

AGENT ORANGE DIOXIN CONTAMINATION IN THE ENVIRONMENT AND HUMAN POPULATION IN THE VICINITY OF DA NANG AIRBASE, VIET NAM

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Abstract

The presence of dioxin in the environment in and around former US military sites in Viet Nam is a direct result of storage, use and spillage of herbicides by the US military and Army of the Republic of Viet Nam (ARVN) forces. Significant quantities of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD), a contaminant in Agent Orange, were detected in samples analyzed from the Da Nang Airbase in December 2006. Dioxin levels recorded in Da Nang soils, sediments, fish and human tissues exceeded all international standards and guidelines for these toxic chemicals. Similar situations can be expected at other major Ranch Hand sites in Viet Nam, especially Bien Hoa. Although dioxins are a significant environmental hazard, the extent and impact of contamination around known dioxin hot spots in Viet Nam has not been adequately assessed. More than 40 years after Agent Orange was introduced to the environment of Viet Nam, the resultant chemical contamination continues to enter the environment and human population to this day. Mitigation measures must be implemented immediately to protect Vietnamese living in the vicinity of dioxin hot spots from further contamination and potential health impacts.

Introduction

Agent Orange has been described as the last remaining vestige of the war to be resolved between the US and Viet Nam. The presence of dioxin in the environment in and around former US military sites in Viet Nam is a direct result of storage and use of herbicides by the US and ARVN forces, spillage, and from improper disposal of empty herbicide barrels. Since the US-Viet Nam war, Vietnamese living in the vicinity of key former Ranch Hand sites (Bien Hoa, Da Nang, Phu Cat and others) have been exposed to contaminated soils, sediments and foods; these areas are referred to as dioxin 'hot spots'^{1,2}. Due to the chemical stability of dioxins, contaminated lands have potential to expose the general population to dioxin for many decades, well beyond initial aerial applications and spillages during wartime Ranch Hand operations. This represents a significant environmental hazard; protection of human health in the vicinity of known dioxin hot spots in Viet Nam is of key concern.

The Da Nang Dioxin Assessment and Mitigation Project was conducted by Hatfield Consultants (Canada) in association with the Ministry of Natural Resources and Environment Office of the National Steering Committee 33 (Viet Nam) between October 2006 and April 2007. The project objective was to investigate the issue of residual dioxin contamination on the Da Nang Airbase and in the surrounding environment and local communities, and to recommend mitigation measures to help prevent the local population from future exposure.

Materials and Methods

Sampling procedures followed those previously developed and applied by Hatfield in previous Agent Orange dioxin assessment projects in Viet Nam^{1,2}. Sampling activities were undertaken in cooperation with Office 33 and relevant Vietnamese Government agencies, especially the Ministry of Defense, Ministry of Health and local Da Nang authorities. All soil and sediment sampling sites were screened for landmines and unexploded ordnance (UXO) in advance of sampling.

Sampling locations were selected through a pre-field desktop review of existing literature on Da Nang, topographic maps and remote sensing information available for the study area, in conjunction with historical sampling results from areas within and surrounding the Da Nang Airbase. Sampling was conducted on the Da Nang Airbase proper, in Thanh Khe District immediately outside the Airbase, and in Hai Chau District (reference location, outside the influence of the Airbase).

Soil sampling was conducted in a similar manner to previous Hatfield programs in Viet Nam (i.e., composite of 10 soil samples)^{1,2}, and to a maximum of 50 cm depth. A number of fish species, including Nile Tilapia (*Oreochromis niloticus niloticus*), were sampled from waterbodies on the Da Nang Airbase. Human blood and breast milk sampling was undertaken according to protocols employed in previous Hatfield/10-80 Division investigations in Viet Nam¹. Hatfield personnel supervised all sample collections; consent forms were obtained in advance from blood and breast milk donors.

All samples were kept cool (4°C), or frozen within 2 hours of collection and shipped to Canada immediately after completion of the field program. Samples were analyzed by AXYS Analytical Laboratories in Sidney (British Columbia) using a Micromass Ultima high resolution mass spectrometer equipped with an HP 6890 gas chromatograph, a CTC autosampler and an Alpha workstation running VG software³. Standard quality assurance and quality control procedures used for all Hatfield field sampling programs in Viet Nam were applied.¹

Results and Discussion

Agent Orange and other herbicides were stored in large quantities at Da Nang Airbase during the US-Viet Nam war; more than 100,000 45-USG (208-litre) barrels of herbicide were used on the Da Nang Airbase. These herbicides were loaded primarily onto C-123 aircraft for aerial spraying in central Viet Nam and Lao PDR; herbicides were also dispensed by truck, backpack spray devices and helicopter. Significant spillage occurred from improper handling and disposal of herbicides; this is well documented in US military records from the war period.^{4,5,6}

Significant quantities of TCDD, a contaminant in Agent Orange and other wartime herbicides, were detected in samples analyzed from the Da Nang Airbase in December 2006. Dioxin congener profiles confirmed that the main source of dioxin contamination at Da Nang Airbase was Agent Orange and other dioxin-containing herbicides. TCDD contributed over 90% of the TEQ (TCDD toxic equivalents) in soil and sediment samples collected from the former Agent Orange Mixing and Loading Area, former Storage Area and Sen Lake, all of which are located on Da Nang Airbase. Samples collected downstream of the Airbase in Da Nang City contained lower levels of Agent Orange dioxin. Other contaminants (including polychlorinated biphenyls, organochlorine pesticides and hydrocarbons) were also present in the environment, both inside and outside the perimeter of Da Nang Airbase. TCDD levels recorded in this study exceeded all international standards and guidelines for these toxic chemicals.

The maximum soil TEQ concentration recorded in this study was 365,000 ppt, from samples collected at the former Mixing and Loading Area; this is 365 times the globally acceptable maximum standard of 1,000 ppt⁷. Over 99% (361,000 ppt) of the TEQ in the sample was TCDD. Three soil samples analyzed were >100,000 ppt TCDD, and 17 of 23 (74%) soil samples analyzed from the Airbase were >1,000 ppt. Maximum sediment sample TCDD concentration was 6,270 ppt. This represents extremely high contamination, and confirms Da Nang Airbase as a significant dioxin 'hot spot'.

Soil dioxin levels recorded in this study are the second highest reported in Viet Nam to date (the highest being >1 million ppt TEQ in soils at Bien Hoa Airbase⁸, although the exact geographical position, origin, and method of extraction of this Bien Hoa Airbase soil sample is unknown, and has never been reported). Soil TCDD levels from this study confirm contamination data previously obtained by the Vietnamese Government and US EPA (unpublished data).

The present study, and previous work by Hatfield/10-80 Division^{1,2}, has verified that the highest concentrations of Agent Orange dioxin in soils/sediments in Viet Nam are found in the top 10 cm layer; some contamination is found at deeper strata (e.g., >30 cm), but only in limited areas on Da Nang Airbase. The movement of dioxin from the former Mixing and Loading and Storage Areas, into Sen Lake, and ultimately into humans (via ingestion of contaminated fish and direct contact with soils and sediments) is without doubt, and is directly linked to historical Agent Orange use on the Airbase. The resulting high dioxin levels in the environment and food chain pose an

unacceptable health risk to exposed populations in the vicinity of the Airbase. Lower dioxin levels were recorded in Da Nang City itself, suggesting that most contamination is restricted to the Airbase.

The maximum TCDD concentration recorded in Tilapia fat in this study was 3,000 ppt (wet weight basis), which is 100 times the acceptable fish consumption level established by Health Canada⁹. Fish originating from the Airbase are contaminated with dioxins and consumed by fishermen (and likely some members of the general public) living considerable distances from the point of herbicide release to the environment; there is a direct connection between Sen Lake and areas outside the Airbase through the local drainage system.

Blood dioxin levels recorded in this study (n=55 patients sampled) for Da Nang residents directly associated with the Airbase were the highest reported for Viet Nam to date, and exceed all international standards for these chemicals. Individuals who harvest fish and plants from Da Nang Airbase had dioxin concentrations in their blood more than 100 times globally acceptable levels. The maximum TCDD concentration of 1,150 ppt lipid (1,220 ppt TEQ; 94% TCDD) was recorded in a 42-year old male who actively harvested fish and plants from the Da Nang Airbase; two other individuals also had >500 ppt TEQ. Previous studies at Bien Hoa recorded a maximum blood TCDD level of 413 pg/g lipid¹⁰. Low blood TCDD concentrations (<8.5 ppt lipid) were recorded at the Hai Chau reference site. A number of other contaminants, including PCBs, were also recorded in blood samples analyzed, and contributed significantly to the Total TEQ.

The people most affected by direct exposure to dioxins from the Da Nang Airbase hot spot are members of an extended family who fish and harvest lotus from Sen Lake, and garden along its banks. At present, it is believed that only a small proportion of the general population of Da Nang City is highly exposed to dioxins. Others may also be affected by eating fish and other aquatic animals harvested from the Airbase lakes, although exact numbers are presently unknown. Exact numbers of highly exposed people should be verified and monitored.

Results from this study support those from previous Hatfield/10-80 Division studies^{1,2}, namely that dioxins are transported from soils to aquatic sediments to fish and other aquatic organism tissues, and ultimately into humans. The high levels of TCDD contributed almost all of the total dioxin toxicity of samples analyzed, indicating that Agent Orange was the principal source of this dioxin congener. Immediate action is therefore necessary at Da Nang and other former Ranch Hand sites to prevent further human health risks from exposure to dioxins.

It is clear that certain health effects are linked to Agent Orange exposure, and that the precautionary principle should apply when dealing with dioxin contamination in the environment and human food chain. This is particularly true at Da Nang Airbase; this study has shown significant concentrations of dioxins in soils, fish tissues and human blood/milk, and direct transfer of dioxins through the food chain. Protection of the local residents known to work on Airbase lakes harvesting fish and other aquatic organisms is therefore paramount, through immediate adoption of mitigation measures at Da Nang Airbase (Table 1).

Although over 40 years have elapsed since Agent Orange was introduced to the Vietnamese environment, the resultant chemical contamination continues to enter the environment, the food chain and the human population living in close proximity to Da Nang Airbase. Similar situations can be expected at other major Ranch Hand sites in Viet Nam, particularly Bien Hoa. The very high dioxin levels at Da Nang Airbase pose a significant public health threat, particularly when considered in relation to global guidelines for protection of the environment and human health. Time is of the essence to move forward with this issue, to protect Vietnamese living in the vicinity of such hot spots from further contamination and associated health impacts.

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Table 1 Summary of proposed mitigation strategies to reduce exposure of the human population to dioxin contamination from historical use of Agent Orange on the Da Nang Airbase.

Location	Recommended Mitigation Strategy
Sen Lake, Lake B, Lake C, West Airbase Fishponds, Xuan Ha Lake and March 29 Lake	Institute an immediate ban on fishing, aquaculture, and consumption of aquatic organisms harvested. Ban the harvest and consumption of lotus and other vegetables raised in soils/sediments from Da Nang Airbase aquatic ecosystems. Ban fishing in waterbodies on the perimeter of the Airbase. Families living on the Airbase near these lakes should be relocated.
Da Nang Airbase perimeter	Install a new 'secure', permanent fence around the perimeter of the Airbase to prevent public access.
Da Nang City	One-on-one consultations should be held with all individuals who provided blood/milk samples under the current study. Educational materials related to preventing further exposure to dioxins and furans should be provided.
Sen Lake Workers, West Airbase Fishpond Workers, Airbase Workers potentially exposed to contaminated soils and sediments	Development of alternate livelihoods for individuals currently earning their living from harvesting fish, lotus and other aquatic organisms and vegetables from Da Nang Airbase. These strategies require development by Vietnamese authorities in a manner that is appropriate to local culture and regulations.
Long-term monitoring	Monitoring of dioxin contamination in soils, sediments, food and residents should be implemented on an annual basis for a period of 5 to 7 years, at a minimum, to verify effectiveness of mitigation measures. Further sampling and health studies may be required to verify the extent of contamination and exposure. Detailed assessment and monitoring should be undertaken at Bien Hoa, Phu Cat, and other identified hot spots.
Former Mixing and Loading Area, former Storage Area, Drainage Canals: Clean up and/or ecologically isolate Airbase hot spots	Appropriate engineered solutions require refining and rapid implementation to prevent further spread of dioxin-contaminated soils and sediments into Sen Lake, and, ultimately, into the human population of Da Nang. Funding for undertaking these activities, and removing dioxin residues from the local ecosystem, needs to be secured as soon as possible.

References

1. Dwernychuk LW, Cau HD, Hatfield CT, Boivin TG, Hung TM, Dung PT, and Thai ND. *Chemosphere* 2002; 47:117-137.
2. Dwernychuk LW. *Chemosphere* 2005; 60: 998-999.
3. AXYS 2007. MLA-017 Analytical Method for the determination of Polychlorinated Dibenzodioxins and Dibenzofurans by EPA Method 1613B, EPA Method 8290/8290A, Env. Canada EPS 1/RM/19 or EPA Method DLM02.0
4. US Army documents (declassified). 1969. Department of the Army. The US Army Center of Military History, Fort Lesley J. McNair DC, 20319-5048, USA.
5. Cecil PF. *Herbicide Warfare: the Ranch Hand Project in Viet Nam*. Praeger, New York, 1986: 290pp.
6. Hatfield Consultants Ltd./10-80 Division of the Ministry of Health. Identification of New Agent Orange/Dioxin Contamination Hotspots in Southern Viet Nam Report prepared for Ford Foundation. 2005.
7. ATSDR. Interim Policy Guideline: Dioxin and dioxin-like compounds in soil. US Department of Health and Human Services, Public Health Service. Atlanta, GA. 1997; p10.
8. Schecter A, Dai LC, Papke O, Prange J, Constable JD, Matsuda M, Thao VD, and Piskac AL. *J. Occup. Environ. Med.* 2001; 43, 435-443.
9. Health Canada. 2004. Priority substances list assessment report no. 1: polychlorinated dibenzodioxins and polychlorinated dibenzofurans. Website: http://www.hc-sc.gc.ca/ewh-semt/pubs/contaminants/ps11-lsp1/dioxins_furans_dioxines_furannes/contam_enviro_e.html
10. Schecter A, Pavuk M, Constable J, Dai LC, and Papke O. 2002. *J. Occup. Environ. Med.* 44, 218-220.