

## SITE INVESTIGATIONS AND HUMAN RISK ASSESSMENT FOR A MERCURY AND DIOXINS CONTAMINATED SITE IN TAIWAN

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### Introduction

The plant located at southern Taiwan manufactured caustic soda, hydrochloride, liquid chlorine and pentachlorophenol in the early time between 1946 and 1966. After the closure, pentachlorophenol was subject to long-term weathering exposure and pollution has reached subsurface. Besides, on the west side near Lu-Erh-Men Creek and north side near Chu-Fa-Gang Creek, there were many fisheries that the neighboring residents made their living on. Since the start of site investigation in 1982, pollution by dioxins<sup>1</sup> and mercury has been found in surface waters, groundwater, soils and sediments. TWEPA (Taiwan EPA) also found in 2003 the residents had high levels of PCDD/Fs in their blood. This led to concerns about the possible effect of dioxins pollution on the health of neighboring resident. In March 19, 2004, TWEPA announced these area be "Soils and Groundwater Pollution Remediation Site", a site that need to take action.

This project was focused on the investigation of contaminants distribution outside the plant, and on the human risk assessment of residents in this neighborhood. Possible remedies were also recommended.

### Materials and Methods

The site TWEPA declared includes 15.4 hectares of plant area (B Zone: Liquid Chlorine Plant; C Zone: Pentachlorophenol Plant), 4.7 hectares of homogeneous plantation area (Zone D), 14.2 hectares of seawater storage lagoon (Zone A) and 1.5 hectares of brushwood area (Zone E). ITRI conducted site investigation in 2005 within EPA declared range, surrounding fishery farms, Lu-Eer-Men Creek and Chu-Fa-Gang Creek.

There were 585 sets of soil/sediments samples, 87 sets of groundwater samples from 12 standard groundwater monitoring wells and 50 piezometers.

The Standard Guide for Risk-Corrective Action Applied at Petroleum Release Sites, RBCA, issued by the American Society for Testing and Materials, ASTM<sup>2,3</sup>, was used for human risk assessment. Gaussian and Domenico Dispersion Models were used to calculate contaminants transport in the air and groundwater, respectively. Mercury and 2,3,7,8-TCDD that both found in this site were selected as the chemicals of concern (COCs). Because the contaminants distributions were quite uneven, 17 areas of concerns (AOCs) were categorized as the "sources". Staffs and students at the elementary school in this neighborhood were designated as receptor 1 and 2, respectively. People who still live in the two old dormitories by the plant are receptor 3.

### Result and Discussions

Result of contaminants distribution is shown in Figure 1. Outside the declared areas, the staff dormitory at north of the site was found to have mercury level in soils as high as 24.9 mg/kg, exceeding the local soil control standard, the action level. Dioxins were found in the sediments from fishery farms and the two creeks with concentrations as high as 1,670 ng-I-TEQ/kg, which exceeded the local soil control standard, 1000 ng-I-TEQ/kg. Soils in the dike at the south side of the plant also had dioxins at levels as high as 3,700 ng-I-TEQ/kg. Within the declared site, both the dioxins and mercury concentrations in soils exceeded soils pollution control standards. The highest mercury concentration was found in liquid chlorine plant and had a level as high as 3,370 mg/kg in soil. Among all, the worst dioxins pollution was at pentachlorophenol manufacturing plant with levels as high as 64,100,000 ng-I-TEQ/kg in soil. It was also noticed that both dioxin concentrations in the surface (0~30 cm) and

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subsurface (30~45 cm) soils exceeded the local soil control standard. The groundwater at pentachlorophenol manufacturing plant had pentachlorophenol at levels as high as 563 mg/L.

Results of this investigation indicate the pollution by dioxins and mercury could have affected the health of residents in this neighborhood. The results of risk assessment (Figure 2) calculated by Tiered 1 approach for receptor 3 showed that the carcinogenic risk<sup>4,5</sup> caused by dioxins in the old dormitory area was the highest among all receptors. The highest characterized risk was 1.24E-04, with a mean value of 5.79E-06. For receptors 2 and 3, the risk characterized by Tiered 2 approach showed that both the calculated carcinogenic risk and hazard index from all 17 AOCs, including the four highly contaminated plants, were far below the recognized acceptable risk level ( $1 \times 10^{-6}$ ).

Based on the investigation results, three possible options for the next phase were suggested. One is to conduct soil and groundwater remediation; another one is to take institutional control forbidding any activities on this area; the last one is to take on-site sealing and storage. The estimated cost for taking soil and groundwater remediation is about NT\$ 5 billion, however, it might provide the ultimate solutions. Constitutional control costs the least, but it requires a fair amount of efforts on monitoring. On-site sealing and storage was suggested to be the most practical way for this contaminated site.

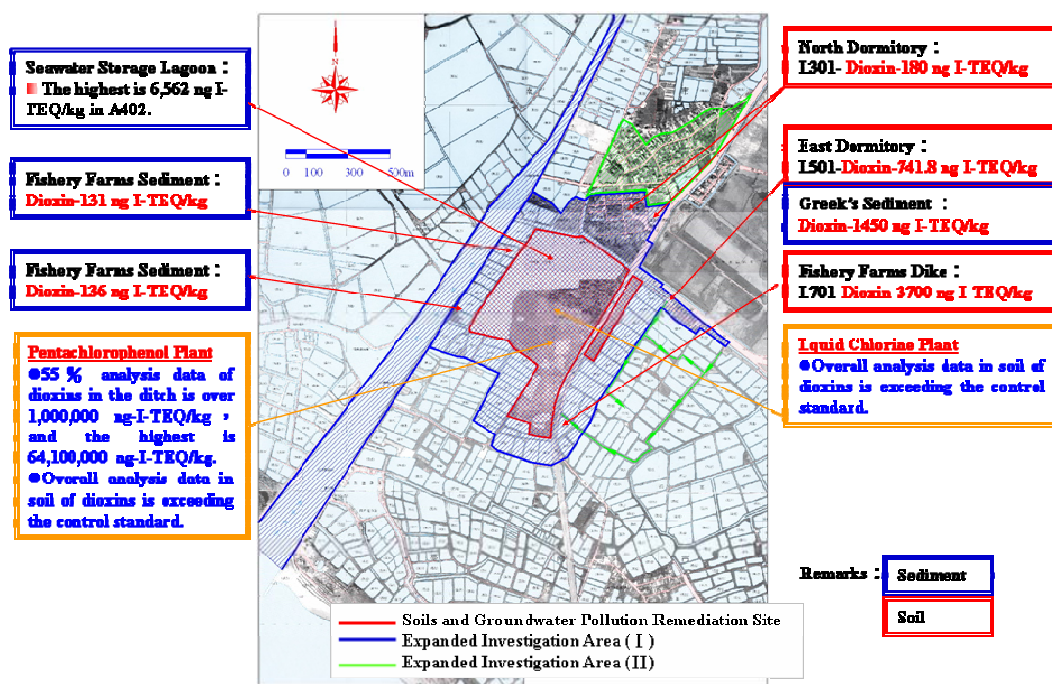


Figure 1. Concentration distributions of mercury and dioxins of the site (Only the highest concentrations were shown)

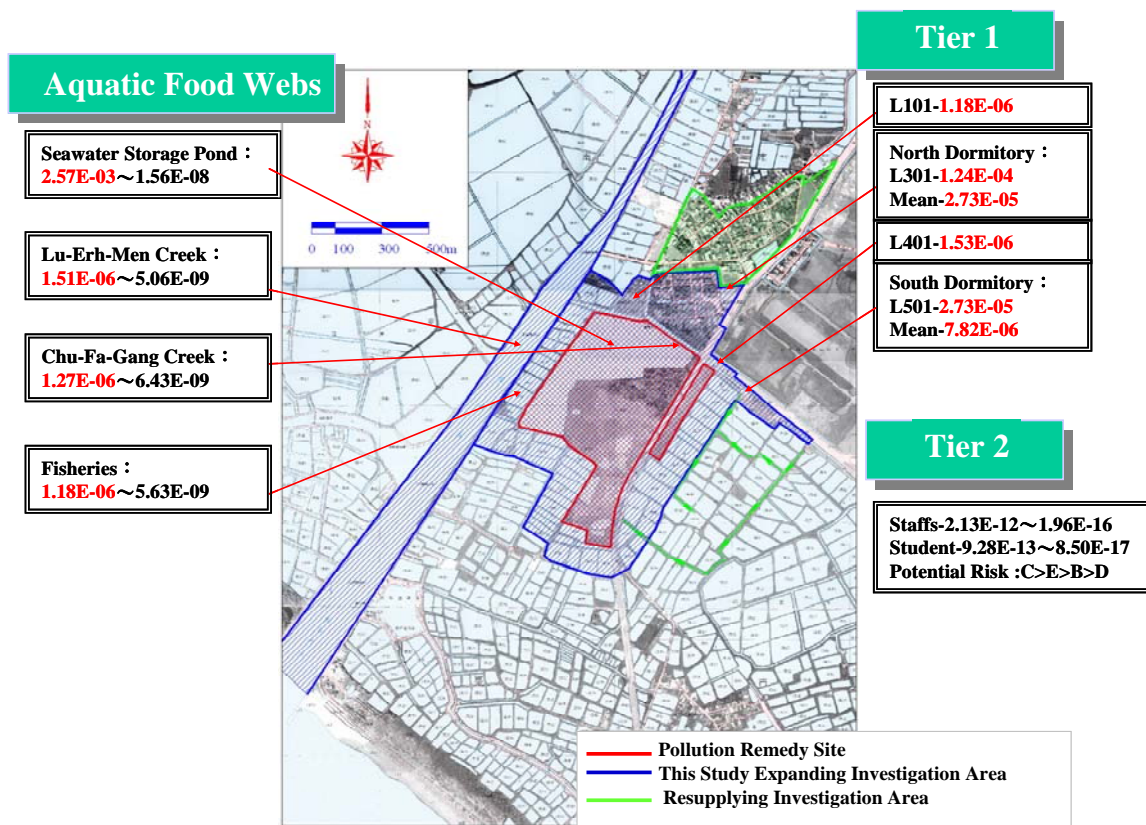


Figure 2. Results of the risk assessment

### Reference

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