



UNITED NATIONS  
ENVIRONMENT PROGRAMME



## GEF: Regionally Based Assessment of Persistent Toxic Substances

Guidance Document for the Collection, Assembly and  
Evaluation of Data on Sources, Environmental Levels  
and Impacts of Persistent Toxic Substances



UNEP Chemicals  
September 2000

**IOMC**

INTER-ORGANIZATION PROGRAMME FOR THE SOUND MANAGEMENT OF CHEMICALS

A cooperative agreement among UNEP, ILO, FAO, WHO, UNIDO, UNITAR and OECD

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*Cover page: Self Poisoning, India, photo by UNEP/Zuben Mathews/TOPHAM*

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## Table of Contents

	Page
1 Introduction	5
2 Expected Results and Activities of the Regionally Based Assessment of Persistent Toxic Substances	7
2.1 Objectives of the Guidance Document	7
2.2 Scope of the Guidance Document	8
3 Selection of Persistent Toxic Substances	9
3.1 Suggested process for final selection of substances at regional level	11
4 General Considerations on Data Collection and Evaluation	13
5 Data Collection	15
5.1 Source Related Information and Data	15
5.2 Environmental Concentrations	25
5.3 Environmental Impacts	33
6 Data Evaluation	39
6.1 Source Related Information and Data	40
6.2 Environmental Concentrations	44
6.3 Environmental Impacts	47
7 <u>ANNEX</u> : Substance-Specific Information on Selected PTS	51
7.1 The Twelve UNEP POPs	51
7.2 Some other examples of PTS	58
8. Suggested Literature and Information Sources	63

## Table of Tables

	Page
Table 1: POP substances being negotiated within UNEP	9
Table 2: OSPAR List of Chemicals for Priority Action ( <a href="http://www.ospar.org/eng/html/sap/strategy_hazardous_substances.html">http://www.ospar.org/eng/html/sap/strategy_hazardous_substances.html</a> )	10
Table 3: General information to be gathered for all PTS source test data	18
Table 4: Additional air/flue gas sampling information for PTS sources to air	19
Table 5: Additional water sampling information for PTS sources to water	20
Table 6: Additional land sampling information for land sources to water, air and land	21
Table 7: Additional waste sampling information for land sources to water, air and land	22
Table 8: Additional product information for land sources to water, air, land, and waste	24
Table 9: General information to be gathered for all environmental samples	26
Table 10: Additional information for soil samples	27
Table 11: Additional information for sediment samples	28
Table 12: Additional information for air samples	29
Table 13: Additional information for water samples	29
Table 14: Additional information for vegetation	30
Table 15: Additional information for aquatic animals	31
Table 16: Additional information for land-based animals and birds	31
Table 17: Additional information for foodstuffs and feed stuffs	32
Table 18: Addition information for human samples	33
Table 19: Information to be gathered for effects and environmental impact	34
Table 20: Information to be gathered for local effects	35
Table 21: Information to be gathered for test results	36
Table 22: Information to be gathered for regional assessments	37
Table 23: Information to be gathered for regional guidance values	38
Table 24: Example of results matrix for soil concentrations for dioxins and furans	45
Table 25: Example Table of Preferred Units TEQ = Toxic equivalent, d.m. = Dry matter	46
Table 26: Preferred units	47
Table 27: EHC documents on high priority POPs.	51
Table 28: WHO TEFs for human risk assessment based on the conclusions of the meeting in Stockholm, Sweden, 15-18 June 1997	54

## Table of Figures

	Page
Figure 1: Generalized flow-charts of PTS sources and release pathways	16
Figure 2: Example of a standardized questionnaire: “Releases to air from waste incineration” from the UNEP Dioxin Inventory Toolkit Main Source Category	17



## 1 INTRODUCTION

This document was assembled as part of the preparatory phase of the Global Environmental Facility (GEF) project on Regionally Based Assessment of Persistent Toxic Substances (PTS) by UNEP Chemicals. It is provided to assist participants in the GEF project to gather data, compile summary information and to evaluate data in a consistent and effective manner. It will be distributed to participants in the project network together with accompanying questionnaires to guide the data collection and evaluation process. This guidance will also assist the Regional Co-ordinator and the Regional Team in preparing the draft Regional Report.

The project aims to provide a scientifically based assessment of the nature and scale of the threats to the environment and its resources posed by persistent toxic substances that will provide guidance to the international community concerning the priorities for future remedial and preventative action. The assessment will lead to the identification of priorities for intervention and through application of a root cause analysis will attempt to identify appropriate measures to control, reduce or eliminate releases of PTS at national regional or global levels.

The actual priorities for action within each region may not be the same reflecting differences between regions in terms of economic development, agricultural and industrial production, climatic, geographic, social and cultural conditions. Therefore, the assessment will be based on an analysis of conditions in each region using information available from a variety of sources but following common methods and approaches.

The assessment will be based on collection and assessment of existing data rather than the generation of new analytical or effect data. It is therefore crucial that data gathered within and between large and diverse geographical regions is comparable to allow a rigorous assessment to be made. In special cases and as the need arises, model projections might be performed to fill data/information gaps and to predict threats to the environment.



## **2 EXPECTED RESULTS AND ACTIVITIES OF THE REGIONALLY BASED ASSESSMENT OF PERSISTENT TOXIC SUBSTANCES**

The aim of the project is to make a global assessment on a regional basis of PTS pollutants.

The proposed activities are designed to obtain the following results:

1. Identification of major sources of PTS at the regional level
2. Identification of environmental levels data from the region
3. Impact assessment of PTS on the environment and human health in the region
4. Assessment of transboundary transport of PTS within and into and out of the region
5. Identification of regional priorities for PTS related environmental issues
6. Assessment of the root causes of PTS related problems and regional capacity to manage these problems
7. Identification of PTS priority environmental issues at the global level.

The implementation of the regional assessment phase is tentatively scheduled to last twelve months. In each region a Regional Co-ordinator will head the Regional Team of 4 to 5 members drawn from government, academia and industry and environmental NGOs. In each region a Regional Team will be responsible for completing the assessment of PTS substances. In addition, a large network of individuals drawn from all sectors of society will participate by contributing information as appropriate.

The project will proceed through several distinct steps including data gathering; data assembly and compilation; data evaluation including health and environmental impact assessment; priority setting including identification of significant data gaps; production of regional reports and assembly of the regional assessments at the global level and identification of global priorities. Individuals and institutions at country level will mainly carry out the data gathering. The subsequent steps will normally be carried out at the Regional Team level. If elements of data assembly and compilation are carried out at the country level it is recommended that all data and supporting information required for assessment be provided to the regional team along with any compiled information. The final step will be carried out at the global level.

### **2.1 Objectives of the Guidance Document**

The objective of this document is to provide guidance to the Regional Teams on the procedures for the collection, compilation and evaluation of relevant data and information on sources, environmental levels and health and environmental impacts of PTS. The guidance is intended to facilitate the preparation of the corresponding chapters of the Regional Reports (see project brief, Annex G).

This document outlines procedures for gathering and assessment of existing data but does not address issues

of project management, organization or timing. Such information will be provided in a separate work plan.

## **2.2 Scope of the Guidance Document**

The guidance outlined in this document is intended to be of assistance in harmonized data collection and assessment.

Guidance is given on three main areas

1. Source information
2. Environmental concentration information
3. Health and environmental impact assessment

For each area two levels of guidance are given:

1. guidance for the gathering of original data and information by individuals and institutions
2. guidance for the compilation and evaluation of the collected data by the Regional Teams

Detailed guidance is provided on data gathering at the country level that is designed to ensure that the information received is suitable for comparison and evaluation to be made at the regional level. The focus of this project is on existing data, however, if additional external funding outside this project is available for generating new data, such data should also be included.

Questionnaires based on the present guidance document will be sent out to participants in the Regional Network, including governments, government agencies and institutions, research institutes, individual scientists and non-governmental organizations from industry, public interest groups and academia.

### 3 SELECTION OF PERSISTENT TOXIC SUBSTANCES

During the PDF-B phase technical expert workshops (WS1, WS2 and WS3) the participating experts developed a basis for defining and delineating PTS in the context of the GEF project. It was agreed that there was no simple wording to define persistent toxic substances but that these substances shared the following characteristics:

- Organic (including organometallic) substances
- slowly degraded in the environment
- accumulating in biota and
- toxic

In addition the experts agreed that there were cases where substances with moderate inherent persistence were continuously released in large quantities over substantial areas, e.g. large international water-bodies. The releases might lead to continuous exposure of organisms that would simulate that of a more persistent substance. These substances should therefore also be considered in the project. The experts did not define parameters for the listed properties above or cut off values for these parameters to limit the group. Until this is done the PTS group is supposed to include substances “with these characteristics”. Among the toxic effects considered for PTS, endocrine disruption should be noted. The twelve persistent organic pollutants (POPs) subject to the on-going intergovernmental negotiations convened by UNEP for a global treaty represent a sub-set of PTS. These substances (often called “the dirty dozen”, see Table 1) are presently regarded as the POPs of most immediate concern.

Table 1: POP substances presently being negotiated at the global level.

Pesticides	Industrial chemicals	Unintended by-products
Aldrin	Hexachlorobenzene	Dioxins
Chlordane	Polychlorinated biphenyls	Furans
DDT		
Dieldrin		
Endrin		
Heptachlor		
Hexachlorobenzene		
Mirex		
Toxaphene		

N.B. Hexachlorobenzene is used both as a pesticide and as an industrial chemical. It may also be unintentionally produced as a by-product of some industrial processes.

The knowledge about these substances is quite extensive, as they have been studied for some 30-40 years. To some extent this knowledge can also be extrapolated to similar PTS but this always has to be done with care. All regions should include the twelve POPs in their assessment.

A number of schemes have been suggested in different international fora for the prioritization of POPs. For the global treaty on POPs the Intergovernmental Negotiating Committee established a Criteria Expert Group (CEG). This group suggested criteria for identifying additional POPs for international action that include persistence (expressed as half-lives in different media), bio-accumulation, evidence

for long-range transport and toxicity. The proposed CEG criteria are aimed at the identification of substances for immediate global action. Any substance identified in a region fulfilling these criteria should also be included in the regional assessments. It is important to note, however, that the present project focuses on PTS, which is a broader concept than POPs. This project should also focus on the regional level. This means that a broader group of substances than the twelve POPs may be included in the project. Inconsiderate application of the CEG criteria may also unnecessarily limit the selection of substances of interest in a region.

There are other international initiatives underway to identify priority persistent pollutants. Some key activities that may provide some guidance for considering additional PTS for assessment are noted below. It should be noted that these lists were developed in different contexts and the results may not be applicable to other areas or to all regions of the world.

The UNEP POPs substances share many properties with the substances in the POPs Protocol under the Geneva Convention on Long-Range Transboundary Air Pollution (LRTAP) under the auspices of the United Nations Economic Commission for Europe (UNECE). A possible expansion of list of the substances to be included in this project may be sought there. The additional entries on the LRTAP list are chlordecone, hexabromobiphenyl, hexachlorocyclo-hexane and polycyclic aromatic hydrocarbons (PAHs). It is uncertain whether chlordecone is a global environmental problem and hexabromobiphenyl has not been produced for many years. Regions might first want to consider whether these substances are candidates of high priority for their region or not. Hexachlorocyclohexane is still in use, especially the gamma isomer (Lindane) and it may be a candidate for inclusion in the regional assessments, as may be the PAHs.

Other groups of substances that were discussed in the preparatory stages of the UN-ECE list are the polybrominated diphenyl ethers (PBDE) and chlorinated paraffins (CP). These two groups of substances are both persistent and bio-accumulating. They are also produced in high volumes and could thus be interesting to include in the regional assessments. Among pesticides endosulfan has been suggested, as well as atrazine.

The Oslo-Paris Convention (OSPAR) has identified a list of PTS for priority concern. Some of the entries on this list are common with the UNEP POPs, but there are also additional substances as can be seen in Table 2.

Table 2: OSPAR List of Chemicals for Priority Action  
([http://www.ospar.org/eng/html/sap/strategy\\_hazardous\\_substances.html](http://www.ospar.org/eng/html/sap/strategy_hazardous_substances.html))

Polychlorinated dibenzodioxins (PCDDs)	Organic tin compounds
Polychlorinated dibenzofurans (PCDFs)	Nonylphenol/ethoxylates (NP/NPEs) and related substances
Polychlorinated biphenyls (PCBs)	Musk xylene
Polyaromatic hydrocarbons (PAHs)	Brominated flame retardants
Pentachlorophenol (PCP)	Certain Phthalates – Dibutylphthalate and Diethylhexylphthalate
Short chained chlorinated paraffins (SCCP)	
Hexachlorocyclohexane isomers (HCH)	
Mercury and organic mercury compounds	
Cadmium	
Lead and organic lead compounds	

OSPAR is also developing a ranking procedure for persistent, bioaccumulating and toxic substances in the marine environment. This work started with a very large number of substances (“the chemical universe”) and ranked measured and predicted data for persistence, bioaccumulation and toxicity to identify a list of candidates. The candidate substances are then ranked by expert judgement to produce

a condensed list of substances of concern. It is expected that the work will be finished by early summer 2000. The output may be useful for selection of chemicals in the present project.

The European Union has recently proposed a Water Framework Directive. In the preparation of this directive an objective method for the selection of chemical parameters to describe the quality of the aquatic environment has been developed (Fraunhofer-Institut, "Revised Proposal for a List of Priority Substances in the Context of the Water Framework Directive (COMMPS Procedure)", 1999). It should be noted that several of these substances would not fulfill criteria for persistence and bioaccumulation, but there are also compounds that belong to the PTS group. Among those are PAHs, pentachlorophenol, short-chained chloroparaffins, bis (2-ethylhexyl) phthalate, octyl- and nonylphenols and brominated diphenyl ethers.

At the PDF-B technical expert workshop on industrial chemicals and by-products a model for the early selection of PTS chemicals for inclusion was developed (UNEP, "Regionally Based Assessment of Persistent Toxic Substances", IOMC 1999, pp. 30-32). This model gives high priority to chemicals binding to the aryl hydrocarbon receptor (AhR), as all binding substances should be included. Substances not binding to the AhR, that are lipophilic ( $\log K_{ow} > 3$ ) and have a molecular weight of  $< 1000$  and are direct biologically active or give rise to active metabolites will also be included in the model. If no information is available on the chemical's mechanism of action or on its kinetic properties it should also be included. The first part of this scheme is new and interesting, putting an "effect" on the top of the prioritization scheme. The full consequence of using the model is for the moment not clear, but it would certainly include a large group of substances, e.g. several PAHs and a number of substances of natural origin. The scheme did not include criteria for persistence at the first step and this would have to be added to identify PTS. The workshop also suggested that a further prioritization should be made among the included substances based on their toxic effects in relation to established guidance values or ADIs. The further development and application of the model requires considerable resources that are beyond the scope of this project.

The inclusion of organometallic substances in the GEF project was discussed at one of the GEF PDF-B workshops and the highest priority was given to organic mercury and tin substances (UNEP, "Regionally Based Assessment of Persistent Toxic Substances", IOMC 1999, pp. 89-95).

As mentioned before it was also agreed during the PDF-B phase that less persistent substances with a high continuous release giving a continuous exposure in large regions should be possible to include in the GEF project. Examples of such chemicals would be phthalates and PAHs.

### **3.1 Suggested process for final selection of substances at regional level**

The actual use of persistent chemicals other than those mentioned above within a region should also guide the choice of substances to be included, especially if there are known problems associated with their use. The choice of substances to be investigated may thus be somewhat different between the regions, but should at least have the twelve UNEP POPs in common. Given the restrictions on time and resources in the project each region will have to focus on the most important chemicals at the regional level. To perform an assessment with sufficient quality the regions should make every effort to keep the number of substances to be assessed at a manageable level.

In each region there is a need for an early agreement on the total list of substances to focus on in the regional work, as the other activities in the region are dependent on the list. One of the first tasks of the Regional Team would be to discuss and agree on the chemicals to be included in their regional assessment. It is suggested that this be done in a two-step process where as a first step preliminary data/information on sources, levels and impacts is gathered from the region. In the second step the list

of suggested substances would be finalized in consultation with the Project Manager and in close co-operation with the other Regional Teams. The outcome of the discussion would be a regional list of substances to be communicated to all participants in the project network.

## 4 GENERAL CONSIDERATIONS ON DATA COLLECTION AND EVALUATION

The data to be assessed in this project will be collected by a large number of participants representing a broad spectrum of backgrounds. To ensure consistency and compatibility of assessments between regions it is therefore highly recommended that the original data are reported to the Regional Team together with any supporting meta-data required for correct conversion of the units; evaluation of the data quality; conclusions whether a certain set of data should be included or excluded and data assessment. If the collected data are altered or converted in any way before submission to the Regional Team this should be stated in the submission. Data quality assurance will also be the responsibility of the Regional Team.

The procedural guidance given in this document relates only to helping to collate data in a way that enables reasonable comparisons to be made. The judgement regarding a possible indication of concern and the prioritization of the results at the regional level have to be developed during the project by the participants of the Regional Teams under the guidance of the Regional Coordinator.

A further possible aim may be to use data as an input to regional or global fate models. There is considerable difficulty in assembling sufficient information for the modelers but further input from modelers at an early stage may assist in gathering important meta-data.

In many regions not all the data will be readily available for each data set. If a rigorous approach is applied that seeks only complete, detailed and highest quality data sets few if any satisfactory data sets will be obtained. In reality the project will deal with a large amount of imperfect data. The aim should be to make the best use possible of limited data sets while ensuring that key shortcomings are noted and these notes carried forward to the analysis stage of the project. Without careful attention to the limitations of the data sets there is a danger of making assumptions and drawing conclusions that are not supported by the data.

The way that comparisons are made and the use to which the PTS data are put must be flexible. At this stage it can be envisaged that some basic comparisons and compilations can be anticipated for each region to give general indications of presence and effects of PTS in the environment.

The data gathering and evaluating processes described below are based on a regionally agreed list of PTS chemicals of concern that has been established earlier in the project by the Regional Team. This list of chemicals of interest would be distributed to all participants in the regional network.

Further needs may be identified after assessment of other information - for example on sources or environmental fate or environmental impact. Simple examples may include gathering environmental information linked to identified sources of PTS, e.g. a pulp mill is found to release into a water body, the environmental data can be sorted by reference to the water body in question and this can be refined with knowledge of general transport conditions- for example if the water body flows consistently in one direction environmental data may provide additional confirmatory data related to the source.



## 5 DATA COLLECTION

The guidance provided in this section is designed to be used at the country level in the process of identification and interrogation of original country data that provides information relevant to:

- Sources of PTS
- Environmental concentrations of PTS
- Environmental and human impacts of PTS.

The base data relevant to meeting the objectives of the GEF project is likely to be incomplete and the coverage patchy. The intention of this guidance document is to assist countries to gather the maximum amount of relevant data so that the assessment stage is based on the broadest possible sweep of information.

### 5.1 Source Related Information and Data

Emission source data of PTS have been assembled only for very few groups of PTS in only very few countries. In addition, most of the PTS release data sets available deal exclusively with POPs. None of the PTS release information has been assembled with the intention of providing comparable data sets. Instead individual studies have been established for purposes of research, monitoring, legislative activities, specific site investigations or to investigate general background levels. Furthermore, there are no universally accepted or applied sampling, analytical and reporting protocols. Data may be assembled on behalf of research organizations or through government organizations, some, but not all, are already or will be made available through the international scientific literature, governmental agencies, and/or UNEP Chemicals.

#### General Information to Be Collected Regarding PTS Releases

The gathering of source related data is a multi-step process. It is clear that detailed inventories will not be available for most areas and there will not be the opportunity to generate these, however, it is essential that basic source related information is assembled that can be used to give an indication of main releases. The first stages will be carried out at the country level to provide guidance for the gathering of information for each selected chemical. An initial data gathering exercise can be followed by a more in-depth evaluation to generate data to address missing and incomplete data sets.

For the data gathering step it has to be taken into account that the PTS chemicals of concern will belong predominantly to one of the following three classes:

- Manufactured Chemical - Pesticide
- Manufactured Chemical - Industrial chemical
- By-Product.

In some cases, a PTS may also fall into two categories. For industrial chemicals and pesticides, the source of its releases into the environment is being determined by the use pattern of the chemical. This information provides a first guidance to the data gatherer to focus his efforts on the main releases. The

above classification can also serve as an important reminder not to ignore the possibilities of by-product releases for chemicals classified as mainly industrial (for example PCB).

Valuable information on sources according to the three classifications can be found in the Workshop reports of the PDF-B phase of the GEF RBA project. The report of Working Group I of Workshop 1 (on manufactured chemicals and by-products) makes detailed reference to the sources identified so far for a number of these chemicals. The report of Workshop 2 gives major fields of application for pesticides and the Workshop 3 report list these fields for the organometallic compounds.

There may be many sources of the PTS chemicals. A generalized flow sheet is shown in Figure 1 that outlines the possible ways that releases may occur.

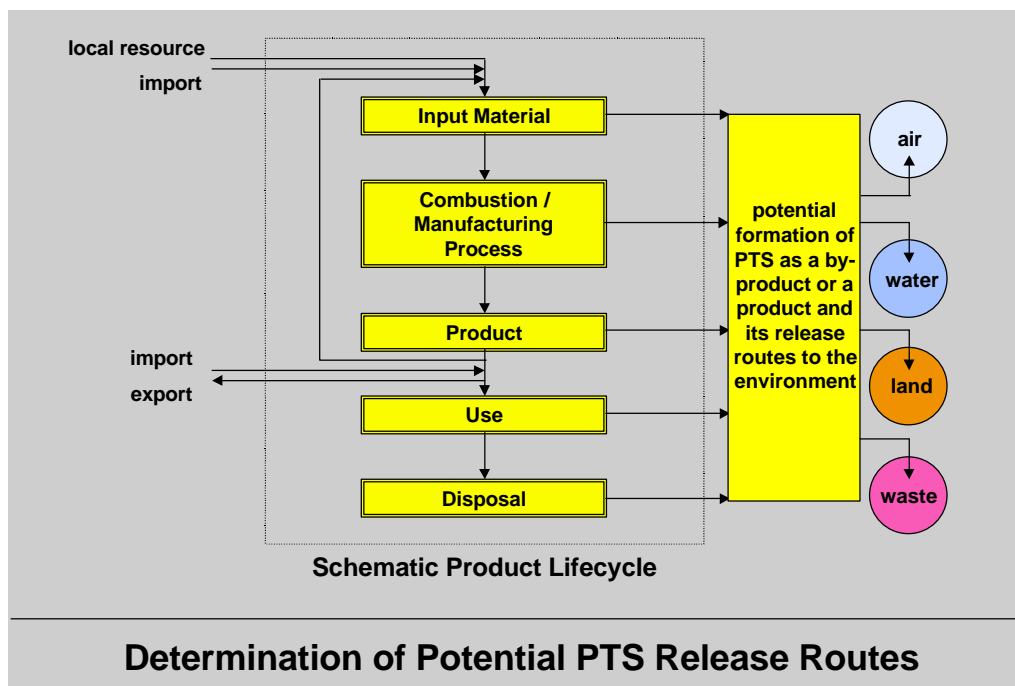


Figure 1: Generalized flow-charts of PTS sources and release pathways

Releases of PTS can occur from and/or into five major environmental compartments and/or media, namely air, water, land, waste, and product. This section describes all the relevant information that should be obtained to allow source quantification and the assembly of a regional PTS emission inventory.

In most cases it will not be sufficient to rely on literature information for data collection only. Industry, which potentially releases – knowingly or unknowingly – PTS and potential users of PTS containing products must be consulted for assistance in gathering as much relevant data for PTS inventory developing purposes as possible. Also, efforts to gather data regarding other non-industrial PTS sources such as accidental fires, anecdotal events and other releases as well as data on existing reservoirs and stockpiles which pose a future potential for PTS releases must be directed and coordinated properly in order to achieve the necessary data quality.

In order to retrieve the necessary data from industry, users as well as all other potentially relevant sources of information, the method of using a questionnaire has been applied successfully. Figure 2 provides an example of a questionnaire for byproducts from combustion sources to air, derived from the UNEP Standardized Dioxin Inventory Toolkit. This might be used as a template for questionnaires

for by-products developed during the GEF project. For industrial chemicals and pesticides similar questionnaires would be developed. It is suggested that such questionnaires be developed for each individual PTS to be assessed. These PTS will then be addressed during the data-gathering phase. The questionnaires serve as guidelines for the data gatherers to ensure that all the relevant information on a particular source for a particular PTS is collected and all the issues regarding data quality assurance are properly addressed. Data that are not gathered properly will automatically diminish the overall data quality and subsequently affect the outcome of the GEF project.

PCDD/PCDF Source Questionnaire											
waste incineration	location	number of furnaces	OC	unit capacity t/d or m <sup>3</sup> /h	operational hours p.a.	Fur. type/HRS	Fur. Temp (°C)	APCS type	APCS inlet Temp (°C)	APCS outlet Temp (°C)	APCS flue gas flow rate (Nm <sup>3</sup> /h)
municipal solid waste incineration (MSWI)											
hazardous waste incineration (HWI)											
sewage sludge incineration											
light weight aggregate (e.g. from shredder)											
medical/hospital waste incineration											
waste wood and biomass combustion											
veterinary waste incineration, animal carcasses rendering											
acronyms:											
<b>furnace type</b>	<b>Fur.</b>			<b>air pollution control system</b>				<b>APCS</b>			
Mass-burn/waterwall (Grate)	Grate			electrostatic precipitator				ESP			
Fluidized-bed	FBI			cyclone				cyclone			
Stoker	Stoker			baghouse filter				BF			
Rotary kiln	RK			wet scrubber				Wet			
Other (please specify)				dry scrubber				Dry			
				lime injection				Lime			
				NaOH injection				NaOH			
<b>operational conditions</b>	<b>OC</b>										
batch type (e.g. 100 kg per burn)	batch			active carbon/coke injection				Coke/carbon			
discontinuous (e.g. 8 hours per day)	dis			carbon bed filter				CarbFil			
continuous (24 hours per day)	con			catalytic converter/SCR system				Cat			
				induced or forced draft fan				fan			
<b>heat recovery system</b> yes/no	<b>HRS</b>			None				None			

**Standardized Questionnaire Example**

Figure 2: Example of a standardized questionnaire: “Releases to air from waste incineration” from the UNEP Dioxin Inventory Toolkit Main Source Category

For the purposes of this work the intention is to gather the maximum amount of existing relevant PTS release data including emissions. In order to provide some guidelines on how to collect data, it must be understood that each individual PTS has some specific needs for data collection. Additionally, each environmental release compartment poses different requirements especially concerning the collection of supporting meta-data. Thus, the following minimum information compiled in Table 3 must be gathered regardless of the environmental compartment or media from which or into which any PTS is released. As a rule, data on past as well as present sources should be sought.

Table 3: General information to be gathered for all PTS source test data

Information	Importance*	Comment
Process or source type	1	Use standard classification
source/reference	1	it is important to enable data to be traced back to the original report to obtain missing information
exact chemical species and/or group reported and possible simplifications used if any	1	Note simplifications or assumptions for chemical groups. If any TEF scheme is applied and if so, identify which one and ensure that the same scheme is applied to all the results compared!
Time units used for reporting the volume or mass flow rates (this usually includes detailed information about operating hours per year, load conditions, annual weighted average of maximum load, etc.)	1	Per hour, per minute, per second, etc.; all reported emission mass flows must be based on the same time units in order to allow for a meaningful comparison. In order to exclude various different yearly operating schemes it is highly recommended to convert all time units to one year of operation in order to obtain an annual mass flow rate in g PTS/a.
detection limits	2	are these high in comparison to the levels measured? Good practice for quality assurance: detection limit less than 10 % of the measured value!
reporting of results below detection limit	2	if some results are below detection limits, how are these handled (e.g. included with the value of the detection limit, half the detection limit or zero)
concentration ranges	2	lowest and highest values
central tendency (if applicable)	3	Mean, median, <i>etc.</i>
period of sampling	3	dates and duration of the sampling campaign
objectives of sampling and site information	3	Regulatory compliance tests, site specifics, general assessment data, etc.

\* the importance ranking in this and subsequent tables indicates

1 = highest importance, 2 = important information, and 3 = helpful information

## Information to Be Collected Regarding Air Releases

Ambient air may act as a source of PTS through long-range transport and subsequent deposition of PTS from other regions. The arctic regions serve as a perfect example for this phenomenon, since many of the PTS found there can be traced back to atmospheric deposition. This section addresses releases into the air whereas PTS carried into a country by ambient air from another region is to be addressed under a separate activity. PTS releases into the atmosphere are continuously removed through atmospheric deposition. The section on environmental levels (Section 5.2) deals more elaborately with the determination of ambient air concentrations of PTS as well as their atmospheric deposition.

Releases of PTS into the atmosphere of by-products most commonly occur from combustion sources via flue gas being discharged from combustion processes. Other industrial thermal processes such as sintering, pyrolysis, drying, smoke treatment and many more must also be considered in the same way as combustion processes with respect to PTS releases. Releases into air also occur by means of evaporation and/or volatilization during and after the use of PTS products such as e.g. pesticides.

Table 4 provides for all the parameters, which must be taken into account in addition to the ones outlined in Table 3 in order to make the air/flue gas test results comparable. Thus all this data as well as the supporting meta-data has to be gathered for allowing meaningful data processing and evaluation for the GEF project with regard to by-products.

Table 4: Additional air/flue gas sampling information for PTS by-product sources to air

Information	Importance	Comment
Flue gas volume or mass flow rate conditions	1	Actual, including density, or normalized, wet, including moisture content, or dry
flue gas conditions regarding temperature, O <sub>2</sub> content and pressure (absolute)	1	Definition of normal/standard conditions with regard to temperature, pressure and O <sub>2</sub> content must be identical for all results to be compared!
units in which the analytical results are reported	1	mass per volume concentrations (e.g. ng/m <sup>3</sup> ) or volume per volume concentrations (e.g. ppm)
sampling method used	2	high volume air sampler, passive gas sampling, extractive gas sampling, iso-kinetic sampling, etc.
sample type	3	Whole air, vapor phase component, suspended phase, etc.

## Information to Be Collected Regarding Water Releases

The analyses of water samples from effluent, sewage and/or runoff into fresh water, estuaries or marine environments provide a direct measure for the PTS contamination. In some cases of such hydrophobic PTS as dioxins, furans and PCB the vast bulk adsorbs onto particulate matter present in the water.

However, some other PTS such as organometallics are hydrophilic and are more soluble in water.

In this section existing water bodies are not considered as a source per se, since long-range transport of PTS in surface and ground waters does not occur to the same extent as it does in the atmosphere. The predominant long-range source of PTS in the hydrosphere is ship traffic, ocean currents and river streams that are contaminated with PTS. The section on environmental levels details most of the sampling issues (Section 5.2). Thus, this issue is not dealt with further in this section. In most cases sampling of liquid effluents is not subject to the same difficulties found with gas sampling, since the volume changes of liquid water with respect to temperature, pressure and pollutant concentration can be largely neglected. One exception is the concentration of solids in the water, since the transition from liquid water to sludge and eventually to solid matter such as soil is fluent. In this context, water is referred to as liquid water with a concentration of solids negligible for the physical and chemical properties of the water such as density, specific weight, boiling and freezing point, etc.

Table 5 provides for all the parameters which must be taken into account additionally to the ones outlined in Table 3 in order to make these collected water data comparable. Thus, all this data as well as the supporting meta-data has to be gathered for allowing meaningful data processing and evaluation for reporting in the GEF project.

Table 5: Additional water sampling information for PTS sources to water

Information	Importance	Comment
units in which the analytical results are reported	1	mass per volume (e.g. mg/l), or mass per mass (e.g. mg/kg) concentrations, volume per volume (e.g. ppm), which in liquid water as defined herein at ambient conditions are all inter-changeable
water volume or mass flow rate conditions	1	Actual (including density) or normalized, wet (including moisture content) or dry
reporting protocol	2	results related to water or to suspended matter
sample type	2	water including suspended matter/suspended matter alone/water excluding suspended matter

### Information to Be Collected Regarding Land Releases

Please note that 'land' in the terminology used here applies to every solid containing matter, which is not covered under the category of water. Thus, land as defined here can in some isolated instances act as a source in case of releases from highly contaminated hotspots, sludge, sediment or other PTS contaminated materials.

In this section, sediments are also considered land and covered under the same categorization. Sediments from lakes, estuaries and oceans can act as sources for the release of PTS, which were deposited there earlier.

Soil samples are commonly analyzed for PTS releases to land as detailed in the section on environmental levels. The soil will tend to act as a long-term accumulator for many of the compounds

of interest and can provide a convenient matrix for sampling and monitoring. Soil surveys may be systematically carried out on a national, regional or local scale, often around a source of contamination.

Soil as being the major part of the land is the main environmental compartment from which PTS enter the land based biosphere. The world's oceans and large fresh water bodies play the same role for the aquatic biosphere. Thus, water and land are not only the ultimate reservoirs for the environmental accumulation and storage of PTS, but also the ultimate source for the release of PTS into the biosphere.

Since land isn't discharged like flue gas and/or water, it follows different requirements in terms of source characterization. Only the special case of contaminated sediment sludge or soil, which is discharged to the environment is further taken into account for, since the sampling requirements for land as a reservoir leading to elevated environmental levels is already accounted for and put forth in the section on environmental levels.

Great care must be taken that the information as outlined in Table 6 below is gathered additionally to the information required in Table 3 and also Table 5 on a case by case basis. It must also be noted that not all the information might be needed depending on the type of land source investigated. It is rather obvious that sludge contaminated with low volatile, hydrophilic PTS and discharged into the ocean doesn't require the same information as soil contaminated with high volatile hydrophobic PTS discharged to a landfill in the desert. Therefore, in any case of doubt, expert discretion is advised in selecting the correct parameters needed as information applicable to each individual case of land that must be considered a source of PTS release. However, the number of cases in which land acts as a source of PTS is rather limited.

Table 6: Additional land sampling information for land sources to water, air and land

Information	Importance	Comment
some physical and/or chemical properties of the contaminated land source	1	Sludge, sediment, soil, organic content, particle size distribution, density, etc.
location and site description of the land source	1	map reference (or reference to publication), known history of chemical use on site or locally, estuarine, fresh water lake/river, oceanic
surrounding environment of the land source	2	Rural, agricultural, residential, industrial
weather during period	3	wind direction, rainfall, solar radiation
Temperature	3	High/low for possible volatilization, drying etc.

### Information to Be Collected Regarding Waste Releases

The disposal of solid waste, the discharge of liquid waste and the emission of waste gas are probably the predominant source of releases of PTS into the environment. Thus, waste must be considered a major source of PTS per se and the predominant media in which many PTS are collected and

concentrated and from which they are released into one or more of the other environmental compartments. Waste as a source leads to releases of PTS into air, water and land. The only compartment which is virtually unaffected by PTS releases from waste is the product compartment. This becomes evident when realized that the waste contains all the undesired material that is separated from the product itself or left over during the production process. Also, the product itself becomes a waste after it has reached the end of its useful life.

In this section the term waste will be used in a way that excludes waste gases – which are covered in the section on air –, wastewater – which is covered in the section on water – as well as waste sludge, sediments and soil – which are covered in the section on land. Thus, the term waste refers mostly to solid waste in one form or another. It includes all kinds of combustion and production residues, municipal solid waste, industrial, mining, and hazardous waste, medical waste etc.

Table 7 summarizes information, which needs to be gathered additionally to the information outlined in Table 3, Table 5 and Table 6.

Table 7: Additional waste sampling information for land sources to water, air and land

Information	Importance	Comment
exact number of chemical species released from the waste	2	usually more than one type of PTS is being released from waste due to the often complex mixture of materials contained in the waste
number of samples	2	statistically significant numbers must be collected in order to account for variability in PTS concentrations
handling of samples	2	Individual samples or composites? If so, how many samples and over what period?

### Information to Be Collected Regarding Product Releases

The releases of PTS in the product compartment can be split into five basic categories, namely:

1. PTS releases through products, which are PTS, themselves. This category is by far the predominant source in the product compartment, since pesticides such as DDT and organometallics such as tributyltin (TBT) are PTS products, which are still widely produced and used around the globe. Thus, the quantities released or the release rates may be well known and may be obtainable from statistics. The product application site may also be well known and if not should be identified to give the site of release or source. The chemical species released is also known. In other words, virtually all the information needed for a source inventory should be readily available and usually very precise and reliable. This may make it easy to follow up on this PTS source type for inventory purposes.
2. PTS releases into products. These may also be well known, since the product quality is continuously monitored in most production processes. If good information is available for both contaminations with a PTS and product use the amounts and whereabouts of the PTS may be found. What makes this category a little more difficult to handle than the first category is the fact that the PTS in the product can only be traced through the product itself. This is somewhat less convenient

than for category 1 since the product applications are not all fully traceable due to the fact that in many cases the PTS contamination was discovered many years after the initial marketing and use of the product. PCB contaminated oil in transformers is a perfect example, since the PCB contamination was initially not recognized as a problem. Only decades after the wide spread use of PCB contaminated transformer oil had been started, the fact that PCBs are PTS, which cause adverse effects in the environment, had been discovered. At that time the records regarding the distribution of the PTS contaminated product was almost not traceable any more.

3. PTS releases from products. This category is the most difficult to quantify. Valuable information is gained by identifying PTS products, PTS in other products and reservoirs of PTS. Ultimately it is important to assess the releases of PTS from all of these to the environment. This includes all the PTS containing products where PTS are released during the lifetime of the products. The plasticisers in PVC which have recently come under suspicion as endocrine disrupters, are typical members of this group. Since it is mostly unclear how, when and where these releases occur, it is very difficult to quantify PTS of this third group as a source for inventory purposes. Fortunately, this category is probably the least significant source of PTS releases of the three categories.
4. PTS reservoirs e.g. in form of a stockpile of PTS products. Even though stockpiles are not considered active PTS sources as long as they do not cause any releases of PTS into the environment, they should still be identified as potential future PTS sources and may be high priority for preventative action. All the available data on PTS stockpiles should be reported to the RT.
5. The import and export of PTS containing products as well as the national production, if any. These figures may be obtained with reasonable accuracy from national statistics and provide a good first estimate on the regional use of PTS and PTS-containing products. Alternatively information may be available from other sources such as the Food and Agriculture Organization or the suppliers, hopefully coordinated at the regional or global level. It should be noted, however, that the categories used in national statistics might differ and not correspond to the needs of the project.

There is some useful information on typical use patterns of pesticides in the reports of the GEF workshops that should be consulted. General guidance could be provided based on this and other work which would help to point the data gatherer to the most likely sources and important areas of use for the listed chemicals. Sampling for PTS in the product compartment is comparatively simple by obtaining a sufficient quantity of the product, ensuring that this is representative of the general production or use. Analysis may be complex and subject to interference. In some cases the composition of the product and the concentration of PTS in it may be known and sampling may not be necessary. In most cases, the composition of the product as well [as] the PTS released through, into or from it, is known exactly which makes sampling efforts obsolete. Therefore the sampling issue is not further detailed here.

Table 8 provides all the information needed in addition to those in Table 3 in order to accurately determine an annual PTS release rate in the product compartment.

Table 8: Additional product information for land sources to water, air, land, and waste

Information	Importance	Comment
exact chemical specification of the PTS (containing) product including trade names	1	this information can usually obtained most reliably from the manufacturer/supplier
amount of product applied or used within the region of the inventory	1	this information may also be readily available from the product sellers and/or users
the quantity of PTS released through or from the product	1	this information can usually also be obtained from the manufacturer
Production exists now or historically periods of production (start and end date)	2	Historic production is important for hot-spot identification
Location, company name	3	
Amount presently produced	2	Give in tons per year
Amounts imported for each year	2	Give in tons per year
Origin of import	3	Country, company, <i>etc.</i>
Amount exported for each year	2	Give in tons per year
Destination for export	3	Country, use
Stockpile: chemical identity	2	List major constituents
Total amount in stockpile	2	
Method of storage	3	Packaged (containers, no containment), open environment, leaking, <i>etc.</i> subject to erosion? <i>Etc.</i>
Local environment	3	Close to receiving waters, residential neighborhood, <i>etc.</i>

## 5.2 Environmental Concentrations

Environmental data are broadly defined and in this document a series of categories are established. For each category guidance is given in the form of a brief introduction and a listing of data that could be used to describe the objectives, approach and findings of a study and place it into context. Each item is assigned an “importance indicator” which shows how critical the information is - 1 being of highest importance, 3 being of lesser importance. These data will help to enable meaningful comparisons to be made from one data set to another.

Information on environmental concentrations of PTS may relate to the following general media:

- Soil
- Sediment
- Air and deposition
- Water (fresh, ocean, estuarine)
- Vegetation
- Animals/Birds (marine and land based)
- Human food and animal feed stuffs
- Humans

### General Guidelines

Most data on the environmental levels of PTS contaminants has not been assembled with the intention of providing comparable data sets, but instead individual studies have been established for purposes of research, monitoring, specific site investigations or to investigate general background levels. Furthermore, there are no universally accepted or applied sampling, analytical and reporting protocols. Data may be assembled on behalf of research organizations or through Government organizations, some, but not all, will be available through the international scientific literature.

For the purposes of this work the intention is to gather the maximum amount of relevant data. The guidance has been designed to assist in assembling and analyzing such information. The guidance given in this section relates to helping to collate data in a way that enables reasonable comparisons to be made.

The guidance indicates valuable additional information from studies that can be assembled to supplement the analytical results. The more similarity between studies the more chance of being able to make comparisons.

Crucially important information for making comparisons includes:

- Having results expressed on the same basis (e.g. fat or dry matter)
- Knowledge of the way results are reported (e.g. mean, median, ranges)
- Good compatibility between the aims of the study (e.g. not to compare survey round a hot spot source with general background from another country)

- Identity in the matrix being sampled (e.g. same type of soil samples or same species animal in different areas)

Important information can be gained from studies that are internally consistent but conducted over a period of years. These may not be immediately comparable to other studies but provided the data were soundly assembled there may be important information on time trends of the PTS of interest.

Some information relating to a sample or the context a study has been performed that has generated the analytical result to be included into the assessment will be common to all environmental samples collected under the GEF project. These general information requirements are listed in Table 9

Table 9: General information needed for all environmental samples

Information	Importance	Comment
Exact chemical species and/or group reported and possible simplifications used if any	1	Note simplifications or assumptions for chemical groups. Use CAS nos. where available. If any TEF scheme is applied and if so, identify which one and ensure that the same scheme is applied to all results compared!
Sample matrix	1	Soil, sediment, air, water, foodstuff, <i>etc.</i>
Source/reference	1	To enable data to be traced
Sample type	1	Individual, composite, pooled
Sampling location	1	Reference map, GPS coordinates, <i>etc.</i>
Sampling method	2	See each matrix
Analytical results and units	1	Exactly specifying units and basis, <i>e.g.</i> fresh weight, dry matter, fat, organic carbon content, <i>etc.</i>
Analytical method and its detection limits	3	
Reporting of results below detection limits	2	Are some results below detection limits, if so how are these reported, <i>e.g.</i> ND=0, ND=DL or ND=DL/2.
Range	2	Minimum, maximum.
Central tendency(if applicable)	2	Specify median/mean and number of points
Objectives of study and outline description	1	Site specific/general assessment/population assessment
Condition of sampling	2	Dates, duration, meteorological conditions

## Soil

Soil samples are commonly analyzed for PTS. The soil will tend to act as a long-term accumulator for many of the compounds of interest and can provide a convenient matrix for sampling and monitoring. Soil surveys may be systematically carried out on a national, regional or local scale (often around a source of contamination).

Soil samples are taken to different depths, sometimes related to the land use (e.g. deeper for ploughed land than for pasture), in some cases results are related to the different layers of soil, also known as horizons. Superficial debris such as leaf litter may or may not be included in the analysis.

Table 10: Additional information for soil samples

Information	Importance	Comment
Surrounding environment	2	Remote, rural (agricultural), residential, industrial
Sample type	1	Surface, grab (sampling depth), core: composite/spot sample
Reporting convention	1	Wet weight/dry weight etc
Moisture content	2	Essential if results on wet basis
Organic carbon content	2	Important for comparing data sets
Sampled soil characteristics	2	Typical grain size; clay, loam, sand, <i>etc.</i>
Soil history	2	Use pattern that is relevant to PTS contamination
Location	1	Map reference or other locator

## Sediment

Sediment samples from lakes, estuaries and oceans are very useful since they can often be sub-sampled and the sub-samples linked to specific and identifiable time periods – this can result in long-term time trend data. In some cases sufficient information exists to allow sediment concentration data to be linked to the rates of input and in some instances, where atmospheric inputs are the sole inputs to a sediment system, to rates of aerial deposition. Of course any significant degradation in the sediments must be considered and accounted for in assessing time trend information.

Table 11: Additional information for sediment samples

Information	Importance	Comment
Location	1	Map reference or other locator
Sample type	1	Grab sample/core etc related to dates?
Reporting convention	1	Results on wet/dry organic carbon basis
Moisture content	2	Essential if data are on wet basis
Organic carbon (OC) content	2	Essential if data are related to OC
Evidence of potential PTS impact	2	Industrial effluent, harbor, <i>etc.</i>
Sample characteristics	2	Grain size
Description of site	2	Estuarine, fresh water lake/river, oceanic; area subject to aerial deposition only

### Air (including deposition)

Monitoring of air for PTS may be on a continuous long time period or for short periods, the samples may be taken from national or regional stations providing a continuous or pseudo-continuous series of air concentrations. Alternatively some air concentration data will relate to discrete sampling episodes often linked to known or suspected sources of contamination.

Some studies measure deposition of PTS from the air. Deposition is affected by a number of properties of the compound of interest, the weather and the design of the sampling system. Deposition from the atmosphere can occur by several mechanisms including “wet deposition” with rain and mist, “dry particle” deposition where material settles out with particles or “dry vapor” deposition where gas phase pollutants adsorb to the receptor.

The results of deposition testing can be heavily influenced by the conditions experienced during testing and the design of the sampling system. Great care needs to be taken in comparing values from one study to another.

Table 12: Additional information for air samples

Information	Importance	Comment
Sampling method	2	Description or reference to standard method
Surrounding environment	2	Remote, rural (agricultural – including predominant practices), residential, industrial. Known potential impact from PTS source
Period of sampling	2	Dates and duration
Weather during period	3	Wind direction, rainfall, temperature; season

## Water

Water samples (from fresh water, estuaries or marine environments) provide a transient measure of the contamination by persistent toxic substances. In the case of PTS such as dioxins, furans and PCB the vast bulk of the pollutants adsorbs to particulate matter present in the water and one alternative strategy is to sample only the particulate matter. The tendency for the pollutants to be highly insoluble means that usually only very low levels would be present in water and therefore sampling and analysis may be difficult. Since water measurements provide only a transient measure of the pollutant concentration and do not act as an integrator, it is possible that water samples may not coincide with releases of the pollutants and therefore provide potentially misleading information. Sediments may provide a better long-term picture.

Table 13: Additional information for water samples

Information	Importance	Comment
Sample type	1	Ground water, surface water, river, ocean, <i>etc.</i> water including suspended matter/suspended matter alone/water excluding suspended matter. Composite <i>etc</i>
Reporting convention	1	Results related to water/solids <i>etc</i>
Period of sampling	2	Dates and duration,
Weather during period	3	If relevant to sample – e.g. storm flow
Potential impact	2	<i>e.g.</i> any known PTS source nearby
Industrial effluents in the area	1	If yes, please specify

## Vegetation

For many of the PTS vegetation may act as a significant entry point into the terrestrial food chain and from there may contribute substantially to human exposure. Where semi-volatile lipophilic compounds are under consideration (typical of POP compounds) the waxy layers on plant leaves/needles act as relatively efficient scavengers of the pollutants from the atmosphere. Therefore, the concentrations in vegetation may be a suitable integrator and indicator of levels of the pollutant in the atmosphere over periods such as weeks, months or up to several years.

Table 14: Additional information for vegetation

Information	Importance	Comment
Surrounding environment	2	Remote, rural (agricultural), residential, industrial, near point source
Reporting convention	1	Results related to dry weight/wet weight etc
Moisture content	2	Essential if results on wet basis
Vegetation name and characteristics	2	Name of plant. Leaf types deciduous, relevant characteristics to sample medium, roots, <i>etc.</i>

## Marine and Freshwater Animals Including Birds

Creatures living in and on the sea and inland waters can act as valuable integrators of environmental pollution – in particular for persistent toxic substances. Sampling particular species of bird, crustacean, fish or mammal can provide information on the levels of pollutants across a wide geographic area and provide useful information on accumulation in the food chain. Such information can be powerful in providing indications of likely contamination of higher animals eating fish for example and also provide direct indications of contribution of certain foods to the human dietary intake of contaminants.

Many surveys of creatures have been carried out in many areas of the world. It is important to understand something of the nature and habits of the sampled matrix in order to exploit the data most effectively e.g. the feeding patterns of particular birds and the range over which a species may forage. Information from migratory species will provide less information that is directly relevant to a particular geographical location.

Table 15: Additional information for aquatic animals

Information	Importance	Comment
Exact description of species type surveyed	2	Latin name as well as common name
Summary information on species	2	Typical behavior – food types, static versus migratory, long lived?
Reporting convention	1	Results on whole weight/fat weight etc
Fat and moisture content and variability	2	Especially important if results are related to fresh weight or fat content
Length, diameter of the animal	2	Indicator of age
Sample number and type	1	Number of samples. Whole animal/single organ, age , sex composites or spot samples

### Land Based Animals Including Birds

Surveys of the levels of PTS in land-based birds and animals can be used to assess likely health impacts on the populations as well as to provide an indication of the geographical spread of pollution. In some cases analysis of high level predators can show accumulation of PTS in the food chain and an indication of the generalized level of the contaminant in the environment under observation.

Table 16: Additional information for land-based animals and birds

Information	Importance	Comment
Description of species types surveyed	1	Exact name
Sample number and type	1	Number of samples. Whole animal, single organ, egg, <i>etc.</i>
Summary characteristics of species	2	Geographical range, local/migratory species, main foods
Reporting convention	1	Results on a whole weight/dry/fat basis

## Foodstuffs and Cows' Milk

Monitoring of human food provides a very direct indication of potential human exposure to persistent toxic substances. Indications of dietary exposure can be built up using average food consumption data coupled with levels of the compounds found in food as it is prepared for consumption (e.g. cooked). Alternatively more localized exposure can be assessed by considering levels in specific produce and local patterns of consumption – for example exposure of subsistence fishermen eating a high proportion of locally caught fish.

Cows' milk has been used in various places as a marker for environmental pollution. For cows grazed on open pasture there is a relatively direct link between levels of many pollutants in grass and the levels of pollutant that are found in the milk. This may be an important indicator since levels in grass tend to reflect levels in air and therefore respond relatively swiftly to changes in releases to air, furthermore the levels in grass and subsequently in grazing animals may form an important fraction of the total dietary exposure in some countries. Where cattle form an important part of agriculture, milk, dairy products and beef may contribute a significant fraction of exposure.

Animal feeds may be analyzed since there is a short pathway from feeding certain animals materials with PTS in them and potential for exposure of ultimate consumers. It is assumed that the data in this field will include surveys and samples taken with the specific intention of assessing concentration in food stuffs as opposed to a survey giving levels in an animal population or in edible vegetation. It is likely therefore that information will be provided on the concentrations of PTS in the edible parts of plants and animals rather than whole animals or specific organs (e.g. liver). Composite samples covering retail food may be analyzed to give a broad assessment of levels or site specific surveys may be done to indicate localized contamination. Such food basket or retail food surveys are likely to show an average contamination and not to pick up the full range of concentrations in the food going up to make the composite samples.

The inclusion of imported food and the transport of food over long distances can mean that few conclusions may be drawn about geographical spread of contamination unless this was a specific objective of the study.

Table 17: Additional information for foodstuffs and feed stuffs

Information	Importance	Comment
Sample type	1	Food group or type. Composite/spot
Description of food type surveyed	1	Cut of meat, name of fruit, edible versus total animal samples Does it include imported food. For animal feeds note the use it is put to. Fat content, if available.
Preparation of food	2	Cooked, raw, whole food or part
Reporting convention	1	Results on whole weight/fat basis

## Human Levels

For many of the PTS the critical exposure group may be humans themselves as they fill the role of top level predator, live for a long time and accumulate contaminants. In addition it is more likely that low level chronic effects in humans and highly exposed sub-populations are of considerable concern whereas in other mammal species the general population health may be of more immediate concern.

Data on the levels of PTS in humans will often consist of pooled samples designed to be as unintrusive as possible - for example pooled blood or human milk samples rather than tissue or organ concentrations.

The levels of PTS will be highly dependent on factors such as diet, occupational exposure, age and any infants that have been breast-fed; therefore this background information is very important.

Table 18: Addition information for human samples

Information	Importance	Comment
Sample type	1	Blood, serum, adipose, liver, breast milk, <i>etc.</i>
Reporting convention	1	Results on whole weight/fat basis, <i>etc.</i>
Summary characteristics of population or sub-population	2	Geographical location, age, sex, occupational exposures, special dietary characteristics, smoker, <i>etc.</i>
Fat content and variability	2	Especially important if results are related to fresh weight or fat content

## **5.3 Environmental Impacts**

Experimental studies on health effects of substances will generally be found in the open literature. In general, health related effects for a given exposure would not differ between regions. The majority of environmental effects experimental data might be found in the open literature developed under standard conditions, which generally reflect temperate region conditions. However, since the conditions in many regions differ from these, as much information as possible on adverse environmental effects from the regions should be gathered. Similarly, it is important to report any effect studies performed with local species and/or under local conditions. The results of any earlier assessments of PTS performed in the region are also very valuable.

### Large-Scale Effects

It is difficult to link large-scale effects with individual persistent chemicals. The environment is exposed to a complex mixture of substances and other stress factors, which makes it almost impossible to link a certain change to a specific substance. It is also difficult to separate effects caused by anthropogenic activities from the large natural variations that occur in the environment.

In spite of these difficulties it is essential that any large-scale effects that have been reported in the

region be collected. The total information from the whole project may disclose correlations that are difficult to see within single regions. The form of this reporting may vary depending on the case, but the most important information is shown in Table 19.

Table 19: Information to be gathered for effects and environmental impact

Information	Importance	Comment
Type of effect	1	List all effects, but note specifically critical effects e.g. cancer and reproductive effects. Note the level of organization tested, e.g. individuals, populations, ecosystems
Species affected	1	Use at least Latin names
Quantitative estimates	1	Numbers of individuals or % of population
Area	1	Type, size and location
Reference	1	Comparison with other area(s) or with earlier situation
PTS information	1	Any data on emissions and/or environmental levels in the area
Source/reference	1	To enable data to be traced
How was the effect found	2	Systematic monitoring, hot spot measurements or by chance
Investigations	2	Any hypothesis tested
Hypothesis	2	Any hypothesis not tested

### Local Effects

The emission of PTS from point sources may cause local effects that are much easier to link to a certain chemical. It may be emissions from production or use of the substance(s) or from accidental spill or waste sites. If there are any such cases reported in the region they will be of interest for the GEF project. The effects may be reported according to the table above for large-scale effects and the emissions and environmental concentrations according [to] the guidance given in those sections of this report.

Table 20: Information to be gathered for local effects

Information	Importance	Comment
Type of effect	1	List all effects, but note specifically critical effects e.g. cancer and reproductive effects. Note the level of organization tested, e.g. individuals, populations, ecosystems
Species affected	1	Use at least Latin names
Quantitative estimates	1	Numbers of individuals or % of population
Area	1	Type, size and location
Reference	1	Comparison with other area(s) or with earlier situation
PTS information	1	Any data on emissions and/or environmental levels in the area
Source/reference	1	To enable data to be traced
How was the effect found	2	Systematic monitoring, hot spot measurements or by chance
Investigations	2	Any hypothesis tested
Hypothesis	2	Any hypothesis not tested

In the local effect scenario it is important to gather information on all chemicals emitted, not just the active ingredient(s). This includes e.g. solvents, inert formulation ingredients, impurities, by-products and other chemicals that may have been emitted.

### Test Results

In addition to standard laboratory data reported in the published literature, test results of effects on local species and/or during local conditions are of great interest in the regional assessment. Any such information should therefore be gathered and the most important information is shown in Table 21.

Table 21: Information to be gathered for test results

Information	Importance	Comment
Substance(s)	1	Name and CAS number
Type of effect	1	List all effects, note particularly critical effects e.g. cancer and reproductive effects. Note level of organization e.g. subcellular, tissue, individual, ecosystem
Species	1	Use at least Latin names
Conditions	1	Temperature, medium, duration of test
Toxicity result (EC <sub>50</sub> , LC <sub>50</sub> , LD <sub>50</sub> )	1	Exactly specifying units
No effect concentration	1	If available. Exactly specifying units
Linear dose-response	2	
Purity of tested substance(s)	2	Exactly specifying units

### Regional Assessments

There may be earlier assessments of effects of PTS in the region and the outcome of these is of great interest for the GEF project. Important information in the reporting of such assessments is described in Table 22.

Table 22: Information to be gathered for regional assessments

Information	Importance	Comment
Substance(s)	1	Name and CAS number
Area	1	Geographic coverage
Critical effect(s)	1	Note NOEL and, if appropriate, LOEL
Species	1	Use at least Latin names
Identified risk	1	Was there an unacceptable risk
Control measures	2	Note any measures taken to improve the situation and their type
Improvements	2	Any information on the present situation
Source/reference	1	To enable data to be traced
Objectives	2	Why was the assessment performed
Monitoring	2	Is the situation followed by any monitoring

Risk assessment may be very site specific and all extrapolations have to be done with care.

### Regional Guidance Values

In the evaluation of the gathered environmental concentrations of PTS it would be useful to have access to any guidance/action values and standards that are applied for environmental media in the region. Such guidelines are often used to protect workers/consumers/wildlife from unacceptable exposure to specific chemicals. A rather comprehensive list of such data for the twelve UNEP POPs is available from the UNEP POP homepage (<http://www.chem.unep.ch/pops/newlayout/infpopalt.htm>) but for additional substances to be studied it is harder to retrieve such data. It is therefore recommended that available information of this kind, at least for the additional PTS substances, are gathered and reported to the Regional Team. There are many different names used for these standards/guidance values and a few examples are

- maximum residue limits/concentrations
- acceptable/tolerable limits
- acceptable/tolerable daily or weekly intakes
- maximum permissible concentrations
- threshold limit values
- guideline levels

Important information to gather from these standards/guidance values is given in the following table.

Table 23: Information to be gathered for regional guidance values

Information	Importance	Comment
Substance	1	Name and CAS number
Numerical value	1	Exactly specifying units
Reporting protocol	1	Concentrations on fresh, dry, or lipid weight basis
Medium	1	Air, water, food, drinking water, groundwater
Protected entity	2	Humans/workers, specific organisms, environment
Formal Status	2	Legal, action, advice
Risk management action	3	What kind of action will be initiated by exceeding guidance levels

## 6 DATA EVALUATION

A major step in the GEF project will be the assembly, organization and evaluation of the information and data collected during the data gathering steps described in Section 5.

Data processing and evaluation should be done exclusively by or under the explicit endorsement of the Regional Team. Since the GEF project is aimed at developing information, which is standardized and comparable around the globe, data quality assurance and measures to ensure standardized evaluation are crucial.

Also, it must be realized that different amounts of data available for the same PTS within different regions will necessarily lead to different data quality. As a general rule the data quality should improve with the amount of data available. Thus, the more data are available, the more stringent the data quality assurance requirements could be set. The cut-off line to eliminate data should be set much lower when few data are available. The Regional Team, which evaluates the data gathered, must make a reasonable judgment between data quality assurance and data availability. In some cases it will be better to use imperfect data rather than not having any data, where as in others only high quality data might be needed for further consideration. In general the safest comparisons can be made between limited data sets obtained under the same conditions and with the same study objectives and design. It is clear that much of the data reaching the RT will not be in this form. This section on data collection within the Guidance Document has been designed to assist the Regional Team (RT) in assembling and analyzing that information. Three key elements in the GEF project with respect to PTS source inventories, environmental concentrations and impacts on humans and the environment will be:

- Making comparisons between areas and regions;
- Assessing the importance of the information reviewed (does it indicate a cause for concern);
- Prioritizing the results, especially in case of concern, to direct possible further GEF interventions.

This report on procedural guidance intends to indicate valuable additional information and experience from studies to supplement the analytical results. The more similarity between studies the more chance of being able to make comparisons. Crucially important information for making acceptable comparisons includes:

- Having results expressed on the same basis.
- Knowledge of the way results are reported (*e.g.* mean, median, ranges)
- Good compatibility between the aims of the study (*e.g.* not to compare survey round a hot spot source with general background from another country)
- Equivalence in the matrix being sampled (*e.g.* equivalent soil samples or combustion flue gas samples)

Important information can be gained from studies that are internally consistent but conducted over a period of years. These may not be immediately comparable to other studies but provided the PTS data were soundly assembled there may be important information on time trends of the PTS of interest for sources, environmental levels or impacts.

This guidance is aimed to be applicable at the level of the Regional Team. The Regional Team will receive data from many individuals or institutions that are assigned to carry out the data gathering step. The collating, compiling and presentation of this mass of data must be carried out in order to be able to make meaningful comparisons at the level of a region. It is clear that the coverage will vary from chemical to chemical and from country to country.

## 6.1 Source Related Information and Data

### Information for the Processing and Evaluation of Air Release Data

In order to determine releases of PTS into ambient air, an emission rate has to be determined. As described earlier, PTS emissions should generally be reported as a mass flow rate of the respective individual and/or group of PTS per unit time.

Especially in case of PTS emissions into the atmosphere, however, it is widely common to report measured concentrations of PTS on a mass basis per unit volume of PTS containing (flue) gas emitted. This reporting directly reflects the analytical results obtained from gas sampling as measured. The associated volume flow rates of PTS containing (flue) gas emitted per unit time are then also reported as measured during the sampling campaign. Both values, if multiplied correctly, lead to the desired PTS mass flow rate per unit time.

However, great care must be taken to multiply the two measured values (PTS concentration and (flue) gas flow rate) correctly. This means that the units of the assumed PTS concentration as well as the units of the assumed (flue) gas flow rate discharged must be consistent in all respects! It is also of crucial importance to clearly define and report the basis for calculating the overall PTS emission rate. Only correct reporting allows the necessary harmonization of the reported results before comparing them.

Air releases are in general the most difficult ones to handle, since air dramatically changes volume with temperature and pressure and varies greatly in moisture and oxygen content. This requires a strict harmonization of the reported concentrations to a common standard, e.g. ng PTS/m<sup>3</sup> dry gas at 0 °C, 101.3 kPa, 11% O<sub>2</sub>. It does not matter which standard is chosen as long as it is consistent throughout the data comparison!

The following example illustrates the correct determination of an annual mass flow rate of PTS; the example data are assumed to be available from a reliable reporting source and adequately referenced for an existing industrial combustion source emitting PTS:

- A measured PTS concentration of 3.5 ng/Nm<sup>3</sup> of flue gas
- A measured actual flue gas volume flow rate of 462,929 m<sup>3</sup>/h at full load.
- A measured actual flue gas temperature of 180 °C, and a pressure of 1028 mbar
- A measured actual moisture content of 20 vol.% and an O<sub>2</sub> content of 13.5 vol.%
- Normalized reporting conditions are a Nm<sup>3</sup> of dry flue gas at 0 °C, 101.3 kPa, 11% O<sub>2</sub>
- The source operates at 100% load for 5600 h/a as an annual weighted average.

This example above shows how a number for a chemical's concentration as obtained from a questionnaire/from a plant has to be converted several times before the mass flow rate of a PTS can be calculated. The final result will be presented in g PTS/a, which is the annual release of a given PTS

from a specified combustion source. First, a normalized volume flow rate must be calculated by multiplying the actual gas flow rate x the dry portion x the temperature correction factor x the pressure correction factor x the O<sub>2</sub> correction factor. This leads to:

$$462,929 \text{ m}^3/\text{h} \times (1-0.2) \times (273 \text{ K} / 273 \text{ K} + 180 \text{ K}) \times (1028/1013) \times (21-13.5/21-11) \\ = 462,929 \text{ m}^3/\text{h} \times 0.8 \times 0.603 \times 1.015 \times 0.75 = 170,000 \text{ Nm}^3/\text{h}$$

Second, the annual PTS mass flow rate must be calculated by multiplying the normalized PTS concentration x the normalized flow rate x the annual operating hours, which leads to:

$$3.5 \text{ ng} \times 10^{-9} \text{ g/ng} \times 1.7 \times 10^5 \text{ m}^3/\text{h} \times 5.6 \times 10^3 \text{ h/a} = 333.2 \text{ g PTS/a}$$

It should be noted that this example shows only some of the corrections, which might be necessary in other cases, in order to make the units consistent!

### Information for the Processing and Evaluation of Water Release Data

The concentration of PTS reported in water can be either on a mass per volume basis e.g. mg/l or on a mass per mass basis e.g. mg/kg or on a volume per volume basis e.g. ppm. Based on the fact that the liquid water discharged is always at or around ambient conditions, where 1 liter equals 1 kg, and as long as the units used for volume and mass remain interchangeable, all three reporting basis can be considered identical. To avoid confusion it is still advisable to report all concentrations in the same units. In case of water releases the most commonly found unit used is ppm or mg/l (both are fully interchangeable at ambient conditions)!

The volume or mass flow rate of water effluent discharged should also be reported in units consistent with the assumed PTS concentrations. As long as this is the case, the assumed PTS concentration and the effluent flow rate can be multiplied directly to achieve the desired PTS mass flow rate per unit time. Again it is highly recommended to base the amount of water discharged on an annual basis in order to account for operational and/or seasonal variability among different sources. It also allows calculating the needed mass flow rate of g PTS/a directly. It should be noted that operational and/or seasonal variability can be rather significant and can lead to very high short term peaks despite fairly low annual release rates.

The following example illustrates the correct determination of an annual mass flow rate of PTS; the example data are assumed to be available from a reliable reporting source and adequately referenced for an existing source discharging agricultural runoff water which is contaminated with PTS:

- A measured PTS concentration of 3.5 ppt (= parts per trillion = ng/kg in water)
- Measured actual discharge water flow rate of 340,000 liters/h at maximum flow.
- The source discharges for 5600 h/a at an annual weighted average of 50 % of the maximum flow.

Contrary to the air release example, these example numbers as obtained for the determination of the annual PTS release of this existing discharge water source must only be multiplied correctly to calculate the desired mass flow rate of PTS in g PTS/a. A lengthy conversion as needed in the air release example can be voided, since the discharged water is at ambient conditions and thus, volume and mass are virtually identical with respect to the normalized conditions.

Thus, the annual PTS mass flow rate must be calculated only by multiplying the PTS concentration x water discharge flow rate x annual operating hours x annual weighted average of the maximum flow.

$$3.5 \text{ ng/l} \times 10^{-9} \text{ g/ng} \times 3.4 \times 10^5 \text{ l/h} \times 5.6 \times 10^3 \text{ h/a} \times 0.5 = 333.2 \text{ g/a}$$

It should be noted that this example also shows only some of the corrections, which might be necessary in other cases, in order to make the units consistent. The annual weighted average flow factor must be examined more closely from an environmental impact point of view. In the case of the chosen example, it is quite possible that the agricultural use of PTS pesticides leads to a maximum flow only during the growing season in which the PTS pesticides are applied. This could mean that the entire PTS flux of 333.2 grams is released during a period of only 2800 hours per year, which is less than 4 months! As a result, very high environmental levels in a short term causing a significant environmental impact could be observed. Consequently, the annual PTS flux must always be investigated in more detail whenever a low annual weighted average is reported in order to recognize the potential of high short term releases of PTS.

### Information for the Processing and Evaluation of Land Release Data

In the case of land acting as a source, the most critical question is not the amount of contaminated land discharged but rather the amount of PTS released from the discharged land. This amount of PTS released again largely depends on the conditions under which and to which the PTS contaminated land is discharged. For example, in case of soil contaminated with hydrophobic PTS discharged to a landfill, the release might be almost insignificant, whereas in case of sludge contaminated with hydrophilic PTS discharged into the ocean, the release of PTS will be nearly 100%. Consequently the information needed to estimate PTS releases from land are more related to the PTS, the composition of the land, and the discharge route rather than the sheer quantities of contaminated land discharged and the concentration of the contaminating PTS.

The release rate again must be expressed in g PTS/a in order to be incorporated into the source inventory. Therefore a source strength must be estimated in the same way as for water. The same simplifications apply also to land, even though the release of PTS from land occurs usually into air by means of evaporation and/or volatilization, into water by means of leaching, and into land by means of leaching and/or mixing. Thus, the determination of the correct release rate from land requires detailed information about each individual case.

Contrary to most air and water sources, land sources are secondary sources which have been contaminated earlier or in which contaminating PTS have been concentrated and are being released from now. Thus, many land samples don't provide a stationary flux of PTS released but rather an absolute quantity spread over a certain period of time. Land sources also tend to be subjected to a constant change in source strength depending on environmental conditions in which these land sources are maintained. Wind, weather and climate as well as on going reactions may alter the land source characteristics constantly. Thus, correct quantification of a land source in the sense used here might be very difficult.

### Information for the Processing and Evaluation of Waste Release Data

Sampling of waste in some cases is easy and in some cases is very complicated. Whenever the waste to be sampled is fairly homogeneous, the sampling procedure is simple and directly comparable to the sampling of water. Most combustion residues as well as most production wastes fall into that category. Also left over PTS products such as organometallics and/or pesticides and PTS containing residues, which have become a waste and need to be disposed of, fall into this category. On the other hand, sampling of waste, which is inhomogeneous such as municipal solid waste, medical waste and most

hazardous waste, is very difficult and comparable to sampling land. Consequently the same restrictions and considerations as for land apply in this case.

Another problem in determining waste as a source for an inventory of PTS releases to the environment is the fact that the quantity and composition of various PTS in waste can vary greatly. Most wastes contain a whole array of numerous PTS in various quantities. This in return makes it reasonably difficult to pin point a certain waste stream as a source for one specific PTS. In most cases a single waste stream is a source of a series of PTS releases, which vary in quantity, time and characteristic. Again the same limitations as for land apply with respect to the PTS release to the environment, which are influenced by the environmental compartment into which the waste stream is being discharged as well as the type of PTS contained in that waste stream. Contrary to land, waste is an extremely abundant source of PTS releases and therefore the problem becomes much more substantial than in the case of land.

This leads to the conclusion that wastes as a source of PTS deserves a lot of attention in order to correctly incorporate it in a PTS source inventory. Since this section refers mostly to solid waste, the PTS concentrations measured and reported in waste are usually on a mass per mass basis. At least this fact makes things easier than with air. However, caution has to be applied, since in most wastes the concentrations of PTS are not uniformly distributed within the waste. Large variations of several orders of magnitude can occur within a batch of waste for one and the same kind of PTS. Thus, it becomes important to gather data not only from representative samples, but also in a statistically significant quantity.

It must be noted that not all the information gathered might be relevant in all cases depending on the type and physical and chemical properties of the waste sampled. As a rule of thumb, the less homogeneous is the waste to be sampled, the more information is required in order to obtain correct data for the estimation of the PTS release from the waste source.

Due to the complexity found in the composition of waste, it is also almost impossible to provide a representative example for the determination of the PTS release rate of a waste source. Thus, a small industrial solid waste landfill was chosen as an example, since landfilling is still the most common method used in the world for the disposal of waste. The data gathered for the determination of the PTS release from a small, existing municipal solid waste landfill is assumed to be available from a reliable reporting source and adequately referenced as follows:

- A measured representative PTS concentration of  $0.35 \mu\text{g}/\text{m}^3$  of waste, 1% of which is being released with every 40 mm of rainfall
- The found PTS is highly hydrophilic, the landfill has no leachate collection system; the leachate from the landfill goes into the ground water.
- A actual volume of waste in the landfill is currently  $500,000 \text{ m}^3$ ;  $50,000 \text{ m}^3$  are being added annually, the landfill was started 10 years ago.
- The landfill covers an area of about  $20000 \text{ m}^2$ , which is subjected to rainwater.
- The average annual rainfall rate is about 2,000 mm, evenly distributed throughout the year

Based on the reported release rate of 1% per 40 mm of rainfall, all the PTS contained in  $1 \text{ m}^3$  of waste is being released in 2 years according to  $(2,000/40) \times 1\% = 50\%/a$ . Thus, the steady state PTS release situation was reached after the second year when 50% of the PTS was still in the landfill from the first  $50,000 \text{ m}^3$  of waste and the second  $50,000 \text{ m}^3$  of waste landfilled in the second year lead also to a release of 50% of the PTS amount. In other words, even though only 50% of the incoming PTS is being released per year, also 50% of the PTS contained in the waste landfilled a year earlier is being released

so that the actual steady state release of PTS equals 100% of the incoming amount of PTS. Consequently, the release rate can be calculated as

$$5 \times 10^5 \text{ m}^3/\text{a} \times 0.35 \text{ } \mu\text{g PTS}/\text{m}^3 \times 10^{-6} \text{ g}/\mu\text{g} = 0.175 \text{ g PTS}/\text{a}$$

This quantity leads to a fairly constant PTS concentration in the leachate from the landfill of

$$0.175 \text{ g}/(2,000 \text{ mm} \times 20,000 \text{ m}^2) = 437.5 \text{ ng PTS}/\text{m}^3 \text{ leachate}$$

It should be noted that this example shows only some of the calculations, which might be necessary in other cases in order to correctly, determine the annual PTS release rate! As stated earlier already, each case must be investigated individually. A thorough assessment of the provided data is the first, inevitable step in determining whether the data are sufficient and correct for the calculation of an annual release rate of PTS from the particular source.

### Information for the Processing and Evaluation of Product Release Data

In most cases, the determination of an annual release rate can be directly derived from the data obtained. Thus, it is not considered necessary to provide an example as done for PTS releases into some of the other environmental compartments.

Data that has been gathered about stockpiles and existing but inactive PTS reservoirs, which represent a potential of future PTS releases, should be pointed out separately. Any further activity, however, needs site specific evaluation and should also be referred back to national policy makers for a decision on how to proceed. If the quality and completeness of the data allows a recommendation to be derived on, the RT should offer to provide some expert guidance for national policy makers regarding the decision on how to proceed. In some instances stockpiles and/or PTS reservoirs might even lead to a high priority for possible future GEF interventions.

## **6.2 Environmental Concentrations**

To meet the project objectives the information arising from the data gathering must be assembled and collated in a consistent and standard way.

It is recommended that information on the environmental levels be collected across countries in the region for each environmental compartment. A series of stages can be used and guidance is provided for the following stages.

Stage 1. Assemble summary data for region

Stage 2. Compare those sets that are immediately comparable

Stage 3. Consider whether it is possible to bringing data back to a comparable format preferably by precise calculation or by estimation

Stage 4. Ways to make comparisons

Stage 5. Evaluation step

Where data are detailed and strong enough for individual environmental compartments this should be processed to bring it back to a comparable form.

## Stage 1 - Basic summarizing and Grouping of Data

Basic assessment requires that studies in each section are grouped where possible using these guidelines:

1. By Chemical Group (so first cut is by chemical)
2. By Environmental Medium (so soil data are gathered together)
3. By Survey Objectives (so background surveys are grouped etc)

Table 24 shows an example that illustrates studies for dioxins and furans in soil for a selected country, grouping studies by chemical and by survey objectives. The results as received are included and the aim is to convert these into the preferred units for the comparisons, the last column (see later stages).

Table 24: Example of results matrix for soil concentrations for dioxins and furans

Country	Study type and geography, reference period	results and units as received	Results in preferred units (e.g. pgTEQ/kg dry wt)
XXX	Background survey, 1990	2-50 TEQ pg/g dry wt	calculated if sufficient info in the study
	background survey	1-75 ppt TEQ wet wt.	
YYY	Background survey	12 pg TEQ/kg	12 pg TEQ/kg
XXX	Contaminated site	10000 pg/g dry wt. total dioxins	Estimated if there is reasonable conversion factor from total to TEQ for similar sites
YYY	Contaminated site	200-20,000 pg/g dry wt. total dioxins	

## Stage 2 - Make Initial Comparisons of Data

For each country results from studies are assembled grouped by country and by study type. In this way only surveys with compatible aims and objectives are grouped and the information and data may be compared. Data are directly inserted in the comparison column in the preferred units and on the preferred basis if they are presented in this form.

## Stage 3 - Common Basis for Reporting - Data Processing

If enough meta-data are available data sets should be processed to bring the results back to a common set of units.

The preferred units and reporting basis can be discussed and agreed at the regional/global level for each environmental medium and each chemical, e.g. on a dry weight basis, or fat weight basis. It is strongly recommended that a table be provided with recommended preferred units for each environmental medium and each chemical. The units in Table 25 are simply examples and are not recommendations.

Table 25: Example Table of Preferred Units  
TEQ = Toxic equivalent, d.m. = Dry matter

Chemical	Reporting Convenience	Soil/Sediment	Ambient Air	Water
Pesticides		mg/kg d.m.	mg/m <sup>3</sup>	ng/L
PCB	total PCB	mg/kg d.m.	ng/m <sup>3</sup> at 25 °C	ng/L
Dioxins and furans	TEQ	ng TEQ/kg d.m.	fg TEQ/m <sup>3</sup>	fg TEQ/L

In addition guidance should be developed on the preferred way of presenting information on chemical concentrations - here for example as 100 % POP for pesticides, or total PCB *etc.* for complex mixtures. In some cases there will be insufficient information to accurately convert data to the preferred format. In such cases it must be considered whether an estimate can be made. For example, the result of a PCB analysis may be reported as the sum of six congeners (28, 52, 101, 138, 153, 180) and the preferred measure may be total PCB. A widely used correlation is that the sum of the 6 congeners represents approximately 20 % of the total mass of PCB and a broad approximation of total PCB might be possible noting that this only holds true where technical mixtures are considered. Further guidance on this could be developed.

#### Stage 4 – Filling Gaps, Estimating Data and Making Comparisons

Basic comparisons can include general background contamination in different environmental media in different countries in the region.

- Time trend information where data are available for the same site over a period of time.
- General coverage of a region
- Hot spot and contaminated site levels
- Levels in environmental media close to common water bodies

At this stage there will be areas in which gaps in data sets can be clearly identified. In some cases it may be possible to make an attempt to fill some of these gaps. For example by broadening the comparison to compare vegetation samples that are not identical but have similar characteristics. Alternatively it may be possible to infer levels of some of the pollutants although analytical data in the preferred form is unavailable – perhaps to make a conversion from total PCB to individual congener levels by analogy to similar data sets elsewhere. Any such estimate or conversion should be clearly noted and subject to review. Time trend or geographical trend data may be apparent. It may be possible to use these data to make estimates of missing data taking due account of the possibility of unforeseen data. For example, when looking at trends in environmental levels knowledge on sources should be taken into account in assessing whether levels in a missing area might be expected to fall on a trend line between neighboring areas).

#### Stage 5 - Evaluation

Detailed statements about making evaluations of environmental level information will have to be linked to the consideration of other information relating to sources, environmental impact assessment and

regional factors.

There are two objectives to the first part of an evaluation step -

- Evaluate extent and quality of data coverage
- Consider implications of the data - compare the environmental level data to established action levels and to levels found in other areas and regions

During this process a clear listing of data gaps will be made. The relative importance of these data gaps cannot be ranked until additional information is considered. For example the lack of environmental data for a chemical may not be critical if good source data shows that there are no significant sources in the regions.

### 6.3 Environmental Impacts

As a first step to support the evaluation procedure it is useful to transform all effects data to uniform units. Due to the high potency of dioxins and furans it is inconvenient to use the same units as for other substances and therefore other units are recommended for the dioxins and furans. The following table gives examples of the preferred units for the results of some effect studies. Please note that to avoid confusion, microgram/L should be spelled out. The commonly used Greek letter for micro is often lost in the electronic transfer of documents. Also, in some regions, the difference between milli ( $10^{-3}$ ) and micro ( $10^{-6}$ ) is not observed which may lead to gross misinterpretations of the data.

Table 26: Preferred units

Toxicity	Measure	Preferred Unit	
		generally	for dioxins and furans
Acute oral toxicity in mammals and birds	LD <sub>50</sub> , ED <sub>50</sub>	mg/kg bw	microg/kg bw
Acute toxicity in aquatic organisms	LC <sub>50</sub> , EC <sub>50</sub>	microg/L	ng/L
Long term effects in mammals and birds	NOEL/NOAEL	mg/kgbw/day	microg/kg bw/day
Long term effects in aquatic organisms	NOEC/NOAEC	microg/L	ng/L

In many studies test organisms are fed contaminated food and results are expressed referring to the concentration of the tested substance in the food. This information is useful and should be reported, but if the food intake is known or can be derived from the study report it should also be reported in the GEF project to make it possible to calculate the intake of the substance as such on a weight/weight basis.

Data from the same or similar species should be assembled together. It is also useful to group data from different organisms according to their position in the food chain or food web e.g. producers and top consumers. Environmental effects data from field studies in the region are of particular interest, but as for other types of field data it is essential to know the exact conditions including the rationale for the study.

## Existing Assessments

To develop a quantitative measure of the health and environment risks resulting from the use of a certain chemical as precise as possible, a comprehensive risk assessment (RA) might be undertaken. In this procedure measured or estimated exposures are compared with 'safe' or no effect concentrations of the investigated substance. Full risk assessments are extremely resource demanding and generally outside the scope of the regional assessments. However, information available from earlier RA work should be used to the greatest extent possible, keeping in mind that risk assessments are often site and situation specific. The twelve UNEP POPs have been assessed in a special review (see Table 27) by the International Program on Chemical Safety (IPCS), and there are several other PTS assessments available in the open literature. Effects related information including assessments on the twelve POPs and other PTS is also available on the UNEP POPs Homepage (<http://www.chem.unep.ch/pops>).

UNEP Chemicals has published an overview of international and national sources to POPs information of all kind, including published hazard and risk assessments. The bibliographic database Riskline (<HTTP://www.kemi.se/default.cfm?page=kemdatbas.htm>) contains updated information on hazard and risk assessments performed for chemicals. UNEP and ECETOC have jointly published an overview of chemicals that has been assessed (ECETOC/UNEP, "Inventory of Critical Reviews on Chemicals", August 1996). The Integrated Risk Information System (IRIS) is a US EPA database that contains scientific consensus positions on human health effects that may result from chronic exposure to chemicals in the environment (<http://www.epa.gov/iris>).

## Suggested Methodology for the Environmental Impact Assessments

To obtain the expected result in the GEF project, the following general procedure is suggested for each individual substance or mixture of substances.

### Gather Existing Knowledge

Measured data describing the concentrations of the PTS in the biotic or abiotic environment form the basis for the evaluation in the EIA. When such data are produced in monitoring programs they may not be routinely published in the open literature. Monitoring programs usually report to the government or a government agency, but the results are often not made available to a wider forum or to the scientific community at large. The procedure of collecting existing measured data on environmental concentrations is described in section 5.2 of this report, and the data handling is described in section 6.2.

There are hardly ever enough measured environmental concentration data, as the analyses are expensive and often there are no measured data available at all. If the production/use volumes and patterns for a substance are known there are several possibilities to predict the distribution of a chemical in environment. The procedure for the gathering of information on sources and emissions is described in section 5.1 of this report. Models to predict environmental concentrations should be selected and used by persons who are well experienced in the field.

All effect studies performed within the region are of high interest, as they probably have used conditions and species of interest for the region.

Available hazard and risk assessments documents for the substance(s) should be consulted. The specific conditions in the region should be kept in mind since the behavior and fate of the substance(s)

may be different from the conditions used in the hazard and risk assessments. The most important information from earlier performed hazard and risk assessments for a substance is

- critical effect
- no adverse effect concentration (NOAEC) or lowest effect concentration (LOEC)
- type of organism
- exposure characteristics e.g. magnitude, duration, pattern and pathway

The inherent properties of the studied chemicals are the same all over the world. However, the effects of a certain chemical might differ from one region to another because of external factors such as pH that can influence the action of certain chemicals dramatically.

### Translate Existing Knowledge to the Actual Region

The distribution of the substance(s) may be different due to several factors, such as climate, use volume and pattern. It is important to know how the emissions are distributed and what effect that will have on the exposure situation. Knowledge about major exposure areas around production or use sites should be gathered. Organisms that are more heavily exposed than others should be identified. The amount of human exposure should be known.

If there are no measured data for a critical medium or a suspected hot spot it might be advisable to identify special expertise to apply models to calculate the concentrations at specific sites.

The exposure will be different in different regions, as will the distribution between environmental compartments. This global project will give a unique opportunity to see how different conditions influence the exposure to this type of chemicals.

### Make Comparisons between the Situation in the Region and Existing Assessments

The Regional Team will do an evaluation of the situation in the region based on the gathered exposure data and the effect data produced in the region and/or found in earlier assessments. The ratio exposure/no effect level will give an indication of the potential risk. The uncertainty in the effect levels has to be kept in mind, and safety factors are often applied for e.g. extrapolation between species and for variation between individuals. Earlier hazard and risk assessments may also have identified safe levels, e.g. an acceptable daily intake (ADI). ADIs for some substances are suggested within the FAO/WHO framework (<http://jecfa.ilsa.org>).

In the exposure estimates, the critical factor is the dose reaching the target organ in the affected organism, but this is not often known. Exposure is therefore often a measure for how the chemical was dosed in the tests used to determine the effect, e.g. concentration in the water for fish toxicity studies or intake per kg body weight and day in studies with mammals. From the available information the critical environmental concentrations of the substance in different environmental media can be calculated.

As several PTS are complex mixtures of different substances, and the composition of the mixtures will be changed in the environment, it can be difficult to describe the true environmental effect. There are, however, no methods to test the “environmental compositions” and most comparisons are done with the composition of the commercial products. For some mixtures e.g. dioxins/furans and PCB, it is possible to determine the individual components and then add at least some effects (see Section 7.1).

From the effect studies the no adverse effect concentration (NOAEC) obtained from the most critical study is the most interesting figure. From this a predicted no effect concentration in an environmental compartment may be calculated. In this calculation safety factors are normally included, e.g. for individual variation in sensitivity (x10) and for extrapolation between species (x10).

By comparison of the predicted or measured environmental concentration in a compartment and the no effect concentration in the same compartment a measure of the risk is obtained:

Risk estimate = environmental concentration (measured or predicted)/ no effect concentration

If this ratio is well below 1 the risk is normally accepted, but if it is above 1 the safety margin decreases and it is generally accepted that there is a reason for concern.

Thus, using the exposure data for the actual region the situation in this area can be compared with the outcome of earlier performed assessments. If no corrections have been done for different sensitivity in the region this comparison will just be between measured or predicted environmental concentrations and no effect levels in critical media. In this way an estimate of the risk is obtained which could be used for priority setting in the region and for comparisons within and between regions.

### Guidance Values for PTS

The results of an assessment of a chemical may be a guidance value describing a safe level in a specific medium. These may be e.g. an ADI for humans or a concentration in sediment over which some sort of action has to be taken. Such data are often useful in the evaluation of a specific situation and may also be of use in the regional assessment within the GEF project. It is important to keep in mind what the guidance value is supposed to protect and what kind of action a level greater than the guidance level will call for.

Guidance values may be global, regional, national, or even local. Generally they are difficult to retrieve outside the area they are meant to protect. Some examples of global to national guidance values are given in the Annex. In the Bibliography there are also some Internet addresses to sites where this type of information can be found, but the listing is far from complete. The regional teams should combine their knowledge in the beginning of the GEF project to add more links to this list.

## 7 ANNEX: SUBSTANCE-SPECIFIC INFORMATION ON SELECTED PTS

### 7.1 The Twelve UNEP POPs

The present ongoing negotiations for a treaty on POPs focus on 12 individual PTS substances or groups of substances. These substances are well studied and there are several risk assessment documents available, e.g. the Environmental and Health Criteria (EHC) documents from the International Program on Chemical Safety (IPCS). In Table 27 the relevant EHC documents are listed.

Table 27: EHC documents on high priority POPs.

Chemical	CAS #	EHC title	EHC #	Publ. Year
Aldrin	309-00-2	Aldrin and dieldrin	91	1989
Chlordane	57-74-9	Chlordane	34	1984
DDT	50-29-3	DDT and its derivatives	9	1979
		DDT and its derivatives – Environmental aspects	83	1989
Dieldrin	60-57-1	Aldrin and dieldrin	91	1989
Dioxins	Several	Polychlorinated dibenzo- <i>p</i> -dioxins and dibenzofurans	88	1989
Endrin	72-20-8	Endrin	130	1992
Furans	Several	Polychlorinated dibenzo- <i>p</i> -dioxins and dibenzofurans	88	1989
Heptachlor	76-44-8	Heptachlor	38	1984
Hexachlorobenzene	118-74-1	Hexachlorobenzene	195	1998
Mirex	2385-85-5	Mirex	44	1984
Polychlorinated biphenyls	Several	Polychlorinated biphenyls and terphenyls	140	1993
Toxaphene	8001-35-2	Campechlor	45	1984

Some of these EHCs are today more than 15 years old and also more recent data have to be taken into account. In the following pages short overviews of some relevant data for “the dirty dozen” are given.

#### Aldrin and Dieldrin

Aldrin is readily converted to dieldrin in the environment, and thus these two substances will be described together. These pesticides have mainly been used for the control of many soil pests and in the treatment of seed. Even if some of the chemicals are lost due to evaporation and runoff the major part of the applied dose will remain in the soil. In temperate climate about three-quarters of Aldrin applied to soil is lost during the first year after application. Dieldrin is lost quickly from soil in tropical areas, up to 90% within one month, while the half-life in temperate soils is approximately 5 years.

Both aldrin and dieldrin are readily absorbed in both humans and animals via oral, dermal and respiratory routes. Bioconcentration factors for whole fish are greater than 10000 and for earthworms

up to 170.

Aldrin and dieldrin show only minor toxicity to soil microorganisms, but are highly toxic for aquatic crustaceans with most LC<sub>50</sub> values below 50 µg/L. The most susceptible aquatic invertebrates are the larval stages of insects with LC<sub>50</sub> 0.5 – 39 µg/L for dieldrin and 1.3 – 180 µg/L for aldrin. Both substances also have high acute toxicity for fish with LC<sub>50</sub> between 2.2 and 53 µg/L for aldrin and between 1.1 and 41 for dieldrin.

There are a few reports on mammal populations affected by dieldrin, one where eating dieldrin-dressed seed killed small mammals, another where bats were killed by dieldrin in wood preservatives.

Aldrin and dieldrin are highly toxic for human beings. The lowest dose with fatal outcome has been estimated to 10 mg/kg bw. The earlier US EPA classification of both substances as “probable human carcinogens” is being changed to “not likely a human carcinogen” after a reassessment (D. E. Stevenson, E. F. Walborg, Jr., D. W. North, R. L. Sielken, Jr., C. E. Ross, A. S. Wright, Y. Xu, L. M. Kamendulis, and J. E. Klaunig. Monograph: reassessment of human cancer risk of aldrin/dieldrin. *Toxicol.Lett.* 109 (3):123-186, 1999).

Water quality criteria (WQC) for aldrin between 0.0001 and 0.18 µg/L have been published, and between 0.0001 and 0.018 µg/L for dieldrin.

The maximum residue limits for aldrin and dieldrin in food recommended by FAO/WHO varies from 0.006 mg/kg milk fat to 0.2 mg/kg meat fat.

## Chlordane

Chlordane is a mixture of at least 23 different substances with the major components heptachlor, alpha- and gamma-chlordane, and trans-nonachlor (the CAS # 12789-03-6 for the technical product is often used instead of 57-74-9). Chlordane has been used as an insecticide on agricultural crops and also extensively to control termites.

Chlordane is highly persistent in soils with a half-life of about 4 years. Although chlordane is bound to soil particles the substances have been found in ground water, especially if applied on sandy soils.

The acute toxicity of chlordane for mammals is moderate with an LD<sub>50</sub> in rat of 200-590 mg/kg body weight. One of the metabolites, oxychlordane, is more toxic as LD<sub>50</sub> comes down to 19 mg/kg body weight in the rat. IARC has classed chlordane as being possibly carcinogenic to humans.

The toxicity of chlordane to birds is moderate, LD<sub>50</sub> in bobwhite quail being 83 mg/kg, but very high to fresh water invertebrates and fish. The LC<sub>50</sub> from 0.4 µg/L (pink shrimp) to 90 µg/L (rainbow trout) have been reported. Chlordane is also highly toxic to bees and earthworms.

Water quality criteria for chlordane of 0.0015 to 0.006 µg/L have been published. The maximum residue limits for chlordane in food are, according to FAO/WHO between 0.002 mg/kg milk fat and 0.5 mg/kg poultry fat.

## DDT

Technical DDT products is mainly containing p, p'-DDT, but [it] contains also some 15% of o, p'-DDT. The product is used as an insecticide and is in the environment metabolized to mainly DDD and

DDE. The latter is often the major substance found in biota. The reported concentrations are often expressed as “total” DDT, which then normally include p, p’-isomers of DDT, DDD and DDE.

DDT substances are very persistent in soil with half-life times of 10 to 15 years. Bio-concentration in fish is high, e.g. 51000 in rainbow trout and 154000 in fathead minnow.

Many aquatic organisms are very sensitive to DDT. Green algae growth and photosynthesis are inhibited already at concentrations of 0.1 µg/L, and at 0.3 µg/L some invertebrates have shown problems with reproduction, development, and neurological changes.

The acute toxicity of DDT is also high in aquatic invertebrates and concentrations as low as 0.3 µg/L causes e.g. impairment of reproduction and development. An LC<sub>50</sub> for largemouth bass of 1.5 µg/L has been reported, while that for guppy is higher, 56 µg/L. Goldfish exposed to 1 µg/L exhibit hyperactivity. There is a report on effects on the hatching of coho salmon eggs at the levels of DDT (1 ng/L) found in the Lake Michigan water.

Residue levels of > 2.4 mg/kg in eggs of the winter flounder result in abnormal embryos in the laboratory, and comparable residue levels have been found to relate to the death of lake trout fry in the wild.

DDT and its metabolites can lower the reproductive rate of birds by causing eggshell thinning and by causing embryo deaths. The lowest dietary concentration of DDT reported to cause shell thinning was 0.6 mg/kg for the black duck.

The maximum residue levels in food recommended by WHO/FAO range from 0.02 mg/ kg milk fat to 5 mg/kg meat fat.

## Dioxins and Furans

The terms dioxins and furans are used to describe two groups of substances with similar properties, the polychlorinated dibenzo-*p*-dioxins and the polychlorinated dibenzofurans. These groups contain 75 and 135 congeners, respectively, but only 17 of these are regarded as very toxic. As these 17 substances are acting through the same mechanism, their expected total activity can be calculated. Toxicity Equivalency Factors (TEFs) describing the potency for an individual substance relative to the most toxic one (2,3,7,8-TCDD) have been developed and are used to convert the concentrations of the toxic congeners to a corresponding TCDD concentration (TEQ). The sum of these TEQs is then used to describe the total “dioxin toxicity” of the sample. At present two systems are used internationally for assigning TEFs. The most recent one is presented in Table 28. When describing dioxin toxicity by TEQs reference should be made to the system used.

Table 28: WHO TEFs for human risk assessment based on the conclusions of the meeting in Stockholm, Sweden, 15-18 June 1997 (Berg M. van den, L. Birnbaum, A. T. C. Bosveld, B. Brunstrom, P. Cook, M. Feeley, J. P. Giesy, A. Hanberg, R. Hasegawa, S. W. Kennedy, T. Kubiak, J. C. Larsen, F. X. van Leeuwen, A. K. Liem, C. Nolt, R. E. Peterson, L. Poellinger, S. Safe, D. Schrenk, D. Tillitt, M. Tysklind, M. Younes, F. Waern, and T. Zacharewski. Toxic equivalency factors (TEFs) for PCBs, PCDDs, and PCDFs for humans and wildlife. *Environ. Health Perspect.* 106 (12):775-792, 1998)

Congener	TEF (WHO)	Congener	TEF (WHO)
<u>Dibenzo-<i>p</i>-dioxins</u>		<u>Non-ortho-PCB</u>	
2,3,7,8-TeCDD	1	PCB 77	0.0001
1,2,3,7,8-PnCDD	1	PCB 81	0.0001
1,2,3,4,7,8-HxCDD	0.1	PCB 126	0.1
1,2,3,6,7,8-HxCDD	0.1	PCB 169	0.01
1,2,3,7,8,9-HxCDD	0.1		
1,2,3,4,6,7,8-HpCDD	0.01	<u>Mono-ortho-PCB</u>	
OCDD	0.0001	PCB 105	0.0001
		PCB 114	0.0005
<u>Dibenzofurans</u>		PCB 118	0.0001
2,3,7,8-TeCDF	0.1	PCB 123	0.0001
1,2,3,7,8-PeCDF	0.05	PCB 156	0.0005
2,3,4,7,8-PeCDF	0.5	PCB 157	0.0005
1,2,3,4,7,8-HxCDF	0.1	PCB 167	0.00001
1,2,3,6,7,8-HxCDF	0.1	PCB 189	0.0001
1,2,3,7,8,9-HxCDF	0.1		
2,3,4,6,7,8-HxcDF	0.1		
1,2,3,4,6,7,8-HpCDF	0.01		
1,2,3,4,7,8,9-HpCDF	0.01		
OCDF	0.0001		

There are also some attempts to develop TEFs for responses in non-mammal species.

Dioxins and furans are not intentionally produced, but they are formed as unwanted by-products in several pesticides and chlorophenol preparations. Dioxins and furans are also formed in combustion processes, and the incineration of municipal waste has been found as one of the major sources of dioxins in the environment.

The acute toxicity of dioxins is very species dependent and for TCDD the oral LD<sub>50</sub> is 0.6 microg/kg body weight in guinea pigs and in Syrian hamster it is 5051 microg/kg body weight.

There are a large number of toxicological studies performed on the dioxins, furans (and co-planar PCBs, see below) and a large number of effects have been found. Both neurotoxic and hormonal effects

have been seen in rhesus monkeys at doses as low as 0.16 ng/kg bw/day. Effects on the immune systems in the mouse have been found at doses of 10 ng/kg bw/day, while reproductive effects were seen in rhesus monkeys at 1-2 ng/kg bw/day. Biochemical effects have been seen in rats down to 0.1 ng/kg bw/day.

In a re-evaluation of the TDI for dioxins, furans (and planar PCB), the WHO decided to recommend a range of 1–4 TEQ pg/kg bw.

### Endrin

Endrin is used as an insecticide in the agriculture, especially on cotton, rice, sugar-cane and maize. It is also used as a rodenticide.

Endrin is very toxic to fish, aquatic invertebrates, and phytoplankton, with LC<sub>50</sub>-values mostly below 1 microg/L. The lowest observed effect level in a life cycle test on the mysid shrimp was established at 30 ng/L.

The oral LD<sub>50</sub> for endrin in laboratory animals is in the range of 3 – 43 mg/kg bw. Long term toxicity in the rat has been studied over two years and a no effect level of 0.05 mg/kg bw/day was found.

Several metabolites of endrin exhibit similar or higher acute toxicity than the parent substance. 12-Ketoendrin has an acute toxicity in rats of 0.8-1.1 mg/kg bw.

### Heptachlor

Heptachlor is used primarily against soil insects and termites. It has also been used against cotton insects, grasshoppers, and malaria mosquitoes. Epoxidation is an important metabolic route leading to heptachloro epoxide, which is of comparable toxicity to heptachlor but more stable in biological systems.

The half-life of heptachlor in soil is in temperate regions 0.75 – 2 years depending on the soil, but it may be shorter in tropical regions.

Bio-concentration of heptachlor in fathead minnow has been reported to be 9500, while the corresponding value for heptachlorepoide was 14400.

The acute toxicity of heptachlor to mammals is moderate; LD<sub>50</sub>-values between 40 and 119 have been published. The toxicity to aquatic organisms is higher and LC<sub>50</sub>-values down to 0.11 microg/L have been found for pink shrimp.

There is a possibility that heptachlor has been responsible for the decline of several wild bird populations. Canada geese experienced lowered reproductive success and increased adult mortality in the end of the 1970's. Analytic results of the heptachlorepoide concentrations in the brains of the dead birds were equal to or exceeded the experimentally determined lethal levels of 8 – 9 microg/g. Low nest success was also associated with egg residue levels of > 10 microg/g. For American kestrels in the same area there was an association between heptachlorepoide levels > 1.5 microg/g and reduced productivity.

In experiments with minks the influence of heptachlor in their diet was studied. The lowest effect level (which also was the lowest level in the study), based on reduced kit growth, was 6.25 microg/g diet.

The maximum residue levels for heptachlor recommended by FAO/WHO are between 0.006 mg/kg milk fat and 0.2 mg/kg meat or poultry fat.

### Hexachlorobenzene (HCB)

HCB was earlier used as a fungicide, especially on grains, but is today mainly used as an intermediate in the production of other chlorinated substances. It is also present as impurity in several biocides and it is formed during incomplete combustion.

The estimated half-life times of HCB in soil range from 2.7 to 22.9 years. It is also quite stable in mammals with half-life times of one month in rats and 2 – 3 years in monkeys. The major metabolites are pentachlorophenol, tetrachlorohydroquinone and pentachlorothiophenol, but more than 43 different metabolites have been described.

The bioconcentration of HCB in fathead minnow have been determined to 22000 and to worms more than 106000.

Water HCB concentrations of 1 microg/L affected the growth of freshwater algae and protozoa and 3 microg/L caused mortality in amphipods and liver necrosis in largemouth bass. LC<sub>50</sub> for fish varies between 50 and 200 microg/L.

The acute toxicity of HCB is low with LD<sub>50</sub> values of 3500 for rats and 4000 for mice. Long-term effects are more serious, and 100 ppm in the rat diet killed 50 % of the offspring. Mild effects of the [rat] liver have been observed at a daily dose of 0.25 mg HCB/kg bw, and alterations of neurotransmitter concentrations was seen in mink dams given a daily dose of 0.16 mg HCB/kg bw.

In a cancer study hamsters were given daily doses of HCB between 4 and 16 mg/kg bw. Also at the lowest dose there were increases in the incidence of liver tumors in both sexes. HCB has been classified as a possible carcinogen to humans by IARC, based on inadequate evidence for carcinogenicity to humans and sufficient evidence for carcinogenicity to animals.

### Mirex

Mirex was used as a pesticide primarily in the USA, but has also been applied in some other continents to combat termites and ants. The substance has, however, another application as flame retardant in plastics, rubber, paper and electrical equipment. This use may have distributed Mirex globally in these products.

Mirex is very persistent and the major degradation pathway seems to be photolysis. Bio-concentration factors of 2600 in pink shrimp and 51400 in fathead minnows have been described.

The acute toxicity of Mirex is low with LD<sub>50</sub> values 125 mg/kg bw in hamster and higher in other mammals. In avian species the lowest LD<sub>50</sub> (1400 – 1600 mg/kg bw) was found in pheasants.

Crustaceans are the most sensitive species regarding Mirex exposure. Delayed mortality occurred at 1 microg/L exposure levels. Mirex is also toxic to fish and can affect fish behavior.

IARC has concluded that there is inadequate evidence for the carcinogenicity of Mirex in humans, but there is sufficient evidence for such effects in animals.

## Polychlorinated Biphenyls (PCB) (including planar PCB)

There are 209 theoretically possible structures of polychlorinated biphenyls. The commercial products can be divided into four main groups depending on the degree of chlorination, which varies from about 42 to 60 %. The Aroclor products are often used to reference these mixtures and Aroclor 1242 contains 42 % chlorine, Aroclor 1248, 1254 and 1260 contain 48, 54, and 60 % chlorine respectively. The PCB concentrations found in the environment are often expressed as concentration of one of these products, especially in earlier analyses. Today indicator congeners (one or several) are normally used.

The PCB congeners with no or only one chlorine atom in *ortho* position to the bridge between the aromatic rings can adopt planar configurations. Their size and planar form means that they can interact with the Ah-receptor. Since these PCB congeners are acting through the same mechanism as the dioxins corresponding TEFs have been developed and TEQ values can be calculated also for these PCB substances. To obtain the whole “dioxin like activity” in a sample the dioxin TEQ and the PCB TEQ are added (see Table 28).

The co-planar PCB constitute a fraction of the technical PCB products that have been produced and emitted in large amounts. PCB products also contain low levels of PCDF.

PCB is probably the most studied PTS group and our knowledge of this group has often been extrapolated to other groups. All 209 congeners have been synthesized and many of them studied individually. This extended knowledge is of course raising new questions, such as how these substances interact with each other (and other chemicals).

The main use of PCB is in electrical appliances, mainly transformers and capacitors. Other applications are as plasticiser, flame retardant, solvent and hydraulic liquid. More than one million ton of PCB has been produced and some production may still be going on, but this is difficult to verify.

In general the persistence of PCB substances increase with increasing chlorine content. In air the half-life time of monochlorobiphenyl is about 10 days and that of a heptachlorobiphenyl about 1.5 years. Microorganisms degrade mono- to trichlorobiphenyls rather rapidly; tetrachlorobiphenyls slowly and higher chlorinated congeners are rather resistant to biodegradation (although there is an influence of the substitution pattern).

Bio-concentration factors in aquatic organisms vary over a wide range and data from 200 to 70000 have been published. LC<sub>50</sub> for the larval stages of rainbow trout is 0.32 microg/L with a no effect level of 0.01 microg/L.

The acute toxicity of PCB in mammals is generally low and LD<sub>50</sub> values in rat of 1 g/kg bw and even higher have been reported. In longer term studies the PCB mixtures are often more potent. Rhesus monkeys given 90 microg Aroclor 1254/kg bw/day for 6 months showed an increased mortality rate, growth retardation, and several other serious effects.

Different PCB products seem to give different response in many of these tests. In a 2-generation reproduction study on rats, a NOEL of 0.32 mg/kg bw were found for Aroclor 1254, while the NOEL for Aroclor 1260 was 7.5 mg/kg bw. An extremely low chlorinated product, Aroclor 1016, gave a NOEL of 30 microg/kg bw and it was not possible to establish a NOEL for Aroclor 1248. One reason for these large differences may be that the products contain different levels of planar congeners and/or polychlorinated dibenzofurans.

IARC has concluded that PCB is carcinogenic to laboratory animals and probably also for humans.

## Toxaphene

Toxaphene is a trade name for a product sold by a US company, and several attempts have been done to find another acronym for this pesticide. IPCS has used polychlorinated camphene (PCC) while others have used Camphechlor. Today the recommended name is chlorinated bornanes (CHB). As UNEP has chosen to use Toxaphene that name will also be used in this report. In addition to the IPCS risk assessment, a Nordic report has been used as a source of the following information on Toxaphene (Audunsson, G, Dybing, E, Hanberg, A, Hietanen, E, Larsen, J, Utne Skaare, J, and Slanina, P. Nordic Risk Assessment of Toxaphene Exposure. 540. 1997. TemaNord.)

Toxaphene is a very complex mixture of polychlorinated terpenes, the theoretically possible number of congeners being at least over 32000. In the commercial products the number of components are certainly smaller, but at least 670 substances have been separated from Toxaphene. The se congeners have different stability and the composition of Toxaphene found in the environment is not the same as that of the used product, a fact that complicates the analyses and the testing. A few congeners seem to be much more persistent than the others are and today some of these are synthesized. Analysis of Toxaphene is therefore today often focussed on just three congeners.

Due to a rather high volatility Toxaphene is effectively transported over long ranges and can today be found in samples from all over the world. The half-life time in soil has been reported to vary between 70 days and 12 years depending on the type and conditions of the soil. Also in some waters it has been shown to persist for years at concentrations that are toxic to fish.

The acute toxicity of Toxaphene is moderate with oral LD<sub>50</sub> in rat ranging from 60 to 293 mg/kg bw. In longer term studies liver is identified as the most sensitive organ. Also the thyroid is affected and NOEL for this effect was in the rat 0.35 mg/kg bw/day and in the dog 0.2 mg/kg bw/day.

IARC concludes that there is sufficient evidence that Toxaphene is carcinogenic in mice and rats. In the absence of adequate data in humans, it is reasonable to regard Toxaphene as if it presented a carcinogenic risk to humans.

## **7.2 Some other examples of PTS**

### Lindane

Lindane is a broad-spectrum pesticide which contains > 99 % gamma-hexachlorocyclohexane (gamma-HCH). Technical grade HCH consists of 65 – 70 % alpha-HCH, 7 – 10 % beta-HCH, 14 – 15 % gamma-HCH and approximately 10 % of other isomers and substances. Earlier the technical product was often applied, but it is only the gamma isomer that has pesticide properties. IPCS has assessed gamma-HCH (WHO, “Environmental Health Criteria 124. Lindane”, 1991,) and alpha- plus beta-HCH (WHO, “Environmental Health Criteria 123, “Alpha- and beta-hexachlorocyclohexane”, 1992) and those reports are the main source of the following information.

The persistence of Lindane in soil varies from a few days to three years depending on the soil, climate and other factors. Even if the half-life time in air is rather short, it is enough to make it possible to transport the lindane over large distances and the substance can be found at any place in the world.

The bioconcentration factors of lindane in aquatic organisms cover the range from 10 to 6000. In rats lindane is rapidly absorbed from the gastrointestinal tract and distributed to all organs within a few

hours.

Lindane is moderately toxic for invertebrates and fish, the LC<sub>50</sub> values for these organisms being 20 - 90 microg/L. In short-term and long-term studies with three species of fish, the NOEL was 9 microg/L.

The acute toxicity of lindane for mice and rats is moderate; the LD<sub>50</sub> values are in the range of 60 – 250 mg/kg bw. For birds this range seems to be even higher, 100 – 1000 mg/kg bw. In a 90-day study in rats, the NOEL was about 0.5 mg/kg bw/day, at higher doses the weights of liver; kidney and thyroid were increased.

### Polycyclic Aromatic Hydrocarbons (PAHs)

PAH is a complex group of aromatic substances most of which are formed during incomplete combustion of organic material. The composition of PAH mixtures vary with the source(s) and also due to selective weathering effects in the environment. The only way to evaluate the environmental impact of PAH is to do it substance by substance.

Today concentrations of PAH are normally reported for the individual substances, but earlier (and also today sometimes) the sum of PAH substances were given. These results depend on how many and which individual substances this sum represents.

IPCS has not evaluated any PAH substances and the following information is gathered from several reports. One very useful is a report from the Swedish National Chemicals Inspectorate (KemI. Hazard Assessments - Chemical substances selected in the Swedish Sunset Project. No 12/95. 19950. The Swedish National Chemicals Inspectorate. KemI Report).

The PAHs are not as persistent as the earlier discussed polychlorinated substances, but as they are used (and unintentionally produced) in large amounts the concentrations in the environment can reach levels where effects appear.

A few individual substances are often used as indicators to describe several aspects of the complex PAH spectrum. Naphthalene is one of those, being the smallest and most volatile member in the family. Anthracene is another substance, present in rather high concentrations in many samples and being somewhere in the middle of the size range. Benzo [a] pyrene is one of the more potent carcinogenic PAHs and is therefore studied a lot.

The low molecular PAHs are most easily degraded. The half-life time in sediment is for naphthalene 9 hours, for anthracene 43 hours and for benzo [a] pyrene 83 hours.

Also the bioconcentration in aquatic organisms increase with increasing molecular size. Calculated values for BCF in fish and shellfish are for naphthalene 90, for anthracene 500 and for benzo [a] pyrene > 4000. Frequently reported measurements of bioconcentration of PAHs are in the range 100 – 2000.

The short term toxicity of PAHs for crustaceans also follow the trend of increasing effect with molecular weight. In *Daphnia pulex* is LC<sub>50</sub> for naphthalene 1.0 mg/L, for phenanthrene 0.1 mg/l and for benzo [a] pyrene 0.005 mg/L.

The acute toxicity of PAHs is moderate with oral LD<sub>50</sub> values in rat of 490 mg/kg bw for naphthalene and 18000 mg/kg bw for anthracene.

The critical effect of many PAHs in mammals is the ability to induce cancer. The metabolic epoxidation of these substances produce intermediates that bind covalently to cellular DNA. IARC has

classified benz [a] anthracene, benzo [a] pyrene and dibenzo [a, h] anthracene as probably carcinogenic to humans. Benzo [b] fluoranthene and indeno [1,2,3-c, d] pyrene were classified as possibly carcinogenic to humans.

### Polybrominated Diphenyl Ethers (PBDE)

PBDE are used as additive flame retardants, which means that they are just added to (or dissolved in) the material to be protected. There are three major products of PBDE with different bromine content: pentabromodiphenyl ethers (PeBDE) with four to six bromine in the molecules; octabromodiphenyl ethers (OBDE) with six to nine bromine in the molecules; and decabromodiphenyl ether (DeBDE) that is fully brominated.

IPCS performed a risk assessment of these chemicals a few years ago (WHO, "Environmental Health Criteria 162. Brominated Diphenyl Ethers", 1994, WHO). The European Union is presently doing separate risk assessments of the three different product types and the environmental parts of these are finished but not yet published. The human parts are expected to appear very soon. The information given below is mainly taken from these documents.

OBDE, and still more DeBDE, are large molecules that are very slowly absorbed by organisms and in spite of the high volumes produced of these products there are few reports on these substances in biological samples. The PeBDE are much more effectively taken up and therefore seems to be present in any environmental sample. The information given here will therefore concentrate on the PeBDE.

Bio-concentration factors for the components in PeBDE (tetra- to hexaBDEs) have been determined. All congeners showed BCF values in the region 1000 – 100000, except for one pentaBDEs, which is the major component in the technical product, which surprisingly gave BCFs in the region 1 – 100. Tetra-, penta, and hexaBDE congeners have been given pike in its food and the uptake efficiencies were found to be 90 %, 60 %, and 40 %, respectively.

The half-lives of PeBDE components in rat adipose tissue varies between 19 and 119 days, the higher values for the higher brominated congeners.

In vitro degradation tests with hepatic microsomes from several marine mammals have been applied on the components in PeBDE. No degradation could be seen, indicating that the PBDE substances are more stable than the most persistent PCB congeners in this test.

PeBDE has been investigated in an algal growth test and inhibition of the growth was seen from 3.3 microg/L. The toxicity to *Daphnia magna* has also been investigated and LC<sub>50</sub> was found to be 14 microg/L with a NOEC of 4.9 microg/L.

The tests in aqueous media are difficult due to the limited solubility of these very lipophilic substances. In a toxicity test with rainbow trout no mortality appeared even at a concentration corresponding to the solubility.

Studies in rats with commercial PeBDE indicate a low acute toxicity via oral and dermal routes of exposure, with LD<sub>50</sub> values > 2000 mg/kg bw. In a 30-day study with rats effects on the liver could be seen at a dose of 2 mg/kg bw/day, with a NOEL at 1 mg/kg bw/day.

### Chlorinated Paraffins (CP)

CPs are polychlorinated alkanes with carbon chain lengths between 10 and 30 and a chlorine content

between 30 and 70 %. The number of possible congeners within these limits is enormous and the commercial products are extremely complex. The products are often divided in three groups depending on chain length: short chain ( $C_{10} - C_{13}$ ), medium ( $C_{14} - C_{17}$ ) and long ( $C_{18} - C_{30}$ ) chain lengths. The major use of CP is as an additive to metal cutting fluids, as plasticiser and as flame retardant. The annual production is estimated to more than 300000 tons.

IPCS have recently performed a risk assessment of CP (WHO, "Environmental Health Criteria 181. Chlorinated paraffins", 1996). Within the work with existing substances in the EU there is an assessment finished (<http://ecb.ei.jrc.it>) on the short chain CP and one to be finished on the medium length CP.

The complexity of the CP products makes them very difficult to analyze, and there are few data on environmental levels. As the composition [is] also changed in the environment there may be differences in activities between what is tested in the laboratory and what is present in the environment.

Short chain CP with less than 50 % chlorine content seem to be degraded under aerobic conditions, whereas this degradation is inhibited for the higher chlorinated substances. The medium and long chain products are degraded more slowly.

CP are bioaccumulated and BCFs are in the range of 7 to 7000 for fish and 200 to 138000 for mussels. For the short-chained products both uptake and elimination are faster for the substances with low chlorine content.

The acute toxicity of CP is low with reported oral  $LD_{50}$  values ranging from  $> 4$  to  $> 50$  g/kg bw. In repeated dose experiments, effects on the liver have been seen at doses of 50 – 100 mg/kg bw/day, with NOEL of 10 mg/kg bw/day. A medium chain length CP at 5.2 – 7.2 mg/kg bw/day affected the reproduction of rats.

Short chain length CP show long-term toxicity to algae, aquatic invertebrates and fish at concentrations as low as 19.6, 8.9 and 3.1 microg/L, respectively. The NOEL appears to be in the range of 2–5 microg/L for the most sensitive species tested.



## 8 SUGGESTED LITERATURE AND INFORMATION SOURCES

The documents and Internet addresses tabled below are primarily intended to provide useful background information and suggested additional reading related to the Guidance document for the members of the Regional Team and other interested participants in the project network. The list is by no means complete. A comprehensive bibliography, primarily with secondary and tertiary literature on persistent toxic substances with a focus on regionally acquired data will be published as a separate document within the project and be made available to all participants in the project network.

In addition to the addresses given below the Regional Teams might consider establishing a short list of useful Internet addresses from within the region and, as appropriate, discussion clubs for participants in the regional network.

### Reports

AMAP Assessment Report: Arctic Pollution Issues. Arctic Monitoring and Assessment Programme, Oslo, 1997.

Arctic Pollution Issues: A State of the Environment Report. Arctic Monitoring and Assessment Programme, Oslo, 1997.

Compilation of EU Dioxin Exposure and Health Data. Report produced for European Commission DG Environment UK Department of the Environment Transport and the Regions (DETR). Commission of the European Community, Brussels, 1999

HELCOM 1996. Third Periodic Assessment of the State of the Marine Environment of the Baltic Sea, 1989-93. Helsinki Commission, Helsinki, 1997.

National and Regional Dioxin and Furan Inventories: National and Regional Emissions of PCDD/PCDF. UNEP Chemicals, Geneva, Switzerland, 1999

Organochlorines Programme. Ministry of the Environment, Wellington, New Zealand, 1998.

Persistent, Bioaccumulative and Toxic Chemicals in Central and Eastern European Countries – State-of-the-Art Report. Draft – 1<sup>st</sup> Version, TOCOEN Report No 150. Recetox TOCOEN & Associates, Brno, Czech Republic, August 1999.

Persistent Environmental Contaminants and the Great Lakes Basin Population: An Exposure Assessment. Ministry of Public Works and Government Services, Canada, 1998.

Persistent Organic Pollutants. Monitor 16. Swedish Environment Protection Agency, Stockholm, 1998.

Regionally Based Assessment of Persistent Toxic Substances. Workshop Reports from a Global Environmental Facility Project. UNEP Chemicals, Geneva. 1999.

THE INVENTORY OF SOURCES OF DIOXIN IN THE UNITED STATES, External Review Draft, EPA/600/P-98/002Aa, 1998

UNEP/IPCS. Training module No. 3. Chemical Risk Assessment. Geneva, 1999.

WHO/IPCS, Environmental Health Criteria Document

- Aldrin, No. 91, 1989.
- Chlordane, No. 34, 1984.
- DDT and its derivatives, No. 9, 1979.
- DDT and its derivatives, Environmental Aspects, No. 83, 1989.
- Dieldrin, No. 91, 1989.
- Endrin, No. 130, 1992.
- Heptachlor, No. 38, 1984.
- Hexachlorobenzene, No. 195, 1998.
- Mirex, No. 44, 1984.
- Polychlorinated biphenyls and terphenyls, No. 140, 1993.
- Polychlorinated dibenzo-*p*-dioxins and dibenzofurans, No. 88, 1989.
- Toxaphene (Camphechlor), No. 45, 1984

### Internet Addresses

UNEP Chemicals is operating a POPs Clearinghouse (<http://www.chem.unep.ch>) which also has extensive links to other international and regional organizations, governments, NGOs, conventions etc. e.g. <http://www.ospar.org>; <http://helcom.fi>; <http://www.ijc.org/> and <http://www.gefweb.org>. You may also join the PBTs (Persistent Bioaccumulating Toxic Substances) Discussion Club No. 1 on <http://recetox.chemi.muni.cz/PBTs/content.htm>. Other useful addresses include Riskline <HTTP://www.kemi.se/default.cfm?page=kemdatbas.htm>, the Integrated Risk Information System (IRIS) in USEPA <http://www.epa.gov/iris> and the European Chemicals Bureau <http://ecb.ei.jrc.it>.