「物質流評估」座談會

Material Flow Assessment Roundtable

主辦單位：財團法人中技社

Organize by CTCI Foundation

97年11月12日

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討論提綱 Discussion highlight：

1. 物質流技術應用及推動的經驗

   The experience in applying and promoting the MF techniques

2. 政府機關及私人部門在物質流研究及運用上應扮演的角色

   The role that governmental agencies and private sectors should play in MF research & applications

3. 協助物質流評估應用所需之資料庫

   About the data banks required to assist the application of MFA

4. 對台灣政府及企業的其他建議

   Other relevant suggestions to Taiwanese government and industries

5. 台灣可以參與未來國際物質流研究的可能性

   The possibility that Taiwan may join in the future international MF studies

1. Your experience in applying and promoting the MF techniques,

   We have applied Material Flow Analysis (MFA) as a key methodology in more than 100 projects for 1) resources management, 2) environmental management, and 3) waste management. The main advantages of MFA are:

   - it is based on the law on the conservation of matter, and thus permits to link inputs and outputs of systems
   - It is a transparent and reproducible method that can be easily visualized and thus fosters trust building.
   - It serves as a necessary base to solve many problems in the above mentioned three fields

   The main disadvantages are:

   - MFA needs expertise, and, if done for the first time or by inexperienced persons, is very time consuming and expensive. However, with experience it becomes more competitive
   - Data availability is a problem due to data scarcity and data sensitivity. Often uncertainties are large, sometimes even unknown
   - Depending on the stakeholders, MFA are not always welcome due to its transparency

   Promoting MFA is a long term task, beginning with students that later carry this tool into their professional practice. National standards can help to disseminate MFA considerably (see below). Laws on the application of MFA can also support dissemination of MFA techniques. However, caution is needed to prevent the collection of large amounts of useless data, which is counterproductive for the long term fate of MFA.

   We have applied MFA in material flow studies in regions and cities for early recognition of future environmental problems, and to set priorities for remediation and protection measures. Examples are studies of the flow of metals from urban surfaces, metal contaminations by railroads, nutrient management in river basins etc. In waste management, we used MFA because of the lack of reliable data: the redundancy of material flow systems enables to calculate missing data. Thus, it is not necessary to know all inputs and outputs of a waste treatment process. For example, we routinely determine MSW compositions by measuring single, easily measurable outputs of MSW incinerators. More recently, we use MFA for resources management because of its power to model material flows through anthropogenic systems and to assess accumulations and depletions of stocks in the anthroposphere. Examples comprise MFA of iron resources, stocks and wastes in Austria: while the natural metal stocks are being

reduced, the man made stocks are increasing. When the iron resource comes to an end, large amounts of secondary iron resources will become available that will need less energy, materials, and space to produce new (secondary) resources than from primary sources.

In recent activities we are focusing on a systematic approach. An example is the application of MFA for waste management in Austria: We established a National Standard for the use of MFA, defining terms and definitions of MFA methodology as well as scope and range of application. We developed a software (STAN) that is based on this standard and that enables easy assessment and balancing of material flows through waste treatment processes. We were instrumental in setting up a certification process for companies that want to become "certified waste management companies". These companies are required to use STAN and to prepare a material flow analysis of their activities in order to qualify for the certificate. Such an MFA based certification process will continuously improve practice and transparency of waste management.

2. The role that governmental agencies and private sectors should play in MF research & applications,
   Private sector: *apply MFA for optimization of processes and systems on all levels in view of costs, resource conservation, environmental protection and waste production.* Examples are: input and flow control of materials in hospitals for waste prevention and reduction; prevention of copper contamination of railroad tracks by analysis and management of input materials; optimization of waste collection by MFA of waste streams including waste compositions;
   Governmental agencies: *apply MFA for establishing knowledgebases about waste management, environmental management and resources management.* Examples are: establish national resource plan based on MFA data, including both geogenic and anthropogenic stocks. Develop national waste data base founded on MFA data. Install regional environmental monitoring system based on MFA. Establish certification systems for waste management companies based on MFA. Make MFA a legal requirement for environmental impact statements. Establish early warning system for hazardous substances based on MFA.

3. About the data banks required to assist the application of MFA.
   The establishing and acquisition of data banks is costly. Thus before establishing data banks, more research is needed: define clearly the goals and purpose of the databank (-> e.g. "we need a new knowledgebase for goal oriented waste

management")? Which data has to be collected? Which data bank system is appropriate to manage the data? How can existing economic data be used to derive MFA data? Who collects, who manages, who controls and who owns the data?

4. Other relevant suggestions to Taiwanese government and industries,
   Use MFA first in a field where a win-win situation for all stakeholders can be established, thus the positive "image" of MFA can start to grow. Establish a national standard defining terms and definitions of MFA (see for instance Austrian Standard ONORM S 2096 "MFA- Application in waste management"). Enforce the use of this standard in reporting data to the government where appropriate, e.g. in waste management. Establish a national research program on MFA "Advanced Application of MFA for Resource Management, Environmental Management and Waste Management"
5. The possibility that Taiwan may join in the future international MF studies
   (e.g. '97 & '00 WRI reports).
   Establish close ties to EU Universities that excel in MFA (MoU with Universities in Austria, Germany, the Netherlands, Sweden). Participate by joining an European consortium in the EU FP 7 research. Establish contact with Yale University (Thomas Graedel) and join the very large "metals" project be sending PhD or postdoc to Yale. Identify MFA research projects worldwide and join forces with the main players.

11-08-2008 Paul H. Brunner

MFA Roundtable

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Overview

1. Experience in applying and promoting MFA
2. Role that government agencies and private sector should play in MFA
3. Databanks required to assist application of MFA
4. General suggestions
5. International studies


GREETINGS FROM
UNIVERSITY OF N.S.W.
SYDNEY

1 Experience in applying and promoting MFA

- Applications:
  - PhD student case studies
  - Scales: Sydney, MIA, Australia
  - Substances: Cd, P, Cu, Pb, C, As
- Promotion:
  - Teaching in BE(Env Eng)_
  - Teaching in coursework masters in environmental engineering…UNSW 50% of coursework masters students in Australia.

2 Role that government agencies (Govt) and the private sector (PS) should play in MFA

- Govt: require data collection and reporting
  - NPI www.npi.gov.au
  - ABS www.abs.gov.au
- Govt: support development of key set of material flow indicators
- Govt/PS: require use of material flow indicators in EIS, EMS, SoE corporate and regional reports
- Govt/PS: Use of material flow indicators in development of policy and decisions on infrastructure development.

3 Databanks required to assist application of MFA

- UNSW PhD reports available on line, with associated data in appendices
- RDMS: Hung Ju-Pin thesis on an integrated database design for material accounting methods to be submitted.
- STAN: use as a basis for standardisation of data definitions on substances, goods, processes, regions, to facilitate data sharing

4 General suggestions

- National material controls
  - Overlapping uncoordinated bureaucratic controls
- International material controls
  - Basel convention limitations
  - Where are the final sinks?

4.1 National material controls: cadmium example

- Emissions to sewerage systems: Water Authorities
- Emissions to waterways: State EPA
- Allowable concentrations in soil additives (fertiliser, trace elements): Agriculture Department
- Emissions in compost, with sewage sludge (biosolids) addition: State EPA, Water Authorities
- Imports of hazardous waste for recycling: National EPA
- ….no-one knows total load on soil, optimal means of controlling the substance to protect the environment.
- Need a substance based over-riding bureaucracy

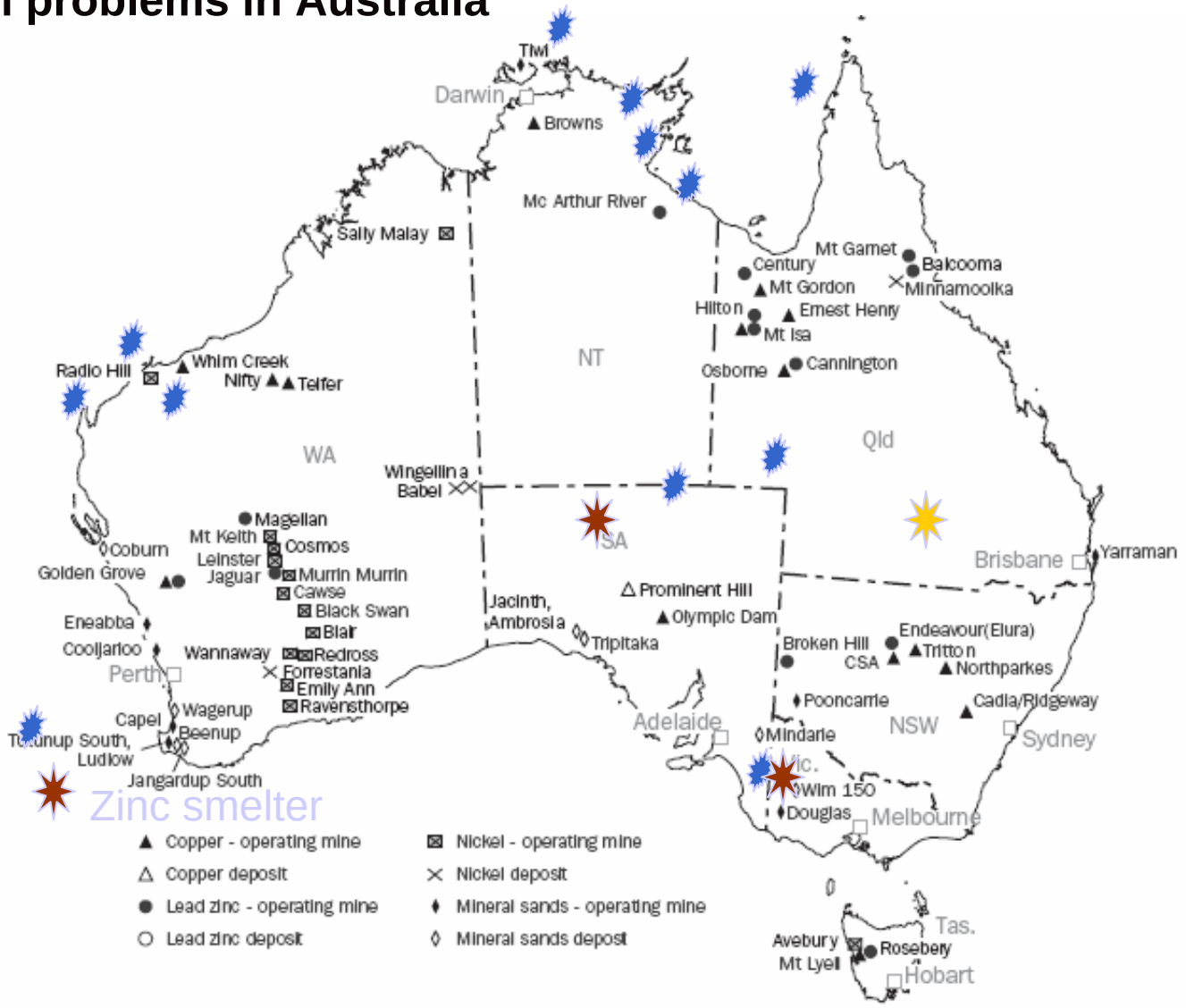
4.2 International material controls: Cd example

Basel convention limitations

Where are the final sinks?

Part 2:Cadmium in Australia

Supply of zinc and cadmium to the global economy
Cadmium problems in Australia



Source: Geoscience Australia.

Australia: Zinc and cadmium reserves

- Cadmium:
  - 18% of global reserves of Cd (& Zn)

Table 3. Cadmium reserves and reserve base, yearend 2000
[In metric tons, contained cadmium. All data are rounded to two significant digits; because of independent rounding, they may not add to totals shown. Plachy, 2001]

	Reserves	Reserve base
United States	90,000	270,000
Australia	110,000	300,000
Canada	55,000	160,000
China	13,000	35,000
Germany	6,000	8,000
Japan	10,000	15,000
Kazakhstan	25,000	40,000
Mexico	35,000	40,000
Russia	16,000	30,000
Other countries	240,000	330,000
World totals	600,000	1,200,000

- Zinc Reserves:
  - Australian reserves: 42Mt (18%, highest in world)
  - Global reserves" 228Mt
- World zinc production: 9.6MT
- Australian zinc mine output:
  - 2005: 1.4MT
  - 2011: 1.9MT
  - 15 – 20% of global supply

Cadmium: intentional uses

Application	*Usage Level (%)*
Ni Cd battery	79% increasing...
Pigment	11% decreasing...
Coatings	7% decreasing...
Stabilizers	2% decreasing...
Minor Uses (alloys)	1%

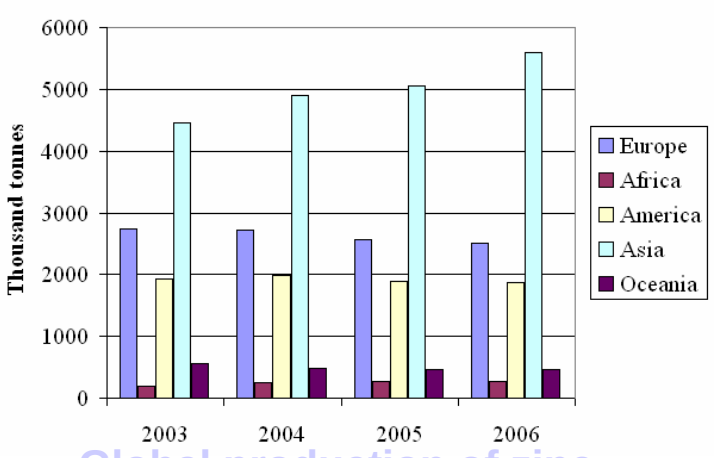
Cadmium: unintentional uses

Sources of exposure to an average non-smoking European 2005

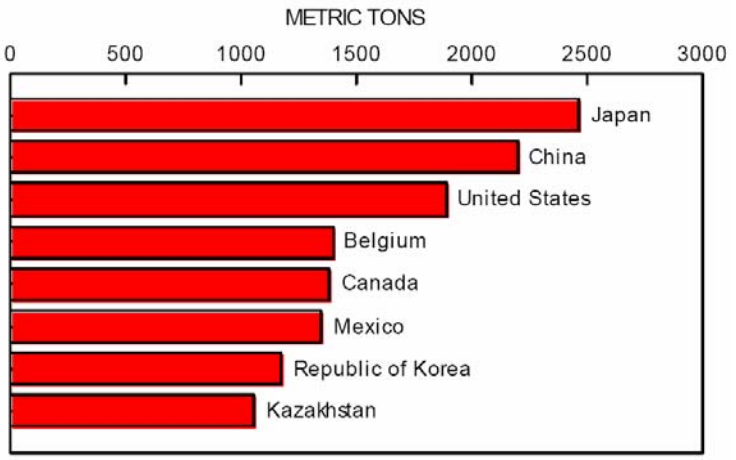
Cadmium source exposed	*Total percentile in the environment*
Phosphate Fertilisers	33 %
Fossil Fuel Combustion	20%
Iron & Steel Production	12%
Natural Sources	20%
Non-Ferrous Metals	4%
Cement Production	6.7%
Cadmium Application	0.3%
Incineration	1.0%

Cadmium: Supply for intentional uses

- Cadmium not intentionally mined as an ore
- Cadmium as a by-product of zinc ore concentration and smelting
- Linked to demand for zinc, increasing at 4%p.a….zinc smelting increasingly in Asia…so supply of Cd increasing at 4% p.a.



Global production of zinc



Cd refining countries…related to zinc smelting

Cadmium: Supply related to unintentional uses

- **Phosphate fertilizers:**
  - EU < 60..40..20mg Cd/Kg P_2O_5
  - (EU <25..17..8.5 mg Cd/kg P)
  - Australia < 300mg Cd/Kg P, generally < 100mg Cd/kg P
  - USA : 85 mg Cd/kgP
  - Japan < 8mg Cd/kg P
  - China? Proposed…8mg Cd/kg P… actual??
  - Thailand?
  - When low Cd phosphate rock depleted?
- **Coal fired electricity production:**
  - OECD (not USA)….reduce ..Kyoto
  - China, India…increase
- **Iron and Steel:**
  - OECD…constant
  - China…increasing
- **Cement production:**
  - OECD…constant, reducing
  - China…increasing

Cadmium source exposed	*Total percentile in the environment to non-smokers in EU*
Phosphate Fertilisers	33 %
Fossil Fuel Combustion	20%
Iron & Steel Production	12%
Natural Sources	20%
Non-Ferrous Metals	4%
Cement Production	6.7%
Cadmium Application	0.3%
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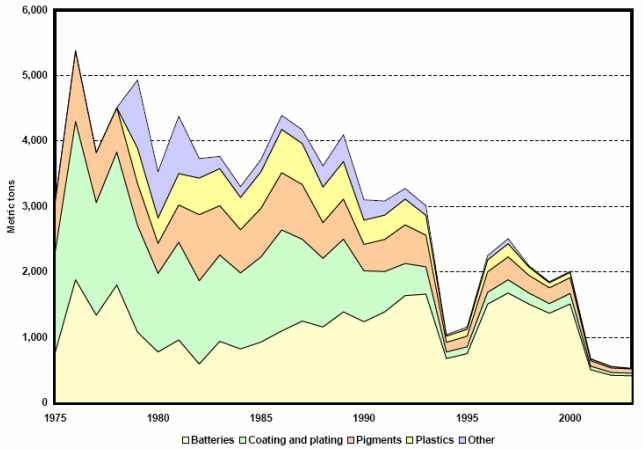
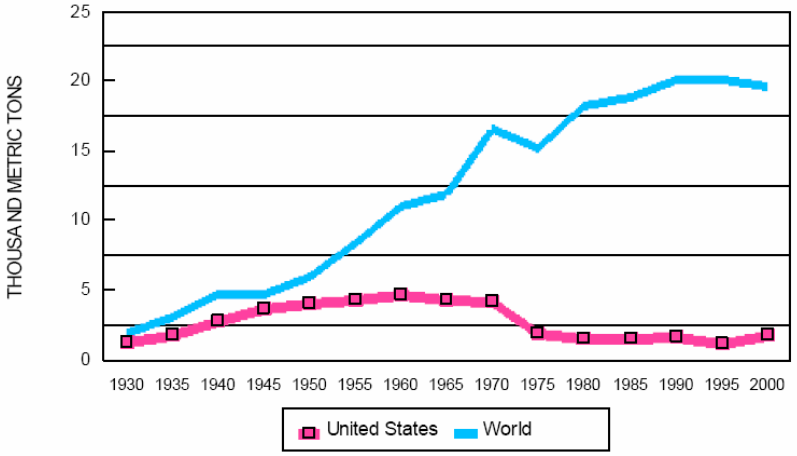
Cadmium: Demand

- Intentional uses:
  - USA and EU..declining, mostly batteries
  - Others: increasing as economy grows, including coatings, plastics
  - Primary cadmium demand reduced to16,000 T/yr; 4000 T/yr from recycled Cd…constant at 20,000T/yr for past 7 years.



Cd use in U.S.A.



Cadmium production

Cadmium: the global issues

- Demand for primary Cd reducing as recycling of concentrated intentional use (NiCd batteries) increases, and overall demand constant.
- But…:
  - Supply increasing from increasing demand for zinc
  - Supply increasing from increasing demand for goods (P, coal, limestone) with Cd as a contaminant, with only OECD country specific controls on levels of Cd contamination.
- Where does the Cd go?..this extra 35% of supplied Cd for intentional uses….and the contamination in unintentionally used Cd goods?

Targeting Zinc Sulphate

Information supplied to EA by industry and CSIRO indicated that imports of zinc sulphate, used in micronutrient fertilisers, could contain up to 11% cadmium.

EA has an interest in this material because it is produced from industrial residues, and if the heavy metals are not removed, is classified as a hazardous waste under the Act. Given the high cadmium content reported, EA requested the Australian Customs Service to monitor these shipments.

Three shipments of this material have been inspected and sampled. Analyses showed that cadmium concentrations in these shipments to be well below the levels of concern. EA and Customs continue to monitor these imports.

EA is also working with industry to further develop strategies to ensure that imports of this material do not contain heavy metals.

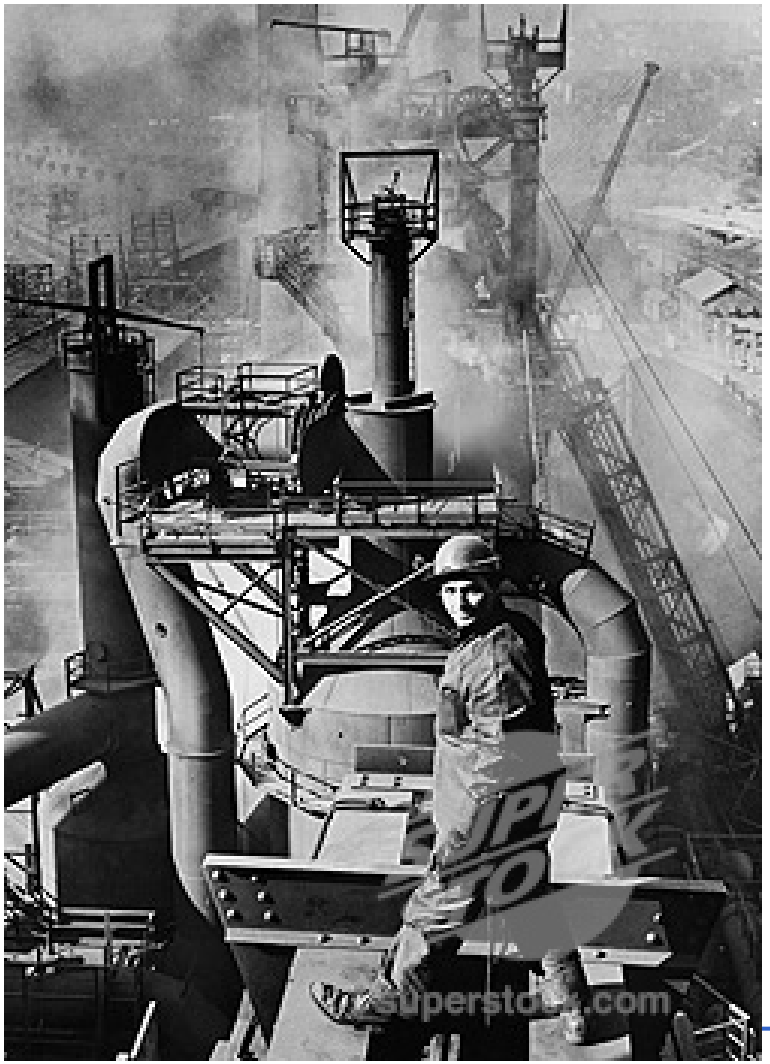
'Container of zinc sulphate'

'Samples of imported zinc sulphate being collected for analyses'

I like Thai jasmine scented rice…at least I do not have to worry about prostate cancer now! (??)

Chinese coal fired power stations and coking coal….
Coal imports from Australia

Increased steel and cement making in China



Where are the final global sinks for the Cadmium intentionally produced in excess of demand?
Is the receiving capacity of regional environments being exceed by intentionally and unintentionally produced cadmium?

- In the zinc smelting countries as hazardous waste?
- Used locally/Exported as a non-reported substance in zinc sulphate trace elements?
  - Failure of Basel convention in managing materials not defined as waste.

→ Need for international agreements on substance flow controls.

5 Taiwan in international MFA studies

- Cadmium example: where are the final sinks in international trade:
  - Australia exports zinc concentrate:
  - Japan, Taiwan as significant importing regions
    - Where does the Cd go?