CASE STUDY

**NDT Supply.com, Inc.**
**7952 Nieman Road**
**Lenexa, KS 66214-1560 USA**

**Phone: 913-685-0675, Fax: 913-685-1125**
**e-mail:** sales@ndtsupply.com, www.ndtsupply.com

# X-ray Fluorescence Technology Helps Researchers Unearth Pollutants Along Taiwan Island's Coast Line

The island of Taiwan enjoys a warm tropical-subtropical climate with abundant rainfall. As a result, the island has an abundance of flora and fauna diversity such as over 4,200 known named species of vascular plants, over 5,740 species of fungi, and over 19,000 species of wild animals.

However, in the last 50 years, rapid population growth, economic development and inappropriate use of natural resources had disrupted the ecosystems and caused the extinction or near extinction of many species.

To arrest these ecological disruptions, the Taiwan Endemic Species Research Institute (台湾特有生物研究保育心 also known as ESRI) was established in 1992 as a government experimental research unit under the Council of Agriculture, Executive Yuan.

With its mission and goal to sustain Taiwan's biodiversity, ESRI focuses on the island's endemic species, precious and rare organisms, and conducts species distribution, ethnic groups, ecological history, habitat environment, rehabilitation methods and ecological education.

Thermo Scientific portable XRF analyzer for instant analysis of heavy metals along the coast of Hsinchu county.

The coast of Taiwan's Hsinchu county. Image provided by Dr. Ching-Yu Liou of Endemic Species Research Institute (ESRI).

Under the vision of "researching biodiversity for the present and the future", ESRI manages the monitoring, collection and analysis of important biodiversity information via information networks through the establishment of partnerships among civil society, government and academic institutions to promote the sustainable development of species conservation.

Dr. Jia-Dong Yang, Director of ESRI, said, "The task of conserving biodiversity is fraught with challenges and requires much time and effort. ESRI's employees care deeply for the land they live on, so much so that they have made it their life's vocation to protect Taiwan's biodiversity and to conserve the integrity of its natural environment. With the support and guidance of government, experts and academics at home and abroad, ESRI aims to become the cornerstone of local biodiversity conservation efforts, and to ensure the genetic, species and ecological diversity of Taiwan for the sustainable use of future generations."

Dr. Ching-Yu Liou is Associate Researcher with Wetland and Coastal Ecosystems, one of the four laboratories within the Division of Habitats and Ecosystems at Endemic Species Research Institute (ESRI). She discusses her work, the challenges that her team faces and how her work helps to make the world cleaner, healthier and safer for everyone.

**1. What is your main area of research and how many years have you been doing research on the coast?**

I have been conducting research on Taiwan island's coastal wetland for many years specializing in the study of the ecology and biology, monitoring of the wetland and assessment for breeding and rehabilitation of plants, and the taxonomy of vegetation.

In my long-term research and monitoring of our coastal wetland, I have discovered that some native species of wetland animals have disappeared over the years. This study of our wetland – from plants to ecology including the study of algal reef – has been a dedication of 26 years, taking me throughout Taiwan island's coastlines.

**2. What are the challenges that you face throughout the research process?**

It has been incredibly challenging and there have been times that I feel helpless. Let me explain: my research is as I have stated – the study of ecology which examines the relationship between organisms and its environment in our coastal wetland – but in reality, I have discovered the impact of pollution from heavy metals on plants and animals in our wetland. Toxins from heavy metals have caused serious biological changes on these communities.

Dr. Liou at her desk looking at the data collected.

Dr. Liou, Associate Researcher with Wetland and Coastal Ecosystems, a lab of the Division of Habitats and Ecosystems at Endemic Species Research Institute.

**3. How does your team work with local stakeholders to make the world cleaner, healthier and safer?**

Our long-term research and monitoring of the ecological developments on the coastal wetland have enabled us to publish quality data for reference by various foundations, universities, conservation groups and environmental organizations. We have also held public lectures and talks to raise awareness of the ecological crisis in Taiwan's coastal wetland.

My work enables me to publish analyses including 'Metal Contents in Algal Reefs of Guanyin Coast in Northwest Taiwan' (台湾西北部观音藻礁海岸重金属含量分析), 'Heavy Metal Contents in the Soil of Miaoli Coast' (苗栗海岸土壤重金属含量分析) and 'An Analysis of Heavy Metal Contents Along the Coast of Southeastern Taiwan' (台湾东南部海岸底质重金属含量分析).

My passion for Taiwan's ecology has driven me to publish books such as 'Treasure Taiwan's Algal Reefs' (珍爱台湾藻礁) and 'Rescuing Taiwan's Algal Reefs – The Disappearing Cornucopia of Life' (抢救台湾藻礁一消失中的生命聚宝盆). These books chronicle the beauty and tragedy of Datan region's algal reefs which are regarded as one of Taiwan's natural assets. My wish is for more people to appreciate their natural beauty and join in the conservation and restoration efforts of these algal reefs. The Datan algal reefs are indicative of the state of environmental well-being along Taiwan's coastline.

I hope that my work on the study of wetland ecology along the coastline could also benefit other scientists and researchers elsewhere around the world who could be grappling with similar challenges.

## Illegal Materials Dumped Along Coastline

Dr. Liou uncovered the impact of illegal dumping on the coast of Hsinchu County located in the north-western part of Taiwan island in Xinfeng Township, a rural area that also served as the major manufacturing and industrial center of Hsinchu County.

This site, located on the coastline, was a temporary revetment of hearthstones and industrial-sized storage bags (known as flexible intermediate bulk container which could store up to 1,000 kg or 2,200 lb of materials) filled with unknown soil materials.

The storage bags were simply stacked along the coast where waves from the daily tide struck, causing severe damage to the bags. As a result, the unknown soil materials spilled out.

## Speeding Up Discovery and Analysis

In order to assess the impact of the illegal dumping on the coast of Hsinchu, Dr. Liou divided the long coastline into 15 sections – from the mouths of each river to the adjoining areas along the coastline – and within these sections there were 65 stations for the collection of samples for research.

She focused her study on the rich biodiversity of plant and animals in the intertidal zone as well as the habitats of microorganisms in this region. The intertidal zone is the area of the marine shoreline exposed to air at low tide but covered with seawater at high tide. Sample collection in this region was performed between 2012 and 2015 with materials such reefs, sand, mud, gravel and hearthstone. “Using a handheld X-ray fluorescence (XRF) spectrometer, we determined the presence of 32 types of elements, including heavy metals, in our samples. In total, we analyzed 507 samples during this period of time,” said Dr. Liou. “Through our research, we found that a bulk bag filled with toxic waste could spill its contents and pollute the coastal region due to the impact of the daily tidal waves. We discovered abnormalities in the neighboring algal reefs and in oysters in the Shihu area due to the prolonged exposure and cumulative absorption of these pollutants.”

Dr. Liou demonstrating the use of XRF analyzer on the soil.

## Dangers to Humankind

In sample collection exercise that involved drying of the samples prior to sending for costly laboratory analyses, elements of some volatile heavy metals could not be detected after the sample had dried. This was a major concern for Dr. Liou as the undetected heavy metals could still be absorbed by fish and other forms of marine life.

“There are many fishermen along this coast which means that the fish or shellfish living in the polluted coastal region would be consumed by humans. Prolonged consumption of toxic heavy metals can cause serious health issues,” said Dr. Liou.

## The Use of XRF Technology

Years prior to her work on Hsinchu, Dr. Liou had previously conducted research on the coast with the assistance of academic organizations to analyze heavy metals. She explained, “The process from sending samples to getting their analysis and reports took a long time. If we needed to test for more trace elements, we would need to incur additional costs which then forced us to choose between added costs or the tests that we needed.”

Finally, Dr. Liou decided to undertake the analysis in-house by investing in a handheld XRF analyzer. She said, “The XRF spectroscopy would be an excellent technology for qualitative and quantitative analysis of material composition as we could conduct on-site analysis of the samples for heavy metals quickly. In fact, we have been using this technology for over 10 years.”

Explaining further, Dr. Liou said, “The XRF spectroscopy provides real-time analysis with detailed data, and it can even save the data for comparison work at a later stage. Using the accurate analysis provided by this XRF analyzer, I am empowered to make fast and effective evaluation in my research on the pollutants and various environmental factors.”

X-ray fluorescence (XRF) spectroscopy is a non-destructive analytical technique used to determine the elemental composition of materials.

XRF analyzers can detect elements and determine their concentrations in samples by measuring the fluorescent (or secondary) X-rays emitted from a sample when the surface of the latter is struck by a primary beam of an X-ray source.

Each of the elements present in a sample produces a set of characteristic fluorescent X-rays ("a fingerprint") that is unique for that specific element, which is why XRF spectrometry is an excellent technology for qualitative and quantitative analysis of material composition.

**Applications of XRF Analyzers:**

- **Detection of Metals / Alloys**
  - Scrap metal recycling
  - Positive material identification (PMI)
  - Manufacturing QA/QC
- **Environmental Hazards**
  - Soils
  - Industrial lead paint
  - Residential lead paint
  - Dust and air filters
- **Mining**
  - Greenfield exploration
  - Brownfield exploration
  - Oil & gas exploration
  - Grade control
  - Rare earth elements
- **Coatings**
  - Metal coatings
- **Precious Metals**
  - Jewelry & precious metals analysis
  - Automotive catalysts
- **Art & Archaeometry**
  - Metal Artifacts, pigments & ceramics, etc.
- **Consumer Goods**
  - Children's toys, apparel, jewelry & furniture, etc
  - RoHS/halogen-free/WEEE

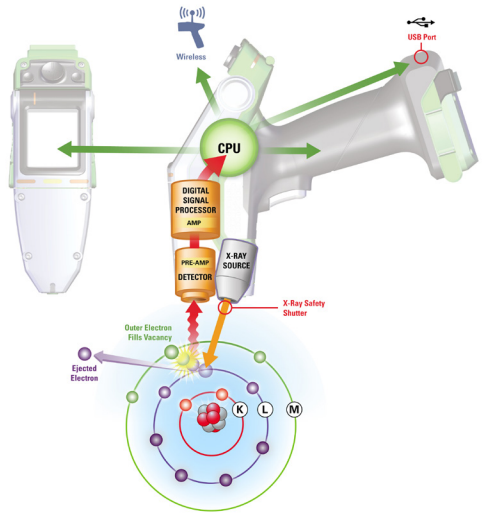
**How XRF Works:**

1. A solid or a liquid sample is irradiated with high energy X-rays from a controlled X-ray tube.

2. When an atom in the sample is struck with an X-ray of sufficient energy (greater than the atom's K or L shell electron's binding energy), an electron from one of the atom's inner orbital shells is dislodged.

3. The atom regains stability, filling the vacancy left in the inner orbital shell with an electron from one of the atom's higher energy orbital shells.

4. The electron drops to the orbital shell by releasing a fluorescent X-ray. The energy of this X-ray is equal to the specific difference in energy between two quantum states of the atom, i.e. of the element. The measurement of this energy is the basis of XRF analysis.




**Lab-quality Results in the Field**

Thermo Scientific portable XRF analyzers have become the standard for non-destructive elemental analysis in a wide range of applications.

Our systems are routinely used for rapid quality control inspection and analysis to ensure product chemistry specifications are met. Lightweight and easy to use, these instruments provide instant analysis in any field environment.

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