# Environmental metrology and implementation of industrial ecology: benefits and limits of monitoring tools for the management of water resources

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## Monitoring tools for the management of water resources

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## Introduction

Industrial ecology mostly remains a macro approach of substance, material and energy flows based on pre-existing data collected from territorial and socioeconomic stakeholders. Incertitude linked to these data may curb the local implementation of industrial ecology.

The implementation and diffusion of industrial ecology would benefit a lot of the use of different monitoring tools. The choice of the data to be collected and thus, the choice of the monitoring tools to use depend on the purpose of the industrial ecology approach. Theoretical and operational objectives have a strong influence on data quality which can be used in an industrial ecology framework. These tools would improve the characterization of materials and substances flows and stocks in order to optimize their management (reduction, reuse, valorization, limitation of dispersion,…). Quantitative measurements for Substance Flow Analysis (SFA) and qualitative approaches (fingerprint or water variability index directly linked with its quality) for process control or characterization of water quality could be developed, based on laboratory methods or on site tools.

## Objectives

To be relevant for industrial ecology, the choice of monitoring tools can be dictated by the following objectives:

✓qualitative and quantitative characterization of anthropogenic emissions (wastes, co-products, waste waters) and their variability, in order to control and reduce their emissions or reuse, recycle or valorize them

✓verification of the conformity of news recycled products, in relation with norms and guidelines,

✓efficient process control, taking into account the data acquired at the previous steps,

✓integration of these tools in a larger strategic planning for environment, safety and sanitary reporting and management of a geographical area (industrial area, town, region), including the identification and reduction of diffuse and point sources of pollution.

Indeed, these objectives can allow to define the measurements to be carried out, as well as monitoring tools among their specificities (lab, on site, reliability, robustness, detection and quantification levels…).

## Different monitoring tools to enhance industrial ecology practices

### 1. Pre diagnosis of metabolism and resources quality of waters based on existing monitoring networks of a catchment area

Metrology
•Use of standard methods of sampling and analysis, approved by regulations.
•Global and specific parameters defined by regulations.

Limits
Composite or spot sampling are the most used but can be limited by the variability of parameters. Thus, the spatial and temporal variability of flows quality is not correctly determined. These methods are also limited in case of the prediction of long term accumulation of substances in the environment.
Furthermore, several database used for the pre diagnostic are not frequently updated or could not be adapted.

Proposed monitoring tools for industrial ecology
The development and implementation of integrative sampling methods allow to have an average concentration, overcoming the variability of parameters and water quality.

### 2. Diagnosis of environmental quality of stocks and flows, identification of hazardous substances and their sources from a site (harbor, sewage network,…) to a catchment area

Metrology
•Use of standard methods of sampling and analysis defined by regulations (quality/use).
•Use of (new) laboratory or on site methods.
•Quantitative measurement of global and specific parameters.

Limits
At the catchment level, these studies are expensive and some analyses may require experts (metal speciation and isotopic analyses) to determine pollution sources, organic compounds congeners and metabolite or degradation products.

Proposed monitoring tools for industrial ecology
On site tools can be used for a preliminary detection of point sources and diagnosis of waters networks. They allow to define sampling spots for laboratory methods and integrative samplers. Laboratory methods can be used to investigate and to define flows and stocks characteristics.
Integrative sampling can be used to assess flows diffuse substances.

### 3. Synergy feasibility study by the means of the investigation on specific water or substance flow at laboratory scale

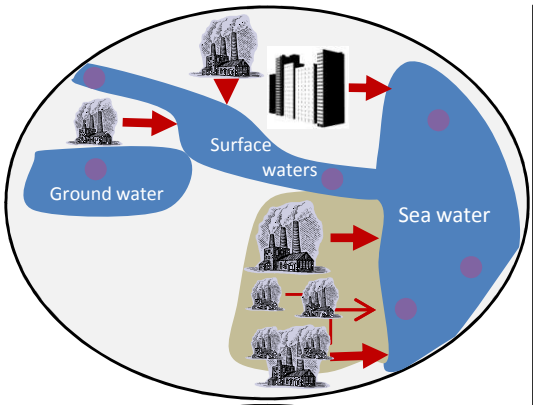
Metrology
•Standard methods defined by technical guidelines and regulations.
•On line or on site monitoring tools and laboratory analyses.
•Global and specific parameters, development and use of quantitative and qualitative measurements.

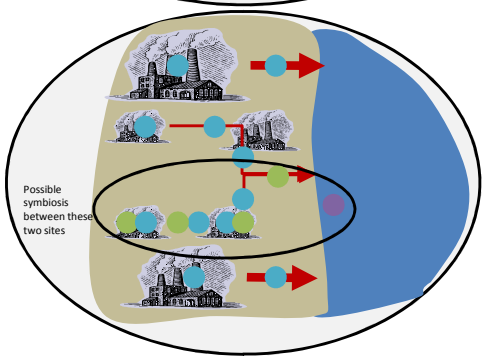
Proposed monitoring tools for industrial ecology
New tools for process optimization and control and additional characterization studies of flows (qualitative, quantitative, variability, environmental and others).
Integration of standard methods results or specific tests in assessment methods or muticriteria decision support making for orientation of flows towards an efficient solution.

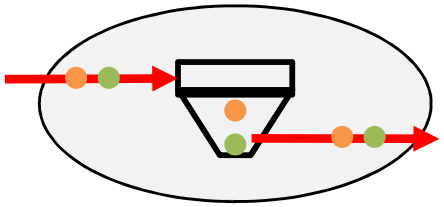
### 4. Assessment and validation of prototype related to specific water or substance flow and receiving waters

Metrology
•Standards methods approved by regulations.
•Use of additional measures (on site, on line or in situ).
•Global and specific parameters, qualitative measurements.

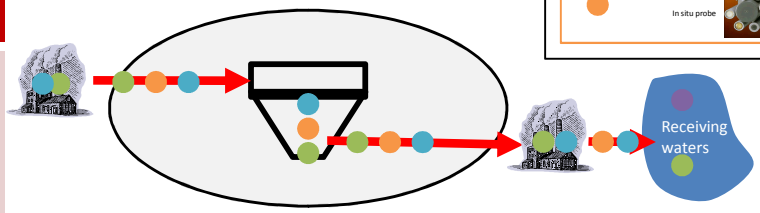
Proposed monitoring tools for industrial ecology
Monitoring environmental impact of the synergies (regulatory parameters, new tools). News proposals of monitoring network and tools may be done in order to move the regulation.
Additional measurements to improve the knowledge of process, optimize it and identify key control parameters.



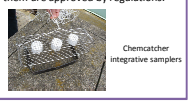
Synergy at laboratory scale (pilot)




Synergy at industrial scale (prototype)

**Available monitoring tools**

Development and validation of integrative samplers for organic compounds and metals. They can be used as monitoring tools for surface and ground waters for steps 1, 2, 4 and 5 for SFA applications. Some of them are approved by regulations.




Development and validation of laboratory analyses.
These techniques could be used to study the speciation of metals and its fate, organic compounds congeners and their metabolites or their degradation products,…
They are performed for steps 2, 3, and 4 and allow a better comprehension of the fate of specific parameters and may support a detailed SFA.


Development and validation of on site tools for detection or quantification of specific or global parameters (organic compounds, metals, COD, BOD, …) or qualitative measurements.
Several techniques may be used, as immunoassay and other biodetection systems, UV, Visible, NIR spectrophotometers, electrochemical apparatus,…
It could be used for steps 2 (preliminary identification of point sources, and SFA, characterization of water quality), and 4 (process control optimization, characterization of water quality).



Development and validation of on line or in situ tools. These tools estimate specific or global parameters. They could also make qualitative measurements.
They could be relevant to process control and to characterize quantitative and qualitative variability of waters. They could be used for steps 3, 4 and 5.


### 5. Monitoring and control of synergies

Metrology and proposed monitoring tools for industrial ecology
•Standard methods can be used for emissions and environmental monitoring of waters according to regulations.
•Integrative sampling could be used, for environmental monitoring of surface and ground waters , and further proposed as regulatory tool.
•On line or in situ methods could be used, for process control and early alert systems, and further proposed as regulatory tools.
•Quantitative and qualitative measurements.

## Conclusions

Implementation of industrial ecology actions needs adapted monitoring tools in order to improve the knowledge of SFA at different scales and propose safe and reliable synergies. Different tools may be used, depending of their performance and the steps required in order to study and carry out a synergy. Furthermore, monitoring tools can support aid decision making and lead to an evolution of regulations.

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