AGENT ORANGE/DIOXIN CONTAMINATION ASSESSMENT AND MANAGEMENT IN VIET NAM

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Introduction

Vietnam has a few dioxin contaminated hotspots due to the armed conflict in between 1961 and 1971. Former military airbases where chemical defoliants were loaded/stored/handled have elevated level of dioxin in soil and sediment due to the ignorance of toxicity of dioxin at that time. Dioxin existed as impurity of an herbicide commonly called Agent Orange (AO). Several researchers have estimated the volume of the herbicides used for the operations and the dioxin loading during that period.

Table 1 Quantity of herbicides used in the South of Vietnam and estimated TCDD loading

Sources	Agent Orange (L)	Agent White (L)	Agent Blue (L)	Agent Purple, Pink, Green (L)	Total (L)	TCDD Qty (kg)
Westing (1976)	44,373,000	19,835,000	8,182,000	-	72,390,000	170
Stellman (2003)	49,268,937	20,556,525	4,741,381	2,387,963	76,954,806	366
Young (2009)	43,332,640	21,798,400	6,100,640	2,944,240	74,175,920	130-144

The high-level contamination has been identified and confirmed at 3 former military airbases, i.e. Da Nang, Bien Hoa and Phu Cat, where Vietnamese Government has made significant efforts to resolve the problems. The Government has conducted several dioxin surveys at suspected dioxin hotspots. The Ministry of National Defence (MOD) started a series of dioxin survey as early as 1993 at Bien Hoa airbase. Since then, the Government, in collaboration with international donors, has assessed and remediated these 3 contaminated hotspots. Vietnam-Russian Tropical Centre is the first research institute that analyzed dioxin contamination in and around the contaminated hotspots.

The Vietnamese Government approved 'National Action Plan to Overcome the Consequences of Toxic Chemicals during the War in Vietnam' in 2012, which emphasizes the complete remediation of these 3 hotspots by 2020. Office of the Steering Committee 33 (Office 33) has implemented and coordinated remediation and research projects. This article reviews the status of 3 dioxin hotspots, assesses and compares the progress, and identifies the challenges and follow-on actions.

Materials and methods

The first assessments to these three hotspots conducted by MOD were called Z1, Z2 and Z3 project for Bien Hoa, Da Nang and Phu Cat, respectively. Since then, dioxin assessments at 3 hotspots have been conducted by various institutions that produced the situation reports[1-8]. Participating agencies includes:

- MOD agencies: VRTC; Military Institute for Chemistry and Environment, Chemistry Division, etc.
- Local research units/organizations: Office 33, Vietnam Academy of Science and Technology; The Monitoring Center Under VEA, Dong Nai DONRE, The 10-80 Committee, etc.
- International organizations: USAID, UNDP, FORD, Hatfield, CDM, etc.

These results were re-compiled and assorted with these 3 hotspots.

Results and discussion

Bien Hoa Airbase

The Bien Hoa airbase is located in Dong Nai Province (Coordinate: 10°58'30" North 106°49'10" East) approx. 700m away from Dong Nai River. During the Vietnam War, the airbase served as the head office of Ranch Hand Operation (From 1/12/1966 to 21/2/1970), which stored and sprayed the herbicides over the southern part of Vietnam. It was also one of the bases to serve Pacer Ivy Operation (17/4/1970-31/3/1972), which re-drummed and shipped unused chemical out of Vietnam. Quantities of herbicides transferred, stored and used were: Agent

Orange: 98,000 barrels, Agent White: 45,000 barrels and Agent Blue: 16,300 barrels. From 12/ 1969 to 03/1970, 4 spillage incidents were reported, which included 2 spillage of Agent White (2,500 litres) and 2 spillage of Agent Orange (25,000 litres) from the 28,000 litre-capacity storage tanks.

Table 2 Dioxin level in and around Bien Hoa Airbase

Location	Sampling year	Media	Sampling number	Dioxin level (pg-TEQ/g)
Z1 area	1994-2001		50	n.d. - 410,000
	2008			109- 262,000
Around Z1 area	2008			6.15 - 13,300
Gate 2 Lake	1994-2001		6	236 - 508
Paddy near Gate 2 Lake	1994-2001	Soil	12	n.d. - 412
	1994-2001	Sediment	2	44 - 59
Bien Hung Lake	1994-2001	Soil		5 - 256
	1994-2001	Sediment		59 - 210
Paddy in Quang Vinh Ward	1994-2001	Soil	7	26 - 108
	1994-2001	Sediment	7	17 - 149
Pacer Ivy area	2008	Soil	11	80 - 22,800
	2008	Sediment	4	1,090 - 5,970
Southwest area	2008	Soil	13	12.8 - 65,500
28 Lakes at north and east	2013	Sediment	35	4.7 - 8,043

AO/dioxin contaminated areas in Bien Hoa Airbase include:

- Z1area (while 94,000m3 of contaminated soil has been contained in 2009);
- Southern part of Z1 covering a contaminated area of ~5-6ha
- Pace Ivy Area (Western airbase) ~6-7ha
- Lakes and ponds in the airbase~10-15ha

Contamination situation in Bien Hoa is complicated and the assessment of contamination has not been completed. The dioxin continues contaminating aquatic organisms and the food chain. Raised and harvested fish from the airbase is heavily contaminated with dioxin so that those who eat fish and other animals from the airbase are discovered having high dioxin concentration in their bodies.

Da Nang Airbase

Geographical location of Da Nang City is 16° North and 108°15‘ East. The Da Nang airbase served the Ranch Hand Operation (from 5/1964 to 7/1/1971). It was used as a base for spraying activities from Latitude 17 southward to Quy Nhon and Kontum. It was also used for Pacer Ivy Operation. The total quantities of herbicides transferred, stored and used were: Agent Orange: 52,700 barrels, Agent White: 29,000 barrels and Agent Blue: 5,000 barrels.

Projects and research programs on the contamination status in Da Nang Airport included Z2 Project by MOD (1997-98), the 33 program (2002-04) and cooperation programs between Office 33, VRTC, Hatfield Consultant & CDM in 2005, 2006, 2009 & 2010.

Table 3 Dioxin level in and around Da Nang Airbase

Location	Sampling year	Media	Sampling number	Dioxin level (pg-TEQ/g)
Within Airbase	1997-1998	Soil	78	51 - 200,400
	1997-1998	Sediment	3	64 - 54,200
Lakes and rivers	2002-2004	Soil	15	1 - 17
	2002-2004	Sediment	43	1 - 12,390
	2002-2004	Fish	28	0.05 - 158
Outside the airport	2005-2006	Soil	21	0.42 - 269
Mixing and loading area	2007	Soil	9	899 - 365,000
Storage area	2007	Soil	9	24.5 - 106,000

Buffer area	2007	Soil	3	170 - 6,520
Surrounding area	2007	Soil	13	0.643 - 5,690
Lakes	2005-2006	Sediment	27	7.14 - 27,700
	2005-2006	Fish	13	0.22 - 3,120 (wet basis)
Da Nang City	2005-2006	Soil & Sediment	10	3.14 - 36.1
Pacer Ivy	2005-2006	Soil	26	1.21 - 20,600
Southern border		Soil	15	1.14 - 161
		Sediment	6	0.54 - 30.8
Center of airport		Soil	19	1.67 - 115
		Sediment	12	2.28 - 191

Phu Cat Airbase
Phu Cat Airbase is located in Binh Dinh Province (Coordinates: 13°57'48" North109°03'57" East), around 30 km to Qui Nhon City in the Northwestern direction bordering the National Highway No. 1 to the east. During the Vietnam war, the Phu Cat airbase was used for a storage, loading and washing of aircraft after spraying herbicides under Ranch Hand Operation (from 6/1968 to 5/1970). The herbicide quantities in the Airbase were: Agent Orange (17,000 barrels), Agent White (9,000 barrels) and Agent Blue (2,900 barrels).

Projects and research programs on the contamination status in Phu Cat Airbase included: Z3 Project, MOD (1999-2002), Hatfield and 10-80 Committee (2004-05), Cooperation program between Office 33, VRTC, and Hatfield, 2008.

Table 4 Dioxin level in and around Phu Cat Airbase

Location	Sampling year	Media	Sampling number	Dioxin level (pg-TEQ/g)
Storage area	2008	Soil	11	352 - 238,000
Loading area	2008	Soil	7	2.6 - 866
Buffer area	2008	Soil	5	1.5 - 2,950
Washing area	2008	Soil	10	1.85 - 6.23
Southeastern part	2008	Soil	11	7.07 - 236
Sediment tank	2008	Sediment	5	3.6 - 127
Lakes	2008	Sediment	5	4.5 - 33.7

Herbicides/Dioxin Contamination Management in hotspots
Office 33 is coordination and implementation agency of AO/dioxin projects. GEF funded dioxin hotspot remediation project is under implementation with following objective and outcomes:

- OBJECTIVE: to minimize disruption of ecosystems and health risks for people from environmental releases of TCDD contaminated hotspots;
- OUTCOME 1: Dioxin in core hotspot areas contained and remediated;
- OUTCOME 2: Land use on and around hotspots eliminates risks and contributes to environmental recovery;
- OUTCOME 3: National regulations and institutional capacities strengthened.

The project has undertaken the containment of dioxin contaminated soil in Phu Cat airbase. The project safely contained over 7,500m3 of dioxin contaminated soil into an on-site landfill that met national and international environmental standards. All activities was done by Vietnamese contractors and no accident and health problem was reported during construction. The lessons learned will benefit Da Nang project and Bien Hoa masterplan.

The landfill structure was designed in compliance with national regulation of hazardous waste management. The bottom structure comprises with 2 HDPE insulation layers serves as leachate collection and leak detection. Top structure was constructed to ensure smooth drainage of rainwater to minimize water intrusion into landfill. Leachate water passes through activated carbon before it is released to environment. Side slope of the landfill is limited to the stable angle so that soil would not collapse during the construction and after completion. Leachate

water is pumped up at sump pit and transferred to the water treatment facility. Smooth drainage of rainwater is secured with roadside ditch that surrounds entire landfill.

Soil excavation was designed for ensuring the complete removal of contaminated soil while avoiding excessive volume increase. After the initial excavation, the bottom of soil was collected and analyzed. If high dioxin level was still observed, such zone was further excavated until the dioxin concentration decreased to acceptable level.

Long-term monitoring plan was designed and implemented in collaboration with a Czech-funded project. After the field survey, the sampling points of ambient air, groundwater and surface water were selected at landfill site, residential area, former contaminated areas. For example, groundwater wells consists of 1 well at upstream of landfill and 4 wells at downstream of landfill so that the source of faulty pollutant level (if detected) can be estimated.

Another main activity of the project is the interim prevention of dioxin spreading from Bien Hoa airbase to downstream communities. The principle of the intervention is to prevent surface water from flowing through the contaminated areas, store and regulate surface water into the contaminated areas, quickly release rainfall outside the contaminated areas.

Communications activity was also conducted for the population around the Bien Hoa airbase. The main message of communication program was: 1) to provide official information on status of dioxin contamination in Bien Hoa airbase, 2) to advise the dioxin exposure pathway and preventing from dioxin exposure, and 3) to improve the communication skill. Main requirements of the communication program was to confirm that the prevention from dioxin exposure can only be controlled by strict compliance with the instructions and avoidance of any confusion in community such as understanding about dioxin so that people can know how to prevent from dioxin exposure.

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