

THE DISTRIBUTION OF PCDD/Fs IN WATER, SEDIEMENT, BIOLOGY SAMPLES AROUND BIEN HOA AGENT ORANGE HOTSPOT

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Introduction

Bien Hoa airport is one of the three spots of Dioxin contamination in Vietnam because it was used to store Agent Orange for the spray during the war in Southern Vietnam. Dioxin monitoring results in the ground, water, sediment show that the residue of Dioxin is still threatening the ecosystems and the community living near Bien Hoa airport. 2,3,7,8- TCDD was found in 16/28 soil samples with maximum concentration: 1.285ng/g (dry weight); in 7/10 sediment samples with maximum concentration: 0.28ng/g (dry weight); in fish: 18.4ng/kg and these values are exceeding the standards compared to International and Vietnamese Standards. The HCA and PCA show that dioxin in these samples have an origin from herbicide containing 2,4,5-T focused on 2,3,7,8-TCDD.

Materials and methods

If considering the whole airport area like a “hot spot”, basing on the slope and the terrain of the airport we have selected the monitoring sites to collect the sample outside airport through sewers and wastewater/runoff canals.

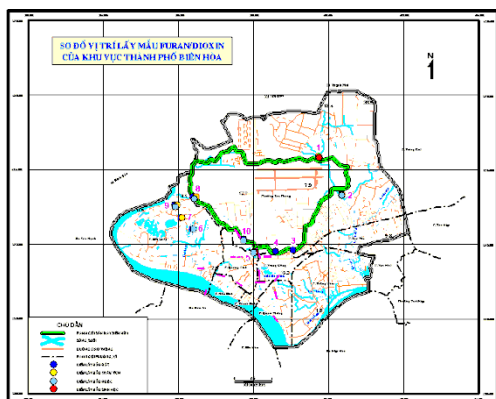


Fig 1. Monitoring sites

These samples were analyzed and determined concentration of 17 toxic compounds on HRGC/HRMS with method that was developed based on US.EPA 8280 method with some modification.

* For sediment samples: Detected TCDD in 7/10 samples at sites 2,4,5 and 10. The presence of TCDD in these samples means these sites are contaminated by toxic chemicals in wastewater/runoff flowing from the airport. Except site 1 having TEQ < PEL value (Probable Effect Level: 0.0215 ng/g dry weight), all the rest sites have TEQ varied from 0.18 to 0.28 ng/g dry weight (8 – 12 times higher than PEL value). Site 10 (a stream connecting with wastewater/runoff from the airport) has very high TEQ (up more 50 times than PEL value).

* For soil samples: Detected TCDD in 16/28 samples at sites 2,3,5, 9 and 10. Maximum detected TCDD concentration was 1.285 ng/g (321 times higher than CCME value). TEQ of topsoil varied from 0.002 to 1.33 ng/g dry weight (highest at site 10 and lowest at site 1). TEQ of deeper layer (50 – 80 cm) was much lower, varied from 0.0001 to 0.267 ng/g dry weight.

* For water samples: Detected TCDD in all water samples. TEQ of ground water samples was very low (below TEQ-Limit : 0.03 ng/L – US.EPA). TEQ of water samples at site 5 – Lake of Entrance 2 and site 10 (a stream connecting with wastewater/runoff from the airport) was much higher than TEQ-Limit.

* For biology samples: TEQ of 7/8 fish samples was very low (below TEQ-Limit : 4 ng/kg – EC, 2001).

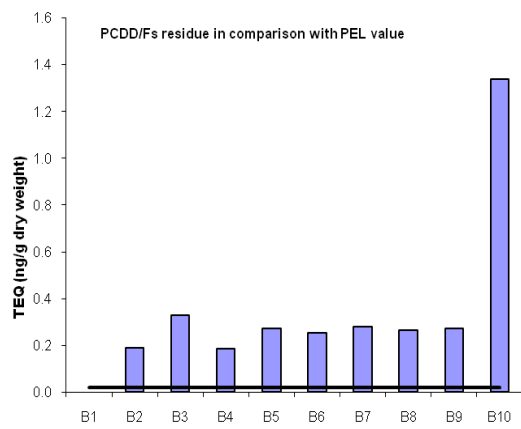


Fig 2. The result of sediment samples

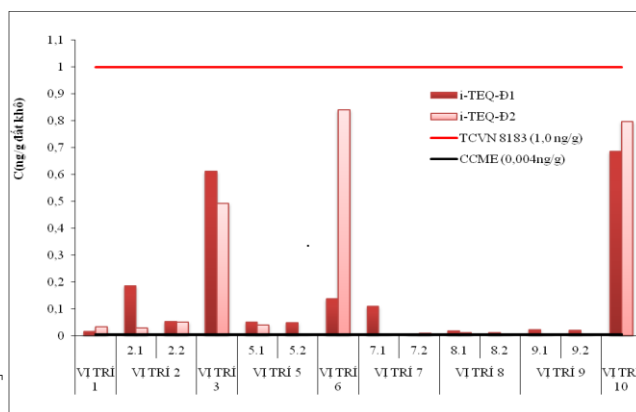


Fig 3. The result of soil samples

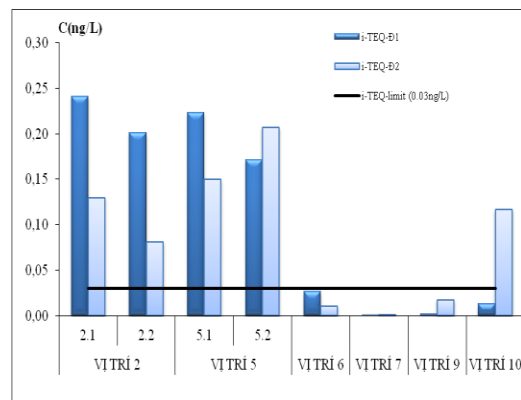


Fig 4. The result of water samples

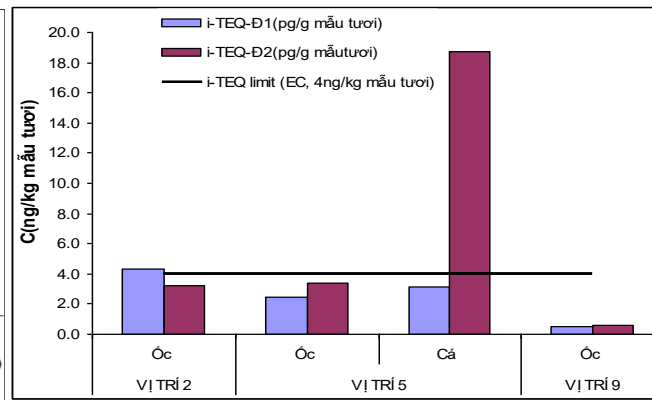


Fig 5. The result of biology samples

- On the results of analysed samples above, we appreciate some following parameters: Toxic concentration percentage of 2,3,7,8-TCDD to TEQ, Quotient between toxic concentration of 1,2,3,7,8-PeCDD and 2,3,7,8-TCDD, Quotient between total concentration of 7 toxic congeners of PCDDs and 10 toxic congeners of PCDFs.
- Statistical methods, such as principal component analysis (PCA) and hierarchical cluster analysis (HCA), are commonly used to evaluate the congener patterns of PCDD/Fs in different environmental matrix, and to reveal the contamination sources of PCDD/Fs. Both the PCA and HCA methods were performed on normalized concentrations of PCDD/Fs using Simca-P. The score plot of PCA shows the relative contributions of 17 toxic PCDD/Fs congeners. The HCA shows the similarities and differences between each collected samples.

Results and discussion

- On the results of analysed samples above, we appreciate parameters including T%, P, R as below:

Table 1 The concentration of PCDD/Fs in different matrixes

	PCDD/Fs			
	Soil (0-30m) (ng/g)	Sediment (ng/g)	Water (ng/L)	Biology samples (ng/g wet)
<i>C</i> (2,3,7,8-TCDD)	0.4886	0.0151	0.0088	0.0011
TEQ	0.4916	0.0324	0.0128	0.0031
<i>C</i> (1,2,3,7,8-PeCDD)	0.0025	0.0025	0	0.0005
$\sum C$ (PCDD) (<i>n</i> = 1-7)	0.5768	4.177	1.6257	0.2269
$\sum C$ (PCDF) (<i>n</i> = 1-10)	0.0091	0.2927	0.0608	0.1072
$T\% = (C_{2,3,7,8-TCDD} / TEQ) \times 100$	99.39	46.60	68.75	35.48
$P = C_{1,2,3,7,8-PeCDD} / C_{2,3,7,8-TCDD}$	0.005	0.167	0	0.455
$R = (\sum C_{PCDD} (n = 1-7)) / (\sum C_{PCDF} (n = 1-10))$	63.38	14.27	26.74	2.12

From study results showed in table 1: T% values in samples are from 35.48 to 99.39%. This shows that 2,3,7,8-TCDD had the most contribution to I-TEQ concentration in the vicinity of Bien Hoa airbase. P values are lower than 1 (from 0.005 to 0.455). This shows that 2,3,7,8-TCDD had the most contribution to I-TEQ concentration. R values in all samples are higher than 1 (from 2.12 to 63.38). The ratios of PCDDs to PCDFs for all samples were more than 1, implied the de novo synthesis is always dominant. Comparison of T%, P, R in all samples shows the common followings: T% > 35%, P < 1, R > 1. This shows that dioxin in these samples have an origin from herbicide containing 2,4,5-T used by U.S. Army in Vietnam war. To better understand the congener profiles of dioxin in all samples, PCA and HCA were used to evaluate the possible groupings of similar emissions and the dominant

congeners in a defined grouping, as well as to illustrate the characteristic profiles for such groupings within the resulting data. .

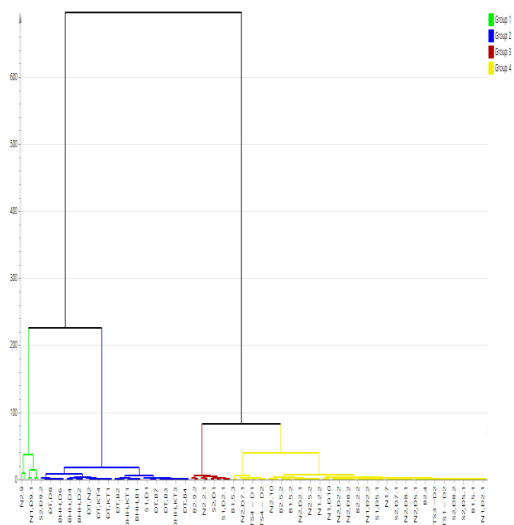


Fig 6. HCA in all samples

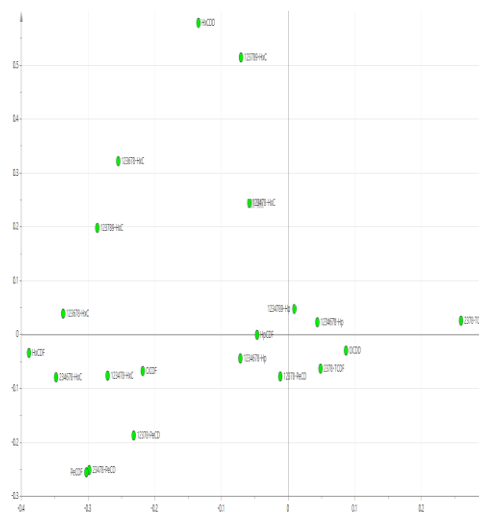


Fig. 7 The PCA in all samples.

The scope plot of principal component analysis for relative contribution of the 17 toxic dioxin congeners in shown in Fig.7, and the similarities and differences in the dioxin patterns are shown in Fig 6. Based on the four group extracted from HCA and PCA show that these multivariate pattern comparison results indicated three groups (groups 1 including H_xCDD, 123789-H_xCDD, 123678-H_xCDD, 123789-H_xCDD, 123478-H_xCDD, group 3 including OCDD, 2378-TCDF, 12378-PeCDD, 1234678-H_pCDF, H_pCDF, 1234789-H_pCDF, 1236789-H_pCDF and group 4 focuses on 2378-TCDD) for all congener patterns. Group 2 focuses on all soil samples in sites 2,9 including H_xCDF, 123678-H_xCDF, 23478-H_xCDF, 123478-H_xCDF, OCDF, 12378-PeCDF, PeCDF, 13478-PeCDF. This shows that dioxin in these samples from the vicinity of Bien Hoa airbase, Dong Nai, Vietnam have an origin from herbicide containing 2,4,5-T used by U.S. Army in Vietnam war focused on 2,3,7,8-TCDD.

References

- 1/ NX Truong, TK Sau, NX Net, LB Hung, ND Hue, DQ Huy, NM Hang (2010). *Organohalogen Compounds*, vol. 72, pp. 896-901.
- 2/ Yumen Ni, Haijun Zhang, Su Fan, Xueping Zhang, Qing Zhang, Jiping Chen (2009). *Chemosphere* vol. 75, pp.1153-1158.
- 3/ Y. Du (2013). *J. Air Waste Assoc*, 63(2):230-6.
- 4/ Hongcai Gao, Yuwen Ni, Haijun Zhang, Liang Zhao, Xueping Zhang, Qing Zhang, Jiping Chen (2009). *Chemosphere*. vol.77, pp.634-639.
- 5/ US.EPA. Method 8280B (1998).