Site Investigation on highly dioxin contaminated field in AnShun —Taiwan

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Introduction

PCP is a biocide used widely as a wood preserve and in agricultural field in Taiwan. The AnShun Chloro-alkali plant has manufactured pentachlorophenol (PCP) for decades, i.e., from 1969 to 1982. The maximum daily production capacity has been 4 tons/day. An estimated amount of 5000 tons of PCP was left in the site after ceased operation in 1982. Awareness of the soil and groundwater contamination by PCP, the Government has started to remedy PCP contamination in the site since 1995. It is well known that dioxins are inevitable impurities during the production of PCP by catalytically chlorination of phenol. In year 2000, the Environmental Quality Protection Foundation has filed a civic action based on our previous work[1] under the newly approved "Soil and Ground Water Pollution Control" act. Nevertheless, the local community speculated that enormous amounts of dioxin were present in this 30-acre field. As high as 5-15 kg TEQ amount of dioxin might rest in the field, based on the typical dioxin concentration in industrial PCP is 1000 ~ 3000μg TEQ/kg[2]. With growing economic activities, the area has developed from a rural industrial field to a potential urban residential area. The crucial question of "How much dioxin is present? Where are they?" needed to be clarified first. The data presented in this paper might be served as the basis for discussion on issues like migration, exposure, risk, impact, compensation and remediation.

Methods and Materials

The AnShun plant (Fig. 1) is located on the bank of LuErMen stream in Tainnan prefecture (Fig. 2), which was at the southwestern Taiwan (Fig. 3). The water in the nearby fishpond can flow freely in and out of the stream during the tide change. There are plenty fishing activities in the fishpond and oyster cultivating activities in the LuErMen stream. A total of 21 soil samples and 6 sediment samples were collected during year 1994, 1996, 2001 and 2002, respectively. Detailed sampling information is listed in Table 1. The samples were collected from 6 different regions around the plant as shown in Fig. 1. We used US EPA Method 1613B to analyze both soil and sediment samples. The reported data all fulfill the QA/QC requirements. A HP-5890GC/Fisson Autospec Ultima HRMS equipped with a J&W DB-5ms fused-silica capillary column (60 m × 0.25 mm i.d. × 0.25 μm film) was used for instrumental analysis. A minimum dynamic mass resolution of 10000 (10% valley definition) was maintained. The toxic equivalents (TEQ) were calculated using the international TEF and normalized to weight of dried matter. The data[3] in year 2001 were taken from the report by National Institute of Environmental Analysis.

Results and Discussion

The TEQ of soil and sediment samples are listed in Table 1. All samples show similar characteristic profiles of PCDD/DF homologues with dominant HpCDD, OCDD, and HxCDF, HpCDF, OCDF. The patterns are similar to those reported by Rappe[4], indicating they were contaminated by the same source, presumably the PCP.

The TEQ of soil samples L1-L13 collected from region B, i.e., the manufacturing area, in 1994 ranges from 0.239 to 1357 ng TEQ/g with a mean of 179.8984 ng TEQ/g and a median of 59.53 ng TEQ/g. Both the mean and median are much higher than the soil standard of 1 ng TEQ/g. The TEQ of soil samples L14-L16[5] collected from a pond in region A two years later. The TEQ ranges from 163.367 to 1857.358 ng TEQ/g. They are still within the same range of those collected in 1994. The TEQ of soil sample L17 collected from region C in 2001, where was used to store the waste from the plant, was as high as 184 ng TEQ/g. This unexpected high dioxin level was worried by the local residents, who speculated if the waste migrated outside the plant or shipped to elsewhere for disposal. The TEQ of soil samples L18, L19 from the neighboring vegetation area is 1.090 and 1.280 ng TEQ/g, respectively. They are still above the regulatory standard. In 2002, the worry by local residents became nightmare when the TEQ of soil sample L20 collected from region F, where a paved road was just completed, is 16.5 ng TEQ/g. The existing data suggest that dioxin contaminated area is not restricted to the manufacturing site only. The waste might be dumped in neighboring area. In response to this concern, an immediate and

comprehensive sampling and analysis of soil samples form larger area surrounding the AnShun site is suggested.

The sediment samples collected in 1996 were from the same pond next to the fishpond at a depth 0-9 cm, 10-18 cm, and 19-27 cm, respectively. The decreased TEQ from the upper to deeper sediment, namely from 891.956, 16.397, to 4.611 ng TEQ/g, indicates that PCDD/DFs continuously flowed into the pond. The PCDD/DFs in the pond could flow freely into the neighboring fishpond. The sediment samples S4, S5 collected in 2001 showed 1.360 and 6.220 ng TEQ/g, supporting this presumption. The same sediment sample collected again in 2002 showed 4.169 ng TEQ/g. The same range TEQ of sediments from the fishpond irrespective of the year indicates that the fishpond might have reached a dynamic equilibrium. However, the water in the fishpond could freely flow into and out of the LuErMen stream. The dioxin contamination of the stream and the cultivated oyster can not be underestimated.

In summary, the PCDD/DFs in soil samples from AnShun indicated that the site was heavily contaminated with PCDD/Fs. Limited data implied that the contaminated area expanded from the site to peripheral area. An immediate and comprehensive sampling and analysis of soil samples form larger area surrounding the AnShun site is suggested to define the impacted area. The PCDD/DFs in sediment samples indicated that PCDD/DFs migrated into the neighboring fishpond. The extent of dioxin contamination of the stream and the cultivated oyster are currently under investigation. The collaborative effort by the academic institute, environmental protection NGO and local community led the Government to recognize and look into the long existing pollution problem might serve as the model for soil and groundwater pollution control in Taiwan.

Acknowledgements

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References

1. D.K. Song, P.C.C. Hou, Y.C. Ling, (1997) J. Chinese Chem. Soc., 44, 545-552.
2. R.E. Alcock, K.C. Jones, (1997) Chemosphere 35(10), 2317-2330.
3. Analysis Report, (2001) National Institute of Environmental Analysis, EPA, ROC.
4. C. Rappe, (1994) *Fresenius* J. Anal. Chem. 348, 63-75.
5. P.C.C. Hou, (1997) Master Thesis, National Tsing Hua University, ROC.

Table 1. Sampling information and concentration (ng TEQ/g dried matter) in soils and sediments

Sample	Area	ng I-TEQ/g	Year	Reference
L1	B	2.150	1994	1
L2	B	99.95	1994	1
L3	B	115.900	1994	1
L4	B	186.000	1994	1
L5	B	59.530	1994	1
L6	B	117.000	1994	1
L7	B	1357.000	1994	1
L8	B	37.120	1994	1
L9	B	3.013	1994	1
L10	B	0.239	1994	1
L11	B	0.980	1994	1
L12	A	0.554	1994	1
L13	A	1.993	1994	1
L14	B	1857.358	1996	5
L15	B	163.367	1996	5
L16	B	230.758	1996	5
S1	B	891.956	1996	5
S2	B	16.397	1996	5
S3	B	4.611	1996	5
S4	A	1.360	2001	3
S5	A	6.220	2001	3
L17	C	184.000	2001	3
L18	D	1.090	2001	3
L19	D	1.280	2001	3
L20	D	0.336	2002	This work
L21	F	16.500	2002	This work
S6	A	4.169	2002	This work

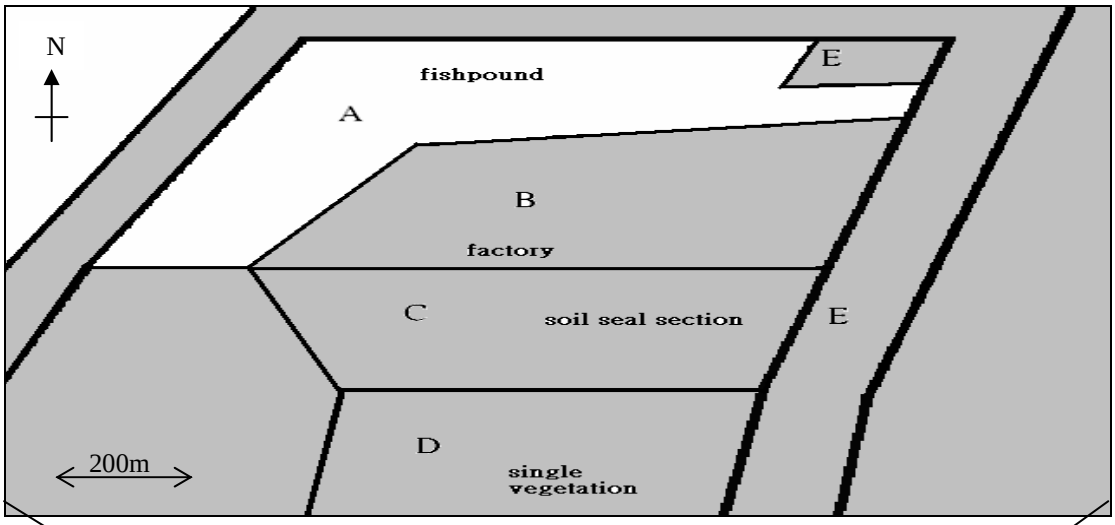

Figure 1. The area map of the AnShun factory in 2001

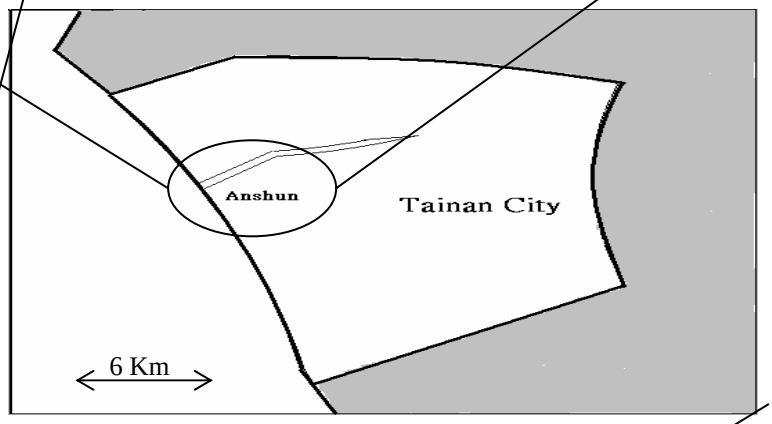

Figure 2. The location of AnShun factory