行政院環境保護署
Environmental Protection Administration
Executive Yuan, R.O.C. (Taiwan)

Sharing lessons-learned: POPs/Dioxin pollution assessment and remediation in Vietnam

Utilizing Biological Rapid Screening Technology to Implement Nationwide Survey of Dioxin Level in Taiwan

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Environmental Analysis Laboratory

Outline

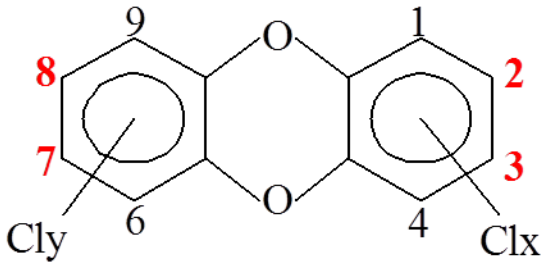
- Introduction
- Introduce Biological Rapid Screening Method
- Improve Chemical Method
- Nationwide Survey of Dioxin Level in soil
- Conclusion

Introduction

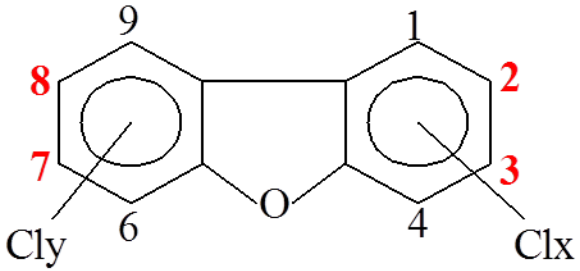
Garbage Resource Recycling (incineration) Plant Building Plan

Since 1991, in compliance with "Garbage Resource Recycling (incineration) Plant Building Plan in the Taiwan Area" enacted by the Executive Yuan, and the "Promotion of Public and Private Participation in Building Refuse Incineration Plant Program" enacted in 1986, the Environmental Protection Administration (EPA) established 21 refuse incineration plants, either by public or via public-private partnership and planned to build another 15 refuse incineration plants by private enterprises.

Dioxin-like Compounds

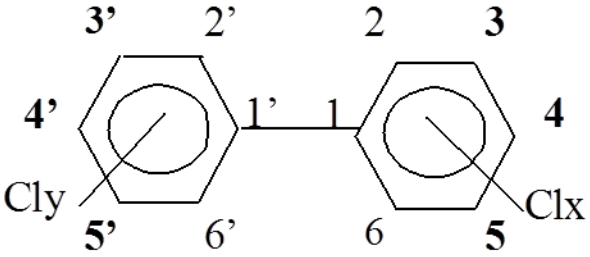


PCDDs(75)



PCDFs(135)

17



PCBs(209)

12

Persistent Organic Pollutants, POPs

First Dioxin Lab in Taiwan(1996)

Environmental Analysis Laboratory, EPA, Taiwan

HRMS 4sets

International Accreditation

GC/HRMS(2001)

DR-CALUX®(2004)

Conventional Method

(Performance-based)

Extraction

Concentr-ation

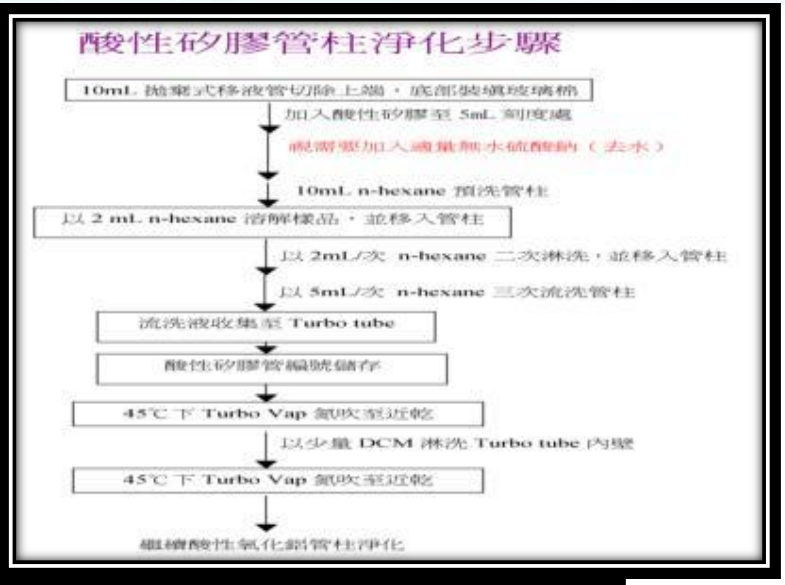
Silica column

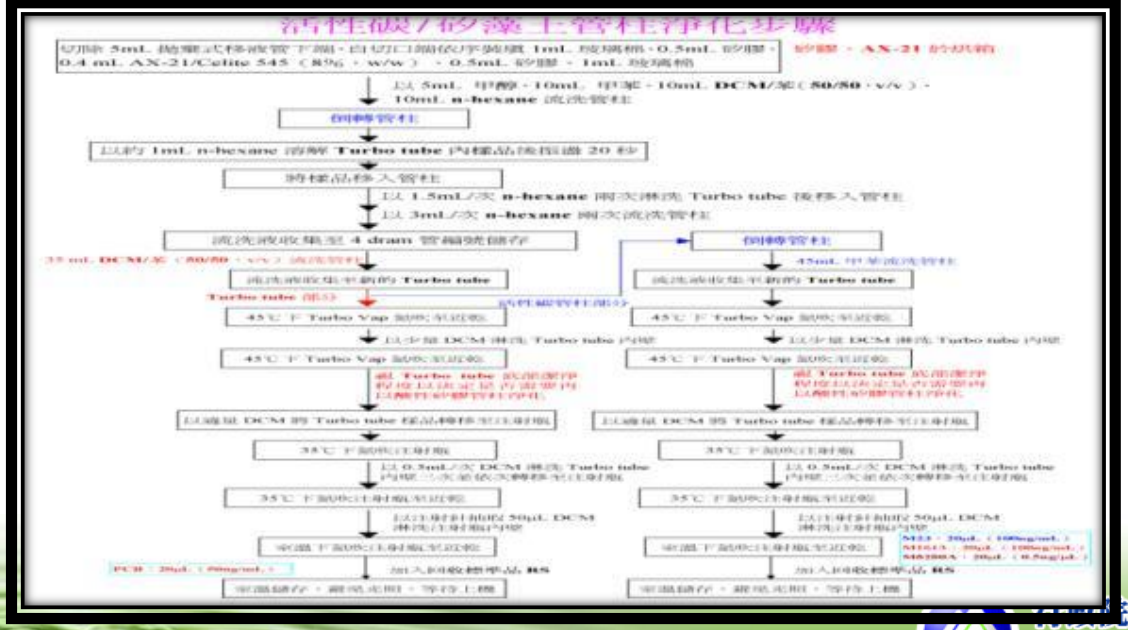
Alumina column

Carbon column

GC/HRMS

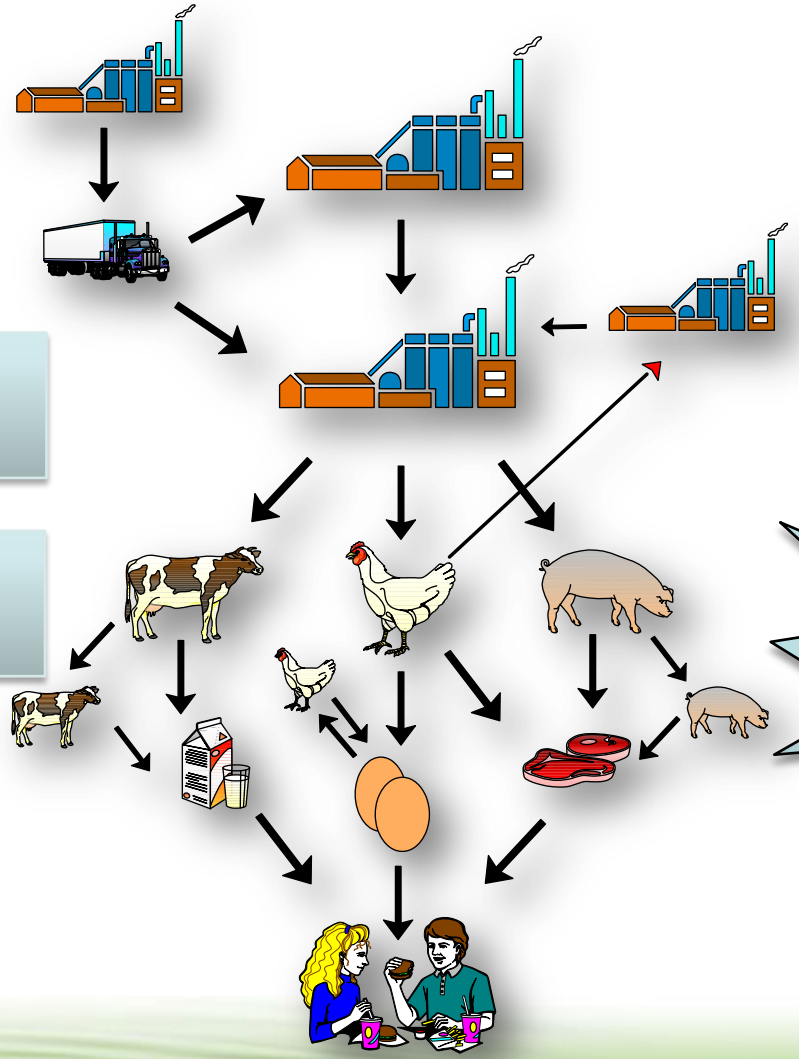
Conventional Cleanup Procedure





Belgium crisis in 1999

Ron Hoogenboom, 2005



US $1700/sample

1 month /batch

Milestone

Pollution site & Food contamination

Pollution site

Food contamination

Dilemma of GC/HRMS method

- **Expensive**
- **Time-consuming**
- **Low throughput**
- **Contamination by high concentration sample**

📖***Introduce screening technology***

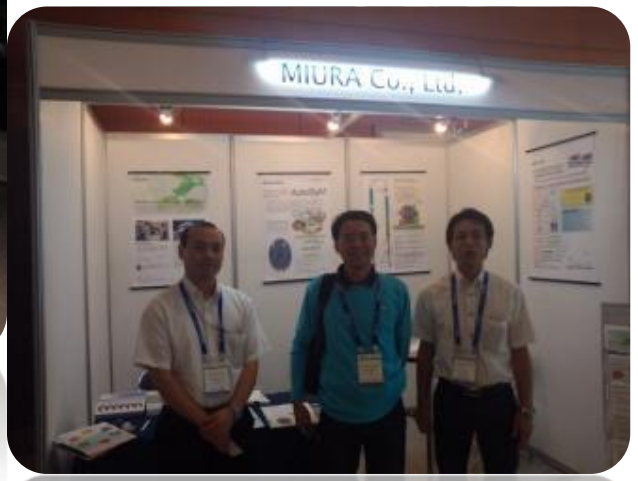
📖***Improve chemical method***

Introduce Biological Rapid Screening Method

Dioxin Conference

2003 in Boston

2007 in Tokyo



2013 in Daegu

Foreign Biological Screening Method

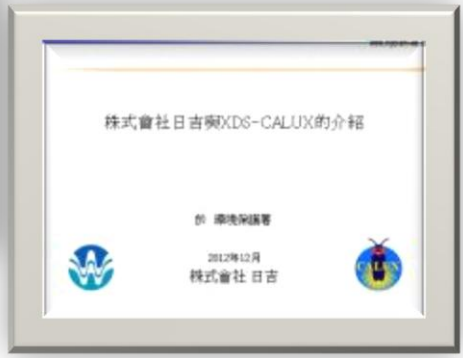
2004：DR-CALUX®
（BDS, Nelerland）
（EU approved）

2005：ELISA
（CAPE, US ）
（US EPA M4025）

2008：Procept®
（Eichrom, US ）
（US EPA M4430）

2013：XDS-CALUX®
（HIYOSHI, Japan）
（US EPA M4435）

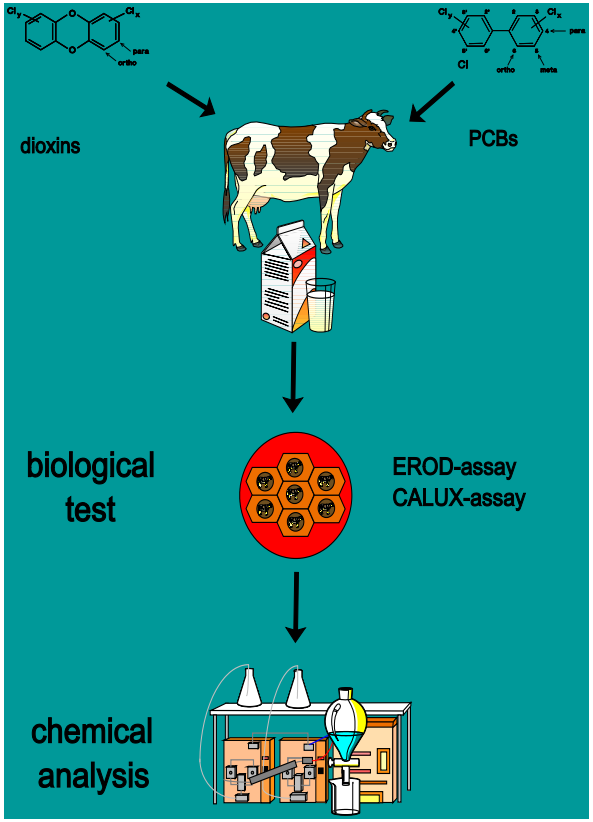
On-site training



Connection

Screening method for dioxins

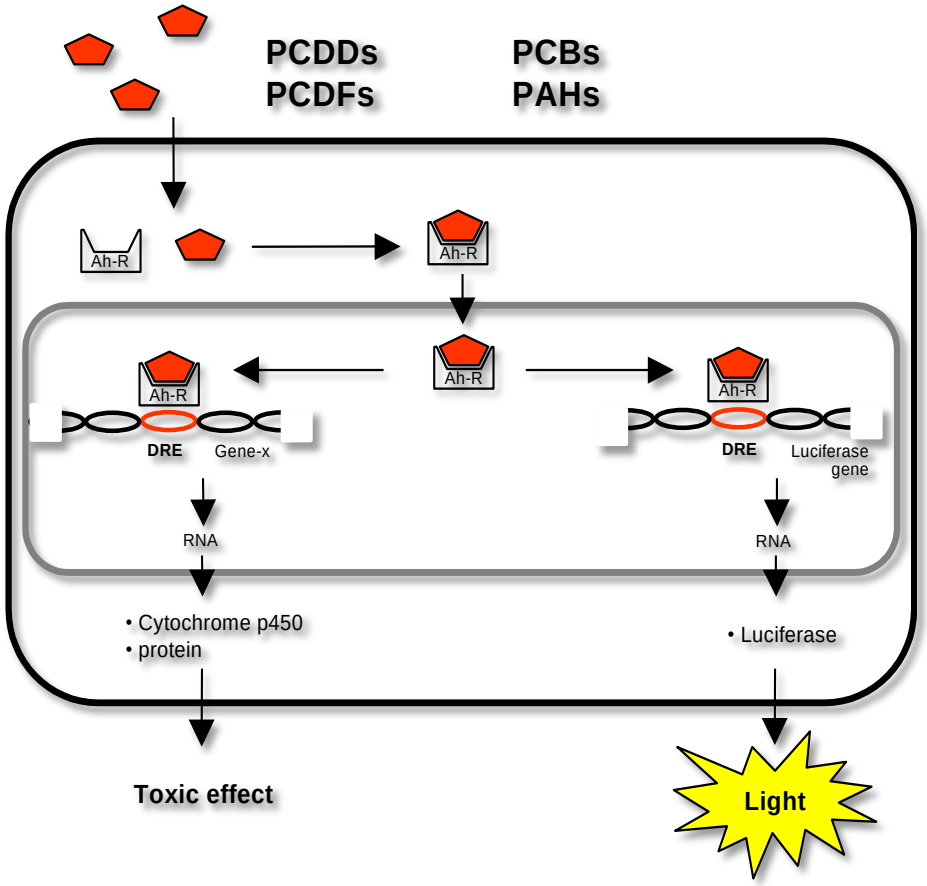
- ***Requierments:***
  - quick and relatively cheap
  - high sample thoughput
  - rapid expansion of capacity (crisis)
  - no false-negatives, few false-positives
  - sensitive at low levels
  - obeying the TEQ-principle



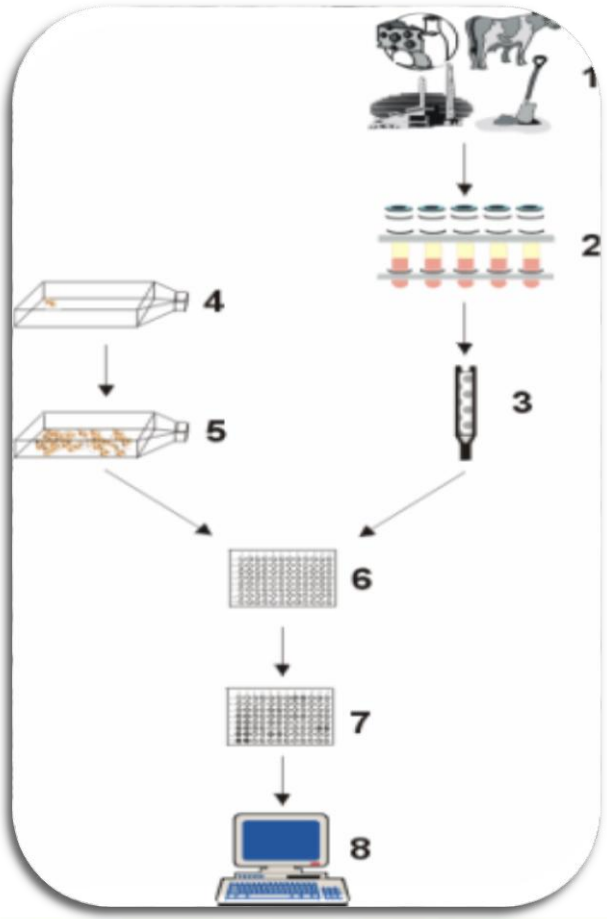
Ron Hoogenboom,2005

CALUX ®

（US EPA M4425 & M4435；DR-CALUX ®）



DR-CALUX®Procedure



1. *Sampling*
2. *Extraction*
3. *Fractionation / clean-up*
4. *Cell culture (a)*
5. *Cell culture (b)*
6. *Exposure in 96-well plates*
7. *Quantification light emission*
8. *Data handling*

ELISA Pretreatment Kit

SP3 Sample Preparation Kit

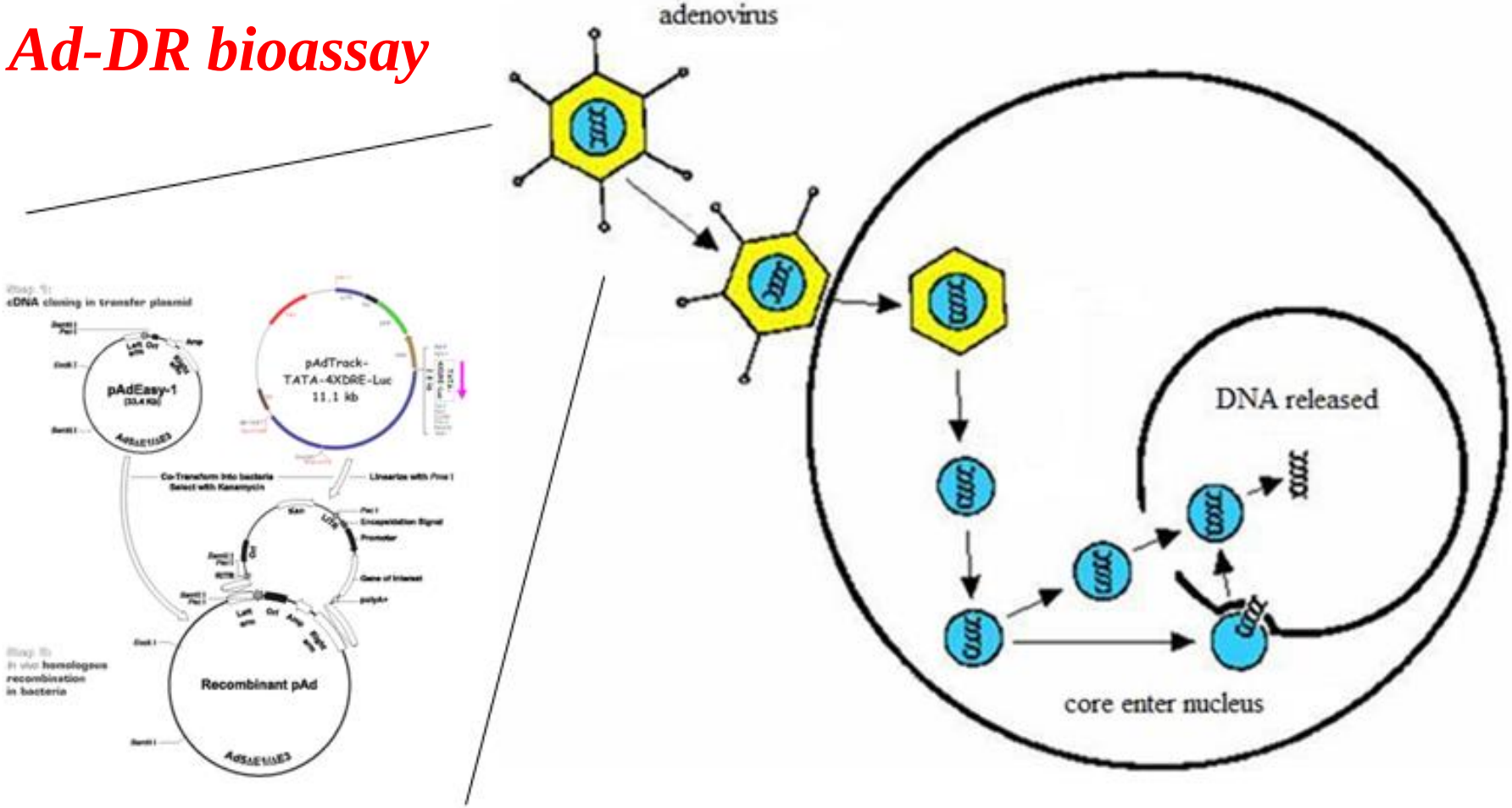
SP2-ST Sample Preparation Starter Kit

SP2-RK rack for column procedure

www.cape-tech.com

Taiwan's Bioassay

Ad-DR bioassay



- We established a new method to obtain **US Patent No. US 2011/0229904 A1.**

Ad-DR bioassay

- Patent: No. US 2011/0229904 A1
- Local bio-technique in Taiwan
- Developed by **Division of Environmental Health and Occupational Medicine, National Health Research Institutes (DEHOM/NHRI) in Taiwan**
- One of ***in-vitro*** **AhR reporter gene assays**
- High sensitivity for dioxin measurements

Substitute GC/HRMS?

HRGC/MS TEQ calculation

Compound 1:	*concentration 1*	*x TEF1 =*	*TEQ1*
Compound 2:	*concentration 2*	*x TEF2 =*	*TEQ2*
Compound 3:	*concentration 3*	*x TEF3 =*	*TEQ3*
Compound n:	*concentration n*	*x TEFn =*	*TEQn* +

Total dioxin toxicity of mixture: ***SumTEQ***

Biological Screening

Confirmation **Finger print**

GC/HRMS

Improve Chemical Method

Disadvantage of Soxhlet

- **Time-consuming （ >16hrs ）**
- **More reagent and energy consumption**
- **Potential safety factor**

Automatic extractor at EAL

Accelerated Solvent Extractor
（ASE ）(1996)

Soxtherm Extractor
（Soxtherm ）(2006)

www.buchi.com

New Automatic Extractor

Fast Soxlet B811 LSV(2011)

The price is **cheaper** than ASE

High recovery on **fly ash** samples

Can extract large volume samples

The price is close to ASE

Extract **in parallel**

No cross contamination

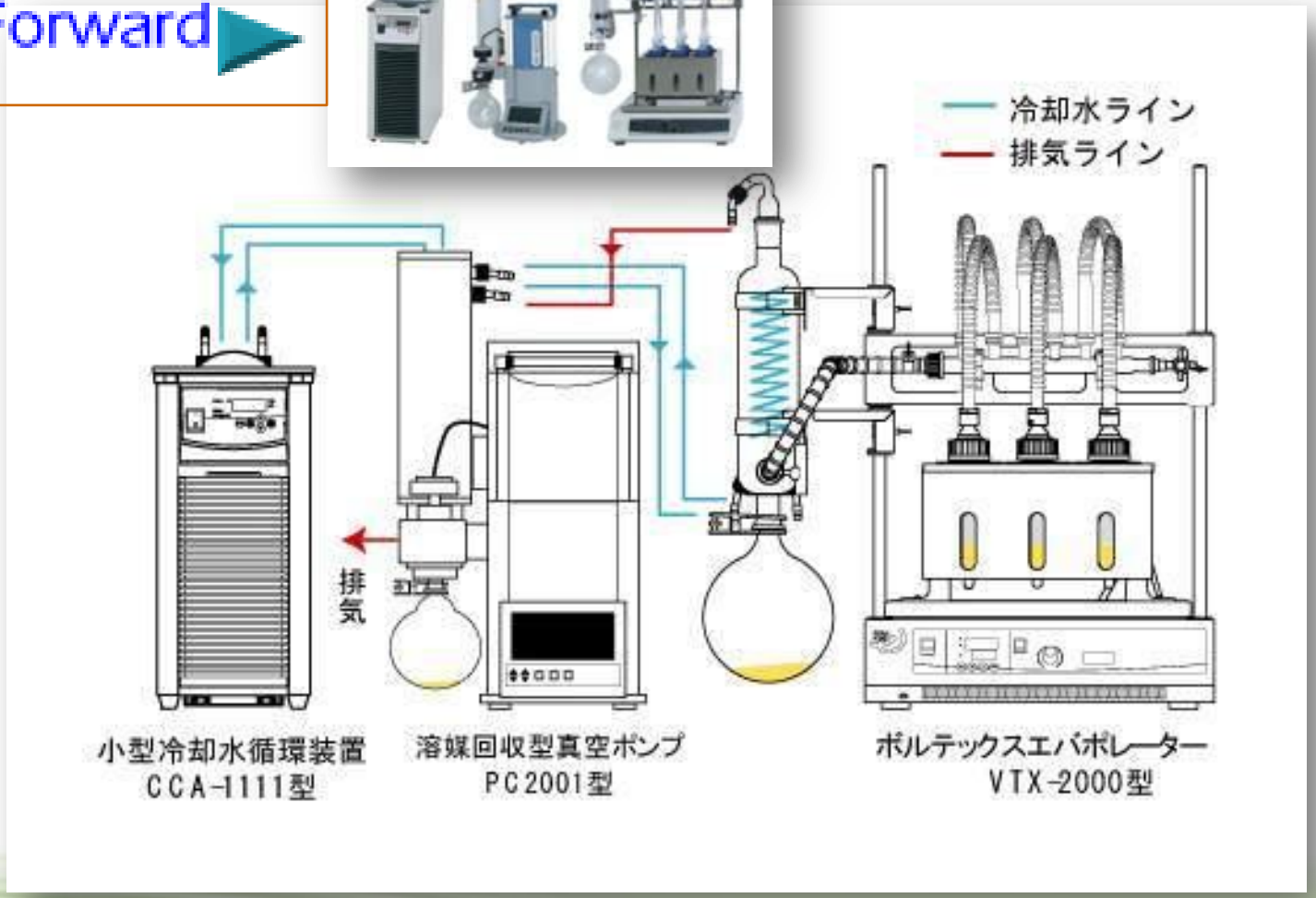
Can not extract large volume samples

Speed extractor E-916(2012)

EYELA Vibration Evaporator

Forward

www.sun-way.com.tw



Improve Cleanup Methods

2005-Power-Prep™

2005-CAPE (Enzyme Immnoassay)

CAPE coupled column

www.cape-tech.com

<US $ 35/sample

Cleanup procedures of CAPE column-1

Used 40mL n-hexane to pre-wash CAPE acid silica column

Set up **CAPE coupled acid silica-carbon column**

Add 10mL n-hexane to rinse and pre-wash column

Add 1mL n-hexane /time x 4 times to transfer sample extract to column.

Add 11mL*1 n-hexane to elute column.

Add 11mL*2 n-hexane to elute column. **(PCBs +PBDEs)**

Remove and transfer carbon mini-column to a clean empty column.

Add 8mL of **1:1 toluene: n-hexane** to elute column **(PCBs +PBDEs)**

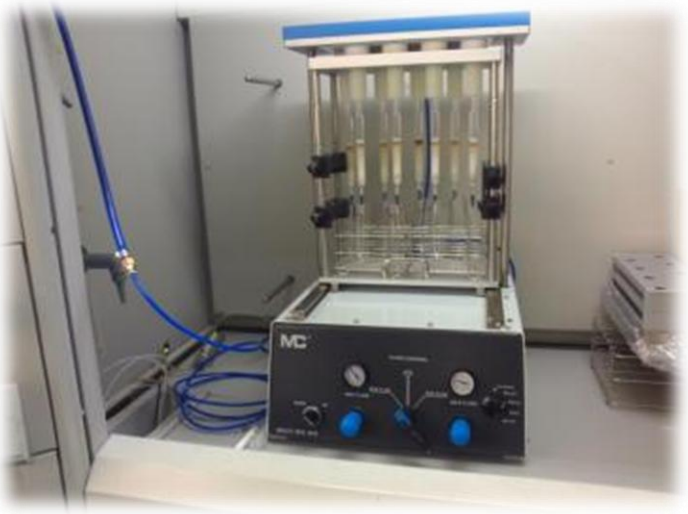
Cleanup procedures of CAPE column-2

Reverse the direction of carbon mini-column

Add 40mL of toluene to elute column (**PCDD/Fs fraction**)

Concentration elute ,then use DCM transfer elute to autosampler vials

New cleanup procedures



Acid silica column(optional)

CAPE coupled column

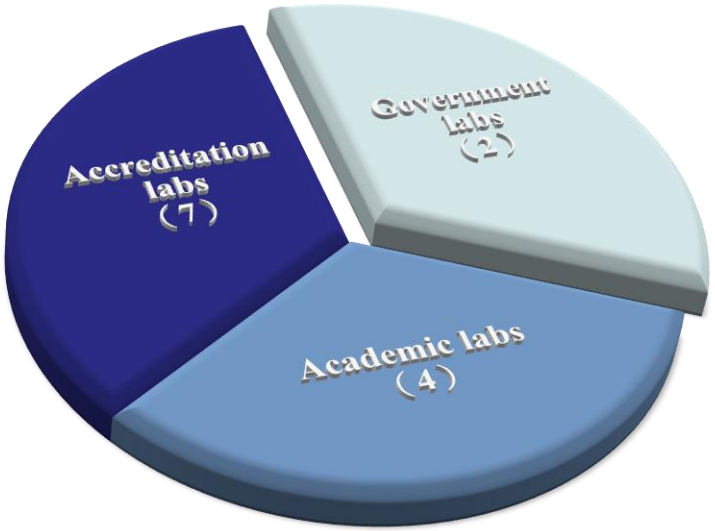
old procedure > 2 days

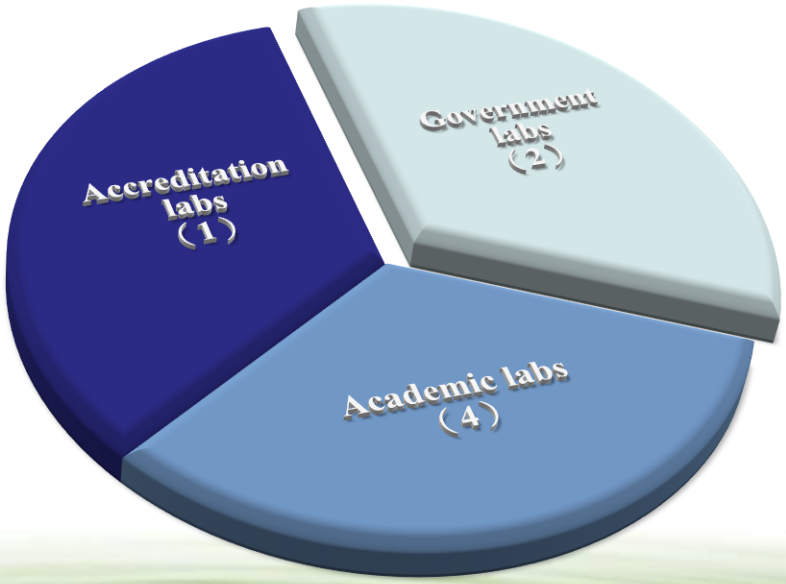
Forward

new procedure < 6 hrs

Share EAL Technology

GC/HRMS Method





Biological Screening Method

Nationwide Survey of Dioxin Level in soil

Best Policy for Large-scale Survey

「Comparison between a rapid biological screening method for TCDDs/TCDFs and chemical analytical methods」
(Anderson et al., 2003)

US EPA M4425 to screening first

Only 10~20% samples need to be confirmed by GC/HRMS method

Nationwide Soil Survey Project

Soil and Groundwater Remediation Fund Management Board

http://sgw.epa.gov.tw/public/En/Default.aspx

- **Since 2011, Taiwan Environmental Protection Agency(EPA) conducted the project of developing screening methods for dioxin in soil and screening for high pollution potential area.**
- **First round project implemented from 2011 to 2012.**
- **800 soil samples were analyzed by screening methods and 80 samples were confirmed by HRMS method.**

High Pollution Potential Area (2011-2012)

North area *unit：ng I-TEQ/kg*

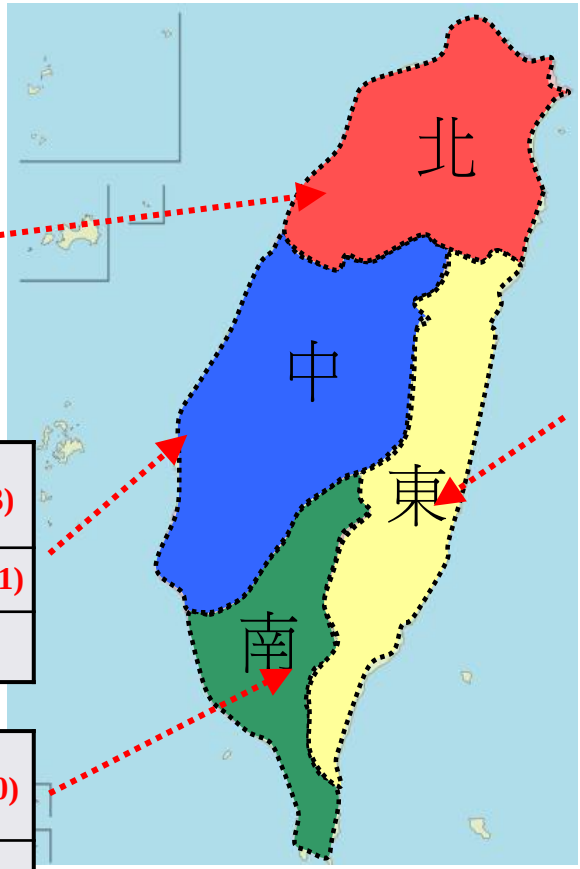
Taoyuan, Guanyin (Guanyin industrial park)	2.9 - 32.5 (18.8)
Taoyuan, Bade	3.4 - 146.5 (21.1)
Hsinchu, Guansi	3.3 - 9.6 (5.8)

Middle area

Changhua, Chengang (Chuansing industrial park)	16.6 – 24 (20.3)
Taichung, Houli	10.2 - 29.8 (23.1)
Changhua, Pitou	5.1 - 8.9 (7)

South area

Kaohsiung, Siaogang (Linhai industrial park)	1.6 - 131.6 (20)
Kaohsiung, Dashu	15.6 - 15.6 (15.6)



East area *unit：ng I-TEQ/kg*

Hualien (meeluen industrial park)	8.1 - 9.4 (8.7)
Hualien, Sincheng	2.6 - 7.9 (5.2)

Second Round Survey Project(2013-2014)

New Strategy is much "Greener"

Cost	Time	Throughput
US $1700/sample	*1 month/batch*	*10 samples/analyst*month*
US $670/sample	7 days/batch	30 samples/analyst*month
<US $200/screening	5 days/screening	100 samples/screening

Less reagent and energy consumption

Conclusion

Conclusion

Biological screening method and new pretreatment procedure are **high throughput**, **cost effect** and **user-friendly**.

Biological **screening first** and the samples over criteria are **confirmed by HRMS method** is the best strategy for large-scale survey project.

Our new strategy is much "**greener**" than conventional one.

Thank you for your attention!

http://www.niea.gov.tw