Inventory development and emission factors for industrial sources

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Outline of talk

- Introduction, background and concepts for inventory development
- Discussion of emission factors and source classification
- Illustrations of international experience in the chemical sector and cement industry
- Questions

Background

- Why compile inventories?
- International commitments:
  - The Stockholm Convention is one of several agreements to control releases of POPs
- An inventory can give guidance about where source reduction efforts should be directed to have greatest impact
  - It can identify major source categories
  - As well as high emitting plants
- It does not (by itself) give exposure information
- Can be used to track trends
- Some will also serve to increase the stock of knowledge on emissions

Why is guidance required?

- Awareness raising workshops identified a need for help on assessing sources of dioxins
- Inventories of PCDD/F had not been assembled in a standard form
- Existing inventories were limited and cannot be easily compared
- In 1998 only 15 countries had inventories - these were largely developed, western countries
- A simple, standard approach would assist developing countries

UNEP Inventory Toolkit

- Aim is to provide a framework to assess releases of PCDD/PCDF, which:
  - is straightforward and resource efficient
  - produces consistent and comparable results
  - does not necessarily require sampling
  - reliably identifies major sources in a country
  - can be used to help prioritize sources
  - can be used to identify potential hot spots
- TO BE DISCUSSED TOMORROW

Inventory objective

- Define your objectives – this helps the design
- Essentially –
  - A listing of releases of a pollutant
  - Usually on an annual basis
  - Usually to air but can be extended to water and land as well as in products
  - By plant or by sector
  - Linked to an identified date or time period

Enhanced by being transparent and repeatable – and by being updated

Compiling an inventory

- Essentially making a list of sources and estimates of releases
- Define boundaries and purpose – what is it for and what is included/excluded
- Basic choice -
  - Measured data
  - Estimates based on emission factors
- Often a combination of both

Develop a suitable taxonomy

- How to structure the sources
- Ensure that all relevant categories and sources are included
- Try to avoid double counting and ambiguity
- Develop mechanism to deal with a situation where no data exist (eg exclude from numerical inventory but include in text with suitable notes)

Structure

- Consider standard or often used format
- This may be from international approach (ie specified by a particular Convention or organisation – or consistent with guidance – eg the UNEP Toolkit)
- It may be based on and be consistent with other National Inventory efforts to maximise comparability
- It should be clear and unambiguous – everyone knows what belongs where and double counting is avoided...

Basic concept

- Annual emission = activity x emission factor
- Made complex because:
  - many sources
  - different technologies have different emission factors
  - activity statistics may be unavailable
  - conditions change with time
  - experience in one country may not be reflected in another

For each source or sector

- Aim to generate an estimate for the category
- Consider the nature of the category and the available data as well as the desired output –
  - Is it a single or few sources/many dispersed sources?
  - How good is the database of emissions?
  - Are the individual sources similar or should they have separate consideration?

Activity data

- Do not neglect this aspect!
- The data you need may not be easily available
- Or the form may not be suitable

- Try to find an activity measure that relates to the emission factors/data that you have or expect to generate

- Often based on production (t/a), mass/volume discharged (t/a, m^3/a), sometimes distance covered (km) or number of repetitions

Data collection

- The most appropriate means of data gathering will depend on the category, the resources available and the potential emissions
  - Use national statistics
  - Regulatory data
  - Different government agencies
  - Trade associations, industry and experts
  - Data from a survey
  - Questionnaires to some or all plants

Emissions data

- Review the available data – both as emissions factors and based on any local testing (ie of some or all of the plants/sources under consideration)
- Assess the applicability of the data –
  - Do the tests relate to plants/sources with sufficiently similar characteristics?
  - Are they good quality?
  - Can they be used?
  - What sort of range may be expected?
- Make sure that the units align – so they can be used taking account of any corrections/adjustments that are needed

Emission factors

- Emissions vary considerably
- Emission factors available are not complete due to a lack of comprehensive data
- Often broad factors suitable as representative of a technology category
- Cannot assume that an emission factor will exactly match emission from an individual plant although it should equal the average for the sub-category

- Usually expressed in µg per tonne of material

Data quality

- For different sources and sectors the data which are available to make estimates will vary
- The overall inventory is affected by the quality of the data that is used
- It is very useful to have an indication of the quality of the data

- Usually useful to have two indicators:
  - Activity data; and
  - Emission data

"Representativeness"

- How well does the estimate represent the source or sector being addressed?
- Inventory estimates should be useful for sector-level assessments
- They are not always so good for individual source estimates

Uncertainty

- There are various sources of uncertainty in inventories
- These should be considered and their importance assessed
- An understanding of the uncertainty can help to frame actions to be taken:
  - Significant uncertainty coupled with high potential releases indicates a need to improve estimates and move to action if supported by additional data
  - Conversely if a source is very small and no realistic change in the emission factor or activity estimate could make it otherwise then it may not merit much additional work (though it might be important to consider potential for exposure)

Extrapolating data

- What do you do when you have limited data?

- Key objective is to identify those factors that have most influence on emissions
- If we know the key factors we can judge whether data can be used to estimate the source in question

Key factors

- The scientific community is learning more about which factors are most important
- Understanding is far better for certain sectors than for others
- The key factors are not always the same
- Understanding and knowledge is increasing over time and new data can change conclusions

- Proceed with caution

Example categories

- Chemical industry
- Cement production
- Waste incineration
- Brick making
- Metal works

Chemical industry

- Historic data indicated that certain processes were capable of producing large amounts of PCDD/F eg:
  - Chlorine production using graphite electrodes
  - Chlorinated phenol production and certain herbicides
  - Certain dyes
- Actions were taken to address these
- Most inventories addressed air releases – chemical industries were generally more linked to land, water, wastes and products (with the exception of incineration)
- Result – sector not well addressed in most inventories

US EPA inventory – chlorine and EDC/PVC

- A key inventory study – extended period & new data
- In 1994 – release estimates for chlorine and EDC/PVC production could not be made but issue raised – source of disagreement

- In 1998 – a few product estimates, others "negligible", PVC/EDC "some evidence indicates this may be a source – but insufficient..."
- 2006 inventory – quantitative estimates
- Improvements based largely on two programmes – the VI study and the CCC study

EDC/PVC

- Major disagreement between industry and public interest groups on importance of this sector as a source of PCDD/F
- In 1993-4 this argument was about application of industry-wide emission factors and high concentrations of PCDD/F found in certain waste/by-product streams
- Vinyl Institute programme* developed by industry with EPA

- * The Vinyl Institute Dioxin Characterization Program, July 2002

VI programme

- Multi-year effort – 1994-2002
- Collaboration between manufacturers representing bulk of US EDC/PVC production
- Study design overseen by independent review group and EPA
- Test data from 20 sites on:
  - Products – pipe, resins, packaging, EDC, HCl
  - Effluents – treated waste waters
  - Wastes – spent catalysts, water treatment solids
  - Stack emissions – various combustors

Key findings

- Chemical production sites were often complex with multiple processes linked to common waste treatment systems –
  - Hard then to link PCDD/F reliably to any one process
- Data generation not simple – required careful design
- Wide range of emissions/concentrations found
- Releases depend crucially on handling of potentially contaminated materials (eg heavy ends)
- Extrapolation to industry depended on knowledge of plant configuration and characteristics

- Review group acts as a bridge between regulator and industry and first line of review

CCC study

- Chlorine Chemistry Council (CCC) working with EPA - contracted review from consultants
- Initiated in 2003 to review PCDD/F releases from sites producing or using large volumes of chlorine
- Different basis compared to VI study (not just EDC/VCM/PVC)
- Assessed 20 plants producing:
  - Chlorine (mercury, membrane, diaphragm cells)
  - EDC/VCM/PVC
  - Solvents, other chemicals (organic and inorganic)

Key lessons learned

- Wide variations in releases
- Substantial reductions had been made once attention was focused on the problems and due to several changes including process refinement, changes to waste handling, upgrades to incineration processes
- No easy way to use general emission factors at this level
- Clearly illustrates the difficulty of dealing with this sector – danger of double counting and mis-assigning releases to particular process – in this case the catch all EDC/PVC/VCM includes some plants that produce quite different products

Cement kilns

- Identified as a potential source of PCDD/F by early 1990s
- Few data initially – limited US data indicated some elevated emissions (1994 inventory
- Focus was on kilns burning hazardous wastes

Evolution in understanding

- First suggestion – hazardous waste
- Further investigation showed that temperature of pollution control device was very important
- Several other factors also at play including –
  - Quality of combustion
  - Nature of gas cooling
  - Plant configuration and stage of the maintenance cycle
  - Nature of the raw materials

Emissions from cement plants

- Most emissions data shows very low emissions for plants of several designs burning a wide range of conventional and waste fuels
- Emissions on a single plant can vary over time and with process changes
- Good stable operation and careful design of combustion and feed systems crucial
- When things are wrong emissions can be orders of magnitude higher than usual

Emissions from cement industry – and single plant - Padeswood

	Production (million tonnes)	Emissions (g I-TEQ/a)
UK estimate 1994	9.8	2 - 11
EU estimate 1997 (17 countries)	57.7	20.4
Padeswood	0.5	23

Waste incineration

- Intensively studied
- Orders of magnitude between emissions from well-controlled, state of the art plants and poorly or uncontrolled systems
- In many inventories now there would be annual tests for large plants

Brick production

- Brick production has been little studied for PCDD/F
- Few data exist and these are for well controlled processes

- How to estimate for an industry that includes:
  - Poor process control
  - Mixed and uncontrolled fuels (including waste)
  - Highly polluting processes

Metal production

- Large scale processes have been studied – in some countries – some have been very high emitters
- Major improvements can be made by focus on control of PCDD/F

- Small scale processes, including artisinal production, may be high emitters
- Defining appropriate controls difficult (“BAT” may be cripplingly expensive)
- Social impacts can be substantial – may be many workers dependent on the industry

Using and understanding the results

- Remember what the purpose was –
  - If the inventory focused on category estimates the results may not tell you what you need to know about individual sources
  - Need to refer to the supporting information to know whether any individual plant is likely to be well described or may be quite different from the central estimate
- For some sectors there is a limit to how far you can go without detailed investigation or testing

Conclusions

- Inventories can be powerful tools to prioritise actions and to track progress, they can contribute to exposure assessment
- Careful design and execution is essential
- They can be good to estimate sector-level releases
- Depending on the characteristics of particular sources the inventory may not give you good information on the plant-level releases
- Knowledge is increasing and should be used to update and review estimates of releases

Challenges

- Ensuring we find the important sources
- Finding cost-effective means to reduce releases
- Linking source reductions to changes in exposure/harm
- Defining what BAT and BEP really are in developing country context
- Integrating decisions on dioxins into sustainable development – it is one problem among many