



Contents lists available at ScienceDirect

International Journal of Hygiene and Environmental Health

journal homepage: www.elsevier.com/locate/ijheh



Environmental health risk assessment of dioxin in foods at the two most severe dioxin hot spots in Vietnam

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ARTICLE INFO

Article history:

Received 17 February 2015

Received in revised form 29 March 2015

Accepted 29 March 2015

Keywords:

Environmental health risk assessment
Dioxin exposure through foods
Bien Hoa dioxin hot spot
Da Nang dioxin hot spot
Vietnam

ABSTRACT

Background: Bien Hoa and Da Nang airbases were bulk storages for Agent Orange during the Vietnam War and currently are the two most severe dioxin hot spots.

Objectives: This study assesses the health risk of exposure to dioxin through foods for local residents living in seven wards surrounding these airbases.

Methods: This study follows the Australian Environmental Health Risk Assessment Framework to assess the health risk of exposure to dioxin in foods. Forty-six pooled samples of commonly consumed local foods were collected and analyzed for dioxin/furans. A food frequency and Knowledge–Attitude–Practice survey was also undertaken at 1000 local households, various stakeholders were involved and related publications were reviewed.

Results: Total dioxin/furan concentrations in samples of local “high-risk” foods (e.g. free range chicken meat and eggs, ducks, freshwater fish, snail and beef) ranged from 3.8 pg TEQ/g to 95 pg TEQ/g, while in “low-risk” foods (e.g. caged chicken meat and eggs, seafoods, pork, leafy vegetables, fruits, and rice) concentrations ranged from 0.03 pg TEQ/g to 6.1 pg TEQ/g. Estimated daily intake of dioxin if people who did not consume local high risk foods ranged from 3.2 pg TEQ/kg bw/day to 6.2 pg TEQ/kg bw/day (Bien Hoa) and from 1.2 pg TEQ/kg bw/day to 4.3 pg TEQ/kg bw/day (Da Nang). Consumption of local high risk foods resulted in extremely high dioxin daily intakes (60.4–102.8 pg TEQ/kg bw/day in Bien Hoa; 27.0–148.0 pg TEQ/kg bw/day in Da Nang).

Conclusions: Consumption of local “high-risk” foods increases dioxin daily intakes far above the WHO recommended TDI (1–4 pg TEQ/kg bw/day). Practicing appropriate preventive measures is necessary to significantly reduce exposure and health risk.

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Introduction (issue identification)

The term dioxin and dioxin-like compounds include 75 individual compounds of PCDD (polychlorodibenzo-p-dioxins), 135 PCDF compounds (polychlorodibenzo-furans), and 209 PCB individual

compounds (polychlorobiphenyls) (Agency for Toxic Substances and Disease Registry, 1998). The most toxic compound of the dioxin family is 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) and is classified into Group I carcinogens (International Agency for Research on Cancer, 1997). In addition to cancer, exposure to dioxin has been linked to reproductive, developmental, and other adverse health impacts (Institute of Medicine, 2014).

Bien Hoa and Da Nang cities are located in the South and Central regions of Vietnam, with total areas of 264.08 km² and 1283 km², and populations of approximately 800,000 and 970,693 people, respectively. Trung Dung, Tan Phong and Buu Long wards in Bien Hoa City and An Khe, Hoa Khe, Chinh Gian and Thanh Khe Tay wards in Da Nang City are seven wards surrounding the Bien Hoa

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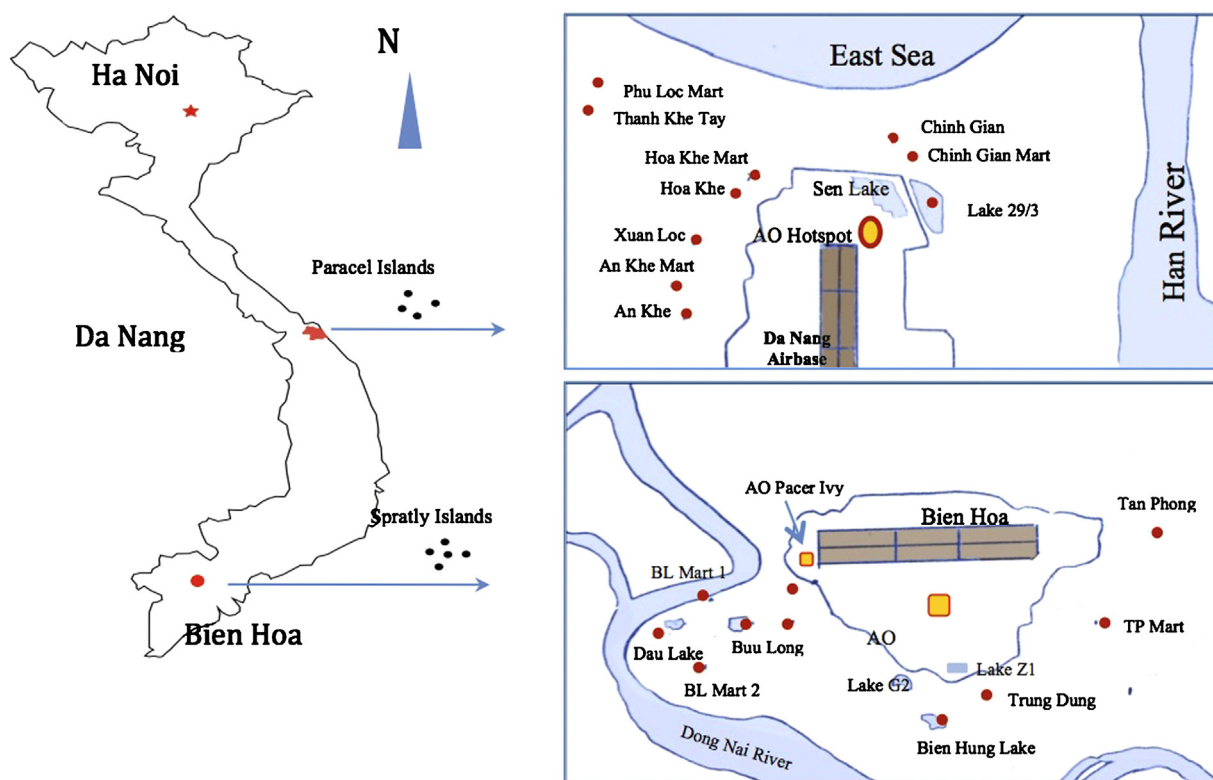


Fig. 1. Bien Hoa and Da Nang dioxin hot spots, and the dots in red were the areas where food samples were collected in 2013 for dioxin analysis. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

and Da Nang airbases (Fig. 1). These areas have received much attention from national and international scientists due to high dioxin contamination caused by Agent Orange and other herbicide spraying during Operation Ranch Hand (Dwernychuk et al., 2002; Schecter et al., 2003; Stellman et al., 2003; Mai et al., 2007; Hatfield Consultants and Office of the National Steering Committee 33 MONRE, 2009).

According to data provided by the US Defense Supply Agency and Air Force Logistics Command, during the period 1961–1972, 74,175,920 l of herbicides, of which Agent Orange accounted for 43,332,640 l, were sprayed in Vietnam (Young, 2009). Most herbicides were stored in tanks in former US airbases, including those at Bien Hoa and Da Nang. Prior to loading onto aircraft for spraying, they were firstly pumped into large 28,000 l tanks. Two major spills of Agent Orange and Agent White from 28,000 l tanks had occurred in December 1969 and 1st March 1970 in Bien Hoa Airbase and spill incidents also occurred at Da Nang Airbase (Young, 2009). As a consequence of the Agent Orange spills, the soil within and around the airbases was polluted severely with dioxin. In addition to dioxin released during the War, environmental contamination in Bien Hoa and Da Nang cities may have occurred through burning of wastes at low temperature, spraying of pesticides and herbicides in agriculture, and from industrial sources. However, a recent study confirmed that Agent Orange was considered the primary source of dioxin in Bien Hoa (Minh et al., 2008). In recent years, samples of soil, sediment, some food samples, breast milk and blood samples of local residents at Bien Hoa and Da Nang cities have been reported to have elevated levels of dioxin (Schecter et al., 2001, 2003; Hatfield Consultants, 2006; Minh et al., 2008, 2011; Hatfield Consultants Ltd and Vietnam-Russia Tropical Centre, 2009; Sorenson et al., 2010).

It is estimated that approximately 240,000 t and 70,000 t of contaminated soil in Bien Hoa and Da Nang airbases, respectively need to be remediated. The current Da Nang Airport Remediation Project costing \$84 million USD, aims to clean up the dioxin

contaminated soil and sediment inside the airbase so that the dioxin concentrations fall below the agreed upon level of 150 pgTEQ/g (TEQ means toxic equivalent) (USAID Vietnam, 2014). This project will only assist in the reduction of the levels of dioxin inside the airbase, not the surrounding residential areas. An assessment in 2007 using limited secondary environmental and biological sample data showed that local people, especially those living at Trung Dung and Tan Phong wards (Bien Hoa City), face health risks due to exposure to dioxin in the environment, particularly through consumption of local contaminated foods (Tuyet Hanh et al., 2010).

In recent years, the Vietnam Public Health Association and its provincial branches implemented public health intervention programs in Bien Hoa (2007–2009) and Da Nang (2009–2011) aimed at reducing the dioxin exposure risks for local residents (Tuyet-Hanh et al., 2013). The current study aimed to undertake an environmental health risk assessment to provide scientific evidence of the current human health risk related to dioxin exposure through foods for local residents living in the seven wards surrounding Bien Hoa and Da Nang Airbases. It also provided recommendations for further risk reduction activities at the two hot spots.

Materials and methods

This study followed the Australian Environmental Health Risk Assessment Framework to assess the risk of dioxin exposure through foods. This included the stages of issue identification, hazard assessment (i.e. hazard identification and dose-response assessment), exposure assessment, risk characterization, stakeholder engagement and risk communication (Australian enHealth Council, 2004). For exposure assessment, data was collected in the following ways: (1) we undertook a comprehensive sampling strategy of commonly consumed local foods; (2) we undertook a food frequency and KAP survey of local residents; and (3) food intake

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