

## CONTAMINATION STATUS AND DISTRIBUTION OF DIOXIN RESIDUE IN THREE AIRBASES IN SOUTH VIETNAM

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### Summary

Dioxin residual levels in several sites of Bien Hoa, Da Nang and Phu Cat airports where herbicides were stored and loaded onto aircrafts during the Ranch Hand operation, were determined by GC/MS method. In heavily herbicide contaminated sites, dioxin levels are much higher than acceptable levels for non-agricultural soil of the US (1000 ppt). Moreover, dioxin was found in soil from deep layers (1.5 m) at a highly contaminated site, suggesting vertical migration of dioxin. On average, 2,3,7,8-TCDD is accounted for 93% of total TEQ, revealing herbicides as original source of dioxin. Basing on the obtained data, total contaminated areas which need to be cleaned up is also estimated.

### Introduction

During the Ranch Hand operation from 1962-1971, approximately 72 millions little of herbicides was sprayed over the South of Vietnam by American army for destroying trees and agricultural products<sup>1-3</sup>. Most of the herbicides were stored in Bien Hoa, Da Nang and Phu Cat airbases<sup>4-6</sup>. Due to the operation and poor handling, a number spilling had occurred in these airbases. More than 7500 gallon of agent orange was leaked at Bien Hoa airbase in the early of 1970<sup>6</sup>. Besides, aircrafts after being used for a number of spraying missions were also washed by water right at herbicides loading sites. As a result, herbicide residue was washed away and usually expanded to around areas. Empty herbicide barrels which in fact still contained about 2 little of herbicide residue<sup>7</sup> were also leaved at dumping ground in the airbases. Erosion of the barrels in turn, caused leaking of significant amount of herbicides to the ground. It should be noted that many herbicides used by the US army in Vietnam such as agent orange contain significant amount of dioxin as the most concerning byproduct.

Dioxin and related compounds are usually persistent with impacts from environment and thus may exist in environment for long time. It is very concerning that off-site migration of dioxin may expand the contamination to larger vicinities. It is therefore very important to assess contamination status and distribution of dioxin in high-potential contaminated sites which are used to be working sites for the Ranch Hand Operation of the US army. In this study, we carried out sampling and analysis for dioxin residues in soil of most potential contaminated sites of three airbases namely Da Nang, Bien Hoa and Phu Cat. This study is also expected to contribute to forthcoming mitigation activities for dioxin contamination in such airbases.

### Materials and Methods

During period from 1993 to date, over 700 samples of soil, sediment, water, animal and vegetable have been collected from Da Nang, Bien Hoa and Phu Cat airbase for analysis and assessment of contamination of 2,4-D, 2,4,5-T and dioxin.

In the study on assessment of dioxin residual in Da Nang airport in cooperation between USEPA with Viet Nam Science and Technology Institute in 2005, 109 samples of soil and sediment were analyzed by Calux and over 50 samples were analyzed by GC/MS high resolution.

In order to collect representative samples, total volume of soil excavated from a hole with dimension (wide x length x depth) of 60 x 60 x 20 cm or 60 x 60 x 30 cm were homologized to produce a composite sample. Each sampling point was selected basing on net mapping design. Besides, soils were also collected vertically at different depths from 0-30 cm, 30-60 cm, 60-90 cm, 90-120 cm and 120-150 cm by similar method. After collecting, soil samples were kept in cleaned glass bottles. Sediment samples were collected by stainless steel

Ekman grab. Before collecting samples, all equipments were cleaned by water, acetone and hexane in order to prevent from cross contamination among collected samples.

Most of samples were analyzed in laboratory of Vietnam Russia Tropical Center by HRGC/LRMS and using method of US EPA8280<sup>10</sup> with minor modification. QA/QC was implemented including blank samples, spiked samples, replicated samples, field duplicated samples and cross-checking with international intercalibration programs. Some representative samples analyzed by our laboratory with concentrations ranging from not detected level to over 100.000 ppt were sent to Russia and Japan for cross checking by HRGC/HRMS. The results among the laboratories were comparable.

### Results and discussion

Concentrations of dioxin in environmental samples collected from dioxin hotspots are summarized in the Table 1. The results on horizontal and vertical distribution of dioxin also help for estimation of total soil and sediment that need to be treated.

Table 1: Summary of dioxin concentrations in dioxin hotspots of the three airports

Location	Sample kind	n	Conc. I-TEQ, pg/g dry wt.			Estimation for dioxin-cleanup area
			Range	Average	% 2,3,7,8-TCDD	
<b>Da Nang</b>						
Loading and washing area	Soil: 0-30 cm	9	638-200,338	83,954	99.3	~15,000m <sup>2</sup>
Dumping site	Soil: 0-30 cm	21	200-139,691	38,800	98.2	~17,000m <sup>2</sup>
Drainage ditch	Surficial sediment	8	332-109,967	41,797	98.1	~2,000m <sup>2</sup>
surrounding area	Soil: 0-30 cm	14	4.3-12,703	1,090	93.1	
Sen Lake	Surficial sediment	11	282-12,393	3,371	94,5	~70,000m <sup>2</sup>
<b>Bien Hoa</b>						
Loading and washing area, Other contam areas	Soil:0-20 cm	23	nd-409,818	27,544	97.0	~30,000m <sup>2</sup>
	Soil:0-30 cm	31	nd-85,205	6,831		
<b>Phu Cat</b>						
Heavily contam. area	Soil: 0-30 cm	12	0.1-49,462	11,367	98.4	> 2,000m <sup>2</sup>

The obtained results have showed that former storing, loading, cleaning, dumping ground and herbicides leaking sites as well as lakes containing runoff water from contaminated sites in airports are heavily contaminated with dioxin. The concentrations of dioxin are tens to hundreds times higher than acceptable level for nonagricultural soil of the US (1.000 pg/g TEQ dry wt.). Contribution of 2,3,7,8-TCDD to total TEQ is accounted for over 93%, suggesting that the contamination of dioxin in these airports relates to herbicides used by US army during the war.

Major pathway for spreading of dioxin to surrounding areas is perhaps due to runoff water through drainage system. Dioxin contaminated soil which is washed away by runoff water in rain and flood events could accumulate ditches of the drainage system and ultimately flow into lakes nearby. Distribution of dioxin in Da Nang airport is an example. The average level of dioxin in sediment from ditches is about 42,000 ppt. Besides, those in Sen lake is about 3,400 ppt. On the other hand, samples from surrounding area contain only 1,100 ppt of dioxin on average, except of one sample with level up to 12,703 pg/g. This sample was collected near heavily contaminated site (dumping ground) and thus might be directly impacted by herbicides spilling during handle of herbicides in past. If excluding this samples, range of dioxin in this area is 4,3-505 pg/g and average

concentration is about 196 pg/g. This range is much lower compared to sediment of Sen Lake which is considered as reservoir containing rain and flood water.

Vertical movement of dioxin into deeper soil layers is also recognized. The level of dioxin residue has decreased with the depth, depending on characteristics of soil and other geological factors. At Da Nang airport, dioxin concentration of around 1.000 pg/g was found at 1.5 m of depth. This concentration was also found in Bien Hoa and Phu Cat at 0.9 m of soil column.

Basing on the available data, estimation for contaminated areas that need to be treated in Da Nang, Bien Hoa and Phu Cat are about 104,000; >30,000 and >2,000 m<sup>2</sup> respectively. However, it should be noted that more studies will be needed to have accurate evaluation for horizon and vertical movement of dioxin so that total volume of contaminated soil can be estimated.

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