Monitoring, Modelling and Information System for Persistent Organic Pollutants

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Motto:
Data reach, information poor
All models are wrong, some can be useful

Abstract. Important targets of many activities are to promote the advancement of international conventions and directives for the reduction of pollutant loads to the aquatic and terrestrial environments and reduction of human exposure. The Stockholm Convention on Persistent Organic Pollutants (POPs) was adopted in May 2001 with the objective of protecting human health and the environment from POPs. The results from the global POPs monitoring programme will be used to determine trends from monitoring POPs globally to support the effectiveness evaluation of the Stockholm Convention. One from the most important problem connected with monitoring of POPs is a production of huge amounts of data which are not effectively for decision making purposes. From this reason, the development of expert system GENESIS for evaluation, interpretation and presentation of data concerning to POPs developing by RECETOX, EU Research Centre of Excellence for Environmental Chemistry and Ecotoxicology, will be discussed.

1 Introduction

The man-made production, use and mobilisation of many new potential harmful chemicals over the last century calls for further development of scientific tools and models, suitable for improved management options and the mitigation of possible negative effects.

Important targets of many activities are to promote the advancement of international and European conventions and directives for the reduction of pollutant loads to the aquatic and terrestrial environments and reduction of human exposure.

2 Definitions

Monitoring is, consistently over time and space, the defined observation of precisely determined indicators at points creating a network, which at certain levels of probability represent a given region and in turn the whole area of a state [1].

Monitoring serves to ensure the maximally objective evaluation of the state and changes of set indicators of the components of the environment in a given region. Monitoring, in general, only observes or signals a state, changes, and their causes, in components of the environment.

Monitoring outputs serve to evaluate exposure within systems evaluating human and ecological risks, the ensuing decisions, changes in economic practises, legislature, operation and strategies, determination of efficiency of accepted measures, funding, etc.

Monitoring programmes should be developed in accordance with the demands of the current legislature and to monitor the efficiency of the strategic documents such as international conventions and protocols or national measures with respect to the environment and its trends. These programmes are essential in identifying subsequent measures.

The crucial elements in the development and preparation of the monitoring programme are the measurement methods and standards. A necessary condition for effective control and monitoring mechanisms is the availability of appropriate measurement methods and the comparability of data.

The control will not be effective enough until unannounced measurements are possible. Control measurements planned ahead do not reflect real operational conditions.

3 Problems of Monitoring

Environmental monitoring is at the very beginning of the environmental information chain - it is the basis of environmental data collection, environmental reporting and environmental research, and the basis of understanding of environmental problems and trends. Environmental monitoring is therefore a powerful tool for supporting decision-making, enforcing policy decisions, and for assessing compliance with policy regulations and objectives [2].

Over the last decade, accounting systems and new indicators have been developed in many countries to measure environmental performance, better integrate environmental and economic decision-making and better communicate environmental information to decision-makers and the public. Each country is searching for cost-effective methods and techniques of environmental monitoring and data collection.

Monitoring institutions have received important autonomy to help ensure the independence and accuracy of their data. The integration of national information systems with international networks has improved, including those co-ordinated by the governing bodies of international environmental conventions, the European Environmental Agency (EEA) and UNEP.

Here something could be added on the value of optimisation and co-ordination of monitoring networks across borders

Despite this progress, a number of important weaknesses remain. The current environmental monitoring systems in many countries do not meet priority demands. Some important environmental areas, such as hazardous waste, heavy metals and other toxic substances, particulate matter, acidification, indoor air quality, drinking water, groundwater and wildlife outside protected areas, are not properly monitored in many European countries. Frequently, national monitoring systems are not coherent as both data systems and methodologies are not harmonized.

Inventories are lacking in several countries of waste of high potential hazard, which were (or continue to be) dumped on landfill sites, especially in rural areas. In a number of countries, biological monitoring systems are too cumbersome and expensive to manage. Monitoring practices to monitor environmental effects of armed conflicts in those countries where these conflicts occurred are practically nonexistent.

There is, furthermore, a contrast between the large volume of data produced and the difficulty in using these data to support decision making. Data banks of time-series data are poorly developed in a number of European countries. This handicaps, in particular, analysis of cause-effect relationships.

This is of particular concern for development of appropriate remedies, whether scientific, policy or legislative, and monitoring of the effectiveness of remedies and policies.

Most countries have increased the amount of environmental data and information provided to the public. Most of them now produce annual state of the environment reports that contain data from main sources. An increasing number provide this information through the Internet. However, not everywhere is free and easy access to environmental information ensured for the general public.

Environmental authorities lack both monitoring experts and technical equipment. Industrial facilities also lack financial resources and are therefore not able to equip the sources of pollution with appropriate monitoring devices. Both the equipment that is available and sampling methods have become obsolete. As a result, routine monitoring activities have been handicapped or even discontinued altogether. The reliability and accuracy of air and water quality information is often questionable in many respects. Thus, it is impossible to fully evaluate the current environmental situation in these countries. Furthermore, ongoing monitoring systems could hardly be integrated in international (global or regional) programmes.

Another aspect to be covered is the dissemination of knowledge: Across the various European Countries, monitoring networks and monitoring strategies are at a different level of development. This co-ordinated action is, amongst others, aimed at harmonising efforts across Europe and exchange of knowledge with regard to:

- Development of monitoring strategies, optimising the cost/benefit ratio and taking transboundary activities into account. In case of the WFD the latter is for instance done on the basis of the pre-defined basin-approach.
- Integration of modelling, GIS, and monitoring
- Truly representative and comparable (amongst others because of harmonisation of methodologies) data-sets.

Fate models may play a role in the whole picture as they may be used as a sophisticated tool to structure monitoring campaigns, to make sure that the monitoring strategies are optimised with regard to compounds sampled, as well as optimal number of locations (combined with knowledge on emission sources and time-dependent emission patterns), and optimal sampling frequency. On the other hand, monitoring serves the purpose of model validation and the integration of modelling and monitoring is essential.

4 Problem of PTS

The introduction of xenobiotic chemicals that are generally referred to as "persistent toxic substances" (PTS) into the environment and resulting effects is a major issue that gives rise to concerns at local, national, regional and global scales [3].

Many of the substances of greatest concern are organic compounds characterised by persistence in the environment, resistance to degradation, and acute and chronic toxicity. In addition many are subject to atmospheric, aquatic or biological transport over long distances and are thus globally distributed, detectable even in areas where they have never been used.

The lipophilic character of these substances causes them to be incorporated and accumulated in the tissues of living organisms leading to body burdens that pose potential risks of adverse health effects.

Toxic chemicals, which are less persistent but for which there are continuous releases resulting in essentially persistent exposure of biota, raise similar concerns. The persistence and bioaccumulation of PTS may also result in increase over time of concentrations in consumers at higher trophic levels, including humans.

A sub-group of the persistent toxic substances are the "persistent organic pollutants" (POPs) identified by the international community for immediate international action[1]. These chemicals have serious health and environmental effects, which may include carcinogenicity, reproductive impairment, developmental and immune system changes, and endocrine disruption thus posing a threat of lowered reproductive success and in extreme cases possible loss of biological diversity.

During the past three decades, analytical data have revealed global contamination of aquatic and terrestrial environments [3-5]. In large measure, this is the logical consequence of the physical and chemical properties of POPs:

- POPs are highly resistant to chemical and biological degradation. Polychlorinated biphenyls (PCBs) and other chlorinated pollutants, particularly the highly chlorinated ones, have been known for some time to persist in soils, water, sediment and biota for long periods of time.
- POPs are non-polar molecules that can accumulate in fatty tissues. This results in their biomagnification in the higher trophic levels of the food chain.

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[1] The initial twelve POPs are: aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, hexachlorobenzene, mirex, toxaphene, polychlorinated biphenyls, dioxins and furans.

- Many from various POPs were/are found in pristine areas where there are no known sources of release to the environment, demonstrating that POPs are subject to long-large transport from their initial source.

Researchers have concluded that the major mechanism for this mobility is a cyclical evaporation from soil and water surfaces in which winds lift POPs into the air along with water vapour and dust, eventually depositing them with rain, snow, or adsorbed to particles. With repeated evaporation and deposition, the net result is movement of POPs such as PCBs and some organochlorinated pesticides (OCPs) over long distances in the direction of atmospheric air movements. Models of this mobile behaviour correlate well with the measured POP concentrations in the northern hemisphere [3].

5 Stockholm Convention

Following the recommendations of the Intergovernmental Forum on Chemical Safety[2], the UNEP Governing Council decided in February 1997 (Decision 19/13 C) that immediate international action should be initiated to protect human health and the environment through measures which will reduce and/or eliminate the emissions and discharges of an initial set of twelve persistent organic pollutants (POPs). Accordingly an Intergovernmental Negotiating Committee (INC) was established with a mandate to prepare an international legally binding instrument for implementing international action on certain persistent organic pollutants. To date three sessions of the INC have been held. These series of negotiations have resulted in the adoption of the Stockholm Convention in 2001.

The Stockholm Convention (SC) on Persistent Organic Pollutants (POPs) was adopted in May 2001 with the objective of protecting human health and the environment from persistent organic pollutants and entered into the force in 17 May, 2004 [6].

Parties to the Stockholm Convention are required to develop National Implementation Plans (NIPs) to demonstrate how the obligations of the Convention will be implemented.

Article 11 of the SC describes the problems of research, development and monitoring including data interpretation and evaluation. This problem is closely connected with Article 16 which is concerning to the effectiveness evaluation of Convention measures. This evaluation will be define by the Conference of the Parties and will need the establishment of arrangements to provide itself with comparable monitoring data on the presence of the chemicals listed in Annexes A, B and C as well as their regional and global environmental transport and will need the effective tool for data evaluation.

[2] Conclusions of the IFCS sponsored Experts Meeting on POPs and final Report of the *ad hoc* working group on POPs, Manila, 17-22 June 1996, "Persistent Organic Pollutants: Considerations for Global Action".

6 Monitoring of POPs

6.1 Introduction

The establishment of an appropriate monitoring capacity in areas where it does not already exist will take two or more years to become operational [3,7]. Furthermore the organization of an assessment of the resultant information on global levels of persistent organic pollutants (POPs) can be expected to require another two or more years. In order to ensure that the first evaluation can be produced four years after entry into force, it is a priority that a clear framework for the gathering of monitoring information and for its assessment be agreed upon at the earliest opportunity.

Although a number of regional and global monitoring programmes have been established to report on the presence of POPs in the environment, there is very little previous experience of POPs monitoring designed to help evaluate the effectiveness of a legally binding international agreement. The 1998 Protocol on POPs under the Convention on Long-range Transboundary Air Pollution (CRLTAP is in force from December 2003) [8] contains Article 8 which requires that Parties **shall encourage** research and monitoring on POPs in the environment. It does not specify who will conduct the work, although this responsibility is in part being taken up by EMEP (b), an organization which formally does not embrace the entire geographic area of the Convention. EMEP is making progress to document trends in association with the heavy metals Protocol under the LRTAP Convention [8]. It is interesting that Article 8 looks towards substances that may be candidates for addition rather than for substances already subject to measures. Article 10 of the Protocol requires that **Parties shall** review information supplied by Parties, EMEP, and other bodies. It is therefore possible to envisage that a review of some aspects of effectiveness may emerge as procedures evolve under the Protocol.

The Stockholm Convention on POPs and other international agreements state that monitoring activities should be established to verify the effective implementation of the conventions and the subsequent improvements in environmental emissions and exposure [9, 10]. National monitoring activities are already in place in many countries, but not in others. There is a 'bias' as to the regions of the world where extensive monitoring is being undertaken. Monitoring programmes differ in their objectives and financial support, sophistication, approaches and methodologies etc. It is therefore difficult to compare rates of change and trends in different parts of the world.

6.2 Site and Matrix Selection

The key point of the construction of any monitoring system is to provide a briefing document to direct discussion of the principles and strategies for ***site and matrix selection*** [9, 11]. In other words, it addresses the question: 'How should we sample regionally and globally, to assess the effectiveness of the Stockholm Convention?

A number of broad discussion points need consideration. It is appropriate that these are considered, to help 'frame the scope' of the monitoring programme(s). The answers to these questions have an important impact on the more specific issues of sample matrix choice, numbers, frequency, analytes etc.

Generic issues include: What are the requirements for monitoring under the Convention? It is appropriate to initially consider the required/intended scope of the monitoring programmes. Pertinent discussion points are [11]:

- Is the requirement to show *source reduction*? If so, does this require attention on sources to the air, to water bodies, to soils, to food chains?
- Is the requirement to show *exposure reduction*? If so, does this require attention on humans (through the monitoring of food or the population) and susceptible biota (e.g. aquatic and terrestrial top predators?)
- Is the requirement to show *effects reduction*? If so, how could this be achieved in a monitoring programme?
- Are there cost-effective strategies, which can provide meaningful information, without requiring elaborate, multi-country, multi-media and highly time resolved data?

What are the possible monitoring strategies that could be adopted? Under this heading, it is appropriate to consider [11]:

- What are the roles and responsibilities of UNEP, and national/regional parties?
- Is UNEP intending to produce *specific recommendations* or a (lower) *level of guidance* on the requirements, design and implementation a monitoring programme?
- How will the resources required to undertake a monitoring programme be made available (i.e. internationally, regionally, nationally?).
- Will UNEP have a role in *co-ordination*?
- Can different levels of cost-effective monitoring be devised? For example, can regional 'super-stations' be developed, coupled to lower intensity monitoring at other locations?

What is the required optimum spatial scale for monitoring? This heading focuses attention on questions such as [11]:

- What do we mean by 'regional' and 'global' monitoring?
- Is it necessary for all signatory countries to provide monitoring data, or is regional information adequate?
- How much variability might there be in trends from one location to another, and what are the implications for the number of sites, sample type and frequency?

What are the issues to do with time for the monitoring programme?

- When we monitor to ensure downward trends are being achieved, what timescales are envisaged (months – years – decades)?
- Will different sampling media decline at similar rates, in response to a reduction in use/emission?
- How quickly do we expect levels of POPs to decline in a given medium, and what are the implications for sample frequency and analytical precision?

- Should sampling be concurrent at different locations regionally/globally, and for different media?

6.3 Background of Data Communication

The results from the global POPs monitoring programme will be used to determine trends from monitoring POPs globally to support the effectiveness evaluation of the Stockholm Convention [12]. Effective data sharing among relevant bodies by consistent data communication methodology is essential to achieving this objective.

Global monitoring data may be reported using wide variety of formats, from appearances, contents to technical information levels and styles. Definition for standardized format will be very important to develop a better data warehouse that can be useful for the purpose of effectiveness assessment.

The phrase "data communication" implies a wide variety of concepts [12]. This fact puts this topic at risk of including too many issues and not resolving them. Therefore, the authors suggest that the general goal of this discussion should be focused on the development of a well-organized data warehouse that contains databases of POPs global monitoring data for the purpose of the planned effectiveness evaluation.

Development of data and metadata structures for effective communication is a basic aspect of data processing [12]. It may be difficult to obtain well-harmonized analytical data as a basis of a data warehouse, because of the variety of analytical methods, sampling protocols and QA/QC practices among data sources. It is a necessary to determine the minimum set of metadata elements that would ensure the quality and consistency of data stored in this data warehouse and a suitable data structure for that purpose.

Development of methodologies for collecting and storing all data from participating countries is other import topic of interest [12]. Some participating countries have developed electronic databases to store monitoring data, however others have not. Also there are international programmes that have developed electronic databases for the purpose. All data from participating countries and international programmes are a valuable part of the POPs database whether electronic or hard copy. Electronically-stored data can be linked by building a new database and migrating data into it or by virtually linking the existing databases together to form a warehouse. Non-electronic data presents a different set of problems. If a new centralized POPs database is developed, data entry mechanisms can be included that would allow the conversion of paper copy to electronic data. Manual data entry can be very costly, so we may wish to consider ways to include non-electronic data in summary reports without manually entering each value into a database.

Development of effective strategies to share information with the public is important for public interpretation of the SC and its measures [12]. Sharing data electronically, through the Internet, is probably the most efficient way to provide information to assessors, stakeholders and the public, however alternatives must also be considered. The advantage of allowing access to a data warehouse via the Internet is that the data is available on demand. Users of the data can access only the portions that they want and can have both summarized/interpreted information and raw data. This type of access is excellent if all data in the database is electronic. If some is not, then the Internet presentation of the data is not complete. Written reports that explain the data as well as present summarizations are costly, but allow a more controlled release of information and allow non-electronic data to be included, presenting a more complete picture. These reports, along with summarized or raw data can be distributed via compact disc (CD or DVD) or by hard copy. This type of distribution, by its nature, limits access to the number of copies of a document or a CD that can be produced. Careful consideration on the ownership and/or intellectual property rights should be placed for the use of data, maybe depending on the strategies to share information.

Whether data is shared electronically of in hard copy, there are two basic ways it can be provided, as raw sampling data or as summarized data [12]. Raw sampling data can be provided electronically as files to download or in tables to examine on the screen or on paper. Summarized data can be displayed using tables, charts, graphs and Geographic Information System (GIS) technology. Using a GIS display has the advantage of providing almost "instant" understanding of place-based data by the general public. It allows different types of information to be displayed at the same time, thereby developing a picture of conditions. However, care must be taken when using this tool. There is a tendency to over summarize on a map, so the results can be deceiving. Statistical presentations using tables, charts and graphs also have these same problems and can be just as visual depending upon how they are used.

Development of strategies for building a data warehouse containing monitoring data that could be assumed to have consistent properties and qualities is also a part of system development. It is expected that a data warehouse will contain several sets of databases containing different types of data. Some topics for discussion in this area would include the most effective way to design a data warehouse from a technical point of view, the pros and cons of centralized vs. dispersed system structure and strategies for storing and presenting data in a consistent manner.

7 The Role of Modelling

7.1 Introduction

Modelling has played a very significant role in the over-all effort to better understand how several families of pollutant behave in the environment. In some cases, modelling has also been an essential tool within the operational framework of international control agreements [10]. A striking example is the use of models to enable the critical load/critical level approach taken in the more recent acidification protocols under the Convention on Long-range Transboundary Air Pollution. The critical load/critical level approach was not pursued in the LRTAP Protocol or the Stockholm Convention because of the complex intercompartmental partitioning dynamics of POPs in the environment.

Nevertheless, POPs modelling continues to make significant contributions to knowledge on how POPs move through and partition within the environment [13, 14]. However, this work is perhaps more at the level of research and development, rather than presently being a proven tool for a task such as "effectiveness evaluation". OECD has recently published a comprehensive review of the further potential of models to assist in the identification of priority substances to be added to existing agreements such as the 1998 LRTAP POPs Protocol and the Stockholm Convention [15].

There is no doubt that modelling activities of the nature described above are legitimate activities to be undertaken with respect to Article 11 of the SC [10]. However, is it necessary that new modelling activities be initiated or undertaken to enable the preparation of the periodic assessments required under Article 16?

Since modelling as a tool for assessment is most likely to be employed for the purpose of commenting upon "regional and global transport", perhaps the next step is for a "mock transport assessment team" to identify a range of practical products for this component of the assessment and to indicate the tools they would require to complete the task at both a regional and global level. In other words, the question should not be "what is the role of a particular tool (i.e. modelling)", but rather what is the job to be done and then what are the tools that would be required [10].

7.2 Basic Aspects of POPs Modelling

As many persistent organic pollutants (POPs) are semivolatile, their atmospheric transport can occur either in the gas phase or in the particle phase of the atmosphere. Due to their low vapour pressure, POPs tend to partition mainly into organic carbon containing media, such as soil, sediment, biota or aerosols. However, their volatility is often high enough to allow for long-range transport in a way that has been described as the "grasshopper effect" [3, 16, 17].

This means that the chemical is trapped in an organic phase without being degraded, and is then released back into the atmosphere, allowing for a short transport, after which it is trapped again and the procedure continues until the chemical is ultimately degraded. This "grasshopper effect" allows persistent chemicals of low vapour pressure to be transported long distances to areas where they have never been used, which is of concern both for ethical and environmental reasons.

Transboundary movement may also be possible via large water bodies, where chemicals of low water solubility can be transported a long way via water particles and suspended sediment material or chemicals with high water solubility can be very effectively transported in the dissolved state. Migrating fish could also contribute to this phenomenon.

Regardless of the medium of chemical transport, what ultimately determines a chemical's potential of long-range transport and thus transboundary movement are its partitioning properties in combination with the nature of the environmental media in or between which such transport occurs. Therefore, in order to achieve an adequate description of a chemical's movement, it is crucial to create a picture which accurately describes the possible transport pathways that a chemical substance can undergo. This is a complicated task, since the complexity of the environment cannot be underestimated.

As a first approach, the environment can however be divided into basic units, or compartments, which might include air with aerosols, water with water particles, soil, sediment and vegetation, or other significant media. The aim is then to achieve a description of transport processes and to derive a full picture of the movement of chemicals within the region being assessed.

7.3 Overview of Existing Modelling Programmes and Projects

It is now increasingly accepted that successful management of chemicals in the environment requires quantitative information on major sources, environmental concentrations, transport pathways and routes of exposure to humans and wildlife [3]. Essential are also assessments of risk as determined by the proximity of measured concentrations or body residues to those at which effects are observed. This quantitative information concerning chemical fate cannot be assembled from monitoring data alone, and is best captured in mass balance models. As a result, environmental fate models are widely used to predict contaminant fate and behaviour profiles and are becoming essential tools in the risk assessment process.

The reliability of such models, however, is paramount if they are to be used successfully. There has also been considerable interest in developing screening models to cope with a range of geographical scales. Until recently much of the research carried out into the fate and behaviour and the likely effects of contaminants in the environment was carried out on a local scale. This usually involved an assessment of the impact of a single point source on the local vicinity. However, as a result of the measurement of contaminants in areas remote from their sources e.g. the arctic there has been increasing interest in the atmospheric transport of contaminants on a regional and global scale. Indeed there has been a suggestion that remote areas such as the arctic may become sinks for semi-volatile contaminants as they are preferentially deposited in cold climes where degradation processes are extremely slow. It is therefore clear that for successful management of contaminants an understanding of their long-term fate and ability to undergo long-range transport is required. As a result, there have been many international meetings of expert groups to discuss these problems and protocols for the control of contaminants that undergo long-range transport have been developed, e.g. UN ECE or UNEP.

The fate and behaviour of contaminants within the environment is an extremely complex issue. Development of predictive models requires an understanding of the release of a contaminant (both quantity and emission route), its migration pathway through a multi-media environment, the dynamics of inter-compartmental exchange (e.g. clearance rates) and its ultimate fate. As the end use of such models is to protect humans or wildlife then these models need to be linked to food-chain models that can be used to predict exposure.

Steady state models

The Mackay suite of fugacity based models are good examples of steady state mass balance models, with the simple models relying on equilibrium partitioning and the more complex assuming that equilibrium is not achieved between compartments [3].

The Level I model describes how a given amount of chemical partitions itself at equilibrium between six media: air, water, soil, bottom sediment, suspended sediment and fish. The area of the unit world into which the chemical is added is 100 000 km^2, which is about the size of England. Simple models such as this require few input parameters and are able to provide a likely distribution pattern for the chemical in a typical environment. However, this model obviously represents an oversimplification of the environment. For example, reactivity is not taken into account.

The Level II model structure is similar but includes loss processes such as degradation. Moving up in complexity, and hence realism, is the ChemCan model. ChemCan is a Level III model and, unlike Level I and Level II calculations, does not assume that the compartments are in equilibrium, although the unit world is still at steady state. The model is divided into four compartments: air, water soil and sediment. In order to improve the sophistication of the model, 12 intermedia transport parameters are included which describe the ease of transfer of the chemical between compartments. As a result, the data input requirements are higher, although the potential output is of a higher quality.

ChemCan divides Canada into regions - each complete with a geographical description, e.g. mean temperature, percentage water coverage etc. Each region can be given defined emission data into air, water, soil or sediment compartments (or a combination). Background emission data can also be included to simulate chemical input from other regions. The output from the model provides a useful indication of the fate and behaviour of a chemical in a defined environment. It can also provide information on the relative importance of chemical loadings as a result of point sources, compared to advected input from neighbouring regions. TaPL3 is another example of a Level III steady state fugacity based environmental fate model which is intended to evaluate the persistence of chemicals and to assess potential for long-range transport in a mobile medium, either air or water [3].

Dynamic models

Most dynamic models are highly complex and location specific such as the EUROS atmospheric transport model developed by RIVM in the Netherlands and the EMEP (MSC-East) multi-media POP transport model [3].

The MPI-MCTM (multicompartment chemistry-transport model of the Max Planck Institute for Meteorology, Hamburg) is designed to describe the environmental fate of semivolatile organic substances consistently with the geospheric transports and transformations including their geographic distribution and temporal variabilities. In the present state of model development it comprises atmosphere (3D), vegetation, soils and ocean (2D distribution of single layer boxes, each) [3]. It is based on an atmospheric general circulation model (GCM). The surface properties (vegetation and soil type distributions, land and sea ice, soil hydrological status) and the large-scale atmospheric circulation patterns are well represented in GCMs. The atmosphere is a three phase system (gas, particles, cloudwater), with the mass exchange between them being controlled by instantaneous equilibria. Degradation is controlled by the hydroxyl and nitrate radical concentrations (3D fields varying with time of day and month). Wet and dry deposition processes are considered for various types, each. Deposition of the gaseous molecules to ground surfaces is described by fixed deposition velocities or by accounting for the atmospheric and surface resistances. The soil is a multiphase system. The ocean is a single phase (neglecting the hydrosol), two layer system (locally and seasonally varying depth of well-mixed surface layer). A 3D ocean GCM will be coupled for the study of the environmental fate of substances, which on the long term might accumulate in the ocean. The model accounts for first-order degradation processes in the compartments and volatilization processes from the ground compartments into the atmosphere. The model is fully dynamic and can be run either in a climatological mode (then generating its own but realistic climate) or simulating historic climate (then driven by weather and sea surface observations).

There are few examples of dynamic fugacity based models. A primary emission driven fugacity model of the historical fate, behaviour and distribution of PCBs in the UK environment has been developed [3, 18]. The model attempts to re-create the temporal release trend of PCBs over the last 40 years and to replicate the observed historical trends in soils and sediments. One from the most known dynamic fugacity based model is POPCYCLING-Baltic [19]. Many very useful results from this model were recently published for example the study by Breivik and Wania on the fate of HCHs in Northern Europe [20, 21].

8 Development of Expert System for Evaluation, Interpretation and Presentation of POPs Data - Project GENESIS

One from the most important problem connected with monitoring of POPs is a production of huge amounts of data which are not effectively for decision making purposes. In many countries of Europe exist long time data concerning to environmental and human contamination by these types of pollutants (UK, Germany, Netherlands, Scandinavian countries, Czech Republic). But the main problem is the using of these information and their evaluation, interpretation, presentation and availability.

As example we can use the situation in the Czech Republic. The development of National Implementation Plan for the implementation of the Stockholm Convention in the Czech Republic including the preparation of National POPs Inventory clearly described the high level of available information concerning to POPs in environment and human. But we can also recognize that the evaluation, interpretation and presentation of these information are not quite effective and sufficient.

From this reason, the development of expert system GENESIS for evaluation, interpretation and presentation of data from National POPs Inventories and National Implementation Plans has started as one from the most important research topic of

RECETOX, EU Research Centre of Excellence for Environmental Chemistry and Ecotoxicology. GENESIS is a Global ENvironmEntal aSsessment and Information System. The development of GENESIS is based on the Article 9 of the Stockholm Convention which is focused on **information exchange** with other Parties.

In upcoming months the main tasks consists of project base finalization and presentation:

- Scientific discussion on exact project definition
- Forming of panel and international collaborations
- GENESIS web portal – project objectives, progress, panel address book and discussion group
- Exhaustive project documentation
- Definitive version of data model (structure of GENESIS database) based on workshop of experts

Basic development and application of GENESIS system tools:

- Data validation
- First version of GENESIS software – visualization and analysis of selected data (surface water quality, persistent organic pollution and epidemiology of some important diseases), basic analysis of data and outputs presentation
- Interesting/important expertly commented outputs of data analysis within GENESIS system and their presentation on GENESIS web portal

Further development and distribution of GENESIS system:

- acquisition of additional data sources on climate, pollution, human population etc., internationally based information service
- further development of analytical capabilities of GENESIS software, expert modules focused on modelling of environmental fate of POPs
- models working with validated reference data focused on early indication of risk development form monitoring process

GENESIS project is primary focused on field of environmental health and ecological risk assessment where participating institutions (RECETOX and other members of Consortium RECETOX - TOCEN & Associates) already have practice. GENESIS project represents synthesis of this knowledge supported by several important other Czech national projects (SVOD – System for visualization of oncological data or TRITON – visualization, analysis ad multivariate typology of surface water biomonitoring data) and new approaches to environmental data, i.e. intuitive aggregation of data on time/space scale, combination of diverse data sources and their connection to robust analytical methods.

Primary goal of the system GENESIS is to develop multidimensional system for management of environmental data dealing with persistent organic pollutants with using of data and information from the firstly Czech Republic, the secondly from direct participate countries of CEECs Region such as Poland, Slovakia, Croatia, Macedonia, Armenia, Hungary, the thirdly any other CEE country and finally any other country of Convention. This part of the project assumes constitution of expert panel for international collaborations standardized on the basis of unique data browsing system.

The first step of the project is to ensure exhaustive audit of data available from the National POPs Inventories, National Implementation Plans and other national source of information and to developed electronic form of documentation. Following phases should develop GENESIS web portal which should become centre of project international communication. Prepared universal data structure of GENESIS will be fine tuned in expert workshops and set to practically acceptable form.

The major end-point of GENESIS project is development of novel tool for complex visualization and analyses of environmental/population data supported by scientific background but on the other hand with comprehensible outputs. The GENESIS system could be applied in level of scientific analysis, governmental institutions or presentation of final outputs of public projects to citizens. Different levels of information service will be directed using modern web technologies.

GENESIS project lead to multiple outputs with different importance and functionality:

- **WEB PORTAL of GENESIS** provides information on project objectives, working panel, progress, results and utilized data sources. Important results of analyses are also presented and could be looked through in project discuss group. In further development web based version of GENESIS system will be provided in minimal version for citizens and under access rights in full version for listed experts.
- **SOFTWARE solution of GENESIS** will be provided in several versions including i) **governmental institutions version**, where maximum accent is put on user friendly environment and simply data presentations (only basic knowledge of data is necessary), ii) **public version** aimed on basic presentations for citizens and iii) **expert version** with complete analytical capability and possibility of inventive analysis. The software has got both **on-line and off-line work** capability – every user of system is able to connect central database of project and in dependency on his/her access rights is able to access and work with data: data could be also downloaded into local database and analyzed in offline regime. Of course in online regime there are some additional features like web conference of project or database of important results presentations.
- **INFO SERVICES of GENESIS** provides information on project topics and/or help and analysis with relevant data. **Consultations** of working panel are accessible on request for institutions or experts: these could be aimed on project function, environmental and other incorporated data analysis or possibility to participate in project. **Impact assessment** analyses of important pollution agents or breakdown events will be provided in collaboration with respective institutions.

GENESIS system offer some new approaches to analysis of above mentioned data like interactive aggregation of data based on time x space scale or in connection to another data source. Possibility of multiple inputs in standard analyses is another innovative attitude; it allows us to view data from unusual points of view and to make top level analysis and decisions based on multiple data types and sources. Novel approach in multivariate data analysis is based on robust metrics and non-parametric approach to multivariate comparison of groups of objects: it allows as comparing data with very low prerequisites on data distributions.

The software tool is not the only result of project, there is also panel able to develop expert interpretations and comments to data. This additional value makes results of complicated science background of data available for non-expert users, for example governmental officials.

National POPs Inventories (NPOPsINVs) and National Implementation Plans (NIPs) summarized huge amount of information from any country - baseline national-level information on the production (intention or unintentional), use, presence in the environment/humans, and disposal of the chemical(s) being addressed. In many countries exist problem of take advantage of these information and using of them for decision making process, policy, strategic conceptions and everyday work of governmental and local authorities and institutions. This problem is sometimes connected with huge amount of data and their form of presentation.

The removal of these problems, better interpretation of POPs and other environmental information and more effective decision process in the case of POPs problems management, is the basic goal of GENESIS expert system. This system will be also very useful and powerful in the reporting process and especially in the phase of SC assessment process during the future period.

Network(s) and expert system will be used by many possible users from existing specialised institutions/agencies, already appointed by the respective ministries to perform the specific tasks, representatives of academia, various sectors of the industry, NGO, public and media. Both tools will be able better exploit the many of basic outcomes of Enabling projects such as better understanding of the POPs related issues, co-ordination of national and regional priorities, raised public awareness and better communication among the stakeholders.

On the regional levels and in the context of whole continent, the common regional strategy will have to be prepared and developed. This strategy will be focused on:

- for information exchange,
- education communication and awareness rising with the respect of national action plans focused on promotion of awareness raising on policy and decision makers with regards to POPs,
- preparation and provision to the public with information on POPs such as basic POPs information,
- their explanation, interpretation and presentation,
- contact details of the relevant bodies dealing with POPs,
- human health and safety,
- inventories of emissions, hot spots and contaminated sites,
- possible exposure to human population and the environment,
- available and suitable destruction technologies and capacities,
- national and regional laboratory capacities.

Many monitoring projects were performed (and currently are performed) and indeed it seems that there is even redundancy of environmental data in European countries. The critical problem however is the availability and validated interpretation of data. Outputs of governmental and non-governmental projects exist in separated databases of many institutions and their combined browsing and analysis are complicated and requires participation of specialists in data mining, data analysis and scientific

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