Papaya Tree at the Border:  
Challenges of Risk Management in a Developing Country

Yi-Ping Lin, Chang-Chuan Chan

林宜平、詹長權
台大公衛學院健康風險及政策評估中心、職業醫學與工業衛生研究所

Center for Health Risk Assessment and Policy, and Institute of Occupational Medicine and Industrial Hygiene, College of Public Health, National Taiwan University (e-mail: yipinglin@ntu.edu.tw)

Abstract

Background: In 2003, large-scale environmental remediation projects were started to remediate heavy metal polluted rice paddies in central Taiwan.

Objectives: To explore the historical and social context of the event, we investigated how rice paddies were polluted by wastewater from nearby electric plating factories, and traced the discovery of and the responses to environmental health problems by local residents, legislators, the mass media, the government, and the scientific community.

Methods: We used an ethnographic approach to study the case. Our methods included participant observations, in-depth interviews, policy analyses, media analyses, and content analyses of documents.

Results: Our study revealed how environmental engineers defined the risks and the “borders” of pollution and why local residents were skeptical of the effectiveness of the remediation and reacted in silence to the illegal wastewater discharge.

Conclusions: Our case study demonstrated how complicated environmental pollution problems can be in a developing country. There exists the new challenge of risk management in light of rapid industrial development in conjunction with ancient agricultural technologies.
Introduction

Rice is the most common crop grown on agricultural land in many Asian countries. In Japanese cadmium-polluted areas, there was a close association between the prevalence of Itai-Itai disease and the cadmium concentration in rice (Inaba et al., 2005). Although no adverse health effects have been observed in Korea, long-term metal exposure through regular consumption of contaminated rice poses potential health problems to residents in the vicinity of a zinc and lead mine (Jung and Thornton, 1997).

In Taiwan, heavy metal contaminants in rice have been a major concern of the consumers, government, and mass media since the 1980s. The sources of heavy metal contaminants in farmlands and rice were mainly from industrial wastewater (Chen, 2000). The maps of spatial components of soil containing heavy metals revealed that the sources of contaminants such as cadmium, chromium, copper, nickel, and zinc were highly correlated to the locations of irrigation systems and industrial plants (Lin, 2002).

In 2000, the Soil and Groundwater Pollution Remediation Act was passed in Taiwan. When levels of soil or groundwater pollution exceed set control standards, the site is listed as a “control site”. Control sites assessed to be at high risk are then listed as “remedial sites”, and the polluter or person involved with the land must remediate the site in accordance to the set regulations. A Soil and Groundwater Pollution Remediation Fund was created after consulting the U.S. Superfund and other similar environmental institutions from European countries.

In 2001, 184 acres of polluted rice paddies in Zhang-Hua were promulgated as the first remediation sites under the newly established remediation fund. The Minister of the Taiwan Environmental Protection Administration (EPA) stipulated that the polluted farmland be cleaned up within two years. In 2003, large-scale environmental remediation projects were started to clean up the rice paddies. Under a tight schedule and a limited budget of 6 million US dollars, the remediation project applied methods of soil tilting and acid washing. The whole process of remediation, however, was controversial and created more problems then anticipated.

In this case study, we applied qualitative methods to investigate how rice
paddies in central Taiwan were polluted by wastewater from nearby electroplating factories, and to trace the discovery of and the responses to environmental pollution by local residents, legislators, the mass media, the government, and the scientific community.

Previous studies of environmental regulations in the western world indicate that risk management is one of the most difficult and challenging tasks confronting industrial nations (Jasanoff, 1986). Our case study, however, explores the complicated historical and social context of environmental risk management in a developing country where rapid industrial development is intertwined with ancient agricultural technologies.

**Materials and Methods**

We used an ethnographic approach to study the case. Our methods included policy and media content analyses, participant observations, and in-depth interviews.

We collected available data related to farmland heavy metal contamination in Taiwan from the 1980s to date. This data included media coverage, legislators’ interpellations, government policies, and official records of factories, households, and farmlands. We retrieved detailed data regarding the contaminated farmlands, which included the lot numbers and the concentrations of heavy metals. We participant-observed all major steps of the remediation projects, from farmland investigation, to community information sessions, to the final stage of tilting and acid washing the soil. We in-depth interviewed managers and engineers of remediation projects, local government officials, scientists, residents, farmers, landowners, and members of environmental activist groups.

**Results**

**One Woman’s Fight against Environmental Pollution**

Our case started with one woman’s fight against environmental pollution, which she presented in the Legislative Yuan of Taiwan. In 2001, Legislator Chou Ching-Yu, representing the Zhang-Hua County, urged the EPA and the Department of Health (DOH) to take action in managing and researching the serious environmental
health risks in her district through repeated interpellations. She even went so far as to
take the Ministers of DOH and EPA to the rice paddies to show them first-hand the
wastewater in the irrigation system and challenged them to state if it was hazardous to
human health.

In response to Legislator Chou’s interpellations, the National Institute of
Health (NIH) conducted serial health studies to investigate the health effects of heavy
metal pollution on local residents.

In August 2001, the Taiwan EPA completed an island-wide farmland
investigation of 319 acres. The concentration of eight heavy metals, cadmium, lead,
chromium, copper, nickel, zinc, mercury, and arsenic, were tested in irrigated rice
paddies. Among the 319 acres, there were 184 acres of heavy metal contaminated
farmland located in Zhang-Hua, a county in central Taiwan. There were 179 acres of
farmland with chromium, copper, zinc, and nickel contaminants, and another 24 acres
with lead and cadmium in addition to the other four contaminants (Figure 1).

In 2002, the local government of Zhang-Hua commissioned nine
environmental engineering projects to remediate the contamination within two years
(Table 1). Six projects applied the method of tilting to remediate the 179 acres
without lead or cadmium contamination, one project applied the method of acid
washing to remediate the 24 acres with lead and cadmium contamination, and two
projects to verify the results of the other remediation projects.

We, researchers working in a newly-founded Center of Risk Assessment and
Policy funded by the DOH, decided to take a qualitative approach in the case study to
help solve the environmental pollution dispute.

**Between Edible and Non-edible Papayas**

In our first visit to the field, we encountered edible and non-edible papayas at
a border. Together with health scientists, environmental engineers, local government
officials, landowners, and residents, we were all searching for the defining lines of
contamination in the field.

Rice production was banned in the 184 acres of more than 800 lots of paddies
as soon as they were found to have been contaminated with heavy metals. Farmers of
contaminated paddies were compensated for their financial losses. The line separating contaminated and non-contaminated paddies was defined by the results of random samplings of soil (per square kilometer) and lot numbers (Figure 2). Lots with three or more samples exceeding heavy metal concentrations limits were defined as contaminated. The residents, farmers, and landowners all found the distinction between polluted and non-polluted paddies hard to comprehend. We observed neighboring paddies sharing the same irrigation systems, where only one of them was identified as contaminated. Many farmers complained about the deterioration of the banned paddies due to weeds, garbage, pests, and rats.

Right next to the paddies banned from seasonal rice growing, however, were old fruit trees growing along the border line between polluted and non-polluted areas. Though they considered the lines artificial, local residents continued to try to follow the bans closely. One of the farmers interviewed even divided her papaya trees along the border of rice paddies, identifying trees as edible and non-edible ones. She propositioned the scientists and engineers visiting her land to determine if the edible papayas were carcinogenic (she had eaten many of them already).

**Tilting and Washing the Soil**

“The best solution for pollution is dilution,” was the philosophy behind tilting the soil. Some of the pollution was so serious that the engineers had to dig deeper and deeper to dilute the heavy metal pollution. Many old farmers stood right next to their paddies in tears during the process, watching their work and land be broken apart.

Many field and pot experiments on remediation techniques for contaminated soils were carried out in Taiwan (Chen, 2000). The methods of tilting and acid-washing were chosen by the government and engineering companies without any consultation with the local residents. Local residents were very skeptical of the effectiveness of the remediation and the reusability of their farmland.

“Our Iron-Buffalo (agricultural machinery) will just sink into the tilted soil”, said an old farmer. Many others complained of the damage to their agricultural top-soil. The idea of “acid-washing” was even harder for residents to comprehend. One of the landowners in our interviews, not knowing that the engineers were using hydrochloric acid to wash his land prior to the acid-washing, was convinced that
hydrochloric acid was the strongest poison in the world. “The Japanese used to use hydrochloric acid to kill the aboriginal people in late 19th century,” he said.

Silence of a Community

“Refocusing upstream” is a popular metaphor in medical sociology (McKinlay, 1990). There is, however, a literal upstream in our field. Residents as well as remediation engineers were concerned about the potential re-contamination of their paddies if the electroplating factory remained in operation. As an engineer described, “It’s like getting the clothes all dirty again right after you finish washing them.” “What’s the use of spending all this money cleaning it if you know it will be contaminated again?” asked residents during an information session with a local government official.

Local environmental officials, on the other hand, counter-questioned the local residents and the landlords for not reporting the illegal discharge of wastewater from the nearby electroplating factories. We also notice that from the beginning, contrary to other environmental pollution disputes in Taiwan, there were no organized community groups in this case. Many local residents reacted to the environmental pollution problems only in private conversations.

Many residents worried about mafia involvement if they reported the illegal wastewater discharges to the government. Their other concerns were related to the fact that many owners of the electroplating factories were the residents’ relatives and old friends. In addition, some of the residents were farmers and water contaminators at the same time. There was a long history of economic development and a very complicated social network at the local level.

We traced the social and historical contexts of the farmland contamination in central Taiwan to three centuries ago. During the Qing dynasty (1644-1911), when the early settlers came to Taiwan from Mainland China, the farmers first spent many years building the complicated irrigation systems before tilling the land into rice paddies. With acres of irrigated paddies, central Taiwan became a “granary” through the Japanese colonial period until World War II (WWII). After WWII, the government of Taiwan encouraged farmers to participate in small manufacturing productions in order to promote industrial development. “My living room is my
“factory” was the popular slogan at that time. There were thousands of small factories in central Taiwan manufacturing umbrellas, sneakers, bicycles, and faucets, and marketing them to the US and the rest of the whole world.

In addition to the thousands of manufacturing factories, there were also thousands of small electroplating factories electroplating the small metal parts for the manufacturing industries. Due to the loose zoning regulations during the past 50 years, it was not uncommon for small electroplating factories to stand right in the middle of rice paddies, sharing the water systems for excreting industrial wastewater and agricultural irrigation (Figure 3).

Enforcing environmental regulations in this area has been a headache for the local government. The numerous electroplating factories are small (many of them have fewer than five employees). Once “legal factories” (factories with official registrations) are found to violate the environmental laws by excreting untreated wastewater into the irrigation systems, they sometimes shut down and operate illegally to avoid penalty. Furthermore, factory owners and the neighboring residents were often related. Though the residents complained about the environmental pollution created by the electroplating factories, they were hesitant to report their friends’ or relatives’ violations to the government hotlines.

**Cadmium Rice Once Again**

In 2005, the tilting and washing of 184 acres of rice paddies was completed and the 800 sites were de-listed. Legislator Chou, however, lost her bid for re-election at the end of 2004.

In Zhang-Hua, sun flowers were grown in the “cleansed” rice paddies, as the residents waited for the final stage of field experiments to be completed and to regain the permissions to grow rice again in the de-listed paddies. In July 2006, some newly-grown rice from the “cleansed” land observed in the field experiment was harvested and found to be high in cadmium. The tilted and washed paddies are still unsafe to grow rice. Laboratory tests of cadmium in the soil and irrigation water, however, all fell under the control standards. EPA officials are busy trying to trace the reasons the rice was high in cadmium. They have suggested that the soil’s high acid content may have facilitated the absorption cadmium, or that the rice was of a
different variety that more easily accumulated cadmium.

Discussion

Regulatory Science and Technical Solutions

The “risk society”, in Ulrich Beck’s notion, is not calculable in the way the insurance industry constructed actuarial tables for accidents in factories of the nineteenth century mechanical age (Beck, 1986). Beck’s argument is that our chemical and nuclear industrial processes are producing risks that we cannot see without scientific instruments, that respect no political or class boundaries, and whose causality and thus liability is hard to trace. In risk society, risks accumulate slowly, and are not limited in time and space.

Funtowicz and Ravetz note that “policy-relevant science” or what Jasanoff calls “regulatory science” operates differently from normal science or even consultancy science (Funtowicz and Ravetz, 1994; Jasanoff, 2005). It is not an application of available knowledge to well characterized problems, but highly uncertain, contested knowledge is generated in support of health, safety, and environmental decisions. It requires a quite different sort of peer review and is extended to multiple stakeholders.

Our field experience revealed a wide gap between the lay and professional perspectives on the remediation projects. Though the government’s policy decisions were based on scientific and technical knowledge and data, the definition of and solution to the environmental pollution was not logical to the local people.

Public participation in environmental policies has been a significant issue in the US and many European countries (Jasanoff, 1986, Wynne 1996). Phil Brown (1987) referred to the local ways of knowing as “popular epidemiology”. In our case, the residents’, farmers’, and landowners’ perspectives on pollution and potential solutions were based on their own personal experiences living and working in the polluted areas. They were skeptical of the provided definition of pollution, the effectiveness of the remediation projects, and the reusability of their farmland.

New Challenges of Risk Management in a Developing Country

In Taiwan, as well as many other developing countries, environmental
pollution has begun to emerge in recent years. Our case of heavy metal pollution was a prime example of the complicated relationship between long-term agricultural and rapid industrial development. Having thousands of small factories sitting right next to the rice paddies, and sharing the irrigation system was a unique sight of Taiwan’s “economic miracle.” Not only was the pollution from the multiple sources hard to trace and control, the environmental health risks were also wide-spread and diffused.

In the Black Foot disease environmental epidemiological study in Taiwan in the 1950s, there was high correlation of arsenic concentration in deep well water and the local residents’ disease prevalence (Tseng, 2005). In the Itai-Itai disease in Japan after WWII, there were also good correlations of cadmium concentration in river water, soil, and the elderly women’s disease prevalence (Inaba, et al., 2005). The arsenic in the Black Foot disease area was of natural sources, and the cadmium in the Itai-Itai disease area was from a zinc mine in the upstream.

In our case study, there were thousands of factories discharging at least eight heavy metals into the irrigation systems. To make the scene even more complicated, the rice that was produced from the polluted paddies could be purchased in most supermarkets and consumed by almost all residents of Taiwan. The local residents, on the other hand, consumed rice, fruit and vegetables not only from their own farmlands, but also from the consumer markets. In a modern consumer society the long-term cumulative environmental exposure data were hard to collect and calculate. We wonder if there could be any environmental epidemiological evidence to support the health effect in this case ever.

We echo Brown’s (2003) suggestions that even when quantitative data are needed to determine the existence of environmental health effects, qualitative data are necessary to understand how people and communities experience and act on these problems, as quantitative data can only render a partial picture of health effects and their causes. In our case study, unitary expertise narratives seem increasingly less robust than dialogic ones. It is urgent to involve different stakeholders to meet new challenges of risk management in the developing world.

Acknowledgments/Disclaimers
This project and the author Yi-Ping Lin were supported by grants from the Bureau of Health Promotion, Department of Health of Taiwan (DOH92-HP-1801; DOH94-HP-1801; DOH95-HP-1801). This article, however, does not represent the opinions of the government of Taiwan.
References


Chen ZS. 2000. Relationship between heavy metal concentrations in soils of Taiwan and uptake by crops. Taipei : Food & Fertilizer Technology Center, ASPAC. Technical bulletin149.


**Table 1.** Remediation Projects

<table>
<thead>
<tr>
<th>Projects</th>
<th>No. of Projects</th>
<th>Area (Acres)</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farmland with Cr, Cu, Zn, Ni</td>
<td>6</td>
<td>179</td>
<td>Tilting</td>
</tr>
<tr>
<td>Farmland with Cr, Cu, Zn, Ni, &amp; Pb, Cd</td>
<td>1</td>
<td>24</td>
<td>Acid washing</td>
</tr>
<tr>
<td>Verification</td>
<td>2</td>
<td>203</td>
<td>Random sampling &amp; retest</td>
</tr>
</tbody>
</table>
**Figure 1.** From farmland investigation to farmland remediation

319 acres
Farmland Investigation
2001/8/31

184 acres
Contraindicated farmland
In Zhang-Hua

Farmland with Cr, Cu, Zn, Ni
179 acres

Farmland with Cr, Cu, Zn, Ni,
& Pb, Cd
24 acres

Remediation
2003/6

CHRAP, NTU
Participant Observation
2004/3
Figure 2. Defining contaminated and not contaminated paddies
Figures 3. Irrigation system, rice paddies, and Electric Plating Factories in central Taiwan