contamination in surface soil and sediment*

It is observed that 34 samples (accounting for 35 percentages of the total samples) exhibited concentration higher than 1,000 pg/g TEQ (detailed data not showed). It should be noted that this level is the national guideline for soil remediation activities in AO Hotspots. The highest concentration is about 962,560 ppt TEQ, found in the top layer of core 11BH-K7, followed by 11BH-H6. Most of high concentrations were at the East and South-east corner of the Pacer Ivy site. However, high concentration in soil was observed at few points in North-west corner of the Pacer Ivy site. In the Pacer Ivy site, there is a higher ground lane separating this site into two parts. Thus the left part (P1-P3-P4) may be thought less to be contaminated than the right part (P1-P2-P4). However, it is important to note that sample 11BH-A3 and 11BH-B5 collected in this part also exhibited high concentration (3980 and 3972 ppt TEQ). The results suggest that current contamination is quite complicated and AO/Dioxin contaminated spots may be resulted from both runoff of storm water and individual activities in the past.

In this study, we collected several sediment samples along the ditch running from taxiway to ponds near the P1-P4 connecting lane. It is also interesting to see that sediment samples from this ditch contain high level of dioxin. Several samples (11BH-DCH1, DCH2, DCH7, DCH8 and DCH9) have dioxin level above 1,000 ppt TEQ. In general, this ditch should be considered for treatment of contaminated sediment.



**Figure 2:** Distribution of TEQ concentration in the Pacer Ivy site (yellow & red: higher 1,000 ppt; figures behind dash for pg/g TEQ concentration)

### *Dioxin contamination in deep soils and sediments*

In the present study, ten cores of soil and sediment were analyzed for determination of dioxin. Depth profiles versus TEQ concentrations in three representative cores (1 sediment core and two soil cores) were presented in Tab1. In the 11BH-H6, soil at the depth of 1,800 cm was collected and the results showed that concentration increasing from the top layer, obtaining the highest concentration at 60-90 cm and slowly decreasing to lower layers. However, very high concentration of dioxin (8,129 ppt TEQ) remained at the depth of 1,800 cm. At this depth, dioxin concentration is still 8-folds higher than the guideline for soil remediation. Sample below 1,800 cm could not be collected due to high water content making it become liquid form.

Core sample 11BH-K7 was collected at highest position near concrete taxiways, extremely high concentration of dioxin (about 962,000 ppt or 0.96 ppm TEQ) was found at the top layer of this core. This is the highest surface concentration we ever found in AO hotspot. The concentration decreased to about 392,000 ppt TEQ at 30-60 cm and rapidly down to 210 ppt TEQ below depth of 60 cm. The depth profile of dioxin concentration in this core is very much different compared to core H6 (showing high dioxin level at 180 cm). Given that K7 was collected at much higher position compared to H6, perhaps altitude of the coring point is one of important factor influencing vertical movement of dioxin. Dioxin concentrations in core 11BH-H21 were also higher than the guideline. In this core, soil was only collected down to 60 cm because below that point, sampling device could not move further due to presence of rocks and stones.

It should be noted that the sampling survey was carried out in the dry season and thus it was able to collect one sediment core (11BH-C3) in a dry pond down to 210 cm. As can be seen in Figure 2, dioxin concentration decreased from 2100 ppt at the top layer to 302 ppt at the depth of 90 cm. Rapid decrease of the concentration was observed after 90 cm and being remained below 10 ppt TEQ for the rest of the core. This is the first time a complete sediment core in a pond can be collected and segmented in optimum conditions. The result indicates high contamination of dioxin at very deep sediment in the pond. However, it is still unclear if

this phenomenon is caused by vertical movement of dioxin to lower sediment or due to continuous accumulation of the contaminated erosion soil from upstream sites.

**Table 1:** Concentration of Dioxin (pg/g TEQ dry wt.) in core samples in Pacer Ivy site

Site name	Depth	Lat (Decimal)	Long (Decimal)	2378-TCDD	TEQ (ppt)	TCDD (%)
11BH-C3-1	C3 (0-30cm)	10.972417	106.802000	2050	2103	97.5
11BH-C3-2	C3 (30-60cm)			2132	2180	97.8
11BH-C3-3	C3 (60-90cm)			299	302	99.0
11BH-C3-4	C3 (90-120cm)			4.93	5.44	90.6
11BH-C3-5	C3 (120-150cm)			4.19	5.21	80.4
11BH-C3-6	C3 (150-180cm)			7.00	8.13	86.1
11BH-C3-7	C3 (180-210cm)			<1.33	1.22	-
11BH-H6-1	H6 (0-30cm)	10.970583	106.805278	72856	73389	99.3
11BH-H6-2	H6 (30-60cm)			108900	109791	99.2
11BH-H6-3	H6 (60-90cm)			317087	318816	99.5
11BH-H6-4	H6 (90-120cm)			183940	185142	99.4
11BH-H6-5-1	H6 (120-150cm)			19560	19692	99.3
11BH-H6-6	H6 (150-180cm)			8087	8129	99.5
11BH-K7-1	K7 (0-30cm)	10.970333	106.805806	949368	962559	98.6
11BH-K7-2	K7 (30-60cm)			388807	392669	99.0
11BH-K7-3	K7 (60-90cm)			209	210	99.5
11BH-K7-4	K7 (90-120cm)			465	466	99.8
11BH-K7-5	K7 (120-150cm)			243	243	100
11BH-K7-6	K7 (150-180cm)			6.68	6.68	100
11BH-K7-7	K7 (180-210cm)			139	145	95.9

### Conclusions

Elevated dioxin concentrations were found in Pacer Ivy site of Bien Hoa airbase, implying this area was contaminated by AO during the wartime. Compared to the Vietnamese guideline for remediation (1,000 ppt TEQ), high contamination was distributed more around the sound boundary and south-east corner of the Pacer Ivy site. However, high concentrations above 1,000 ppt TEQ were also found in the north-west corner and in all of ponds, suggesting wider transport of the contamination to the surrounding areas. For average estimation, if we presume depth of the high contamination is about 1.2 m, there would be about 90,000 m<sup>3</sup> of contaminated soil and sediment for necessary remediation.

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