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TNO-report

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Dioxin emissions in Candidate Countries

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1. Introduction

To secure better protection of human health and of the environment from the effects of dioxins and PCBs, on 24th October 2001 the Commission adopted a « Communication on a Community Strategy for Dioxins, Furans and Polychlorinated Biphenyls » COM(2001)593. The Communication outlines the problem of dioxins and PCBs, the progress in addressing the problem, the remaining gaps, the basis for Community action and it develops a strategy to reduce the presence of these compounds in the environment, in feed and food. Dioxins are widely encountered toxic substances. They are found in all environmental compartments, are persistent and, being fat soluble, they tend to accumulate in higher animals - including humans. Their resistance to degradation and semi-volatility means that they may be transported over long distances and give rise to trans-national exchanges of pollutants.

As a result of the enlargement of the European Union (EU) to include Candidate Countries (CCs) the European Commission reckons with the possibility of increased average exposure to dioxins in the EU. However a harmonized dioxin emission inventory as exists for the current Member States is not available yet.

Against this background, the European Commission has commissioned a study "Dioxin Emissions in Candidate Countries" to a consortium lead by TNO (contract No B4 3040/2002/348064/MAR/C2). Other partners in the consortium were IUTA from Germany, IOW from France and SHMU from Slovakia.

Together with the DG ENV funded study « Dioxins & PCBs : Environmental Levels and Human Exposure in Candidate Countries » (ELICC) this study should serve as both a basis for an integral assessment of dioxin-related issues in the Candidate Countries and a starting point for focusing dioxin abatement measures.

The goal of the present study is to lay the foundation for a consistent and harmonised dioxin emission estimate for air, land and water emission in CCs. The study, being developed in close cooperation with authorities, institutions and experts will lead to substantial further dioxin inventory capacity building in CCs. Through extensive feedback and mutual aid, harmonization of methodologies will be achieved and institutional strengthening in the CCs is achieved.

The 13 countries in central and Eastern Europe, participating in this study are:
1) Bulgaria
2) Cyprus
3) Czech Republic
4) Estonia
5) Hungary
6) Latvia
7) Lithuania

8) Malta
9) Poland
10) Romania
11) Slovak Republic
12) Slovenia
13) Turkey

When the project was commissioned, these countries were referred to as EU candidate member countries. Since June 2004, 10 of these countries are full members of the EU. Bulgaria, Romania and Turkey now are still candidate members.

The project clearly connects to other activities by the European Commission:

1) The PECO project, run by JRC, aimed at development of dioxins expertise in the candidate countries.
2) A DG ENV funded project, lead by Consortium ELICC, aimed at estimating the environmental levels and human exposure to dioxins and PCBs in Candidate Countries.

2. Approach

The project contains two major activities:

1) Development of an emission inventory of dioxins for the candidate countries for emissions to air, water and land.
2) Carrying out of a series of supporting air emission measurements to improve the quality of the knowledge on dioxin emissions in the candidate countries.

These activities have as a secondary objective to support the development of capacities and expertise within the countries to a level that is needed for the EU policy in the field of dioxins. Both the development of the inventory and the carrying out of the measurements will therefore be achieved in close co-operation with the national experts. The results of the study can help countries to develop and complete a list (database) of dioxin sources and emission factors as well.

To achieve both goals for both activities a series of two workshops were organised in Bratislava (Slovak Republic). These workshops served to set the stage for the project, to agree on approaches and methods and to connect optimally with possible information available in the participating countries. We stress however that the results as presented in this report and its annexes is fully for the responsibility of the consortium. The participation of the countries' experts does not imply that the national authorities of these countries fully agree with the results.

The results of the project are described in detail in the annexes to this report:
Part A: Emissions to Air (TNO and SHMU)
Part B: Emission measurement Program (IUTA)
Part C: Emissions to Land and Water (IOW)

Each of the reports includes a separate discussion and summary chapter, with specific conclusions for each subject. The next chapter of the main report draws from these chapters.

The over all conclusions are presented in chapter 4.

3. Results

3.1 Capacity building

Both through the workshops and intensive contacts between the national experts, participating at the workshops and consortium members, a strong interaction between both inventory experts and measurement experts in the candidate countries on the one hand and the consortium members on the other hand has been established. Also the mutual interaction between the experts from the participating countries at the workshops has evidently contributed to the harmonization of the resulting national inventories.

In addition, due to the measurement campaigns organized within this project, sampling teams and laboratories in the participating countries have been able to develop some experience on such measurements.

Further details on the interaction between the national experts and the consortium members are presented in the detailed reports, below.

3.2 Air Emission Inventory

In this study we developed in close co-operation with national experts air emission inventories for the 10 “New” EU Member States (Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovak Republic, Slovenia) and the three EU Candidate Countries (Bulgaria, Romania, Turkey). Our approach assures

1) Consistency and comparability between the 13 national inventories for these countries.
2) Consistency and comparability with the inventories of the 15 “Old” EU Member States, published earlier.
3) Optimal use of national information as far as available via the national experts participating in this project.
4) Transparency: all detailed data are copied in the annexes with this report.

3.2.1 Summary of findings

Emissions to air are estimated by multiplying activity rates with emission factors. Estimation of emissions to air suffer from high uncertainties, both in activity data for some sources and in emission factors. Available literature and measurements show that emission factors for some sources might vary over more than an order of magnitude although processes and abatement techniques might be comparable. Taking these uncertainties into account, the national total emissions in each of the 13 countries are summarized in Table 1. For each country, both the value as ob-

tained from this study and the lower and upper limits of the 90 % confidence intervals are presented. The numbers have been rounded to two significant digits.

The total dioxin emission to air in the thirteen countries is estimated at 3.2 kg I TEQ per year. The uncertainty range around this value is 1.3 to 8.0 kg I-TEQ per year (90 % confidence interval).

Major sources of dioxins are (see Figure 1):
- Several waste incineration and combustion processes
  - Hospital waste incineration
  - Industrial waste incineration
  - Open burning of domestic wastes
- Several industrial processes
  - Iron sinter plants
  - Cement kilns
- Residential heating (coal and wood) in small stoves

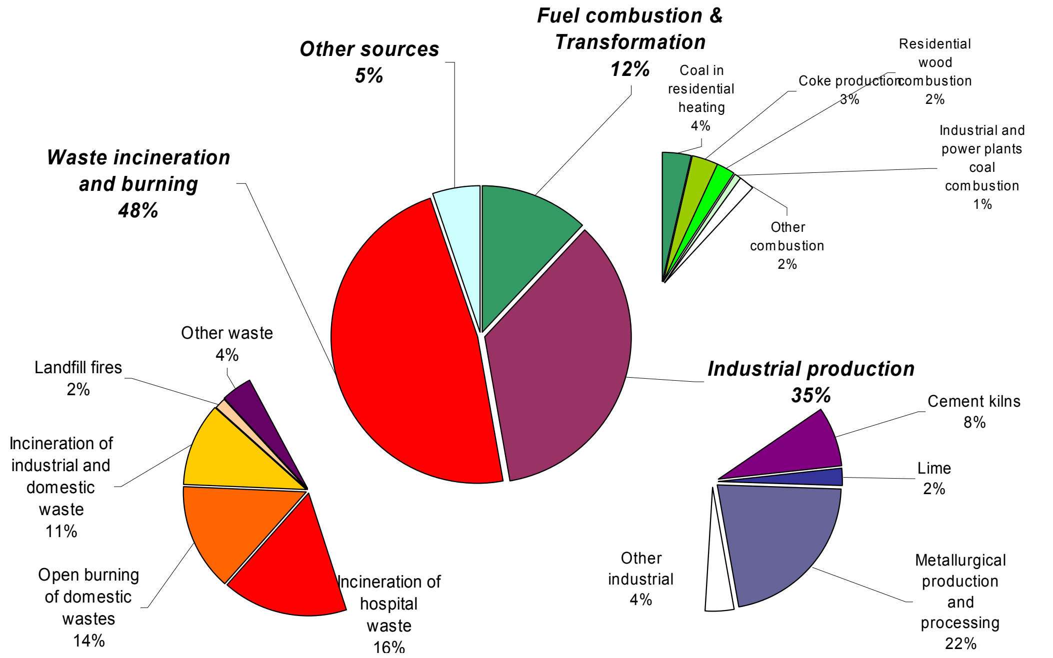

Figure 1 Sources and relative sizes of dioxin emissions to air in the thirteen countries.

Together these sources are responsible for over 60 % of the total dioxin emissions in the study area.

Table 1 National total emissions in the participating counties. The numbers have been rounded to two significant digits.

	This study's estimate	Lower limit of the 90 % confidence interval	Upper limit of the 90 % confidence interval
Bulgaria	290	70	810
Cyprus	6.6	2.5	38
Czech Republic	320	84	990
Estonia	8.7	2.8	46
Hungary	120	46	450
Latvia	18	10	270
Lithuania	48	9.3	190
Malta	3.9	0.4	13
Poland	790	260	1900
Romania	490	120	1300
Slovak Republic	180	47	530
Slovenia	36	8.7	100
Turkey	960	200	2800
Total[1]	**3 200**	**1 300**	**8 000**

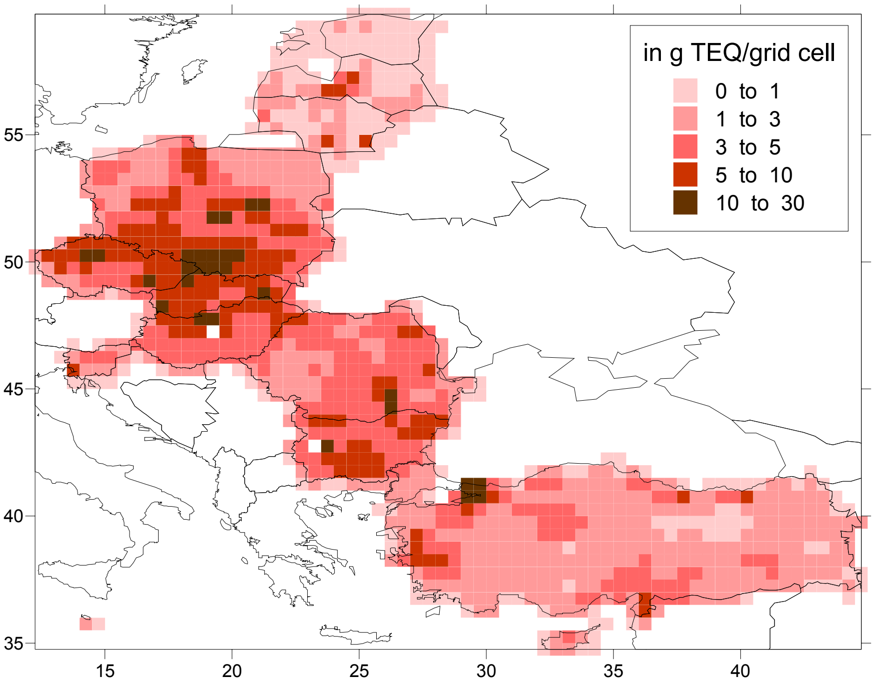

Figure 2 Spatial resolved annual emission of dioxins in the thirteen countries.

Major dioxin emission sources occur both in a limited number of larger industrial facilities and in numerous small residential sources (stoves, uncontrolled burning, fires etc.). Our best estimate of the contribution between these two source catego-

1 Please note that the totals are not equal to the sum of the values of each country

ries shows that 30 to 40 % of the emissions might arise from the small residential sources. This number however is highly uncertain.

An estimate of historic and possible future dioxin emissions to air shows that, due to the decrease of economic activities in the countries, following the political changes in the early 1990s, the emissions have decreased. Due to the expected increases of economic activity however, the emission will rise again to 1990 levels in the coming decades, if the technologies applied in these countries are not improved. If however we assume that all technologies applied in these countries will match the best ones already in place, emissions will not increase, but further decrease.

3.2.2 Assessment of findings

In this study we have shown that the dioxin emissions to air in the new EU Member States (10 countries) and the Candidate Countries (3 countries) are on a comparable level at a per capita basis as in the 15 “Old” EU Member States.

A preliminary spatial disaggregation shows that highest emissions could occur around each countries capitals and in the heavily populated and industrialized areas of the “Black Triangle” (on the borders between Poland, Czech Republic and Slovak Republic). A similar spatial disaggregation is not available for the 15 “Old” EU Member States.

Comparing the emission factors used in this inventory with those measured for the production processes (excluding energy production; see measurements sub-report) the Toolkit factors selected by us are on the average about a factor of four higher than the measured ones. This is consistent with our approach to produce a conservative estimate by selecting the highest or highest but one emission factor whereever no further information was available. If the measurements were representative for all emission factors in the thirteen countries, this would lead to a considerably lower total emission estimate. We also showed that the assumption for waste incineration not to use the highest, but the highest but one emission factors could underestimate the emissions by a factor of four to five. This range of uncertainty is consistent with the uncertainties as estimated using a Monte Carlo uncertainty analysis.

Taking these findings into account we conclude that the best estimate for the total emissions of dioxins to air in the thirteen countries in this study is about 3.2 kg I-TEQ. The uncertainty around this value however is quite large and this value could be in a factor of two lower or a factor of six higher. The uncertainty of the emission estimate for the fifteen “old” EU Member States is not known, but will not be very different.

About one third of the emissions of dioxins to air are due to non-industrial (area) sources, where low level emission occurs in large numbers of small equipment (stoves, cars, open waste burning). These emissions obviously occur in the direct neighbourhood where people live and hence will give rise to concentrations of dioxins in the direct surroundings of where people live. Industrial sources on the other hand tend to be larger sources with higher stacks. Depositions from these sources will be spread out over larger areas than for the small sources. The emission of each individual source however will be higher. The small, low sources might give rise to hotspots in densely populated areas, whereas the highest concentrations, caused by the larger elevated sources might occur at several kilometres from the stack.

The effects of these different dispersion behaviour of smaller lower on the one hand and larger higher sources on the other, is difficult to estimate in general terms. Detailed location information of all sources in a region is needed to run air pollution dispersion models to calculate dioxin concentrations in the air. Since however most industrial sources are located in the same areas (on a spatial scale of several kilometres) where people live, we do not expect that the geographic emission and concentration patterns are very different for both type of sources. The same is more or less to be expected in the fifteen EU Member States. So, given the high uncertainties in emissions, we do not expect the concentration levels in the thirteen countries to differ significantly from those in the "old" 15 EU Member States. More geographical information is needed to run air quality and effect models to investigate this issue.

On the basis of these results we conclude that there is no reason to assume that the concentrations of dioxins in the air in the thirteen countries are significantly higher than in the 15 "Old" EU Member States. This however does not exclude possible "hot spots", where relatively high concentrations could occur, due to for instance uncontrolled burning of chlorine containing wastes.

The implementation of the EU Waste Incineration Directive and the IPPC Directive in the thirteen countries will bring the emissions of dioxins down to a level that is comparable or even below the level in the "old" EU Member States. Since this might take some time, it might be worthwhile to perform air quality modelling studies for some areas within the thirteen countries. The preliminary geographical distribution, shown in Figure 2, suggests that such a study could be best performed form the so-called Back Triangle (Poland, Czech Republic, Slovak Republic border area) and for the surroundings of Istanbul.

3.2.3 Recommendations

Dioxins are released to air, both from larger industrial facilities and from small residential stoves (coal and wood) and uncontrolled domestic waste burning. Since

there is no significant difference in dioxin emissions (and dioxin contamination (see the results of the ELICC project) between the thirteen countries in this study and the fifteen “old” EU Member States, no specific action is needed for the new EU Member States.

Uncontrolled burning of domestic waste in backyards or small stoves is a practice that should not occur for other reasons than for dioxin emissions (recovery of valuable materials; emissions of other pollutants as POPs, PAH, particulates, black smoke, etc.). The EU has already legislation in place that aims at improving waste management and waste treatment. The Commission could support programs to inform and educate the public to properly dispose of wastes via waste collection and waste treatment systems, using incineration in modern waste incinerators and land filling in modern well managed and well protected waste disposal sites.

Residential coal and wood combustion in small stoves might be phased out because of other environmental problems like the emissions of particulates and PAHs. The emissions of dioxins from these sources adds to the problems caused by the use of solid fuels for small residential heating systems.

Dioxin emissions from larger (industrial) facilities could be abated by technical measures. Implementation of the relevant EU Directives (Waste Incineration Directive) and Best Applicable Technologies (BAT) as described in the IPPC-BREF documents, will significantly reduce the dioxin emissions from these larger industrial facilities.

Over all: there is no need for further specific new legislation to bring the dioxin emissions down. Implementation and probably enforcement of the existing legislation (Waste Incineration Directive, IPPC, Waste Directive (Council Directive of 15 July 1975 on waste (75/442/EEC), article 4 and following) however deserves attention as well as prevention of "illegal" activities in the field of waste combustion.

3.3 Measurement Program

The emission measurement program embedded in the project “Dioxin emissions in Candidate Countries” comprised a number of potentially relevant sources for dioxins and furans like iron ore sinter plants and facilities in the non-ferrous metal industry. Beside these installations also industrial plants with particular importance for the specific country were investigated. Table 2 presents an overview of the countries where measurements took place.

Table 2 Number of proposed, selected and measured facilities by country.

Country	**No of facilities**		
	Proposed	**Selected**	**Measured**
Bulgaria	1	1	1
Cyprus	2	2	2
Czech Republic	1		
Estonia	2	1	1
Latvia	1	1	
Lithuania	2	1	
Malta	1	1	1
Poland	14	5	5
Slovakia	3	2	1
Turkey	4	2	2
Total	**31**	**16**	**13**

The measurements and analyses were carried out mostly by companies and institutes located in the area of interest; moreover, some joint sub-projects were established which involved experienced Western European laboratories and less experienced teams of local authorities.

The results have shown again, as already known from the Western European dioxin inventory projects, that metallurgical plants are of particular importance for the release of dioxins and furans to air. Several of the measured facilities exceeded the orientation level of 0.1 ng I-TEQ/m³ of waste gases that has been set as emission limit for waste incineration. Concerning the annual emissions, however, almost all installations kept the dioxin and furan EPER threshold value of 1 g I-TEQ/year.

With respect to the air emission inventory, facility related emission factors were calculated from the measured flue gas concentrations and plant operation data. These emission factors were compared to the appropriate figures given in the UNEP toolkit (version 2003). In general, the comparison showed acceptable to good agreement if the range of emission factors underlying the toolkit figures are taken into account. The measurements therefore do not indicate that applying the UNEP toolkit emission factors for releases to air would lead to significant over- or underestimations of the annual emissions. It should be noted however, that only a small fraction of existing emission sources were investigated. Hence, there is a considerable range of uncertainty when conclusions are drawn by scaling up these results to the situation in the entire region of the thirteen countries in this study.

3.4 Emissions to Land and Water

3.4.1 Summary of findings

There is a high level of uncertainty about this estimation of dioxin releases to water and to land because of:
- uncertainty in emission factors due to the hypotheses we choose and variability of processes and dioxin concentration;
- uncertainty in activity data;
- lack of data.

Nevertheless, estimated dioxin releases to water and to land for the sources for which estimates have been made are as followed:
- Releases to land in the 13 candidate countries: 8000 g I-TEQ/Year.
- Releases to water in the 13 candidate countries: 50 g I-TEQ/Year.
- The 13 candidate countries contribute for 17% of total release to land in the European Union as a whole (old member states and candidate countries).

In the area covered by the 13 candidate countries, the contributors to release to land and water follow the distribution presented below, according to the maximum and minimum estimates.

Table 3 Percentage of each country contribution to dioxin release in the area.

	Releases to land (in %)		**Releases to water (in %)**	
	Mini	**Maxi**	**Mini**	**Maxi**
Turkey	26.9	29.2	12.5	8.5
Poland	16.5	28.6	22.1	18.2
Hungary	16.1	11.7	2.6	2.7
Romania	8.3	10.8	28.3	32.8
Czech republic	16.0	7.7	11.1	10.7
Bulgaria	4.1	4.5	4.3	4.4
Slovak republic	6.6	3.0	2.5	1.6
Cyprus	0.5	0.29	0.3	1.4
Lituania	1.2	1.3	13.8	17.0
Slovenia	1.2	1.2	0.4	0.4
Latvia	1.8	1.2	1.4	2.0
Estonia	0.5	0.3	0.5	0.5
Malta	0.2	0.2	0.1	0.05
Total of the area	**100%**	**100%**	**100%**	**100%**

This table clearly points out the range of uncertainty linked to the estimates.
The major contributor of release of dioxins to land in candidate countries is Turkey (nearly 28% of the total release in this area) followed by Poland (between 17 and 28%) and Hungary (between 11 and 16%).

The major contributor of release to water in studied region is Romania followed by Poland and Lithuania.

The same analysis per activity for the whole 13 countries is presented in Table 4.

Table 4 Percentage of each activity contribution to dioxin release in the area.

Activity sector	Release to land (in %)		Release to water (in %)	
	Minimum	Maximum	Minimum	Maximum
Power generation and heating				
combustion of coal - power stations	0.4%	0.9%		
combustion of coal - industry	NA			
combustion of wood - industry	NA			
combustion of coal - domestic	4%	26%		
combustion of wood - domestic	-	-		
Ferrous and non-ferrous metal production				
sinter plant	-	0.2%		
primary copper production	-	-		
secondary lead production	1.7%	0.5%		
secondary zinc production	0.1%	0.2%		
secondary copper production	-	0.3%		
secondary aluminium production	-	-		
aluminium production (electrolysis)				
coke production			16%	-
electric furnace steel plant	0.7%	0.6%		
Production and use of chemicals and consumer goods				
pesticide production	3% (?)	33% (?)		
paper and pulp production	NA	NA	NA	NA
Mineral products				
cement production	-	0.5%		
lime production	-	-		
Waste incineration				
incineration of domestic / municipal waste	30%	6%		
incineration of industrial waste	-	-	1%	6%
incineration of sludge from wastewater treatment	NA	NA	NA	NA
incineration of hospital waste	2%	0.3%		
Disposal / landfill				
improper waste oil disposal			13%	7%
disposal of municipal solid waste to landfill	54%	27%	3%	1%
wastewater treatment in residential / Commercial sector			67%	86%
sewage sludge spreading in agriculture	0.5%	0.2%		
compost production from waste	0.1%	-		
Agricultural activities				
pesticide uses	2%	4%		
Uncontrolled combustion processes				
accidental fires	NA	NA		
bonfires and other incidental fires	NA	NA		

NA: not available or not enough data available

[grey box]: not relevant

The presented contributions of activities have to be taken with precaution. Percentages could be different if uncertainty of emission factors were more limited and if missing activity rates were available. Thus, the quantity of sewage sludge from wastewater treatment incinerated is only known for one country: Poland. Pulp and paper production could also be a significant source of dioxin release to water but no activity rate could be collected.

According to this estimation, it is not possible to point out a link between emissions and levels of contamination of surface waters or ground waters. First of all, because in this report, we have no indication about the sources of emission (point sources), and also because levels of uncertainty are too high.

3.4.2 Recommendations

According to this study and its comparison with "old member states", it becomes evident that there is a certain similarity in all the European countries. The same major sources of release to land and to water have been identified: incineration of municipal solid waste, disposal of municipal solid waste to landfill.
Combustion of coal for domestic use seems to be a particularity of the 13 "candidate countries". Impact of accidental fires have nit been estimated in this area because of lack of data but could be important.

It would be interesting to improve the quality of emission factors to water and land by measurement campaigns on identified point sources of dioxins to water and land, especially for activity sectors which have a high potential of release such as wastewater treatment, incineration of domestic waste, disposal of municipal solid waste in landfill and pesticide production. It could be also essential to obtain activity data in all the potential sources of release. For example, paper and pulp production present a high potential of release but could not have been estimated because of lack of data. The same for accidental fires and bonfires and other incidental fires for which we did not succeed to estimate the release when they could represent an important release. Thus, accidental fires present an emission factor to land between 40 and 190000 µg I-TEQ / Tonne which is quite significant.

According to release to land, it could be important to have a precise idea of the fate of residues in each of the studied countries. We chose to take into account the worst situation which is not representative of the reality in all the cases. Such precision could be useful to clarify the level of release to land and the potential of contamination of ground waters.

On the other hand, it is not possible to analyse or suggest any effects by intake of these waters by human or animals. Further research could be pertinent in order to assess the relevance of this potential way of human and animal contamination.

Direct human contamination through drinking water is not known. Levels of dioxin in water seem to be too low to have a direct impact but this could be demonstrated. But accumulation through food chain is the subject of researches and news that have clearly point out this way of contamination (contamination through milk or chickens) even if it is difficult to separate the ways of contamination between air and water.

Further researches in this areas could be relevant in order to improve this inventory and precise the best ways to decrease the release to land and water.

4. Conclusions

The project described in this report succeeded in

1) Developing a close co-operation with national experts in the ten “New” EU Member States and the three Candidate Countries. This has resulted in a better understanding of and experience with the compilation of dioxin emission inventories and dioxin measurements.
2) The air emission inventory for these countries shows that there is probably not a larger problem with dioxins than the ones in the “Old” EU Member States. The per capita emissions in all these countries are in the same order of magnitude.
   However, due to the increasing economic activity in the countries, emissions might increase significantly in the coming decades. Implementation of the provisions of the Waste Incineration Directive and the Integrated Pollution Prevention and Control (IPPC) Directive will decrease the emissions by about a factor of two.
3) This project is the first one presenting an inventory of emissions of dioxins to water and land. Whether or not these emissions contribute to environmental and/or health risks is not known.

Although a high uncertainty exists in both the emission inventories for air, land and water, the main conclusion of this study is that there are no reasons to expect that the situation in the new Member States deviates significantly from the one in the “old” EU 15 Member States. No specific legislation therefore seems to be needed for the New Member States.

There are however a few points of concern:

– Due to the expected economic development of the new Member States, emissions from industry and larger facilities could increase, unless implementation of Best Available Technologies (BAT) is achieved. Both the EU Waste Incineration Directive and the IPPC Directive could support this implementation.
– Wood and coal are still used to a considerable extent in residential heating by small stoves and domestic waste might be burned without any controls in back yards. These practices can give rise to locally high emissions. However, uncontrolled waste burning should be abandoned by introducing well managed waste collection and waste handling systems in the countries. Residential heating by wood and coal causes a number of other air pollution problems (particulates). The emissions of dioxins from this combustion adds to the need to decrease wood and coal combustion in small residential stoves.

5. Authentication

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Date upon which, or period in which, the research took place:
-

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Part A Emissions to Air (TNO and SHMU)

Dioxin emissions in Candidate Countries

Part A; Emissions to air

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Summary

This report presents part of the results of then project “Dioxin Emissions in Candidate Countries”, as commissioned by the European Commission to a consortium lead by TNO.

The emissions have been estimated, using a method that is consistent for all countries in this study and the earlier EU Dioxin Inventory for the 15 “Old” EU Member States. The project has applied a conservative approach: whereever detailed information was not available, the method chosen ensures a relatively high emission estimate. The resulting emission inventory therefore should be considered as a relatively high estimate.

The national inventories in this study has been discussed with national experts from each of the thirteen countries and all information obtained in this process has been included. Where national information was made available the estimate is no longer “conservative” but should be regarded as the best estimate, taking into account available national knowledge and data.

It is shown that the emissions to air in the thirteen countries in this study (the 10 “New” EU Member States (Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovak Republic, Slovenia) and the three EU Candidate Countries (Bulgaria, Romania, Turkey)) probably are comparable to those in the 15 “Old” EU Member States. This conclusion however is rather dependent on the assumption of the emission factors in waste incineration. An uncertainty analysis in the report shows that, if these assumptions are not correct, the emissions might be a factor of 4 to 5 higher.

The study also presents a first estimate of past and future dioxin emissions in these countries. It shows that future emissions could increase unless better technologies than the ones used now are implemented in the countries. If these better technologies in all countries are comparable with the best ones already implemented in some of these, the emissions could decrease in the next few decades. Since waste incineration is the major contributing sector in all countries, implementing improved technologies in these processes could greatly improve the situation. In other words: implementing the EU Waste Incineration Directive and the IPPC Directive in these countries is a crucial step in minimizing the dioxin emissions and contamination in these countries

Given the rather high uncertainties in emission factors, caused by both

1) extrapolation of the highly variable instantaneous emission factors as measured towards annual total mass flows
2) limited availability of emission factors for specific process conditions

the emission inventory as derived in this project will be as good as can be achieved within a relatively limited budget. The uncertainties in emission factors outweigh those in activity data. So improving the inventory is only possible if much better emission factors or direct continuous emission measurements would be available. This would be a very expensive exercise.

About one third of the emissions of dioxins to air are due to non-industrial (area) sources, where low level emission occurs in large numbers of small equipment (stoves, cars, open waste burning). These emissions obviously occur in the direct neighbourhood where people live and hence will give rise to concentrations of dioxins in the direct surroundings of where people live. Industrial sources on the other hand tend to be larger sources with higher stacks. Depositions from these sources will be spread out over larger areas than for the small sources. The emission of each individual source however will be higher. The small, low sources might give rise to hotspots in densely populated areas, whereas the highest concentrations, caused by the larger elevated sources might occur at several kilometres from the stack.

The effects of these different dispersion behaviour of smaller - lower on the one hand and larger - higher sources on the other, is difficult to estimate in general terms. Detailed location information of all sources in a region is needed to run air pollution dispersion models to calculate dioxin concentrations in the air. Since however most industrial sources are located in the same areas (on a spatial scale of several kilometres) where people live, we do not expect that the geographic emission and concentration patterns are very different for both type of sources. The same is more or less to be expected in the fifteen EU Member States. So, given the high uncertainties in emissions, we do not expect the concentration levels in the thirteen countries to differ significantly from those in the “old” 15 EU Member States. More geographical information is needed to run air quality and effect models to investigate this issue.

On the basis of these results we conclude that there is no reason to assume that the concentrations of dioxins in the air in the thirteen countries are significantly higher than in the 15 “Old” EU Member States. This however does not exclude possible “hot spots”, where relatively high concentrations could occur, due to for instance uncontrolled burning of chlorine containing wastes.

The implementation of the EU Waste Incineration Directive and the IPPC Directive in the thirteen countries will bring the emissions of dioxins down to a level that is comparable or even below the level in the “old” EU Member States. The major cause of uncertainties in our estimate is the emission factors for waste incineration. This uncertainty will also be decreased considerable if the requirements of this directive will be implemented. Since this might take some time, it might be worthwhile to perform air quality modelling studies for some areas within the thirteen countries. The

preliminary geographical distribution, shown in Figure 3, suggests that such a study could be best performed for the so-called Back Triangle (Poland, Czech Republic, Slovak Republic border area) and for the surroundings of Istanbul.

1 Introduction

As part of a project, performed for DG Environment, called “Dioxin Emissions in Candidate Countries”, an inventory of emissions to air in the 13 countries in central and Eastern Europe was compiled. These 13 countries are:

3) Bulgaria
4) Cyprus
5) Czech Republic
6) Estonia
7) Hungary
8) Latvia
9) Lithuania
10) Malta
11) Poland
12) Romania
13) Slovak Republic
14) Slovenia
15) Turkey

When the project was commissioned, these countries were referred to as EU candidate member countries. Since June 2004, 10 of these countries are full members of the EU. Bulgaria, Romania and Turkey now are still candidate members.

This report presents the results of the air emissions inventory compilation:

1) Chapter 2 presents the methods and procedures used;
2) Chapter 3 presents the results;
3) Chapter 4 estimates past and possible future levels of dioxin emissions in these countries; and
4) Chapter 5 presents a discussion and conclusions.

Detailed data and documentation are presented in Annexes to this report.

2 Methods

2.1 Procedure

The compilation of the dioxin emission inventory for the 13 countries in this study was a stepwise approach, aimed at making optimal use of both available expertise at the partners in the consortium and the knowledge and expertise in the countries.

A first draft release of a Candidate Countries dioxin emission inventory has been compiled and presented at a first workshop (Bratislava, March 10, 2003) to the national experts from the participating countries. The main purpose of this first draft inventory was to discuss the structure of the inventory in terms of sector definitions and data sources. The resulting emission estimates in this draft inventory were very preliminary and quite rough. The discussions at the workshop resulted in acceptance of the database structure and the mutual understanding between the partners in the consortium and the country experts on the availability, the possibilities and limitations of several data sets to be used.

The comments and information obtained from the countries at the workshop and afterwards have been incorporated into a second version of the inventory. This inventory was described in the project's Interim Report and was presented at the second workshop (again Bratislava, February 2 and 3, 2004). The discussions at the second workshop were more oriented towards the activity data, the emission factors and the resulting emission estimates and again comments, additions and corrections were received from the participating countries.

The dioxin air emissions inventory as presented in this report is the result of this procedure and contains an estimate of these emissions that is consistent between countries, based on data that have been checked by countries as far as possible and therefore might be regarded as the best estimate at this moment in time.

2.2 Methods

2.2.1 Algorithm

The method applied in compiling the air emission inventory for dioxins in the thirteen countries of this study, is the one generally applied in almost all emission inventories. For each relevant sector and fuel, the emission is

calculated by multiplying an activity rate with an appropriate emission factor:

EQUATION 1

$$Emissions_{sector,fuel} = Activity_{sector,fuel} \times Emission\,Factor_{sector,fuel}$$

Please note that only combustion processes will use the specification of “fuel”. For non combustion processes, this equation could read:

EQUATION 2

$$Emissions_{sector} = Activity_{sector} \times Emission\,Factor_{sector}$$

When we however introduce an entry “no fuel used” in the list of fuels, we still can apply Equation 1.

The total inventory then is simply the sum of these sectoral emissions for all sectors and fuels.

EQUATION 3

$$Emissions = \sum_{sectors,fuels} Emissions_{sectors,fuel}$$

In compiling the emission inventory for a country, for each relevant sector and fuel activity data and appropriate emission factors must be collected. The total emission inventory database therefore will be a collection of activity data and emission factors for each country.

2.2.2 Database structure

2.2.2.1 Sector definitions

Emission inventories in most countries now are compiled using a set of sector definitions that has been developed under the work of IPCC to be applied in emission inventories for the Climate Change convention (UNFCCC). Recently, the Convention on Long Range Transboundary Air Pollution (LRTAP) has also adopted a set of sector definitions that is fully consistent with these IPCC sector definitions [5] The IPCC set now is known as “CRF” sectors, whereas the LRTAP set is known as “NFR”

At the first workshop within this project, we proposed to also use these sector definitions in this project. This proposal has been accepted by the countries. In Table 1 all relevant CRF/NFR sectors are presented.

Table 1 Relevant CRF / NFR sector definitions in the dioxin emission inventory. Please note that all sector codes starting with "1.A"refer to combustion processes. The numbers indicate the number of activity / fuel combinations for each country.

CRF/NFR Code	Crf/nfr description	Total number of emissions	BGR	CYP	CZE	EST	HUN	LTU	LVA	MLT	POL	ROM	SVK	SVN	TUR
1.A.1.a	Public electricity and heat production	56	6	2	5	4	5	3	3	2	5	6	5	5	5
1.A.2.b	Non-ferrous metals	1									1				
1.A.2.d	Pulp, paper and print	5	1			1	1				1	1			
1.A.2.f	Other (please specify in a covering note)	10	1			1	2	1	1		1	1	1	1	
1.A.3.b	Road transport	1		1											
1.A.4.b.i	Residential plants	63	6	2	6	5	6	4	5	1	4	8	5	6	5
1.B.1.b	Solid fuel transformation	8	1		1	1	1				1	1	1		1
2.A.1	Cement production	12	1	1	1	1	1	1	1		1	1	1	1	1
2.A.2	Lime production	13	1	1	1	1	1	1	1	1	1	1	1	1	1
2.A.6	Road paving with asphalt	1					1								
2.A.7	Other including non fuel mining & construction (please specify in a covering note)	3					3								
2.B	Chemical industry	1													1
2.B.5	Other (please specify in a covering note)	1					1								
2.C.1	Iron and steel production	1			1										
2.C.1.1	Steel	2					1				1				
2.C.1.2	Pig iron	3			1		1				1				
2.C.1.3	Sinter	8	1		1		1				1	1	1	1	1
2.C.2	Ferroalloys production	1			1										
2.C.3	Aluminium production	6			1		1				1	1	1		1
2.C.5	Other (please specify)	20	3		2		2				4	2	3	1	3
2.D.1	Pulp and paper	2					1								1
3.D	Other including products containing hms and pops (please specify in a covering note)	26	2	2	2	2	2	2	2	2	2	2	2	2	2
6.C	Waste incineration	67	5	4	6	4	6	6	5	4	7	6	5	5	4

The table shows that for most countries, combustion processes are the most frequent sources of dioxin emissions. A second important source is the waste incineration.

It should be noted here, that within each sector different subsectors could occur, and in our inventory indeed do occur. These subsectors are defined where-ever data or information from countries makes this necessary. Table 2 presents an overview of these.

Table 2 Detailed sector definitions, within the CRF/NFR definitions of Table 1

CRF/NFR Code	CRF/NFR Description	Description	Count Of Emission
1.A.1.a	public electricity and heat production	Auto-producer electricity, heat and CHP plants, and public heat plants	12
		Public power plants	44
1.A.2.b	non-ferrous metals	Combustion in non-ferous metal	1
1.A.2.d	pulp, paper and print	Industrial combustion in the paper and pulp industry	5
1.A.2.f	other (please specify in a covering note)	Industrial combustion in other industrial sectors	10
1.A.3.b	road transport	4-stroke engines, leaded fuel	1
1.A.4.b.i	residential plants	Residential heating in small stoves or centralized heating systems	60
		Residential, commercial, institutional and other combustion	3
1.B.1.b	solid fuel transformation	Solid fuel transformation | Coke production	8
2.A.1	cement production	Cement kilns	12
2.A.2	lime production	Lime production	13
2.A.6	road paving with asphalt	Asphalt mixing	1
2.A.7	other including non fuel mining & construction (please specify in a covering note)	Brick and tile production	1
		Ceramics	1
		Glass production	1
2.B	chemical industry	Chemical industry PVC	1
2.B.5	other (please specify in a covering note)	Production of EDC	1
2.C.1	iron and steel production	Steel production | Clean scrap	1
2.C.1.1	steel	Iron and steel plants (steel)	2
2.C.1.2	pig iron	Iron and steel plants (pig iron)	3
2.C.1.3	sinter	Iron ore sintering	8
2.C.2	ferroalloys production	Foundries	1
2.C.3	aluminium production	(Secondary) aluminium production	6
2.C.5	other (please specify)	Brass and bronze production	1
		Primary copper	3

CRF/NFR Code	CRF/NFR Description	Description	Count Of Emission
		Secondary copper	7
		Secondary lead production	3
		Secondary zinc	6
2.D.1	pulp and paper	Pulp and paper industry Kraft process	1
		Pulp and paper mills	1
3.D	other including products containing hms and pops (please specify in a covering note)	Fires	13
		Preservation of wood	13
6.C	waste incineration	Hazardous waste incineration	3
		Incineration of hospital waste	13
		Industrial waste	6
		Landfill fires	1
		Municipal / industrial waste incineration (legal)	4
		Open burning of agricultural wastes	26
		Open burning of domestic wastes	13
		Open burning of wood	1

2.2.2.2 Fuel definitions

Fuels as used in this project are the same ones as defined in other inventory projects and are derived from fuel definitions as used by the International Energy Agency (IEA). Table 3 presents an overview of all fuels that are relevant for this dioxin emission inventory.

Table 3 Relevant fuel definitions in the dioxin emission inventory. Please note that "no" stands for non combustion processes. The numbers indicate the number of emission data for each country.

CRF/NFR Code	CRF/NFR Description	Total number of emissions	BGR	CYP	CZE	EST	HUN	LTU	LVA	MLT	POL	ROM	SVK	SVN	TUR
no	-	176	14	8	18	9	22	10	9	7	22	15	15	11	16
BLO	Black liquor and other bio wastes	25	3	1	1	3	2	2	2	0	3	3	2	2	1
BRC	Brown coal	20	2	0	2	2	3	1	1	0	1	2	2	2	2
DIE	Gas/Diesel Oil	8	1	0	1	1	1	1	1	0	0	1	0	1	
HDC	Hard Coal	13	2	0	1	1	0	0	1	1	1	2	2		2
CCK	Hard coal coke, brown coal coke and petroleum c	11	1	0	2	0	2	0	0	0	1	2	1	2	
HFO	Heavy Fuel Oil	24	2	1	2	2	3	1	2	1	2	2	2	2	2
MOG	Motor Gasoline	1	0	1	0	0	0	0	0	0	0	0	0	0	0
NGS	Natural Gas	11	1	0	1	1	1	1	1	0	1	1	1	1	1
FOW	Solid and liquid waste fuels, waste tires, slud	3	0	0	0	0	0	1	0	0	1	1	0	0	0
SBC	Sub-Bituminous Coal	6	1	1	0	0	1	0	0	0	0	1		1	1
FWW	Wood and wood waste	13	1	1	1	1	1	1	1	1	1	1	1	1	1
Total		**311**	**28**	**13**	**29**	**20**	**36**	**18**	**18**	**10**	**33**	**31**	**2**	**7**	**5**

The table shows that non combustion processes are quite frequent, whereas in combustion the solid and heavy liquid fuels are the most important ones.

2.2.2.3 Technologies

To calculate the emissions for each of the activities in the sectors as defined above, emission factors are needed. These emission factors depend on the technology that is applied to perform the activity. Any activity could in principle be performed with different technologies in different countries, or even with different technologies within one country. This is also reflected in available emission factors like the UNEP Chemicals Toolkit [3]

2.2.2.4 Over all database structure

To accommodate the method as described above, a relational database structure was developed for this project to store all relevant data. This structure is given in Figure 1:

1) Activity data are stored in a table "AR", with reference to a country, a subsector of the CRF/NFR sector definitions and a fuel.
2) Emission factors are stored as an additional property of a table of "Technologies". Each technology in this table can be applied for several activity and fuel combinations and different technologies could be available to choose between for each activity and fuel combination..
3) A table "Select Technologies" connects at least one specific technology to each activity rate in every country. If more than one technology is used, the fraction of the activity connected to each technology can be entered in a special field.

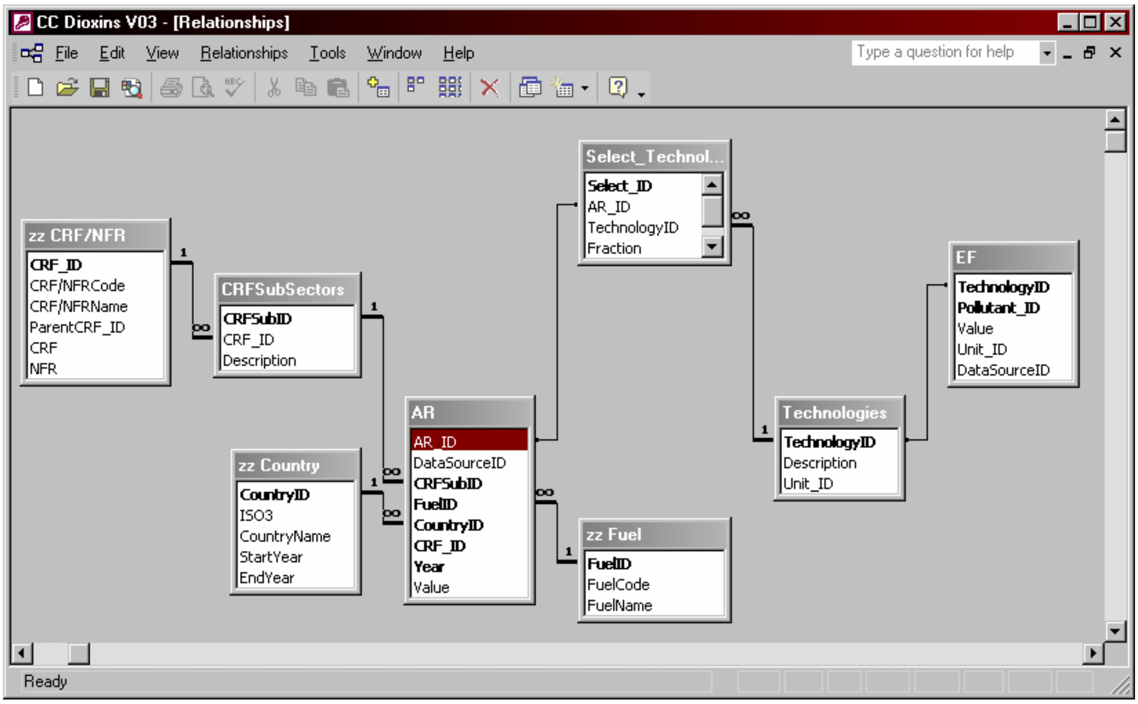

Figure 1 Database structure for the participating country Dioxin Air Emission Inventory

This structure allows for application of different emission factors in different countries, related to the technologies applied. The table of technologies is build on top of the table of emission sources as defined in the UNEP Chemicals Toolkit. Each of the air emission factors provided in the Toolkit is interpreted as one technology that could be applied in one or more sectors.

2.2.3 Activity data

Activity data for the inventory were obtained from a series of data sources as presented in Table 4:

1) The activity data used in the CEPMEIP-project to estimate particulate matter emissions in Europe [1], [2]. These data are derived from international statistics from IEA and other international organisations. For each relevant fuel combustion process, the IEA data set provides the amount of fuel combusted, both in mass terms and in energy terms. Attribution of the fuel combustion to source sectors is based on the sector descriptions (“flows”) in the IEA dataset.
2) Corrections, additions and updates of these data obtained from the national experts participating in the project; the corrections were used to overwrite the CEPMEIP interpretation of the IEA dataset.
3) Additional data provided to IOW while collecting the water and land emissions inventory; these data were complimentary to the CEPMEIP and national data.
4) TNO’s estimate, based on a proxy approach. As a proxy population sizes and data for some countries as available in the European Dioxin Emission Inventory ([1], [2]) were used. Where this approach was used an averaged per capita emission factor was derived from the EU inventory and applied to the thirteen countries in this study:
   a) Preservation of wood: an emission factor of 1 µg I-TEQ per inhabitant was assumed
   b) Fires: an emission factor of 1 µg I-TEQ per inhabitant was assumed
   c) Domestic waste burning: we assumed 10 kg of waste / inhabitant per year;
   d) Incineration of hospital waste: 1.5 kg / inhabitant per year, based on an averaged value of 1.7 kg / inhabitant [per year for the EU15 countries; in the EU15 countries this value variaes over a factor of 4 between countries
5) EUROSTAT data as published on the web site of the European Environment Agency (EEA, [6])

Table 4 Data sources for the activity data as used in the inventory.

Country Name	CEPMEIP activity data	Data from Candidate Country	Data obtained by IOW	Estimated by TNO on basis of population sizes	EUROSTAT data obtained from EEA web site	Grand Total
Bulgaria	21		3	1	2	**27**
Cyprus	3	8				**11**
Czech Republic	9	16	1		2	**28**
Estonia	15	1	1		2	**19**
Hungary	7	23		1	2	**33**
Latvia	13		1	1	2	**17**
Lithuania	6	7	1	1	2	**17**
Malta	6			1	2	**9**
Poland	14	10	4	1	2	**31**
Romania	7	15	2		2	**26**
Slovak Republic	19	2	2		2	**25**
Slovenia	17		2	1	2	**22**
Turkey	15	5	2	1	2	**25**
Grand Total	**152**	**87**	**19**	**8**	**24**	**290**

The number of data for each country will differ, depending on whether or not certain activities occur in the country. As can be seen from the table some countries provided quite a number of updates, whereas others were only able to provide a small number of data.

2.2.4 Emission factors

2.2.4.1 Data sources

Table 5 presents the data sources for emission factors, used in this study. The majority of emission factors is derived from the UNEP Chemicals Toolkit [3]. For two sectors emission factors from the European Dioxin emission inventory ([1], [2]) have been used. A number of countries has provided country specific emission factors.

Table 5 Data sources for emission factors used in this study

Country Name	Data from Candidate Country	Personal communication Ulrich Quass	The European Dioxin Inventory	UN Chemicals Dioxins Toolkit	Grand Total
Bulgaria		1	2	24	**27**
Cyprus			2	9	**11**
Czech Republic	10	1	2	15	**28**
Estonia	1		2	16	**19**
Hungary	13		2	18	**33**
Latvia			2	15	**17**
Lithuania			2	15	**17**
Malta			2	7	**9**
Poland	12	1	2	16	**31**
Romania		1	2	23	**26**
Slovak Republic	2	1	2	20	**25**
Slovenia			2	20	**22**
Turkey	2		2	21	**25**
Grand Total	**40**	**5**	**26**	**219**	**290**

2.2.4.2 Technology selection

Since the emission factors depend on the technology applied in each country (comparable to the column "description" in Table 8), the selection of technologies is a crucial step in the inventory.

In the inventory we used emission factors according to the following approach:

1) If an emission factor given by a participating country differs less than a factor 3 from the corresponding Toolkit factor we used the Toolkit factor (in the assumption that less than a factor 3 difference is not relevant because differences between succeeding Toolkit factor usually are about a factor of 10).
2) If an emission factor given by a participating country differs more than a factor 3 from the corresponding Toolkit factor we used the participating country factor for that country.
3) For all activities, where the UN Chemicals Toolkit provides more than one emission factor, we selected the highest one, unless the country indicated that some kind of abatement technology was installed. In such cases a lower emission factor technology from the Toolkit was selected.
4) For waste incineration (Category 1 in the UNEP Chemicals Toolkit) the highest but one emission factor was selected, unless better information

was available. The highest emission factors here are applicable for fully uncontrolled incineration in open fires and were assumed to be too high for the countries in this study. For municipal solid waste incineration the highest but one emission factor is comparable to the one for uncontrolled waste burning of category 6 of the Toolkit. Comparable emissions factors for these types of incinerations seems to be sensible.
This assumption however is very crucial for the inventory, since selecting the highest emission factors would result in dioxin emissions that are about a factor of five to ten higher in all countries, resulting in considerably higher total emissions (see also section 3.2.2.1)

5) For wood waste and waste biomass incineration, we assumed that 5 % of the product is containing chlorine and therefore only this 5 % gives rise to dioxin emissions.

Table 6 presents an overview of the number of entries, where country provided data were used, where country provided data did not differ significantly (less than a factor of three) from Toolkit emission factors and where TNO made the selection as described above.

Table 6 Data source of technology selection

Country Name	**Data from Candidate Country**	**Toolkit factor selected by TNO**	**Toolkit factor, confirmed by or consistent with participating country Data**	**Grand Total**
Bulgaria	1	26		**27**
Cyprus		9	2	**11**
Czech Republic	7	11	10	**28**
Estonia	1	16	2	**19**
Hungary	15	10	8	**33**
Latvia		17		**17**
Lithuania		7	10	**17**
Malta		9		**9**
Poland	13	15	3	**31**
Romania	1	25		**26**
Slovak Republic	3	22		**25**
Slovenia		22		**22**
Turkey	2	23		**25**
Grand Total	**43**	**212**	**35**	**290**

2.2.4.3 Comparison of given participating country emission factors and TNO selected emission factors

As has been stated in section 2.2.4.2 for all activities, where the UNEP Chemicals Toolkit provides more than one emission factor (EF), we selected the highest one for the first inventory. Only for waste incineration the highest but one was selected. The result of this inventory per participating country has been send to the representative of the specific country for comment. Some participating countries did return the inventory with corrections in the TNO selected emission factors, based on measurement information available in the specific participating country.

In Table 7 the emission factors from the participating countries that have been used in the final inventory are compared with those selected by TNO if no additional information from the participating countries was available. In the table the range and the geometric mean of the emission factors from the participating countries is given. The use of the geometric mean is based on the fact that the emission factors in the Toolkit for different subsequent technologies per activity differ by a factor (in most cases about a factor 10).

From this table the following can be seen:

1) For Waste incineration TNO selected the second highest emission factors from the Toolkit and the geometric mean of the emission factors given by the participating countries fit best with the third highest from the Toolkit.
2) For Power generation and heating TNO selected the corresponding emission factors from the Toolkit (there is only one corresponding emission factor in the Toolkit) and the geometric mean of the emission factors given by the participating countries are a factor of 2 to 100 (one case only) higher than the corresponding ones from the Toolkit.
3) For Metal Production and Production of mineral products (cement and lime) TNO selected the highest emission factors from the Toolkit and the geometric mean of the emission factors given by the participating countries fit best with the second highest from the Toolkit that are a factor of 10 lower than the highest emission factors from the Toolkit.

From this it can be concluded that in the mean the TNO selected emission factors do not differ more than a factor 10 which is more or less equivalent with one class higher or lower factor in the UNEP Chemicals Toolkit.

Table 7 TNO selected emission factors in relation to emission factors given by participating countries and emission factors in BREF documents

	EFs from participating countries		**Ranking of mean emission factors from participating countries in relation to Toolkit**			**TNO selected emission factors**	**EF in BREF**
Plant type description	**range**	**geometric mean (number of emission factors)**	**highest*)**	**second highest**	**third highest**	**[µg TEQ/Mg]**	**[µg TEQ/Mg]**
Waste incineration							[µg TEQ/Mg]
Hazardous waste	0.75 - 90	10 (2)			10	- -	< 0,5
Hospital/medical waste	5 - 14000	200 (5)			525	3000	< 0,5
Municipal/industrial waste	0.5 - 3500	25 (4)			30	350	< 0,5
Power generation and heating							[µg TEQ/TJ]
Public power plants (solid fuels)	2.4 - 150	25 (4)	10 /			10	< 0,5
Public power plants (liquid fuels)	2.5 - 25	5 (3)	2.5 /			2.5	- -
Industrial combustion (solid fuels)	90 -15000	1000 (2)	10 /			10	- -
Industrial combustion (liquid fuels)	38283	15 (2)	2.5 /			2.5	- -
Residential heating (coal)	70 -770	300 (5)	70 /			70	- -
Residential heating (wood)	100 - 360	250 (3)	100 /			100	- -
Metal production							[µg TEQ/Mg]
Steel production	38027	3 (5)		3		- -	< 0,1
Iron ore sintering	1.5 - 20	5 (2)		5		20	< 0,5
Secondary aluminium	35 - 150	100 (3)		35		350	< 10
Secondary copper	50	50 (2)		50		800	< 10
Secondary zinc	150	150 (5)		100		1000	< 10
Production of mineral products							[µg TEQ/Mg]
Cement kilns	0.07 - 0.6	0.4 (5)		0.6		5	< 0,2
Lime production	0.07 - 10	0.5 (5)		0.07		10	< 0,2
*) In column Ranking "x/" means that there is no lower emission factor in the UNEP Chemicals Toolkit							

2.2.4.4 Emission factors for residential combustion of wood and coal in small stoves

Not too many measurements are available for the emission factors of combustion of coal and wood in small residential stoves. The UNEP Chemicals toolkit provides values in the range of 70 to 100 µg TEQ/TJ. Countries provided values in the range of 70 to 700 µg TEQ/TJ and at the workshops even higher values have been mentioned.

A recent paper[1] provides a range of values between 23 and 4500 µg I-TEQ/TJ, with a arithmetic mean of 75 and a geometric mean of 180 µg I-TEQ/TJ, as measured from 15 individual stoves, fuelled by different types of wood, sometimes mixed with different types of coals.

In this study we use the value 100 µg TEQ/TJ for both fuels in residential combustion in small stoves.

Since at the workshops the possibility of substantial higher emission factors for these sources was discussed, we will also assess the sensitivity of the national total emissions to this parameter by using a range of 100, 350, 700 and 1000 µg TEQ/TJ for these emissions factors (section 3.2.2.2).

2.2.4.5 Reduction of emission factors resulting from implementation of BAT reference documents

In the last column of Table 7 the emission factors are given that can be derived from the BAT reference (BREF) documents from IPPC. Upon full implementation of the BAT by 2010,[2] these emission factors can be reached.

From Table 7 it follows that fully implementation of the BREF documents will result in a reduction of the emission factors for the mentioned activities by a factor of 1000 for waste incineration, a factor of 10 for solid fuel powered public power plants and a factor of 10 to 100 for industrial activities.

2.2.4.6 Comparison of emission factors obtained from measurements with UNEP Chemicals Toolkit emission factors

Table 8 presents a comparison of the emission factors, provided in the Toolkit, with those derived from the measurements within this project.

From this we observe the following:

1) Iron ore sintering:
   Measured emission factors are in conformation (differ less than a factor 10) with Toolkit factor based on the same or similar process description
2) Zinc sintering/recovery/melting:
   Measured emission factors are in conformation (differ less than a factor 10) with Toolkit factor based on same process description.

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1 C. Hübner, R.Boos and T.Prey (2005), In-field measurements of PCDD/F emissions from domestic heating appliances for solid fuels, Chemosphere 58, pp 367-372.

2 According to the IPCC Directive, all member states have to implement the provisions of IPPC by 2007. Some “New Member States” (in particular Poland) has a transition period (up to 2010) for a restricted list of particular installations.

Table 8 Comparison of emission factors obtained from measurements with UNEP Chemicals Toolkit emission factors

Plant type	**Description**	**EF measured (µg I-TEQ/Mg)**	**EF UNEP Chemicals Toolkit (µg I-TEQ/Mg)**	
			Based on description	**Total range**
Iron ore sintering	High technology, emission reduction	0.43	0.3	0.3 - 20
Iron ore sintering (2 lines)	?	2.2 - 4.3	5	0.3 - 20
Zinc oxide ore sintering	Hot briquetting/ Rotary furnaces, basic control	110	100	0.3 - 1000
Zinc recovery by rotary kiln	Hot briquetting/ Rotary furnaces, basic control	130	100	0.3 - 1000
Melting of electrolytically produced zinc	Melting (only)	0.04	0.3	0.3 - 1000
Sec. Aluminium prod.	Processing scrap, min input treatment, simple dust control	3.74	150	0.5 - 150
Sec. Aluminium prod.	Processing scrap, min input treatment, simple dust control	0.52	150	0.5 - 150
public power plant (4 boilers)	Coal fired	1.3 – 10.3	10	0.5 - 35
Public power plant	Brown coal, ESP	0.81	10	0.5 - 35
Public Power plant	Heavy fuel oil	12.1	2.5	0.5 – 35
Cement wet kiln	Electrostatic prec. (ESP) at < 200 °C	0.073	0.05	0.05 – 5
Cement dry kiln	Two stage pre-heater; bag filter	0.003	0.05	0.05 - 5
Pulp & paper industry (bark combustion)	Bark boiler only	3.78	0.4	0.07 – 0.4

3) Secondary Aluminium production:
Measured emission factors are more than a factor 100 lower than in Toolkit factor based on same process description. Measured emission factor's are in the range for well controlled optimized processes. Low measured concentration appear to be the result of sampling problems and relatively clean input materials

4) Coal fired public power plant:
Measured emission factors are in conformation (differ less than a factor 10) with Toolkit factor based on same process description.

5) Cement kilns:
For wet kiln emission factor is in conformation (differ less than a factor 10) with Toolkit factor based on same process description. For dry kiln measured emission factor is a factor 20 lower than corresponding Toolkit factor.

6) Pulp & Paper industry (Bark combustion):
Measured emission factor is just a factor 10 higher than Toolkit factor based on same process description (bark boilers only).

From this we conclude the following:

1) Most measured emission factors are consistent (differ less than a factor 10) with the Toolkit factor based on same process description.
2) For Secondary Aluminum Production the measured emission factors are more than a factor 100 lower than the Toolkit factor based on the same process description. Low measured concentrations appear to be a result of sampling problems and relatively clean input materials.
3) Results of dioxin measurements performed during this project indicate that dioxin emission factors for these processes in eastern European countries can not be shown to differ significantly from emission factors in western European countries under comparable process conditions.

3 Results

3.1 National total emissions

National total emissions in the thirteen participating countries are presented in Table 9 and Figure 1. The total emissions in these countries amount to about 3.4 kg I-TEQ. Major contributing countries are the largest ones in the group: Poland and Turkey with emissions of somewhat less than 1 kg I-TEQ per year.

Table 9 National total emissions of dioxins to air in the thirteen countries in this study. The national totals in earlier estimates are given as a comparison.

Country Name	Count of Emission	Sum of Emission	National estimate
Bulgaria	27	288.81	230
Cyprus	11	6.61	9
Czech Republic	28	319.49	205
Estonia	19	8.69	14
Hungary	33	121.87	74
Latvia	17	17.69	25
Lithuania	17	48.32	-
Malta	9	3.92	-
Poland	31	785.72	505
Romania	26	485.42	307
Slovak Republic	25	177.69	-
Slovenia	22	36.05	-
Turkey	25	964.14	-
Total	**290**	**3264.42**	**g I-TEQ**

In Figure 3 the geographical distribution of dioxin emissions in the thirteen countries, based on population densities, is presented. This map should be regarded as a preliminary estimate. The locations of individual sources are not known. The gridding has been performed assuming that the majority of activities takes place where people live at the geographical resolution applied (0.5 x 0.5 longitude latitude grid cells; typical size in this area 25 x 50 kilometres, depending on latitude).

Not surprisingly, in most countries the capital area appears to show highest emission densities. Furthermore the so-called black triangle (at the borders between Poland, Czech Republic and Slovak Republic) and the Istanbul area are the areas with high emission densities.

Comparing the national total emissions as estimated in this study with those provided by the countries based on earlier studies (where available), differences up to 50% are obtained. As we will show below, this is well within the uncertainty range for these estimates.

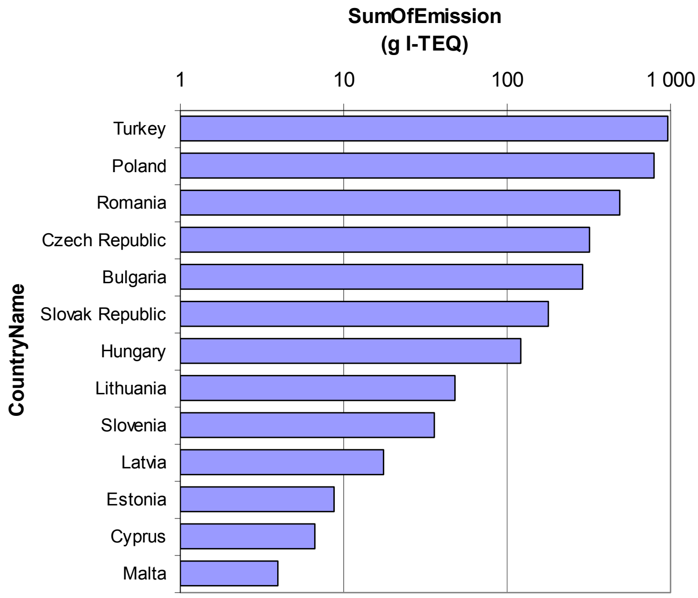

Figure 2 *National total dioxin emissions to air for the thirteen countries in this study (please note: the horizontal scale is logarithmic!).*

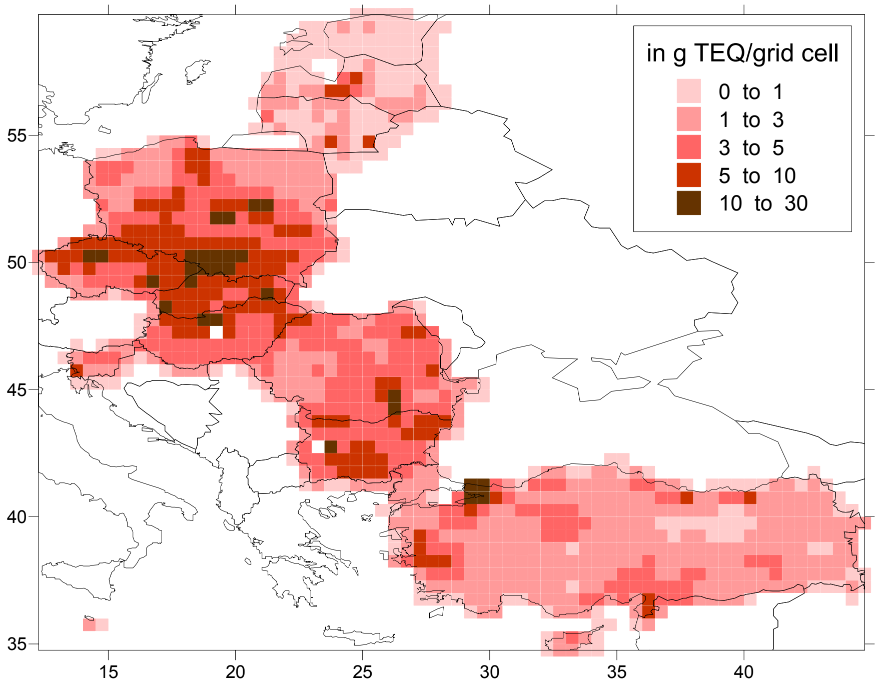

Figure 3 *Spatial resolved annual emission of dioxins in the thirteen countries*

Larger countries obviously will show higher emissions. Figure 4 compares the emissions of these countries on the basis of the population size.

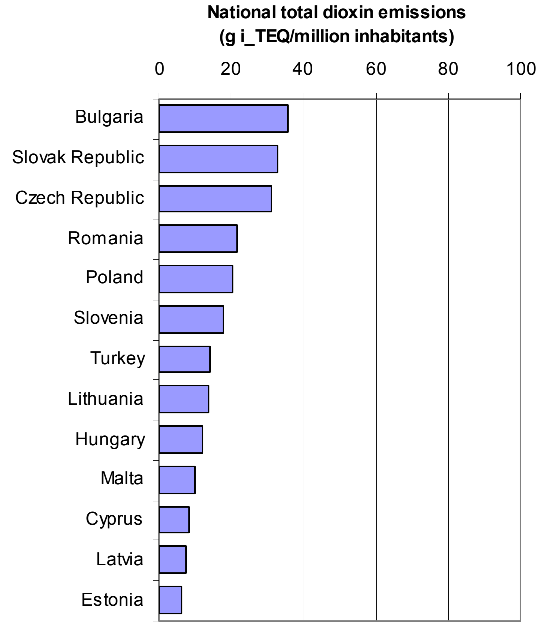

Figure 4 *Relative national total emissions of dioxins to air for the thirteen participating countries*

Emissions in the thirteen countries vary between 35 (Bulgaria) and 8 (Malta) g I-TEQ per one million inhabitants. As a comparison, Figure 5 presents the relative emissions in the Western European countries (the "old" EU 15 Member States, Norway and Switzerland). For these countries the emissions vary between 125 (Luxembourg) and 7.5 (Netherlands) g I-TEQ per one million inhabitants. The emissions in the majority of these countries are between 10 and 20 g I-TEQ per one million inhabitants.

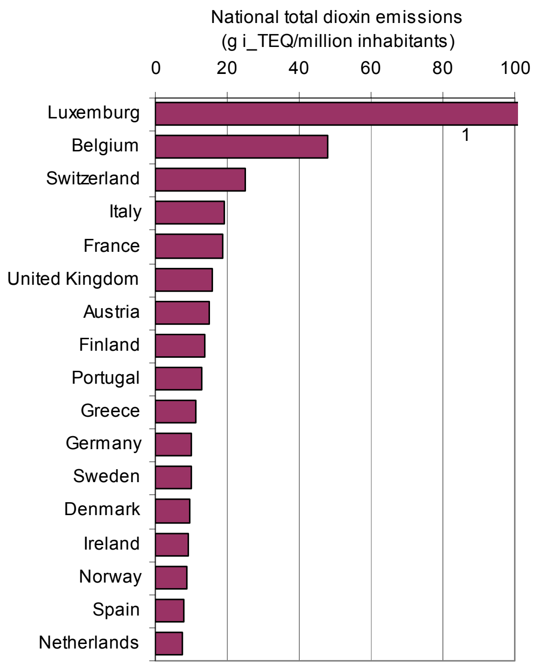

Figure 5 *Relative national total emissions of dioxins to air for the fifteen "old" EU Member States (data from the European Dioxin Inventory [1],[2])*

We conclude that on a per capita basis the dioxin emissions to air in the thirteen countries in this study are comparable to the emissions in Western European countries.

3.1.1 Sector contributions

The contributions by different sectors to the total emissions are given in Figure 6. Important sources are in the waste sector, industrial production (metals and minerals). Minor contributions are from product use and fuel combustion. Within the uncertainties of both this and the EU inventory (see section 3.2 and EU Inventory II stage [2][3]) the EU inventory shows a comparable distribution. Important sources in both inventories are waste treatment, metal production and fuel combustion activities. The low value for domestic waste burning in the EU inventory might be due to the fact that the EU inventory did not estimate open burning of wastes. It only includes "illegal combustion of domestic or municipal wastes".

[3] The EU Inventory stage 2 provides a "minimium" and a "maximum" value for each sector. In this comparison the geometric mean of these two values was used.

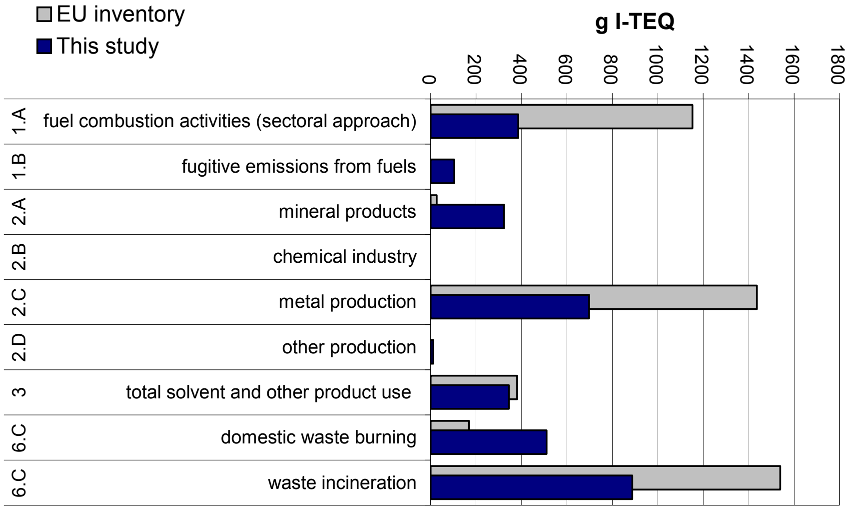

Figure 6 Sector contributions to dioxin emissions to air in the thirteen Table 10 Detailed source contributions(g I-TEQ/year) to the dioxin emissions to air in the thirteen countries in this study.

CRF/NFR Code	Sector	Description	Sum Of Emission
1.A	fuel combustion activities (sectoral approach)	Residential heating in small stoves or centralized heating systems	260.02
		Public power plants	37.98
		Residential, commercial, institutional and other combustion	35.13
		Combustion in non-ferous metal	18.00
		Auto-producer electricity, heat and CHP plants, and public heat plants	14.67
		Industrial combustion in other industrial sectors	10.29
		Industrial combustion in the paper and pulp industry	9.17
1.B	fugitive emissions from fuels	Solid fuel transformation | Coke production	103.71
2.A	mineral products	Cement kilns	252.02
		Lime production	69.60
		Ceramics	0.96
		Brick and tile production	0.84
		Asphalt mixing	0.20
		Glass production	0.08
2.B	chemical industry	Production of EDC	0.32
		Chemical industry PVC	0.02
2.C	metal production	Iron ore sintering	431.50
		(Secondary) aluminium production	81.77
		Secondary copper	64.74
		Iron and steel plants (pig iron)	62.70
		Iron and steel plants (steel)	20.00
		Steel production | Clean scrap	18.00
		Secondary zinc	14.19
		Secondary lead production	2.60
		Brass and bronze production	2.00
		Foundries	0.37
		Primary copper	0
2.D	other production	Pulp and paper industry Kraft process	10.50
		Pulp and paper mills	1.49
3	total solvent and other product use	Fires	171.91
		Preservation of wood	171.91
6.C	waste incineration	Incineration of hospital waste	527.30
		Open burning of domestic wastes	452.25
		Industrial waste	237.23
		Hazardous waste incineration	77.43
		Landfill fires	49.00
		Municipal / industrial waste incineration (legal)	45.43
		Open burning of agricultural wastes	8.88
		Open burning of wood	0.24
		Total (g I-TEQ)	**3264.45**

Table 11 Detailed sector split of dioxin emissions to air in the thirteen countries

Pollutant	dioxins and furans to air
E_Unit	g I-TEQ

Sum of Emission		CountryName													
CRF/NFR Code	Description	Bulgaria	Cyprus	Czech Republic	Estonia	Hungary	Latvia	Lithuania	Malta	Poland	Romania	Slovak Republic	Slovenia	Turkey	Grand Total
1.A.1.a	Public power plants	2.2	0.1	6.4	0.9	14.6	1.5	0.1	0.1	3.5	2.8	0.8	0.6	4.4	38.0
	Auto-producer electricity, heat and CHP plants, and public heat plants	0.7		1.4	2.0	0.1		0.8		0.7	1.4	1.6	0.1	6.0	14.7
1.A.2.b	Combustion in non-ferous metal									18.0					18.0
1.A.2.d	Industrial combustion in the paper and pulp industry	0.0			0.4	0.0				7.5	1.3				9.2
1.A.2.f	Industrial combustion in other industrial sectors	0.1			0.2	2.8		0.1		2.6	3.2	0.0	1.3		10.3
1.A.4.b.i	Residential, commercial, institutional and other combustion							0.3		33.0	1.8				35.1
	Residential heating in small stoves or centralized heating systems	4.0	0.1	21.1	1.5	16.0	3.1	2.1	0.1	175.1	7.4	2.8	1.2	25.5	260.0
1.B.1.b	Solid fuel transformation | Coke production	37.2		0.8	0.1	2.0				34.5	14.1	5.7		9.3	103.7
2.A.1	Cement kilns	10.5	0.8	24.0	0.2	2.1	0.1	0.4		1.0	28.5	14.5	5.0	165.0	252.0
2.A.2	Lime production	8.0	0.0	12.0	0.0	0.0	0.1	0.9	0.1	12.0	18.0	8.0	1.5	9.0	69.6
2.A.6	Asphalt mixing					0.2									0.2
2.A.7	Brick and tile production					0.8									0.8
	Ceramics					1.0									1.0
	Glass production					0.1									0.1
2.B	Chemical industry PVC													0.0	0.0
2.B.5	Production of EDC					0.3									0.3
2.C.1	Steel production | Clean scrap			18.0											18.0
2.C.1.1	Iron and steel plants (steel)					6.0				14.0					20.0
2.C.1.2	Iron and steel plants (pig iron)			47.0		2.7				13.0					62.7
2.C.1.3	Iron ore sintering	50.0		130.0		2.5				12.0	80.0	66.0	5.0	86.0	431.5
2.C.2	Foundries		0.0	0.4											0.4
2.C.3	(Secondary) aluminium production		0.0	1.2		12.3				43.1	0.2	0.5		24.5	81.8
2.C.5	Primary copper									0.0		0.0		0.0	0.0
	Secondary copper	4.0		0.6		1.5				23.2	14.4	13.6		7.4	64.7
	Secondary lead production	0.8								1.2			0.6		2.6
	Secondary zinc	0.8		0.2						2.0	0.1	0.2		11.0	14.2
	Brass and bronze production					2.0									2.0
2.D.1	Pulp and paper industry Kraft process													10.5	10.5
	Pulp and paper mills					1.5									1.5
3.D	Fires	8.1	0.7	10.0	1.4	10.0	2.4	3.5	0.4	39.0	22.0	5.4	2.0	67.0	171.9
	Preservation of wood	8.1	0.7	10.0	1.4	10.0	2.4	3.5	0.4	39.0	22.0	5.4	2.0	67.0	171.9
6.C	Hazardous waste incineration			3.9		0.1				73.5					77.4
	Incineration of hospital waste	36.5	1.5	0.2	0.0	0.1	0.6	15.8	1.8	26.3	99.0	6.6	9.0	330.0	527.3
	Industrial waste	93.1						9.5		45.5	87.5		1.7		237.2
	Municipal / industrial waste incineration (legal)			0.2		0.4					15.4	29.5			45.4
	Open burning of agricultural wastes	0.4	0.1	2.3	0.2	2.9	0.3	0.7	0.0	0.3	0.3	1.1	0.1	0.4	8.9
	Open burning of domestic wastes	24.3	2.6	30.0	0.3	30.0	7.2	10.5	1.2	117.0	66.0	16.2	6.0	141.0	452.3
	Open burning of wood							0.2							0.2
	Landfill fires									49.0					49.0
Grand Total		288.8	6.6	319.5	8.7	121.9	17.7	48.3	3.9	785.7	485.4	177.7	36.1	964.1	3 264.4

A more detailed overview is given in Table 10. This table shows that several waste incineration processes contribute to the emissions. In the metal production iron ore sintering is the major source. In minerals production,

cement industry is the main contributor. Table 11 presents the same information at the level of individual countries.

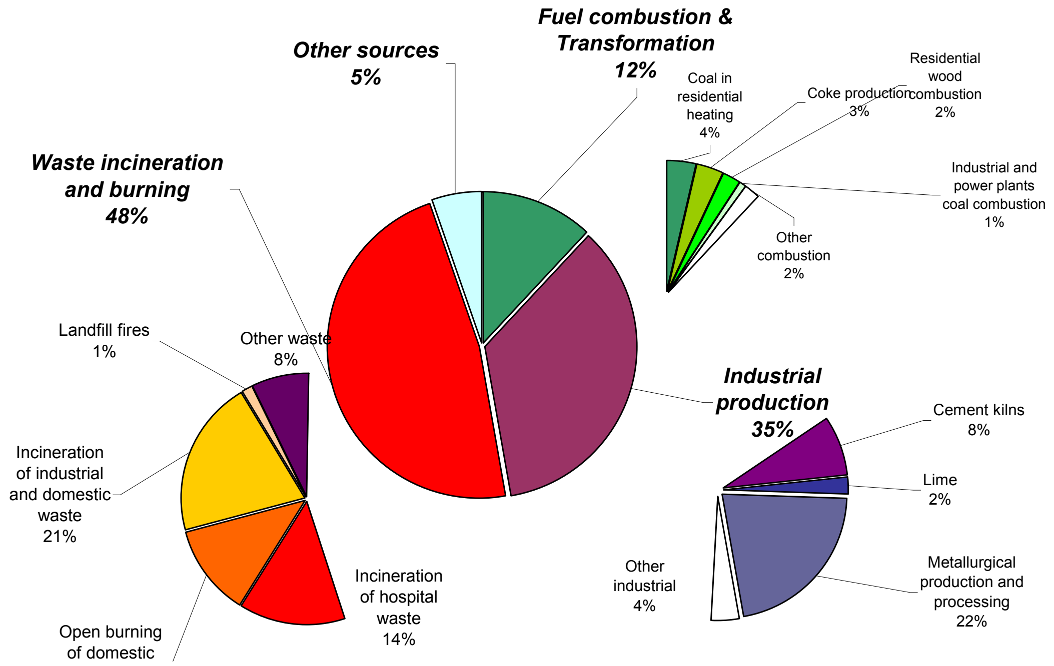

Figure 7 Sources and relative sizes of dioxin emissions to airin the thirteen countries.

The sector contributions to the total dioxin emissions, as given above, are also given in the pie charts of Figure 7. The major sources of dioxin emissions to air in the thirteen countries are in waste incineration and burning and in the metallurgical industry. Waste burning and incineration amount to almost half of all emissions in the region. Within these, incineration of hospital wastes, of industrial and domestic waste and the open burning of domestic wastes have a similar contribution.

For the total of the thirteen countries about one third of the emissions is due to non-industrial sources (residential heating, uncontrolled waste burning, road transport) and about two thirds to industrial sources. There is a considerable variation in this split between the countries (Figure 8), where Cyprus shows a high share of non-industrial sources, whereas Bulgaria and Latvia show quite low contributions of non-industrial sources.

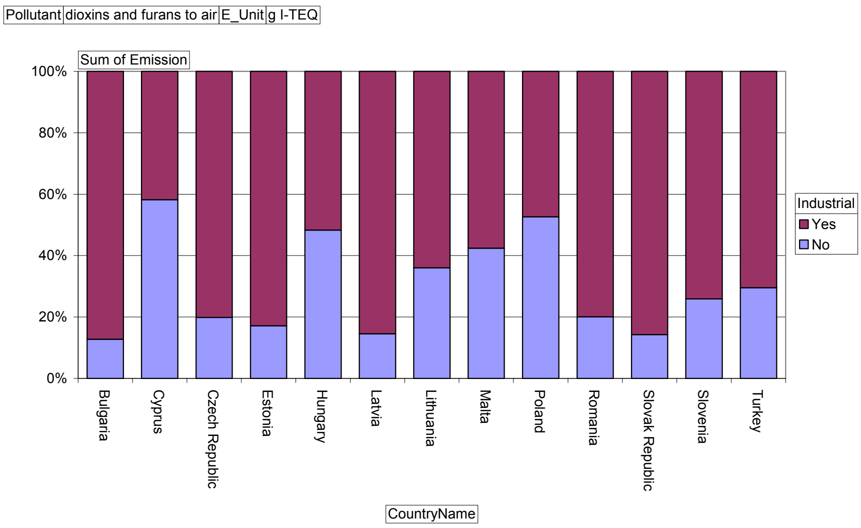

Figure 8 Contribution of industrial and non-industrial sources to emission of dioxins to air in the 13 countries in this study.

3.1.2 Fuel contributions

In the fuel combustion sector, not only the subsector where the combustion takes place is important, but also the fuel combusted. Table 12 presents the emissions in the fuel combustion sector (almost 370 g I-TEQ per year) with reference to the different fuels. As can be seen, solid fuels dominate the contribution. Hard coal (40 % of total), wood (20 % of total), brown coal (15 %) and solid waste fuels (10 %) are responsible for almost 90 % of the fuel combustion emissions.

Table 12 Dioxin emissions to air, due to fuel combustion.

CRF/NFR Code	Fuel Name	Sum Of Emission
1.A	Hard coal coke, brown coal coke and petroleum c	151.58
1.A	Wood and wood waste	73.17
1.A	Brown coal	61.49
1.A	Solid and liquid waste fuels, waste tires, slud	35.13
1.A	Black liquor and other bio wastes	32.85
1.A	Hard Coal	7.04
1.A	Sub-Bituminous Coal	3.69
1.A	Heavy Fuel Oil	2.96
1.A	Gas/Diesel Oil	0.69
1.A	Motor Gasoline	0.29
1.A	Natural Gas	0.26
	Total	**369.15 g I-TEQ**

The relative importance of coal and wood fuels to the emissions from fuel combustion are due to the relatively high emission factors for these fuels.

3.2 Uncertainties

3.2.1 Data quality

One important aspect of the data quality is the data sources for both the activity data and the emission factors. Table 13 and Table 14 present the total emissions as calculated on the basis of this different data sources.

About 40 % of the emissions is based on activity rates, derived from the CEPMEIP database and for about 40 % country data could be used. For about 20 % of the data TNO produced an estimate, using proxies.

The vast majority of emissions is based on UN Chemical Toolkit emission factors. As is shown in the measurements part of this project, the Toolkit emission factors were comparable to the measurements, where-ever a comparison could be made.

Table 13 Emissions of dioxins to air collected using activity data from different data sources

Country Name	**CEPMEIP activity data**	**Data from Candidate Country**	**Data obtained by IOW**	**Estimated by TNO on basis of population sizes**	**EUROSTAT data obtained from EEA web site**	**Toolkit factor, confirmed by or consistent with CC Data**	
Bulgaria	105.1		131.1	36.5	16.2		
Cyprus	0.1	6.5					
Czech Republic	200.3	99.1	0.2		20.0		
Estonia	2.8	2.9	0.1		2.8		
Hungary	33.3	68.4		0.1	20.0		
Latvia	7.7	5.2			4.8		
Lithuania	13.3	2.8	9.5	15.8	7.0		
Malta	1.4			1.8	0.8		
Poland	190.6	409.6	81.2	26.3	78.0		
Romania	90.4	249.4	101.6		44.0		
Slovak Republic	125.1	36.1	5.7		10.8		
Slovenia	20.8		2.3	9.0	4.0		
Turkey	296.4	489.0	9.3		134.0	35.5	
Grand Total	**1 087.3**	**1 369.0**	**340.9**	**89.4**	**342.4**	**35.5**	**g I-TEQ**

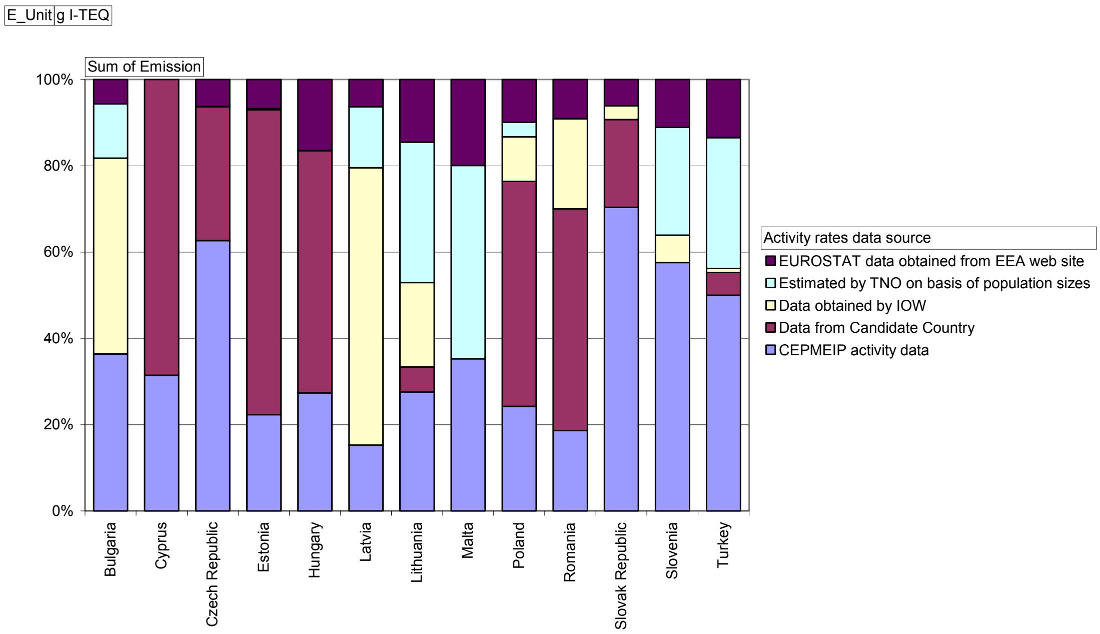

Figure 9 *Emissions of dioxins to air collected using activity data from different data sources*

Table 14 *Emissions of dioxins to air collected using data sources for technology selection.*

Country Name	**Data from Candidate Country**	**Toolkit factor selected by TNO**	**Toolkit factor, confirmed by or consistent with CC Data**	**Grand Total**	
Bulgaria	0.8	288.0		288.8	
Cyprus	0.0	5.8	0.8	6.6	
Czech Republic	89.1	79.4	150.9	319.5	
Estonia	0.0	7.5	1.1	8.7	
Hungary	47.4	56.4	18.0	121.9	
Latvia		17.7		17.7	
Lithuania		34.0	14.4	48.3	
Malta		3.9		3.9	
Poland	383.7	298.0	104.1	785.7	
Romania	0.1	485.3		485.4	
Slovak Republic	36.2	141.4		177.7	
Slovenia		36.1		36.1	
Turkey	10.5	953.6		964.1	
Grand Total	**568.0**	**2 407.1**	**289.3**	**3 264.4**	**g I-TEQ**

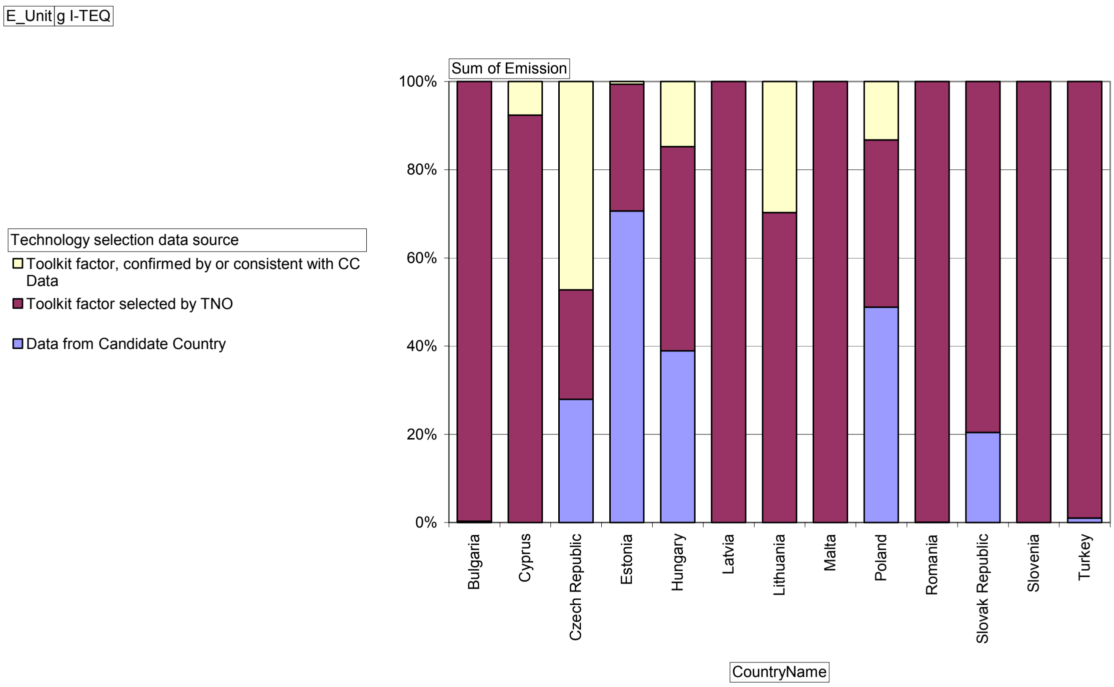

Figure 10 Emissions of dioxins to air collected using data sources for technology selection.

3.2.2 Selection of emission factors

3.2.2.1 Technology selection

Emission estimates of dioxins are very uncertain. Apart from the uncertainties in the emission factors, also uncertainty is introduced in our estimate, by the assumptions of the technologies implemented in the Candidate Countries. To investigate the dependence on the selection of the technology, we varied the choice of technologies applied for the most important activities in each country in all cases where Toolkit emission factors were used. Where-ever a lower or higher Toolkit emission factor was available, these replaced the ones used in our estimate to obtain a low and a high estimate respectively.

The results of this analysis are presented in Table 15. The five activities included in this analysis cause almost 60 % of the dioxin emissions. It is shown that, due to the very high values of emission factors for waste incineration that might occur under some conditions, the emissions from these sectors could be about five times higher than our estimate. When higher quality processes would be applied, the emissions could be about a factor of two lower.

Table 15 Low and high estimates of emissions from some sectors.

CRF/NFRCode	Description	Best estimate	High estimate	Low estimate
2.A.1	Cement kilns	252.0	278.0	34.4
2.C.1.3	Iron ore sintering	431.5	439.0	118.8
6.C	Incineration of hospital waste	527.3	6 620.6	119.7
	Industrial waste	237.2	1 962.8	51.0
	Open burning of domestic wastes	452.3	1 507.5	90.5
Total for these sources		**1 900.3**	**10 807.9**	**414.1**
Other sources		1 364.1		
Grand total		**3 264.4**	**12 172.3**	**1 364.1**

These results compare reasonably well with those of the Monte Carlo analysis. Due to the statistical assumptions of the Monte Carlo analysis it is highly improbable that all emission factors for these processes in all countries are chosen either to low or too high. The high value in Table 15 is at 99 percentile of the distribution in Figure 12, whereas the low value is at the 15 percentile. This asymmetric behaviour can be explained by the skewness of the distributions of emission factors.

The higher values here are illustrative of the consequences on the assumptions on emission factors for the waste incineration activities as explained in section 2.2.4. If the assumption in that section is wrong, the emissions in the thirteen countries could be considerably higher.

Table 16 High and low estimates for national total emissions in the 13 countries.

Country Name	Best estimate	High estimate	Low estimate
Bulgaria	288.8	1 633.0	102.1
Cyprus	6.6	37.3	3.3
Czech Republic	319.5	389.5	176.9
Estonia	8.7	11.4	8.5
Hungary	121.9	214.5	97.9
Latvia	17.7	41.9	11.4
Lithuania	48.3	355.0	17.7
Malta	3.9	28.3	1.5
Poland	785.7	1 058.7	692.1
Romania	485.4	2 647.9	180.9
Slovak Republic	177.7	215.5	102.5
Slovenia	36.1	176.2	14.1
Turkey	964.1	5 363.1	369.4
Grand Total	**3 264.4**	**12 172.3**	**1 778.3**

3.2.2.2 Sensitivity to the residential combustion emission factors

As indicated above (section 2.2.4.4) a rather high uncertainty exists in the emission factors for residential combustion of coal and wood in small stoves. To assess the sensitivity of the estimated national emissions to the values of the emission factors for these sources, these national totals were calculated using the following values: 100, 350, 700 and 1000 µg I-TEQ/TJ. The results of this analysis are presented in Figure 11. For comparison the estimate used in this study is also given.

It is shown that varying the value of this emission factor over one order of magnitude, changes the estimate of the nationals total emissions by about 20 % for all countries. This is well within the uncertainty range as derived above (3.2.2).

For some countries (Czech Republic, Hungary, Poland) national values were provided, higher than the 100 µg I-TEQ/TJ value applied here. For these countries the lower value in this analysis obviously will produce an estimate that is below the one we derived in this study.

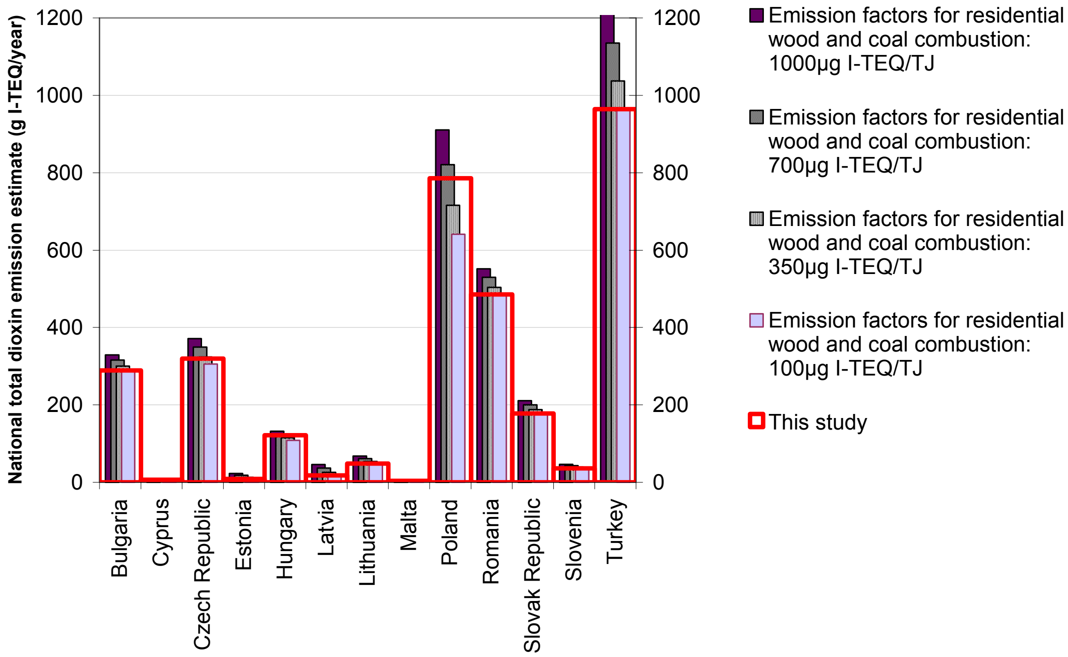

Figure 11 Sensitivity of national total emissions estimate to the emission factors in coal and wood combustion in small residential stoves.

3.2.3 Monte Carlo simulation

3.2.3.1 Assumptions

A Monte Carlo uncertainty analysis[4] can be used to establish 95 % confidence intervals for each country and the thirteen countries in this study together. For such an analysis, both point estimates (the most probable or modal value) and uncertainty ranges for each activity rate and emission factor must be chosen. In our approach we assumed lognormal distributions for all variables and parameters.

We do not have independent information on the uncertainty ranges in activity data, but from the corrections given by countries to our earlier values, we estimate that this uncertainty will be in the order of magnitude of 10 to 50 %. In our analysis we used the value of ± 20 % for most activities and a factor of three for the activity rates estimated by TNO on the basis of population densities. This factor of three is equivalent to the assumption that the order of magnitude might be correct (see also section 2.2.4). The analysis was relatively insensitive to the exact choice of the 20% assumption here between 10 and 50 %.

Uncertainty ranges for emission factors are derived from the Toolkit. We assumed that for all processes, where the Toolkit provides more than one emission factor, the minimum and maximum value indicate the upper and lower limits of the confidence interval for the emission factors applicable for this process. For those where we used country specific data or data derived from measurements we assumed a better quality and selected a default value of ± 50 %. A re-analysis using a factor of three for this value did not produce dramatically different results. We assumed that the uncertainty for emission factors is due to a variation of these in the real world. This means that the uncertainties in the emission factors for the same technology, applied in different processes in different countries are not correlated.

3.2.3.2 Total annual emission in the study area

The results of this Monte Carlo analysis (10,000 iterations, run in the @Risk add in in MS Excel) is presented in Figure 12 for the total of the thirteen countries. Results for the individual countries are presented in Table 17.

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[4] IPCC Good Practice Guidance and Uncertainty Managment (IPCC, 2000)

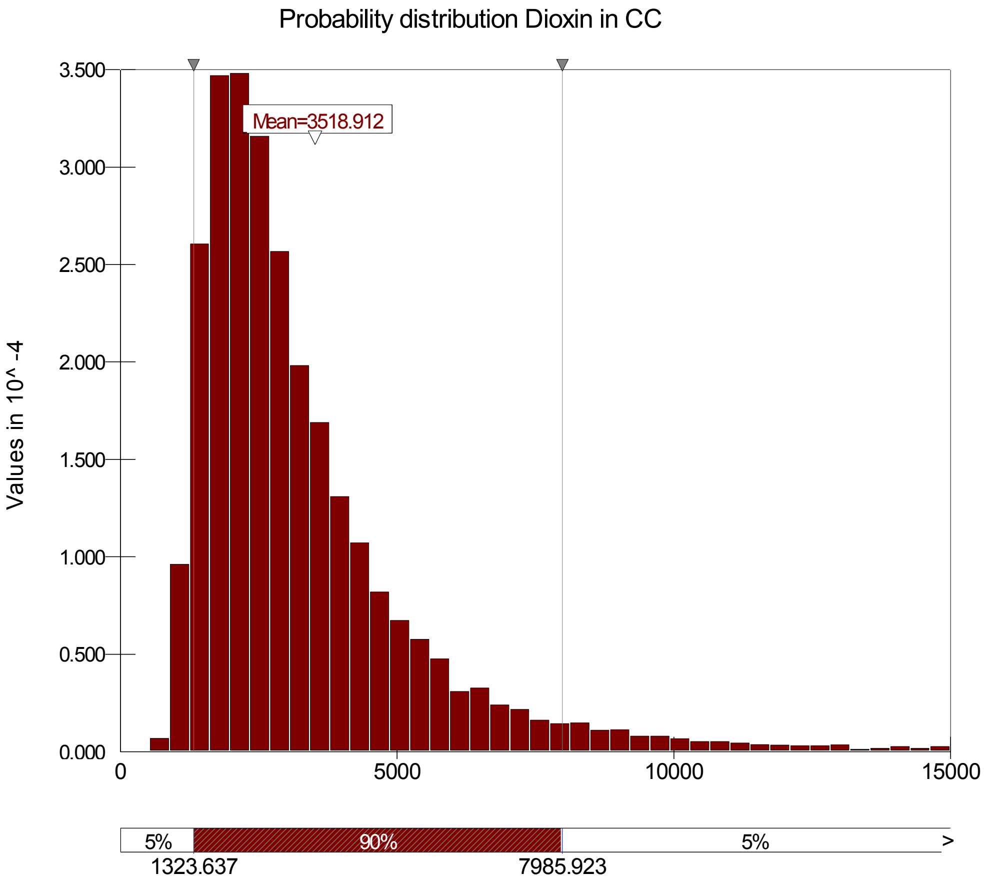

Figure 12 Monte Carlo analysis (20,000 iterations) on the uncertainty of the total dioxin emissions to air in the thirteen countries.

As is shown in Figure 1, the 90 % confidence interval (5 % percentile to 95 % percentile) for the total emissions lies between 1.4 and 7.9 kg I-TEQ per annum. The median value in a lognormal distribution occurs around 2.8 kg I-TEQ. Since the distribution of values, obtained in the analysis is clearly skewed towards higher values, the arithmetic average, obtained in the analysis is around 3.5 kg I-TEQ per annum.

Figure 13 presents an analysis of the largest contributions to the uncertainty in the emissions, by means of a regression between sampled input values and the resulting output value. The higher the regression coefficient, the higher the influence of the input variable's uncertainty on the total uncertainty. The most important uncertainty is the uncertainty in the emission factor for open burning of domestic waste (correlation coefficient: 0.398, assumed uncertainty range: a factor of three). In this case we applied a value of 3000 g I-TEQ/ton, whereas the Toolkit provides values in the range between 525 and 40000.

The figure shows that the highest contributions to uncertainty are the emission factors applied in the waste incineration sector. Improving these values will therefore decrease the uncertainty in the total estimate the most.

Of the twelve top contributors to uncertainty are nine referring to emission factors (EF), three to activity data (AR). Two of the latter are activity data for incineration of hospital waste in Turkey and Romania respectively.

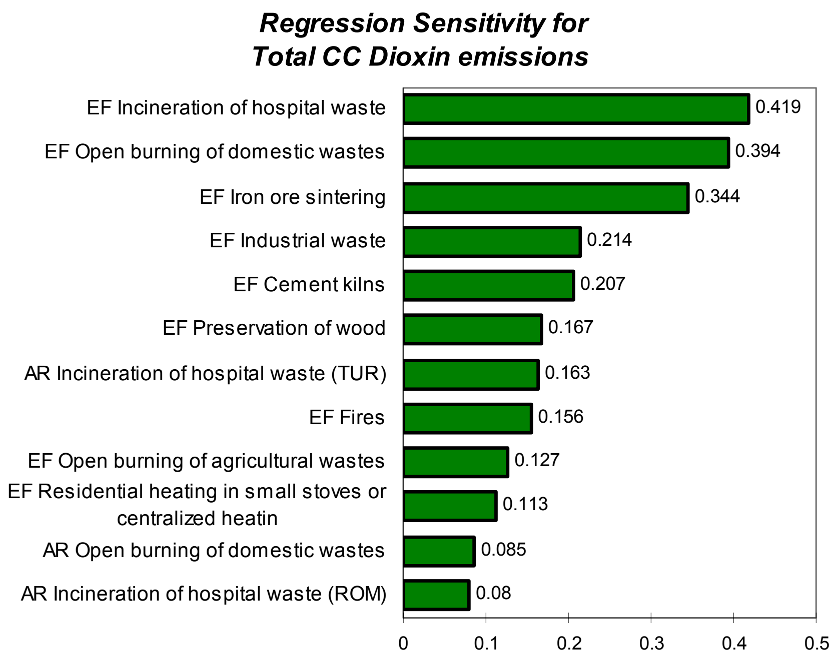

Figure 13 The most important causes for the uncertainty.

3.2.3.3 Uncertainties in national total emissions

Table 17 Summary statistics for national total emissions Monte Carlo analysis (10,000 iterations); please note that for the statistics the participating country total does not equal the sum of the countries!

	5 percentile	**point estimate**	**95 percentile**
Bulgaria	69.4	288.8	811.3
Cyprus	2.5	6.6	38.1
Czech Republic	84.2	319.5	990.6
Estonia	2.8	8.7	45.5
Hungary	46.4	121.9	446.4
Latvia	10.2	17.7	265.0
Lithuania	9.3	48.3	188.4
Malta	0.4	3.9	12.9
Poland	258.8	785.7	1902.1
Romania	117.1	485.4	1327.6
Slovak Republic	46.5	177.7	525.7
Slovenia	8.7	36.1	102.0
Turkey	195.4	964.1	2811.5
Total	**1323.6**	**3264.4**	**7985.9**

For individual countries, the uncertainty as expressed in the 90 % confidence intervals are broader than for the 13 countries jointly. This is caused by the implicit assumption in the analysis that the uncertainties are not correlated.

The results of this analysis are in line with the results of the assessment in sections 3.2.1 and suggest that the uncertainty in our emission estimate is in the order of magnitude of a factor of two to three. In other words: the best estimate for the emissions in the thirteen countries is about 3.2 kg I-TEQ per annum, The probability that this estimate is wrong by more than a factor of two to three is about 10 %.

3.2.3.4 Uncertainties in the distribution between industrial and non-industrial sources

An important issue for policy makers is the distinction between industrial and non-industrial sources (see also Figure 8). To investigate the uncertainty in the split between these two groups of sources, the Monte Carlo analysis, described in section 3.2.2 was used to derive the probability distribution for this source split. Figure 14 presents the results.

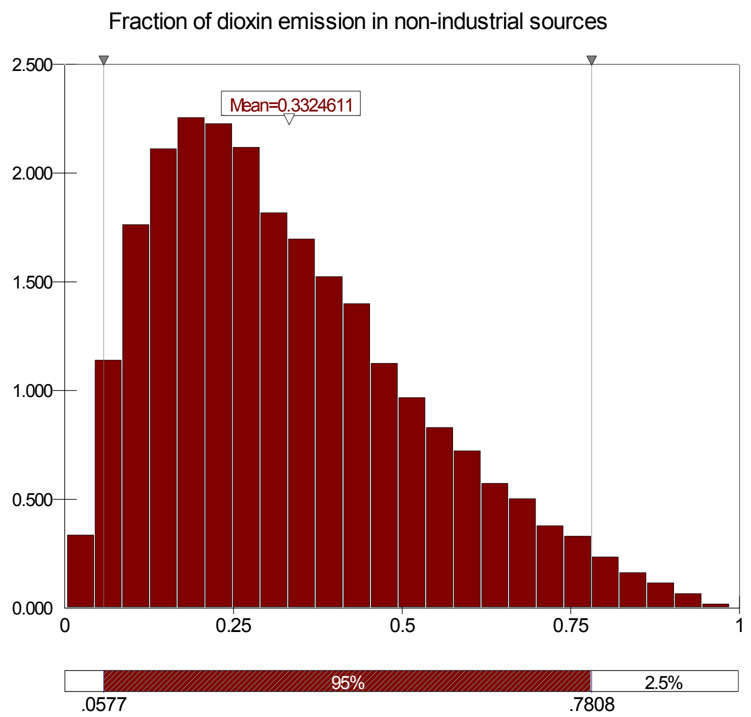

Figure 14 Probability distribution for the fraction of dioxin emissions from non-industrial sources; Monte Carlo analysis a in Figure 12

This analysis shows that, due to the high uncertainties, the contribution of non-industrial sources could vary over the full range, while the 90 % confidence interval would be between 6 and 78 %. The highest probabilities are around 25 to 30 %, in agreement with the results as presented in Figure 8.

3.3 Developments in time

3.3.1 Introduction

This chapter presents a relatively simple analyses on the past and possible future emissions of dioxins to the air in the thirteen countries in this study.

3.3.2 Methods

Within the European Union's CAFÉ project IIASA has defined a baseline scenario for the development of energy using and other activities. This scenario is available via IIASA's web site at http://www.iiasa.ac.at/web-apps/tap/RainsWeb/. Here energy use projections for the ten "new" Member States of the EU can be found and downloaded. This data set provides national total energy data. The aggregated dataset is reproduced in Table 1. Projected data are available for every 5 years between 1990 and 2030 at the level of individual countries.

These data are used to scale the inventory compiled in this study to the years for which energy use data are available in the IIASA scenario. The fuels as defined in the IIASA “activities” were mapped on the fuels as used in this study. This enables all emissions, related to the fuel combustion to be estimated on the projected fuel use in the years covered by the base line scenario.

Energy is one of the main indicators for a countries economy. Most activities in countries therefore correlate quite well with the total energy use. We assume that activities other then fuel combustion therefore also correlate quite well with total (expected) energy use. This will incorporate the increasing per capita economic activities into the projection. Since major sources are waste incineration, cement kilns and metal industries, this assumption implies that the production of waste (to be incinerated), cement and metals grows proportional to the growth in total national energy consumption. This seems to be a reasonable assumption, that can be applied by lack of better information.

Since the IIASA scenario does not contain data for Bulgaria, Romania and Turkey, we assumed that these three countries developments are similar to the total of the ten other countries.

These assumptions allow to estimate a time series of national dioxin emissions to air for each of the thirteen countries in this study. It will however be quite clear that the assumptions above induce considerable uncertainty.

Table 18 IIASA's Baseline scenario (BL_CLE_Apr04 (IIASA)), aggregated for the 10 new EU Member States.

IIASA Code	IIASA "Activity"	1990	1995	2000	2005	2010	2015	2020	2025	2030
BC1	Brown coal/lignite, high grade	2,069	895	843	850	700	547	486	411	335
BC2	Brown coal/lignite, low grade	0	0	0	0	0	0	0	0	0
HC1	Hard coal, high quality	2,570	3,166	2,521	2,130	1,980	1,945	1,589	1,600	1,775
HC2	Hard coal, medium quality	0	0	0	0	0	0	0	0	0
HC3	Hard coal, low quality	0	0	0	0	0	0	0	0	0
DC	Derived coal (coke, briquettes)	466	273	230	176	129	107	100	94	89
OS1	Other solid-low S (biomass, waste, wood)	170	202	248	266	289	278	273	290	310
OS2	Other solid-high S (incl. high S waste)	0	19	23	36	110	112	115	102	104
HF	Heavy fuel oil	982	687	570	568	547	542	533	548	568
MD	Medium distillates (diesel, light fuel oil)	658	569	678	755	837	902	966	1,013	1,066
GSL	Gasoline	566	612	652	718	817	909	992	1,036	1,077
LPG	Liquefied petroleum gas	31	60	97	103	110	115	119	119	117
MTH	Methanol	0	0	0	0	0	1	1	2	2
ETH	Ethanol	0	0	0	0	0	0	0	0	0
H2	Hydrogen	0	0	0	0	0	1	1	2	3
GAS	Natural gas (incl. other gases)	1,916	1,638	1,771	1,964	2,327	2,741	3,290	3,503	3,642
LFL	Leaded gasoline	0	0	0	0	0	0	0	0	0
REN	Renewable (solar, wind, small hydro)	0	1	2	16	38	69	107	144	179
HYD	Hydro	42	56	57	79	85	89	92	95	96
NUC	Nuclear	617	589	620	701	625	621	623	447	224
ELE	Electricity	-27	-23	-78	-73	-67	-68	-68	-54	-54
HT	Heat (steam, hot water)	-10	0	-3	2	0	0	0	0	0
NOF	No fuel use	0	0	0	0	0	0	0	0	0
Sum		10,049	8,743	8,231	8,289	8,526	8,912	9,219	9,352	9,532

3.3.3 Results

Figure 15 presents the projected dioxin emissions in each of the thirteen countries in this study, estimated as described above. It is shown that, according to this estimate, the dioxin emissions to air in the thirteen countries decreased from about 4.5 in 1990 to 3.6 kg I-TEQ per annum in 2000. The decrease is relatively largest in Slovakia and the Baltic states. This is due to the decrease of energy use, caused by the economic slow down occurring after the collapse of the planned economies in these countries over that period. This happened to a relatively lesser extent in the other countries. Please note that Bulgaria, Romania and Turkey follow the over all pattern. This might be an artefact of the method.

In the coming 30 years the emissions will, according to this scenario, again rise to 4.4 kg I-TEQ / year. A relatively large increase is expected in Poland,

due to the assumed increase in use of biomass wastes and other solid fuels (OS1 and OS2) in this country.

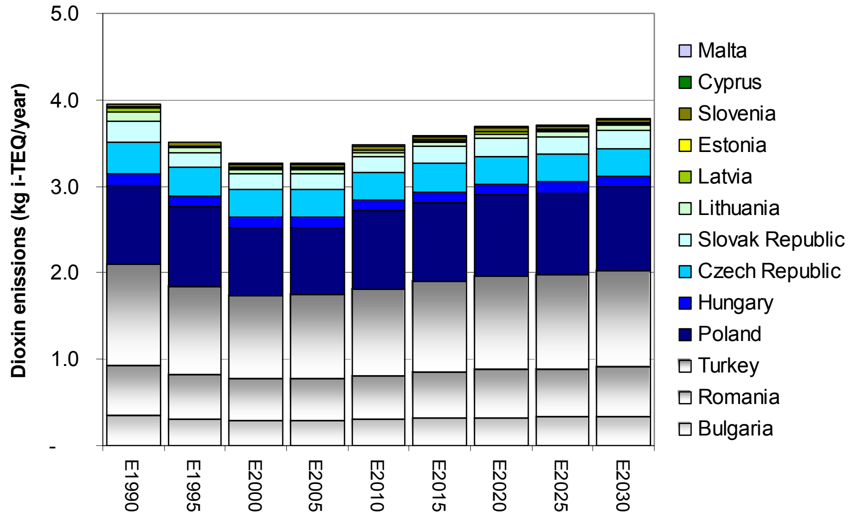

Figure 15 Projected dioxin emissions to air 1990 to 2030 by country.

The projection as presented above, assumes no changes in the emission factors. However it might be expected that in the coming 30 years the technologies involved will improve and emission factors will go down. Figure 16 shows that the introduction of better technologies indeed will decrease the emissions of dioxins well below the actual value. It is shown that, if all countries apply a technology that is one step better than the present one (see section 3.2.2.1 for an explanation) the emissions might go down from 3.4 kg I-TEQ now to 2.5 kg I-TEQ ("low estimate"). If all technologies comply with the IPPC requirements as given in the BREFs, a further decrease to 1.8 kg I-TEQ is possible.

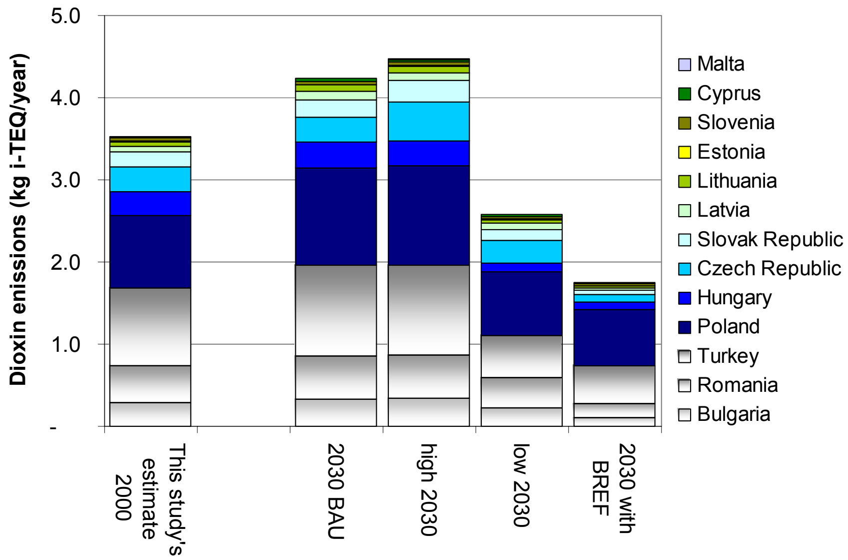

Figure 16 Implementation of better technologies by 2030 (low estimate and BREF). The high estimate is given for comparison.

From this analysis we conclude that

1) Emissions of dioxins to air have decreased in the period 1990 to 2000, mainly due to the decrease of energy consumption in these countries.
2) The increase in energy consumption, expected to occur according to the IIASA base line scenario, might lead to an increase of dioxin emissions to air of about one quarter in the period till 2030.
3) When however in all countries the technologies used for all processes are improved to the ones already in use now in some of these countries by this date, the total emissions of dioxins to air might decrease with about 25 %.
4) When all installations in the countries will comply with the requirements of the IPPC Directive, as given in the respective BREF documents, emissions might decrease by almost 50 % relative to the present emissions.

4 Discussion and Conclusions

In this study we developed in close co-operation with national experts air emission inventories for the 10 “New” EU Member States (Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovak Republic, Slovenia) and the three EU Candidate Countries (Bulgaria, Romania, Turkey). Our approach assures

1) Consistency and comparability between the 13 national inventories for these countries
2) Consistency and comparability with the inventories of the 15 “Old” EU Member States, published earlier ([1], [2]).
3) Optimal use of national information as far as available via the national experts participating in this project.
4) Transparency: all detailed data are copied in the annexes with this report.

4.1 Summary of findings

Estimation of emissions to air suffer from high uncertainties, both in activity data for some sources and in emission factors. Available literature and measurements show that emission factors for some sources might vary over more than an order of magnitude. Taking these uncertainties into account, the national total emissions in each of the 13 countries are summarized in Table 19. For each country, both the value as obtained from this study and the lower and upper limits of the 90 % confidence intervals are presented. The numbers have been rounded to two significant digits.

The total dioxin emission to air in the thirteen countries is estimated at 3.2 kg I-TEQ per year. The uncertainty range around this value is 1.3 to 8.0 kg I-TEQ per year (95 % confidence interval).

Major sources of dioxins are:

- Several waste incineration and combustion processes
    - Hospital waste incineration
    - Industrial waste incineration
    - Open burning of domestic wastes
- Several industrial processes
    - Iron sinter plants
    - Cement kilns
- Residential heating (coal and wood) in small stoves

Together these sources are responsible for over 60 % of the total dioxin emissions in the study area.

Table 19 National total emissions in the participating counties. The numbers of Table 17 have been rounded to two significant digits.

	this study's estimate	lower limit of the 90 % confidence interval	upper limit of the 90 % confidence interval
Bulgaria	290	70	810
Cyprus	6.6	2.5	38
Czech Republic	320	84	990
Estonia	8.7	2.8	46
Hungary	120	46	450
Latvia	18	10	270
Lithuania	48	9.3	190
Malta	3.9	0.4	13
Poland	790	260	1900
Romania	490	120	1300
Slovak Republic	180	47	530
Slovenia	36	8.7	100
Turkey	960	200	2800
Total[5]	**3 200**	**1 300**	**8 000**

Major dioxin emission sources occur both in a limited number of larger industrial facilities and in numerous small residential sources (stoves, uncontrolled burning, fires etc.). Our best estimate of the contribution between these two source categories shows that 30 to 40 % of the emissions might arise from the small residential sources. This number however is highly uncertain.

An estimate of historic and possible future dioxin emissions to air shows that, due to the decrease of economic activities in the countries, following the political changes in the early 1990s, the emissions have decreased. Due to the expected increases of economic activity however, the emission will rise again until 1990 levels in the coming decades, if the technologies applied in these countries is not improved. If however we assume that all technologies applied in these countries will match the best ones already in place, emissions will not increase, but further decrease.

4.2 Assessment of findings

In this study we have shown that the dioxin emissions to air in the new EU Member States (10 countries) and the Candidate Countries (3 countries) are on a comparable level at a per capita basis as in the 15 "Old" EU Member States.

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5 Please note that the totals are not equal to the sum of the values for each country.

A preliminary spatial disaggregation shows that highest emissions could occur around each countries capitals and in the heavily populated and industrialized areas of the “Black Triangle” (on the borders between Poland, Czech Republic and Slovak Republic). A similar spatial disaggregation is not available for the 15 “Old” EU Member States.

Comparing the emission factors used in this inventory with those measured for the production processes (excluding energy production; see measurements sub-report) the Toolkit factors selected by us are on the average about a factor of four higher than the measured ones. This is consistent with our approach to produce a conservative estimate by selecting the highest or highest but one emission factor where-ever no further information was available. If the measurements were representative for all emission factors in the thirteen countries, this would lead to a considerably lower total emission estimate. We also showed that the assumption for waste incineration not to use the highest, but the highest but one emission factors could underestimate the emissions by a factor of four to five. This range of uncertainty is consistent with the uncertainties as estimated using a Monte Carlo uncertainty analysis.

Taking these findings into account we conclude that the best estimate for the total emissions of dioxins to air in the thirteen countries in this study is about 3.2 kg I-TEQ. The uncertainty around this value however is quite large and this value could be in the order of a factor of two lower or a factor of five higher. The uncertainty of trhe emission estimate for the fifteen “old” EU Member States is not known, but will not be very different.

About one third of the emissions of dioxins to air are due to non-industrial (area) sources, where low level emission occurs in large numbers of small equipment (stoves, cars, open waste burning). These emissions obviously occur in the direct neighbourhood where people live and hence will give rise to concentrations of dioxins in the direct surroundings of where people live. Industrial sources on the other hand tend to be larger sources with higher stacks. Depositions from these sources will be spread out over larger areas than for the small sources. The emission of each individual source however will be higher. The small, low sources might give rise to hotspots in densely populated areas, whereas the highest concentrations, caused by the larger elevated sources might occur at several kilometres from the stack.

The effects of these different dispersion behaviour of smaller - lower on the one hand and larger - higher sources on the other, is difficult to estimate in general terms. Detailed location information of all sources in a region is needed to run air pollution dispersion models to calculate dioxin concentrations in the air. Since however most industrial sources are located in the same areas (on a spatial scale of several kilometres) where people live, we do not expect that the geographic emission and concentration patterns are very different for both type of sources. The same is more or less to be

expected in the fifteen EU Member States. So, given the high uncertainties in emissions, we do not expect the concentration levels in the thirteen countries to differ significantly from those in the “old” 15 EU Member States. More geographical information is needed to run air quality and effect models to investigate this issue.

On the basis of these results we conclude that there is no reason to assume that the concentrations of dioxins in the air in the thirteen countries are significantly higher than in the 15 “Old” EU Member States. This however does not exclude possible “hot spots”, where relatively high concentrations could occur, due to for instance uncontrolled burning of chlorine containing wastes.

The uncertainties in the emission level are quite large; the 90 % confidence interval of our estimate is in the order of plus or minus a factor of two to three. Since however the uncertainty in the inventory for the “Old” 15 EU Member States ([1], [2]) is not published, we cannot compare both inventories on this respect.

Largest contributions are from the incineration of different kinds of wastes (incineration of hospital waste, burning of household waste, incineration of industrial waste), cement kilns and iron ore sintering.

The implementation of the EU Waste Incineration Directive and the IPPC Directive in the thirteen countries will bring the emissions of dioxins down to a level that is comparable or even below the level in the “old” EU Member States. Since this might take some time, it might be worthwhile to perform air quality modelling studies for some areas within the thirteen countries. The preliminary geographical distribution, shown in Figure 3, suggests that such a study could be best performed form the so-called Back Triangle (Poland, Czech Republic, Slovak Republic border area) and for the surroundings of Istanbul.

4.3 Recommendations

Dioxins are released to air, both from larger industrial facilities and from small residential stoves (coal and wood) and uncontrolled domestic waste burning. Since there is no significant difference in dioxin emissions (and dioxin contamination (see the results of the ELICC project) between the thirteen countries in this study and the fifteen “”old” EU Member States, no specific action is needed for the new EU Member States.

Uncontrolled burning of domestic waste in backyards or small stoves is a practice that should occur for other reasons than for dioxin emissions (recovery of valuable materials; emissions of other pollutants as POPs, PAH,

particulates, black smoke, etc.). The EU has already legislation in place that aims at improving waste management and waste treatment. The Commission could support programs to inform and educate the public to properly dispose of wastes via waste collection and waste treatment systems, using incineration in modern waste incinerators and land filling in modern well managed and well protected waste disposal sites.

Residential coal and wood combustion in small stoves might be phased out because of other environmental problems like the emissions of particulates and PAHs. The emissions of dioxins from these sources adds to the problems caused by the use of solid fuels for small residential heating systems.

Dioxin emissions from larger (industrial) facilities could be abated by technical measures. Implementation of the relevant EU Directives (Waste Incineration Directive) and Best Applicable Technologies (BAT) as described in the IPPC-BREF documents, will significantly reduce the dioxin emissions from these larger industrial facilities.

Over all: there is no need for further specific new legislation to bring the dioxin emissions down. Implementation and probably enforcement of the existing legislation (Waste Incineration Directive, IPPC, Waste Directive (Council Directive of 15 July 1975 on waste (75/442/EEC), article 4 and following) however deserves attention as well as prevention of "illegal" activities in the field of waste combustion.

References

[1] The European Dioxin Inventory: **Ulrich Quass, Michael Fermann** (1997), Identification of Relevant Industrial Sources of Dioxins and Furans in Europe - Final Report - Materialen No. 43, Landesumweltamt Nordrhein-Westfalen

[2] The European Dioxin Inventory Stage II: **Ulrich Quass, Michael Fermann, Günter Bröker** (2001), Executive Summary - Materialen No. 59, Landesumweltamt Nordrhein-Westfalen

[3] Standardized Toolkit for Identification and Quantification of Dioxin and Furan Releases, 1st edition (2003), UNEP Chemicals, Geneva

[4] Integrated Pollution Prevention and Control Bureau (IPPC); Reference Documents on Best Available Techniques for:

- Production of Iron and Steel, December 2001;
- Cement and Lime manufacturing Industries, December 2001;
- Non Ferrous Metals Industries, December 2001;
- Large Combustion Plants, Draft November 2004;
- Waste Incineration, Draft March 2004

these documents are available from http://eippcb.jrc.es/pages/FActivities.htm.

[5] Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories; Paris, IPCC/OECD/IEA 1997, http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.htm

[6] EEA Data Service at http://dataservice.eea.eu.int/dataservice/default.asp?refid=911B582A-806E-4758-892E-9AB9AFB47B84

Annex 1 Country experts participating in this study

Bulgaria:	Evelina Nikolova
Cyprus:	Stelios Georghiades
Czech Republic:	Jitka Hlavicová, Ivan Holoubek, Jiří Kohoutek
Estonia:	Natalija Kohv
Hungary:	Ákos Fehérváry
Latvia:	Gunars Civjans
Malta:	Charmaine Vassallo
Poland:	Iwona Kargulewicz
Slovakia	Gabriela Fischerová
Lithuania	Vytautas Krusinskas
Romania	Ionela Draghici

Annex 2 Activity data details

<<Activity Rates Documentation>>

CountryName **Bulgaria**

CRF/NFRCode *1.A.1.a*

Description	FuelName	Value	DataSource
Auto-producer electricity, heat and CHP plants, and public heat plants	Black liquor and other bio wastes	1 400.00 TJ	CEPMEIP
Public power plants	Brown coal	170 000.00 TJ	CEPMEIP
Public power plants	Hard Coal	28 000.00 TJ	CEPMEIP
Public power plants	Hard coal coke, brown coal coke and petroleum c	18 000.00 TJ	CEPMEIP
Public power plants	Heavy Fuel Oil	8 700.00 TJ	CEPMEIP
Public power plants	Natural Gas	44 000.00 TJ	CEPMEIP

CRF/NFRCode *1.A.2.d*

Description	FuelName	Value	DataSource
Industrial combustion in the paper and pulp industry	Black liquor and other bio wastes	2.00 TJ	CEPMEIP

CRF/NFRCode *1.A.2.f*

Description	FuelName	Value	DataSource
Industrial combustion in other industrial sectors	Black liquor and other bio wastes	230.00 TJ	CEPMEIP

CRF/NFRCode *1.A.4.b.i*

Description	FuelName	Value	DataSource
Residential heating in small stoves or centralized heating systems	Brown coal	17 000.00 TJ	CEPMEIP
Residential heating in small stoves or centralized heating systems	Gas/Diesel Oil	12 000.00 TJ	CEPMEIP
Residential heating in small stoves or centralized heating systems	Hard Coal	80.00 TJ	CEPMEIP
Residential heating in small stoves or centralized heating systems	Heavy Fuel Oil	2 000.00 TJ	CEPMEIP
Residential heating in small stoves or centralized heating systems	Sub-Bituminous Coal	2 100.00 TJ	CEPMEIP
Residential heating in small stoves or centralized heating systems	Wood and wood waste	25 000.00 TJ	CEPMEIP

CRF/NFRCode *1.B.1.b*

Description	FuelName	Value	DataSource
Solid fuel transformation | Coke production	-	12 400 000.00 ton	IOW

CRF/NFRCode *2.A.1*

Description	FuelName	Value	DataSource
Cement kilns	-	2 100 000.00 ton	CEPMEIP

CRF/NFRCode *2.A.2*

Description	FuelName	Value	DataSource
Lime production	-	800 000.00 ton	CEPMEIP

CRF/NFRCode *2.C.1.3*

Description	FuelName	Value	DataSource
Iron ore sintering	-	2 500 000.00 ton	CEPMEIP

CRF/NFRCode *2.C.5*

Description	*FuelName*	*Value*	*DataSource*
Secondary copper	-	5 000.00 ton	CEPMEIP
Secondary lead production	-	10 000.00 ton	IOW
Secondary zinc	-	5 500.00 ton	CEPMEIP

CRF/NFRCode *3.D*

Description	*FuelName*	*Value*	*DataSource*
Fires	-	8 100 000.00 inhabit	EUROSTAT
Preservation of wood	-	8 100 000.00 inhabit	EUROSTAT

CRF/NFRCode *6.C*

Description	*FuelName*	*Value*	*DataSource*
Incineration of hospital waste	-	12 150.00 ton	TNO estimate
Industrial waste	-	266 000.00 ton	IOW
Open burning of agricultural wastes	-	290 000.00 ton	CEPMEIP
Open burning of agricultural wastes	-	290 000.00 ton	CEPMEIP
Open burning of domestic wastes	-	81 000.00 ton	CEPMEIP

CountryName Cyprus

CRF/NFRCode *1.A.1.a*

Description	*FuelName*	*Value*	*DataSource*
Public power plants	Heavy Fuel Oil	37 500.00 TJ	CC information

CRF/NFRCode *1.A.4.b.i*

Description	*FuelName*	*Value*	*DataSource*
Residential heating in small stoves or centralized heating systems	Gas/Diesel Oil	6 000.00 TJ	CC information
Residential heating in small stoves or centralized heating systems	Wood and wood waste	1.00 TJ	CC information

CRF/NFRCode *2.A.1*

Description	*FuelName*	*Value*	*DataSource*
Cement kilns	-	1 400 000.00 ton	CC information

CRF/NFRCode *2.A.2*

Description	*FuelName*	*Value*	*DataSource*
Lime production	-	5 500.00 ton	CC information

CRF/NFRCode *2.C.2*

Description	*FuelName*	*Value*	*DataSource*
Foundries	-	500.00 ton	CC information

CRF/NFRCode *2.C.3*

Description	*FuelName*	*Value*	*DataSource*
(Secondary) aluminium production	-	250.00 ton	CC information

CRF/NFRCode *3.D*

Description	*FuelName*	*Value*	*DataSource*
Fires	-	720 000.00 inhabit	CC information
Preservation of wood	-	720 000.00 inhabit	CC information

CRF/NFRCode *6.C*

Description	*FuelName*	*Value*	*DataSource*
Incineration of hospital waste	-	500.00 ton	CC information

Open burning of agricultural wastes	-	61 000.00 ton	CEPMEIP
Open burning of agricultural wastes	-	61 000.00 ton	CEPMEIP
Open burning of domestic wastes	-	8 600.00 ton	CC information

CountryName Czech Republic

CRF/NFRCode 1.A.1.a

Description	*FuelName*	*Value*	*DataSource*
Auto-producer electricity, heat and CHP plants, and public heat plants	Black liquor and other bio wastes	2 800.00 TJ	CEPMEIP
Public power plants	Brown coal	510 000.00 TJ	CC information
Public power plants	Hard coal coke, brown coal coke and petroleum c	120 000.00 TJ	CC information
Public power plants	Heavy Fuel Oil	29 000.00 TJ	CC information
Public power plants	Natural Gas	13 000.00 TJ	CEPMEIP

CRF/NFRCode 1.A.4.b.i

Description	*FuelName*	*Value*	*DataSource*
Residential heating in small stoves or centralized heating systems	Brown coal	52 000.00 TJ	CC information
Residential heating in small stoves or centralized heating systems	Gas/Diesel Oil	2 900.00 TJ	CC information
Residential heating in small stoves or centralized heating systems	Hard Coal	5 000.00 TJ	CC information
Residential heating in small stoves or centralized heating systems	Hard coal coke, brown coal coke and petroleum c	6 000.00 TJ	CC information
Residential heating in small stoves or centralized heating systems	Heavy Fuel Oil	1 100.00 TJ	CEPMEIP
Residential heating in small stoves or centralized heating systems	Wood and wood waste	10 000.00 TJ	CC information

CRF/NFRCode 1.B.1.b

Description	*FuelName*	*Value*	*DataSource*
Solid fuel transformation | Coke production	-	2 500 000.00 ton	CC information

CRF/NFRCode 2.A.1

Description	*FuelName*	*Value*	*DataSource*
Cement kilns	-	4 800 000.00 ton	CEPMEIP

CRF/NFRCode 2.A.2

Description	*FuelName*	*Value*	*DataSource*
Lime production	-	1 200 000.00 ton	CEPMEIP

CRF/NFRCode 2.C.1

Description	*FuelName*	*Value*	*DataSource*
Steel production | Clean scrap	-	6 000 000.00 ton	CC information

CRF/NFRCode 2.C.1.2

Description	*FuelName*	*Value*	*DataSource*
Iron and steel plants (pig iron)	-	4 700 000.00 ton	CC information

CRF/NFRCode 2.C.1.3

Description	*FuelName*	*Value*	*DataSource*
Iron ore sintering	-	6 500 000.00 ton	CEPMEIP

CRF/NFRCode 2.C.2

Description	*FuelName*	*Value*	*DataSource*
Foundries	-	370 000.00 ton	CC information

CRF/NFRCode *2.C.3*

Description	FuelName	Value	DataSource
(Secondary) aluminium production	-	35 000.00 ton	CC information

CRF/NFRCode *2.C.5*

Description	FuelName	Value	DataSource
Secondary copper	-	12 000.00 ton	CEPMEIP
Secondary zinc	-	1 000.00 ton	IOW

CRF/NFRCode *3.D*

Description	FuelName	Value	DataSource
Fires	-	10 000 000.00 inhabit	EUROSTAT
Preservation of wood	-	10 000 000.00 inhabit	EUROSTAT

CRF/NFRCode *6.C*

Description	FuelName	Value	DataSource
Hazardous waste incineration	-	43 000.00 ton	CC information
Incineration of hospital waste	-	15 000.00 ton	CC information
Municipal / industrial waste incineration (legal)	-	370 000.00 ton	CC information
Open burning of agricultural wastes	-	1 500 000.00 ton	CEPMEIP
Open burning of agricultural wastes	-	1 500 000.00 ton	CEPMEIP
Open burning of domestic wastes	-	100 000.00 ton	CEPMEIP

CountryName Estonia

CRF/NFRCode *1.A.1.a*

Description	FuelName	Value	DataSource
Auto-producer electricity, heat and CHP plants, and public heat plants	Black liquor and other bio wastes	4 000.00 TJ	CEPMEIP
Public power plants	Brown coal	89 000.00 TJ	CC information
Public power plants	Heavy Fuel Oil	2 900.00 TJ	CC information
Public power plants	Natural Gas	17 700.00 TJ	CC information

CRF/NFRCode *1.A.2.d*

Description	FuelName	Value	DataSource
Industrial combustion in the paper and pulp industry	Black liquor and other bio wastes	725.00 TJ	CC information

CRF/NFRCode *1.A.2.f*

Description	FuelName	Value	DataSource
Industrial combustion in other industrial sectors	Black liquor and other bio wastes	459.00 TJ	CC information

CRF/NFRCode *1.A.4.b.i*

Description	FuelName	Value	DataSource
Residential heating in small stoves or centralized heating systems	Brown coal	1 400.00 TJ	CEPMEIP
Residential heating in small stoves or centralized heating systems	Gas/Diesel Oil	260.00 TJ	CC information
Residential heating in small stoves or centralized heating systems	Hard Coal	674.00 TJ	CC information
Residential heating in small stoves or centralized heating systems	Wood and wood waste	13 600.00 TJ	CC information

CRF/NFRCode *1.B.1.b*

Description	FuelName	Value	DataSource
Solid fuel transformation | Coke production	-	40 000.00 ton	IOW

CRF/NFRCode *2.A.1*

Description	FuelName	Value	DataSource
Cement kilns	-	405 000.00 ton	CEPMEIP

CRF/NFRCode *2.A.2*

Description	FuelName	Value	DataSource
Lime production	-	20 000.00 ton	CEPMEIP

CRF/NFRCode *3.D*

Description	FuelName	Value	DataSource
Fires	-	1 400 000.00 inhabit	EUROSTAT
Preservation of wood	-	1 400 000.00 inhabit	EUROSTAT

CRF/NFRCode *6.C*

Description	FuelName	Value	DataSource
Incineration of hospital waste	-	9.50 ton	CC information
Open burning of agricultural wastes	-	130 000.00 ton	CEPMEIP
Open burning of agricultural wastes	-	130 000.00 ton	CEPMEIP
Open burning of domestic wastes	-	1 000.00 ton	CEPMEIP

CountryName **Hungary**

CRF/NFRCode *1.A.1.a*

Description	FuelName	Value	DataSource
Auto-producer electricity, heat and CHP plants, and public heat plants	Black liquor and other bio wastes	220.00 TJ	CEPMEIP
Public power plants	Brown coal	54 500.00 TJ	CC information
Public power plants	Hard coal coke, brown coal coke and petroleum c	57 000.00 TJ	CC information
Public power plants	Heavy Fuel Oil	44 000.00 TJ	CC information
Public power plants	Natural Gas	67 000.00 TJ	CEPMEIP

CRF/NFRCode *1.A.2.d*

Description	FuelName	Value	DataSource
Industrial combustion in the paper and pulp industry	Black liquor and other bio wastes	4.00 TJ	CEPMEIP

CRF/NFRCode *1.A.2.f*

Description	FuelName	Value	DataSource
Industrial combustion in other industrial sectors	Brown coal	26 000.00 TJ	CC information
Industrial combustion in other industrial sectors	Heavy Fuel Oil	21 000.00 TJ	CC information

CRF/NFRCode *1.A.4.b.i*

Description	FuelName	Value	DataSource
Residential heating in small stoves or centralized heating systems	Brown coal	16 000.00 TJ	CC information
Residential heating in small stoves or centralized heating systems	Gas/Diesel Oil	14 000.00 TJ	CC information
Residential heating in small stoves or centralized heating systems	Wood and wood waste	10 000.00 TJ	CC information

CRF/NFRCode *1.B.1.b*

Description	FuelName	Value	DataSource
Solid fuel transformation | Coke production	-	680 000.00 ton	CC information

CRF/NFRCode *2.A.1*

Description	FuelName	Value	DataSource
Cement kilns	-	3 450 000.00 ton	CC information

CRF/NFRCode *2.A.2*

Description	FuelName	Value	DataSource
Lime production	-	350 000.00 ton	CEPMEIP

CRF/NFRCode *2.A.6*

Description	FuelName	Value	DataSource
Asphalt mixing	-	2 900 000.00 ton	CC information

CRF/NFRCode *2.A.7*

Description	FuelName	Value	DataSource
Brick and tile production	-	4 200 000.00 ton	CC information
Ceramics	-	4 800 000.00 ton	CC information
Glass production	-	395 000.00 ton	CC information

CRF/NFRCode *2.B.5*

Description	FuelName	Value	DataSource
Production of EDC	-	340 000.00 ton	CEPMEIP

CRF/NFRCode *2.C.1.1*

Description	FuelName	Value	DataSource
Iron and steel plants (steel)	-	2 000 000.00 ton	CC information

CRF/NFRCode *2.C.1.2*

Description	FuelName	Value	DataSource
Iron and steel plants (pig iron)	-	1 350 000.00 ton	CC information

CRF/NFRCode *2.C.1.3*

Description	FuelName	Value	DataSource
Iron ore sintering	-	500 000.00 ton	CC information

CRF/NFRCode *2.C.3*

Description	FuelName	Value	DataSource
(Secondary) aluminium production	-	35 000.00 ton	CC information

CRF/NFRCode *2.C.5*

Description	FuelName	Value	DataSource
Brass and bronze production	-	2 000 000.00 ton	CC information
Secondary copper	-	30 000.00 ton	CC information

CRF/NFRCode *2.D.1*

Description	FuelName	Value	DataSource
Pulp and paper mills	-	496 000.00 ton	CC information

CRF/NFRCode *3.D*

Description	FuelName	Value	DataSource
Fires	-	10 000 000.00 inhabit	EUROSTAT
Preservation of wood	-	10 000 000.00 inhabit	EUROSTAT

CRF/NFRCode *6.C*

Description	FuelName	Value	DataSource
Hazardous waste incineration	-	78 000.00 ton	CC information

Incineration of hospital waste	-	15 000.00 ton	TNO estimate
Municipal / industrial waste incineration (legal)	-	353 000.00 ton	CC information
Open burning of agricultural wastes	-	1 900 000.00 ton	CEPMEIP
Open burning of agricultural wastes	-	1 900 000.00 ton	CEPMEIP
Open burning of domestic wastes	-	100 000.00 ton	CEPMEIP

CountryName Latvia

CRF/NFRCode 1.A.1.a

Description	*FuelName*	*Value*	*DataSource*
Public power plants	Hard coal coke, brown coal coke and petroleum c	1 000.00 TJ	CC information
Public power plants	Heavy Fuel Oil	8 200.00 TJ	CC information
Public power plants	Natural Gas	25 000.00 TJ	CC information
Public power plants	Peat	2 000.00 TJ	CC information
Public power plants	Wood and wood waste	9 000.00 TJ	CC information

CRF/NFRCode 1.A.4.b.i

Description	*FuelName*	*Value*	*DataSource*
Residential heating in small stoves or centralized heating systems	Gas/Diesel Oil	3 000.00 TJ	CC information
Residential heating in small stoves or centralized heating systems	Hard Coal	1 500.00 TJ	CC information
Residential heating in small stoves or centralized heating systems	Wood and wood waste	30 000.00 TJ	CC information

CRF/NFRCode 2.A.1

Description	*FuelName*	*Value*	*DataSource*
Cement kilns	-	200 000.00 ton	CEPMEIP

CRF/NFRCode 2.A.2

Description	*FuelName*	*Value*	*DataSource*
Lime production	-	14 000.00 ton	CEPMEIP

CRF/NFRCode 3.D

Description	*FuelName*	*Value*	*DataSource*
Fires	-	2 400 000.00 inhabit	EUROSTAT
Preservation of wood	-	2 400 000.00 inhabit	EUROSTAT

CRF/NFRCode 6.C

Description	*FuelName*	*Value*	*DataSource*
Incineration of hospital waste	-	200.00 ton	CC information
Open burning of agricultural wastes	-	180 000.00 ton	CEPMEIP
Open burning of agricultural wastes	-	180 000.00 ton	CEPMEIP
Open burning of domestic wastes	-	24 000.00 ton	CEPMEIP

CountryName Lithuania

CRF/NFRCode 1.A.1.a

Description	*FuelName*	*Value*	*DataSource*
Auto-producer electricity, heat and CHP plants, and public heat plants	Black liquor and other bio wastes	1 600.00 TJ	CEPMEIP
Public power plants	Heavy Fuel Oil	21 000.00 TJ	CC information
Public power plants	Natural Gas	47 000.00 TJ	CC information

CRF/NFRCode 1.A.2.f

Description	*FuelName*	*Value*	*DataSource*

Industrial combustion in other industrial sectors	Black liquor and other bio wastes	150.00 TJ	CEPMEIP

CRF/NFRCode *1.A.4.b.i*

Description	*FuelName*	*Value*	*DataSource*
Residential heating in small stoves or centralized heating systems	Brown coal	570.00 TJ	CC information
Residential heating in small stoves or centralized heating systems	Gas/Diesel Oil	51.00 TJ	CC information
Residential heating in small stoves or centralized heating systems	Wood and wood waste	21 000.00 TJ	CC information
Residential, commercial, institutional and other combustion	Solid and liquid waste fuels, waste tires, slud	220.00 TJ	CC information

CRF/NFRCode *2.A.1*

Description	*FuelName*	*Value*	*DataSource*
Cement kilns	-	650 000.00 ton	CEPMEIP

CRF/NFRCode *2.A.2*

Description	*FuelName*	*Value*	*DataSource*
Lime production	-	88 000.00 ton	CEPMEIP

CRF/NFRCode *3.D*

Description	*FuelName*	*Value*	*DataSource*
Fires	-	3 500 000.00 inhabit	EUROSTAT
Preservation of wood	-	3 500 000.00 inhabit	EUROSTAT

CRF/NFRCode *6.C*

Description	*FuelName*	*Value*	*DataSource*
Incineration of hospital waste	-	5 250.00 ton	TNO estimate
Industrial waste	-	27 000.00 ton	IOW
Open burning of agricultural wastes	-	460 000.00 ton	CEPMEIP
Open burning of agricultural wastes	-	460 000.00 ton	CEPMEIP
Open burning of domestic wastes	-	35 000.00 ton	CEPMEIP
Open burning of wood	-	4 000.00 ton	CC information

CountryName **Malta**

CRF/NFRCode *1.A.1.a*

Description	*FuelName*	*Value*	*DataSource*
Public power plants	Hard Coal	1 300.00 TJ	CEPMEIP
Public power plants	Heavy Fuel Oil	19 000.00 TJ	CEPMEIP

CRF/NFRCode *1.A.4.b.i*

Description	*FuelName*	*Value*	*DataSource*
Residential heating in small stoves or centralized heating systems	Wood and wood waste	1 000.00 TJ	CEPMEIP

CRF/NFRCode *2.A.2*

Description	*FuelName*	*Value*	*DataSource*
Lime production	-	5 000.00 ton	CEPMEIP

CRF/NFRCode *3.D*

Description	*FuelName*	*Value*	*DataSource*
Fires	-	390 000.00 inhabit	EUROSTAT
Preservation of wood	-	390 000.00 inhabit	EUROSTAT

CRF/NFRCode *6.C*

Description	*FuelName*	*Value*	*DataSource*

Incineration of hospital waste	-	585.00 ton	TNO estimate
Open burning of agricultural wastes	-	960.00 ton	CEPMEIP
Open burning of agricultural wastes	-	960.00 ton	CEPMEIP
Open burning of domestic wastes	-	3 900.00 ton	CEPMEIP

CountryName Poland

CRF/NFRCode 1.A.1.a

Description	*FuelName*	*Value*	*DataSource*
Auto-producer electricity, heat and CHP plants, and public heat plants	Black liquor and other bio wastes	1 300.00 TJ	CEPMEIP
Public power plants	Brown coal	530 000.00 TJ	CEPMEIP
Public power plants	Hard Coal	910 000.00 TJ	CEPMEIP
Public power plants	Heavy Fuel Oil	6 600.00 TJ	CEPMEIP
Public power plants	Natural Gas	110.00 TJ	CEPMEIP

CRF/NFRCode 1.A.2.b

Description	*FuelName*	*Value*	*DataSource*
Combustion in non-ferous metal	-	1 200.00 TJ	CC information

CRF/NFRCode 1.A.2.d

Description	*FuelName*	*Value*	*DataSource*
Industrial combustion in the paper and pulp industry	Black liquor and other bio wastes	15 000.00 TJ	CEPMEIP

CRF/NFRCode 1.A.2.f

Description	*FuelName*	*Value*	*DataSource*
Industrial combustion in other industrial sectors	Black liquor and other bio wastes	5 100.00 TJ	CEPMEIP

CRF/NFRCode 1.A.4.b.i

Description	*FuelName*	*Value*	*DataSource*
Residential heating in small stoves or centralized heating systems	Hard coal coke, brown coal coke and petroleum c	200 000.00 TJ	CC information
Residential heating in small stoves or centralized heating systems	Heavy Fuel Oil	8 800.00 TJ	CEPMEIP
Residential heating in small stoves or centralized heating systems	Wood and wood waste	100 000.00 TJ	CC information
Residential, commercial, institutional and other combustion	Solid and liquid waste fuels, waste tires, slud	22 000.00 TJ	CEPMEIP

CRF/NFRCode 1.B.1.b

Description	*FuelName*	*Value*	*DataSource*
Solid fuel transformation | Coke production	-	11 500 000.00 ton	IOW

CRF/NFRCode 2.A.1

Description	*FuelName*	*Value*	*DataSource*
Cement kilns	-	14 000 000.00 ton	CEPMEIP

CRF/NFRCode 2.A.2

Description	*FuelName*	*Value*	*DataSource*
Lime production	-	1 200 000.00 ton	CC information

CRF/NFRCode 2.C.1.1

Description	*FuelName*	*Value*	*DataSource*
Iron and steel plants (steel)	-	7 000 000.00 ton	CC information

CRF/NFRCode 2.C.1.2

Description	*FuelName*	*Value*	*DataSource*

Iron and steel plants (pig iron)	-	6 500 000.00 ton	CC information

CRF/NFRCode *2.C.1.3*

Description	***FuelName***	***Value***	***DataSource***
Iron ore sintering	-	8 000 000.00 ton	CC information

CRF/NFRCode *2.C.3*

Description	***FuelName***	***Value***	***DataSource***
(Secondary) aluminium production	-	123 000.00 ton	CC information

CRF/NFRCode *2.C.5*

Description	***FuelName***	***Value***	***DataSource***
Primary copper	-	406 000.00 ton	IOW
Secondary copper	-	29 000.00 ton	CEPMEIP
Secondary lead production	-	15 000.00 ton	IOW
Secondary zinc	-	13 000.00 ton	CEPMEIP

CRF/NFRCode *3.D*

Description	***FuelName***	***Value***	***DataSource***
Fires	-	39 000 000.00 inhabit	EUROSTAT
Preservation of wood	-	39 000 000.00 inhabit	EUROSTAT

CRF/NFRCode *6.C*

Description	***FuelName***	***Value***	***DataSource***
Hazardous waste incineration	-	2 100.00 ton	CC information
Incineration of hospital waste	-	58 500.00 ton	TNO estimate
Industrial waste	-	13 000.00 ton	IOW
Landfill fires	-	49 000.00 ton	CC information
Open burning of agricultural wastes	-	170 000.00 ton	CEPMEIP
Open burning of agricultural wastes	-	170 000.00 ton	CEPMEIP
Open burning of domestic wastes	-	390 000.00 ton	CEPMEIP

CountryName **Romania**

CRF/NFRCode *1.A.1.a*

Description	***FuelName***	***Value***	***DataSource***
Auto-producer electricity, heat and CHP plants, and public heat plants	Black liquor and other bio wastes	2 800.00 TJ	CEPMEIP
Public power plants	Brown coal	250 000.00 TJ	CC information
Public power plants	Heavy Fuel Oil	100 000.00 TJ	CC information
Public power plants	Natural Gas	175 000.00 TJ	CC information

CRF/NFRCode *1.A.2.d*

Description	***FuelName***	***Value***	***DataSource***
Industrial combustion in the paper and pulp industry	Black liquor and other bio wastes	2 600.00 TJ	CC information

CRF/NFRCode *1.A.2.f*

Description	***FuelName***	***Value***	***DataSource***
Industrial combustion in other industrial sectors	Black liquor and other bio wastes	6 400.00 TJ	CEPMEIP

CRF/NFRCode *1.A.4.b.i*

Description	***FuelName***	***Value***	***DataSource***
Residential heating in small stoves or centralized heating systems	Brown coal	300.00 TJ	CC information
Residential heating in small stoves or centralized heating systems	Gas/Diesel Oil	4 200.00 TJ	CEPMEIP

Residential heating in small stoves or centralized heating systems	Hard Coal	90.00 TJ	CEPMEIP
Residential heating in small stoves or centralized heating systems	Heavy Fuel Oil	120.00 TJ	CC information
Residential heating in small stoves or centralized heating systems	Wood and wood waste	73 000.00 TJ	CC information
Residential, commercial, institutional and other combustion	Solid and liquid waste fuels, waste tires, slud	1 200.00 TJ	CEPMEIP

CRF/NFRCode *1.B.1.b*

Description	FuelName	Value	DataSource
Solid fuel transformation | Coke production	-	4 700 000.00 ton	IOW

CRF/NFRCode *2.A.1*

Description	FuelName	Value	DataSource
Cement kilns	-	5 700 000.00 ton	CC information

CRF/NFRCode *2.A.2*

Description	FuelName	Value	DataSource
Lime production	-	1 800 000.00 ton	CEPMEIP

CRF/NFRCode *2.C.1.3*

Description	FuelName	Value	DataSource
Iron ore sintering	-	4 000 000.00 ton	CC information

CRF/NFRCode *2.C.3*

Description	FuelName	Value	DataSource
(Secondary) aluminium production	-	700.00 ton	CC information

CRF/NFRCode *2.C.5*

Description	FuelName	Value	DataSource
Secondary copper	-	18 000.00 ton	CC information
Secondary zinc	-	770.00 ton	CC information

CRF/NFRCode *3.D*

Description	FuelName	Value	DataSource
Fires	-	22 000 000.00 inhabit	EUROSTAT
Preservation of wood	-	22 000 000.00 inhabit	EUROSTAT

CRF/NFRCode *6.C*

Description	FuelName	Value	DataSource
Incineration of hospital waste	-	33 000.00 ton	CC information
Industrial waste	-	250 000.00 ton	IOW
Municipal / industrial waste incineration (legal)	-	44 000.00 ton	CC information
Open burning of agricultural wastes	-	170 000.00 ton	CC information
Open burning of agricultural wastes	-	170 000.00 ton	CC information
Open burning of domestic wastes	-	220 000.00 ton	CEPMEIP

CountryName Slovak Republic

CRF/NFRCode *1.A.1.a*

Description	FuelName	Value	DataSource
Auto-producer electricity, heat and CHP plants, and public heat plants	Black liquor and other bio wastes	3 100.00 TJ	CEPMEIP
Public power plants	Brown coal	43 000.00 TJ	CEPMEIP
Public power plants	Hard Coal	33 000.00 TJ	CEPMEIP
Public power plants	Heavy Fuel Oil	5 200.00 TJ	CEPMEIP

Public power plants	Natural Gas	40 000.00 TJ	CEPMEIP

CRF/NFRCode *1.A.2.f*

Description	***FuelName***	***Value***	***DataSource***
Industrial combustion in other industrial sectors	Black liquor and other bio wastes	2.00 TJ	CEPMEIP

CRF/NFRCode *1.A.4.b.i*

Description	***FuelName***	***Value***	***DataSource***
Residential heating in small stoves or centralized heating systems	Brown coal	20 000.00 TJ	CEPMEIP
Residential heating in small stoves or centralized heating systems	Hard Coal	6 300.00 TJ	CEPMEIP
Residential heating in small stoves or centralized heating systems	Hard coal coke, brown coal coke and petroleum c	1 600.00 TJ	CEPMEIP
Residential heating in small stoves or centralized heating systems	Heavy Fuel Oil	1 200.00 TJ	CEPMEIP
Residential heating in small stoves or centralized heating systems	Wood and wood waste	8 000.00 TJ	CEPMEIP

CRF/NFRCode *1.B.1.b*

Description	***FuelName***	***Value***	***DataSource***
Solid fuel transformation | Coke production	-	1 900 000.00 ton	IOW

CRF/NFRCode *2.A.1*

Description	***FuelName***	***Value***	***DataSource***
Cement kilns	-	2 900 000.00 ton	CEPMEIP

CRF/NFRCode *2.A.2*

Description	***FuelName***	***Value***	***DataSource***
Lime production	-	800 000.00 ton	CEPMEIP

CRF/NFRCode *2.C.1.3*

Description	***FuelName***	***Value***	***DataSource***
Iron ore sintering	-	3 300 000.00 ton	CEPMEIP

CRF/NFRCode *2.C.3*

Description	***FuelName***	***Value***	***DataSource***
(Secondary) aluminium production	-	1 400.00 ton	CEPMEIP

CRF/NFRCode *2.C.5*

Description	***FuelName***	***Value***	***DataSource***
Primary copper	-	7 000.00 ton	IOW
Secondary copper	-	17 000.00 ton	CEPMEIP
Secondary zinc	-	1 000.00 ton	CEPMEIP

CRF/NFRCode *3.D*

Description	***FuelName***	***Value***	***DataSource***
Fires	-	5 400 000.00 inhabit	EUROSTAT
Preservation of wood	-	5 400 000.00 inhabit	EUROSTAT

CRF/NFRCode *6.C*

Description	***FuelName***	***Value***	***DataSource***
Incineration of hospital waste	-	8 100.00 ton	CC information
Municipal / industrial waste incineration (legal)	-	131 070.00 ton	CC information
Open burning of agricultural wastes	-	700 000.00 ton	CEPMEIP
Open burning of agricultural wastes	-	700 000.00 ton	CEPMEIP
Open burning of domestic wastes	-	54 000.00 ton	CEPMEIP

CountryName **Slovenia**

CRF/NFRCode *1.A.1.a*

Description	FuelName	Value	DataSource
Auto-producer electricity, heat and CHP plants, and public heat plants	Black liquor and other bio wastes	110.00 TJ	CEPMEIP
Public power plants	Brown coal	48 000.00 TJ	CEPMEIP
Public power plants	Hard coal coke, brown coal coke and petroleum c	16 000.00 TJ	CEPMEIP
Public power plants	Heavy Fuel Oil	200.00 TJ	CEPMEIP
Public power plants	Natural Gas	50.00 TJ	CEPMEIP

CRF/NFRCode *1.A.2.f*

Description	FuelName	Value	DataSource
Industrial combustion in other industrial sectors	Black liquor and other bio wastes	2 600.00 TJ	CEPMEIP

CRF/NFRCode *1.A.4.b.i*

Description	FuelName	Value	DataSource
Residential heating in small stoves or centralized heating systems	Brown coal	1 500.00 TJ	CEPMEIP
Residential heating in small stoves or centralized heating systems	Gas/Diesel Oil	24 000.00 TJ	CEPMEIP
Residential heating in small stoves or centralized heating systems	Hard coal coke, brown coal coke and petroleum c	3 100.00 TJ	CEPMEIP
Residential heating in small stoves or centralized heating systems	Heavy Fuel Oil	360.00 TJ	CEPMEIP
Residential heating in small stoves or centralized heating systems	Sub-Bituminous Coal	700.00 TJ	CEPMEIP
Residential heating in small stoves or centralized heating systems	Wood and wood waste	6 000.00 TJ	CEPMEIP

CRF/NFRCode *2.A.1*

Description	FuelName	Value	DataSource
Cement kilns	-	990 000.00 ton	CEPMEIP

CRF/NFRCode *2.A.2*

Description	FuelName	Value	DataSource
Lime production	-	150 000.00 ton	CEPMEIP

CRF/NFRCode *2.C.1.3*

Description	FuelName	Value	DataSource
Iron ore sintering	-	250 000.00 ton	CEPMEIP

CRF/NFRCode *2.C.5*

Description	FuelName	Value	DataSource
Secondary lead production	-	7 500.00 ton	IOW

CRF/NFRCode *3.D*

Description	FuelName	Value	DataSource
Fires	-	2 000 000.00 inhabit	EUROSTAT
Preservation of wood	-	2 000 000.00 inhabit	EUROSTAT

CRF/NFRCode *6.C*

Description	FuelName	Value	DataSource
Incineration of hospital waste	-	3 000.00 ton	TNO estimate
Industrial waste	-	4 800.00 ton	IOW
Open burning of agricultural wastes	-	75 000.00 ton	CEPMEIP
Open burning of agricultural wastes	-	75 000.00 ton	CEPMEIP

Open burning of domestic wastes	-	20 000.00 ton	CEPMEIP

CountryName Turkey

CRF/NFRCode 1.A.1.a

Description	FuelName	Value	DataSource
Auto-producer electricity, heat and CHP plants, and public heat plants	Black liquor and other bio wastes	12 000.00 TJ	CEPMEIP
Public power plants	Brown coal	400 000.00 TJ	CEPMEIP
Public power plants	Hard Coal	28 000.00 TJ	CEPMEIP
Public power plants	Heavy Fuel Oil	39 000.00 TJ	CEPMEIP
Public power plants	Natural Gas	120 000.00 TJ	CEPMEIP

CRF/NFRCode 1.A.4.b.i

Description	FuelName	Value	DataSource
Residential heating in small stoves or centralized heating systems	Brown coal	67 000.00 TJ	CEPMEIP
Residential heating in small stoves or centralized heating systems	Hard Coal	32 000.00 TJ	CEPMEIP
Residential heating in small stoves or centralized heating systems	Heavy Fuel Oil	53 000.00 TJ	CEPMEIP
Residential heating in small stoves or centralized heating systems	Sub-Bituminous Coal	940.00 TJ	CEPMEIP
Residential heating in small stoves or centralized heating systems	Wood and wood waste	180 000.00 TJ	CEPMEIP

CRF/NFRCode 1.B.1.b

Description	FuelName	Value	DataSource
Solid fuel transformation | Coke production	-	3 100 000.00 ton	IOW

CRF/NFRCode 2.A.1

Description	FuelName	Value	DataSource
Cement kilns	-	33 000 000.00 ton	CEPMEIP

CRF/NFRCode 2.A.2

Description	FuelName	Value	DataSource
Lime production	-	900 000.00 ton	CEPMEIP

CRF/NFRCode 2.B

Description	FuelName	Value	DataSource
Chemical industry PVC	-	150 000.00 ton	CC information

CRF/NFRCode 2.C.1.3

Description	FuelName	Value	DataSource
Iron ore sintering	-	4 300 000.00 ton	CEPMEIP

CRF/NFRCode 2.C.3

Description	FuelName	Value	DataSource
(Secondary) aluminium production	-	70 000.00 ton	Toolkit & CC data

CRF/NFRCode 2.C.5

Description	FuelName	Value	DataSource
Primary copper	-	80 000.00 ton	IOW
Secondary copper	-	9 300.00 ton	CC information
Secondary zinc	-	11 000.00 ton	Toolkit & CC data

CRF/NFRCode 2.D.1

Description	FuelName	Value	DataSource

Pulp and paper industry Kraft process	-	1 050 000.00 ton	CC information

CRF/NFRCode *3.D*

Description	***FuelName***	***Value***	***DataSource***
Fires	-	67 000 000.00 inhabit	EUROSTAT
Preservation of wood	-	67 000 000.00 inhabit	EUROSTAT

CRF/NFRCode *6.C*

Description	***FuelName***	***Value***	***DataSource***
Incineration of hospital waste	-	110 000.00 ton	CC information
Open burning of agricultural wastes	-	280 000.00 ton	CEPMEIP
Open burning of agricultural wastes	-	280 000.00 ton	CEPMEIP
Open burning of domestic wastes	-	470 000.00 ton	CC information

Annex 3 Emission Factor details

<<Emission Factor Documentation>>

Description		*Value*	*Unit*
DataSource **BREF documents**			
233	Cement kilns (LTV)	0.25	µg I-TEQ/ton
228	Cement kilns BREF	0.2	µg I-TEQ/ton
224	Iron ore sintering BREF	0.5	µg I-TEQ/ton
229	Lime production BREF	0.2	µg I-TEQ/ton
221	Public power plants on solid fuels BREF	0.5	µg I-TEQ/TJ
225	Secondary aluminium BREF	10	µg I-TEQ/ton
226	Secondary copper BREF	10	µg I-TEQ/ton
227	Secondary zinc BREF	10	µg I-TEQ/ton
223	Steel production BREF	0.1	µg I-TEQ/ton
219	Waste Incineration Hazardous Waste, Hospital Waste, Municipal/Industrial Waste BREF	0.5	µg I-TEQ/ton
DataSource **Data from Candidate Country**			
181	Aluminium production | secondary aluminium (CZE)	35	µg I-TEQ/ton
194	Brass Production (HUN)	1	µg I-TEQ/ton
212	Cement kilns (POL)	0.07	µg I-TEQ/ton
187	Chemical industry | PVC (TUR)	0.1	µg I-TEQ/ton
184	Incineration of hazardous waste (CZE)	90	µg I-TEQ/ton
196	Incineration of hazardous waste (HUN)	0.75	µg I-TEQ/ton
217	Incineration of hazardous waste (POL)	35000	µg I-TEQ/ton
185	Incineration of hospital waste (CZE)	14	µg I-TEQ/ton
207	Incineration of hospital waste (EST)	3000	µg I-TEQ/ton
195	Incineration of hospital waste (HUN)	5	µg I-TEQ/ton
215	Incineration of hospital waste (POL)	450	µg I-TEQ/ton
216	Incineration of industrial waste (POL)	3500	µg I-TEQ/ton
183	Incineration of Municipal Waste (CZE)	0.5	µg I-TEQ/ton
197	Incineration of municipal/industrial waste (HUN)	1	µg I-TEQ/ton
210	Industrial combustion in non-ferrous industry; all fossil fuels (POL)	15000	µg I-TEQ/TJ
191	Industrial Combustion: brown coal (HUN)	90	µg I-TEQ/TJ
192	Industrial Combustion: fuel oil (HUN)	23	µg I-TEQ/TJ
189	Industrial waste incineration (SVK)	275	µg I-TEQ/ton
214	Iron ore sintering (POL)	1.5	µg I-TEQ/ton
190	Medical/hospital waste incineration (SVK)	815	µg I-TEQ/ton
188	Municipal waste incineration (SVK)	225	µg I-TEQ/ton
179	Pig Iron Tapping (CZE)	10	µg I-TEQ/ton
203	Public Power Plants (hard coal, coke, brown coal and pertroleum cokes (HUN)	150	µg I-TEQ/TJ
202	Public power plants Brown Coal (HUN)	90	µg I-TEQ/TJ
204	Public Power Plants Heavy fuel oil (HUN)	25	µg I-TEQ/TJ
208	Public power plants; brown coal or hard coal (POL)	2.4	µg I-TEQ/TJ
186	Pulp and paper | recycling paper (TUR)	10	µg I-TEQ/ton
198	Pulp and Paper mills (HUN)	3	µg I-TEQ/ton
200	Residential heating Brown Coal (CZE)	345	µg I-TEQ/TJ
201	Residential heating Hard Coal (CZE)	193	µg I-TEQ/TJ

Description		Value	Unit
205	Residential heating in small stoves, Brown Coal (HUN)	770	µg I-TEQ/TJ
206	Residential heating in small stoves, Wood and Wood Waste (HUN)	357	µg I-TEQ/TJ
209	Residential heating in small stoves; solid fuels (POL)	700	µg I-TEQ/TJ
211	Residential heating in small stoves; wood and wood waste (POL)	350	µg I-TEQ/TJ
218	Residential heating; brown coal (HUN)	770	µg I-TEQ/TJ
182	Secondary copper (CZE)	50	µg I-TEQ/ton
178	Solid Fuel Transformation (CZE)	0.3	µg I-TEQ/ton
180	Steel production | Clean scrap (CZE)	3	µg I-TEQ/ton
213	Steel production and pig iron tapping (POL)	2	µg I-TEQ/ton
193	Steel Production: BOF - Electrical Arc (HUN)	3	µg I-TEQ/ton
DataSource	**Estimated by TNO on basis of population sizes**		
199	Waste incineration; Waste wood and waste biomass incineration; clean wood	0	µg I-TEQ/ton
DataSource	**Personal communication Ulrich Quass**		
177	Secondary zinc production	150	µg I-TEQ/ton
DataSource	**The European Dioxin Inventory**		
176	Fires	1	µg I-TEQ/inhabi
175	Preservation of wood	1	µg I-TEQ/inhabi
DataSource	**TNO increased value upon request by JRC**		
238	Domestic heating in small stoves (Coal) 100	100	µg I-TEQ/TJ
236	Domestic heating in small stoves (Coal) 1000	1000	µg I-TEQ/TJ
230	Domestic heating in small stoves (Coal) 350	350	µg I-TEQ/TJ
234	Domestic heating in small stoves (Coal) 700	700	µg I-TEQ/TJ
239	Domestic heating in small stoves (Wood) 100	100	µg I-TEQ/TJ
237	Domestic heating in small stoves (Wood) 1000	1000	µg I-TEQ/TJ
232	Domestic heating in small stoves (Wood) 350	350	µg I-TEQ/TJ
235	Domestic heating in small stoves (Wood) 700	700	µg I-TEQ/TJ
DataSource	**UN Chemicals Dioxins Toolkit**		
2	1a1: Waste incineration; Municipal solid waste incineration; Low technol. combustion, no APC system	3500	µg I-TEQ/ton
3	1a2: Waste incineration; Municipal solid waste incineration; Controlled comb., minimal APC	350	µg I-TEQ/ton
4	1a3: Waste incineration; Municipal solid waste incineration; Controlled comb., good APC	30	µg I-TEQ/ton
5	1a4: Waste incineration; Municipal solid waste incineration; High tech. combustion, sophisticated APCS	0.5	µg I-TEQ/ton
6	1b1: Waste incineration; Hazardous waste incineration; Low technol. combustion, no APC system	3500	µg I-TEQ/ton
7	1b2: Waste incineration; Hazardous waste incineration; Controlled comb., minimal APC	350	µg I-TEQ/ton
8	1b3: Waste incineration; Hazardous waste incineration; Controlled comb., good APC	10	µg I-TEQ/ton
9	1b4: Waste incineration; Hazardous waste incineration; High tech. combustion, sophisticated APCS	0.75	µg I-TEQ/ton
10	1c1: Waste incineration; Medical/hospital waste incineration; Uncontrolled batch combustion, no APCS	40000	µg I-TEQ/ton
11	1c2: Waste incineration; Medical/hospital waste incineration; Controlled, batch, no or minimal APCS	3000	µg I-TEQ/ton
12	1c3: Waste incineration; Medical/hospital waste incineration; Controlled, batch comb., good APC	525	µg I-TEQ/ton

Description		Value	Unit
13	1c4: Waste incineration; Medical/hospital waste incineration; High tech, continuous, sophisticated APCS	1	µg I-TEQ/ton
14	1d1: Waste incineration; Light fraction shredder waste incineration; Uncontrolled batch comb., no APCS	1000	µg I-TEQ/ton
15	1d2: Waste incineration; Light fraction shredder waste incineration; Controlled, batch, no or minimal APC	50	µg I-TEQ/ton
16	1d3: Waste incineration; Light fraction shredder waste incineration; High tech, continuous, sophisticated APCS	1	µg I-TEQ/ton
17	1e1: Waste incineration; Sewage sludge incineration; Old furnaces, batch, no/little APCS	50	µg I-TEQ/ton
18	1e2: Waste incineration; Sewage sludge incineration; Updated, continuously, some APCS	4	µg I-TEQ/ton
19	1e3: Waste incineration; Sewage sludge incineration; State-of-the-art, full APCS	0.4	µg I-TEQ/ton
20	1f1: Waste incineration; Waste wood and waste biomass incineration; Old furnaces, batch, no/little APCS	100	µg I-TEQ/ton
21	1f2: Waste incineration; Waste wood and waste biomass incineration; Updated, continuously, some APCS	10	µg I-TEQ/ton
22	1f3: Waste incineration; Waste wood and waste biomass incineration; State-of-the-art, full APCS	1	µg I-TEQ/ton
23	1g1: Waste incineration; Animal carcasses burning; Old furnaces, batch, no/little APCS	500	µg I-TEQ/ton
24	1g2: Waste incineration; Animal carcasses burning; Updated, continuously, some APCS	50	µg I-TEQ/ton
25	1g3: Waste incineration; Animal carcasses burning; State-of-the-art, full APCS	5	µg I-TEQ/ton
26	2a1: Ferrous and Non-Ferrous Metal Production; Iron ore sintering; High waste recycling, incl. oil contamin. materials	20	µg I-TEQ/ton
27	2a2: Ferrous and Non-Ferrous Metal Production; Iron ore sintering; Low waste use, well controlled plant	5	µg I-TEQ/ton
28	2a3: Ferrous and Non-Ferrous Metal Production; Iron ore sintering; High technology, emission reduction	0.3	µg I-TEQ/ton
29	2b1: Ferrous and Non-Ferrous Metal Production; Coke production; No gas cleaning	3	µg I-TEQ/ton
30	2b2: Ferrous and Non-Ferrous Metal Production; Coke production; Afterburner/ dust removal	0.3	µg I-TEQ/ton
35	2c1: Ferrous and Non-Ferrous Metal Production; Iron and steel Foundries; Cold air cupola or rotary drum, n	10	µg I-TEQ/ton
31	2c1: Ferrous and Non-Ferrous Metal Production; Iron and steel production plants; Dirty scrap, scrap preheating, li	10	µg I-TEQ/ton
36	2c2: Ferrous and Non-Ferrous Metal Production; Iron and steel Foundries; Rotary Drum - fabric filter	4.3	µg I-TEQ/ton
32	2c2: Ferrous and Non-Ferrous Metal Production; Iron and steel production plants; Clean scrap/virgin iron, afterbur	3	µg I-TEQ/ton
37	2c3: Ferrous and Non-Ferrous Metal Production; Iron and steel Foundries; Cold air cupola, fabric filter	1	µg I-TEQ/ton
33	2c3: Ferrous and Non-Ferrous Metal Production; Iron and steel production plants; Clean scrap/virgin iron, BOS furn	0.1	µg I-TEQ/ton
38	2c4: Ferrous and Non-Ferrous Metal Production; Iron and steel Foundries; Hot air cupola or induction furna	0.03	µg I-TEQ/ton
34	2c4: Ferrous and Non-Ferrous Metal Production; Iron and steel production plants; Blast furnaces with APC	0.01	µg I-TEQ/ton
39	2d1: Ferrous and Non-Ferrous Metal Production; Copper production; Sec. Cu - Basic technology	800	µg I-TEQ/ton
40	2d2: Ferrous and Non-Ferrous Metal Production; Copper production; Sec. Cu - Well controlled	50	µg I-TEQ/ton
41	2d3: Ferrous and Non-Ferrous Metal Production; Copper production; Sec. Cu - Optimized for PCDD/PCDF control	5	µg I-TEQ/ton
42	2d4: Ferrous and Non-Ferrous Metal Production; Copper production; Smelting and casting of Cu/Cu alloys	0.03	µg I-TEQ/ton
43	2d5: Ferrous and Non-Ferrous Metal Production; Copper production; Prim. Cu – all types	0.01	µg I-TEQ/ton

Description		Value	Unit
44	2e1: Ferrous and Non-Ferrous Metal Production; Aluminum production (all sec.); Processing scrap Al, minimal treatment of inputs,	350	µg I-TEQ/ton
45	2e2: Ferrous and Non-Ferrous Metal Production; Aluminum production (all sec.); Scrap treatment, well controlled, good APCS	35	µg I-TEQ/ton
46	2e3: Ferrous and Non-Ferrous Metal Production; Aluminum production (all sec.); Shavings/turning drying	10	µg I-TEQ/ton
47	2e4: Ferrous and Non-Ferrous Metal Production; Aluminum production (all sec.); Optimized process, optimized APCS	1	µg I-TEQ/ton
48	2f1: Ferrous and Non-Ferrous Metal Production; Lead production; Sec. lead from scrap, PVC battery separators	80	µg I-TEQ/ton
49	2f2: Ferrous and Non-Ferrous Metal Production; Lead production; Sec. from PVC/Cl2 free scrap, blast furnaces with FF	8	µg I-TEQ/ton
50	2f3: Ferrous and Non-Ferrous Metal Production; Lead production; Sec. Lead, PVC/Cl2 free scrap in furnaces other than blast or bl	0.5	µg I-TEQ/ton
51	2g1: Ferrous and Non-Ferrous Metal Production; Zinc production; Kiln with no dust control	1000	µg I-TEQ/ton
52	2g2: Ferrous and Non-Ferrous Metal Production; Zinc production; Hot briquetting/rotarry furnaces, basic control	100	µg I-TEQ/ton
53	2g3: Ferrous and Non-Ferrous Metal Production; Zinc production; Comprehensive control	5	µg I-TEQ/ton
54	2g4: Ferrous and Non-Ferrous Metal Production; Zinc production; Melting (only)	0.3	µg I-TEQ/ton
55	2h1: Ferrous and Non-Ferrous Metal Production; Brass and bronze production; Simple melting furnaces	1	µg I-TEQ/ton
56	2h2: Ferrous and Non-Ferrous Metal Production; Brass and bronze production; Sophisticated equipment, e.g. induction ovens with A	0.1	µg I-TEQ/ton
57	2I1: Ferrous and Non-Ferrous Metal Production; Magnesium production; Using MgO/C thermal treatment in Cl2, no effluent treatment	250	µg I-TEQ/ton
58	2I2: Ferrous and Non-Ferrous Metal Production; Magnesium production; Using MgO/C thermal treatment in Cl2, comprehensive polluti	50	µg I-TEQ/ton
59	2j1: Ferrous and Non-Ferrous Metal Production; Thermal Non-ferrous metal production (e.g., Ni); Contaminated scrap, simple or no	100	µg I-TEQ/ton
60	2j2: Ferrous and Non-Ferrous Metal Production; Thermal Non-ferrous metal production (e.g., Ni); Clean scrap, good APCS	2	µg I-TEQ/ton
61	2l1: Ferrous and Non-Ferrous Metal Production; Shredders; Metal shredding plants	0.2	µg I-TEQ/ton
62	2m1: Ferrous and Non-Ferrous Metal Production; Thermal wire reclamation; Open burning of cable	5000	µg I-TEQ/ton
63	2m2: Ferrous and Non-Ferrous Metal Production; Thermal wire reclamation; Basic furnace with after burner, wet scrubber	40	µg I-TEQ/ton
64	2m3: Ferrous and Non-Ferrous Metal Production; Thermal wire reclamation; Burning electric motors, brake shoes, etc., afterburner	3.3	µg I-TEQ/ton
65	3a1: Power Generation and Heating; Fossil fuel power plants; Fossil fuel/waste co-fired power boilers	35	µg I-TEQ/TJ
66	3a2: Power Generation and Heating; Fossil fuel power plants; Coal fired power boilers	10	µg I-TEQ/TJ
67	3a3: Power Generation and Heating; Fossil fuel power plants; Heavy fuel fired power boilers	2.5	µg I-TEQ/TJ
68	3a4: Power Generation and Heating; Fossil fuel power plants; Light fuel oil/natural gas fired power boilers	0.5	µg I-TEQ/TJ
69	3b1: Power Generation and Heating; Biomass Power Plants; 1. Other biomass fired power boilers	500	µg I-TEQ/TJ
70	3b2: Power Generation and Heating; Biomass Power Plants; 2. Wood fired power boilers	50	µg I-TEQ/TJ

Description		Value	Unit
71	3c1: Power Generation and Heating; Landfill and biogas combustion; Biogas-fired boilers, motors/turbines and flaring	8	µg I-TEQ/TJ
72	3d1: Power Generation and Heating; Household heating and cooking - Biomass; Contaminated wood/biomass fired stoves	1500	µg I-TEQ/TJ
73	3d2: Power Generation and Heating; Household heating and cooking - Biomass; Virgin wood/biomass fired stoves	100	µg I-TEQ/TJ
74	3e1: Power Generation and Heating; Domesting heating - Fossil fuels; Coal fired stoves	70	µg I-TEQ/TJ
75	3e2: Power Generation and Heating; Domesting heating - Fossil fuels; Oil fired stoves	10	µg I-TEQ/TJ
76	3e3: Power Generation and Heating; Domesting heating - Fossil fuels; Natural gas fired stoves	1.5	µg I-TEQ/TJ
77	4a1: Production of Mineral Products; Cement kilns; Wet kilns, ESP temperature >300 °C	5	µg I-TEQ/ton
78	4a2: Production of Mineral Products; Cement kilns; Wetkilns, ESP/FF temperature 200 to 300 °C	0.6	µg I-TEQ/ton
79	4a3: Production of Mineral Products; Cement kilns; Wet kilns, ESP/FF temperature <200 °C and all types of dry kilns	0.15	µg I-TEQ/ton
80	4b1: Production of Mineral Products; Lime; Cyclone/no dust control	10	µg I-TEQ/ton
81	4b2: Production of Mineral Products; Lime; Good dust abatement	0.07	µg I-TEQ/ton
82	4c1: Production of Mineral Products; Brick; Cyclone/no dust control	0.2	µg I-TEQ/ton
83	4c2: Production of Mineral Products; Brick; Good dust abatement	0.02	µg I-TEQ/ton
84	4d1: Production of Mineral Products; Glass; Cyclone/no dust control	0.2	µg I-TEQ/ton
85	4d2: Production of Mineral Products; Glass; Good dust abatement	0.015	µg I-TEQ/ton
86	4e1: Production of Mineral Products; Ceramics; Cyclone/no dust control	0.2	µg I-TEQ/ton
87	4e2: Production of Mineral Products; Ceramics; Good dust abatement	0.02	µg I-TEQ/ton
88	4f1: Production of Mineral Products; Asphalt mixing; Mixing plant with no gas cleaning	0.07	µg I-TEQ/ton
89	4f2: Production of Mineral Products; Asphalt mixing; Mixing plant with fabric filter, wet scrubber	0.01	µg I-TEQ/ton
90	5a1: Transport; 4-Stroke engines; Leaded fuel	2.2	µg I-TEQ/ton
91	5a2: Transport; 4-Stroke engines; Unleaded fuel without catalyst	0.1	µg I-TEQ/ton
92	5a3: Transport; 4-Stroke engines; Unleaded fuel with catalyst	0	µg I-TEQ/ton
93	5b1: Transport; 2-Stroke engines; Leaded fuel	3.5	µg I-TEQ/ton
94	5b2: Transport; 2-Stroke engines; Unleaded fuel without catalyst	2.5	µg I-TEQ/ton
95	5c1: Transport; Diesel engines; Diesel engines	0.1	µg I-TEQ/ton
96	5d1: Transport; Heavy oil fired engines; All types	4	µg I-TEQ/ton
97	6a1: Uncontrolled Combustion Processes; Fires/burnings - biomass; Forest fires	5	µg I-TEQ/ton
98	6a2: Uncontrolled Combustion Processes; Fires/burnings - biomass; Grassland and moor fires	5	µg I-TEQ/ton
99	6a3: Uncontrolled Combustion Processes; Fires/burnings - biomass; Agricultural residue burning (in field)	30	µg I-TEQ/ton
100	6b1: Uncontrolled Combustion Processes; Fires, waste burning, landfill fires, industrial fires, accidental fires; Landfill fires	1000	µg I-TEQ/ton
101	6b2: Uncontrolled Combustion Processes; Fires, waste burning, landfill fires, industrial fires, accidental fires; Accidental fir	400	µg I-TEQ/ton

Description		Value	Unit
102	6b3: Uncontrolled Combustion Processes; Fires, waste burning, landfill fires, industrial fires, accidental fires; Uncontrolled d	300	µg I-TEQ/ton
103	6b4: Uncontrolled Combustion Processes; Fires, waste burning, landfill fires, industrial fires, accidental fires; Accidental fir	94	µg I-TEQ/ton
104	6b5: Uncontrolled Combustion Processes; Fires, waste burning, landfill fires, industrial fires, accidental fires; Open burning o	60	µg I-TEQ/ton
106	7a1a: Production of Chemicals, Consumer Goods; Pulp and paper mills; Boilers; Black liquor boilers, burning of sludges, wood	0.07	µg I-TEQ/ton pu
107	7a1b: Production of Chemicals, Consumer Goods; Pulp and paper mills; 2. Bark boilers only	0.4	µg I-TEQ/ton pu
140	7b52a: Production of Chemicals, Consumer Goods; Chemical industry; Modern Plants; EDC/VCM and/or EDC/VCM/PVC	0.95	µg I-TEQ/ton
141	7b52b: Production of Chemicals, Consumer Goods; Chemical industry; Modern Plants; PVC only	0.0003	µg I-TEQ/ton
147	8a1: Miscellaneous; Drying of biomass; Clean wood	0.01	µg I-TEQ/ton
148	8a2: Miscellaneous; Drying of biomass; Green fodder	0.1	µg I-TEQ/ton
149	8a3: Miscellaneous; Drying of biomass; PCP- or otherwise treated biomass	10	µg I-TEQ/ton
150	8b1: Miscellaneous; Crematoria; No control	90	µg I-TEQ/ton
151	8b2: Miscellaneous; Crematoria; Medium control	10	µg I-TEQ/ton
152	8b3: Miscellaneous; Crematoria; Optimal control	0.4	µg I-TEQ/ton
153	8c1: Miscellaneous; Smoke houses; Treated wood, waste fuels used as fuel	50	µg I-TEQ/ton
154	8c2: Miscellaneous; Smoke houses; Clean fuel, no afterburner	6	µg I-TEQ/ton
155	8c3: Miscellaneous; Smoke houses; Clean fuel, afterburner	0.6	µg I-TEQ/ton
158	8e1: Miscellaneous; Tobacco smoking *; Cigar (per item)	0.3	pg I-TEQ/ton
159	8e2: Miscellaneous; Tobacco smoking *; Cigarette (per item)	0.1	µg I-TEQ/ton
174	9e1: Disposal/Landfill; Waste oil disposal; All fractions	4	µg I-TEQ/ton

Annex 4 Detailed Emission Inventory data

<<Emissions full report>>

Pollutant dioxins and furans to air

CountryName *Bulgaria*

CRF/NFR	Description	Fuel	Activity		Emission		Emission Factor	
1.A.1.a	Auto-producer electricity, heat and CHP plants, and public heat plants	Black liquor and other bio wastes	1 400.00	TJ	100%	0.70 g I-TEQ	500 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.1.a	Public power plants	Brown coal	170 000.00	TJ	100%	1.70 g I-TEQ	10 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.1.a	Public power plants	Hard Coal	28 000.00	TJ	100%	0.28 g I-TEQ	10 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.1.a	Public power plants	Hard coal coke, brown coal coke and petroleum c	18 000.00	TJ	100%	0.18 g I-TEQ	10 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.1.a	Public power plants	Heavy Fuel Oil	8 700.00	TJ	100%	0.02 g I-TEQ	2.5 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.1.a	Public power plants	Natural Gas	44 000.00	TJ	100%	0.02 g I-TEQ	0.5 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.2.d	Industrial combustion in the paper and pulp industry	Black liquor and other bio wastes	2.00	TJ	100%	0.00 g I-TEQ	500 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.2.f	Industrial combustion in other industrial sectors	Black liquor and other bio wastes	230.00	TJ	100%	0.12 g I-TEQ	500 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.4.b.i	Residential heating in small stoves or centralized heating systems	Brown coal	17 000.00	TJ	100%	1.19 g I-TEQ	70 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.4.b.i	Residential heating in small stoves or centralized heating systems	Gas/Diesel Oil	12 000.00	TJ	100%	0.12 g I-TEQ	10 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.4.b.i	Residential heating in small stoves or centralized heating systems	Hard Coal	80.00	TJ	100%	0.01 g I-TEQ	70 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.4.b.i	Residential heating in small stoves or centralized heating systems	Heavy Fuel Oil	2 000.00	TJ	100%	0.02 g I-TEQ	10 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.4.b.i	Residential heating in small stoves or centralized heating systems	Sub-Bituminous Coal	2 100.00	TJ	100%	0.15 g I-TEQ	70 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.4.b.i	Residential heating in small stoves or centralized heating systems	Wood and wood waste	25 000.00	TJ	100%	2.50 g I-TEQ	100 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.B.1.b	Solid fuel transformation | Coke production	-	12 400 000.00	ton	100%	37.20 g I-TEQ	3 µg I-TEQ/ton	Toolkit factor selected by TNO
2.A.1	Cement kilns	-	2 100 000.00	ton	100%	10.50 g I-TEQ	5 µg I-TEQ/ton	Toolkit factor selected by TNO
2.A.2	Lime production	-	800 000.00	ton	100%	8.00 g I-TEQ	10 µg I-TEQ/ton	Toolkit factor selected by TNO
2.C.1.3	Iron ore sintering	-	2 500 000.00	ton	100%	50.00 g I-TEQ	20 µg I-TEQ/ton	Toolkit factor selected by TNO
2.C.5	Secondary copper	-	5 000.00	ton	100%	4.00 g I-TEQ	800 µg I-TEQ/ton	Toolkit factor selected by TNO
2.C.5	Secondary lead production	-	10 000.00	ton	100%	0.80 g I-TEQ	80 µg I-TEQ/ton	Toolkit factor selected by TNO
2.C.5	Secondary zinc	-	5 500.00	ton	100%	0.83 g I-TEQ	150 µg I-TEQ/ton	Data from Candidate Country
3.D	Fires	-	8 100 000.00	inhabitant	100%	8.10 g I-TEQ	1 µg I-TEQ/inha	Toolkit factor selected by TNO

CRF/NFR	Description	Fuel	Activity		Emission		Emission Factor		Source
3.D	Preservation of wood	-	8 100 000.00	inhabitant	100%	8.10 g I-TEQ	1	µg I-TEQ/inha	Toolkit factor selected by TNO
6.C	Incineration of hospital waste	-	12 150.00	ton	100%	36.45 g I-TEQ	3000	µg I-TEQ/ton	Toolkit factor selected by TNO
6.C	Industrial waste	-	266 000.00	ton	100%	93.10 g I-TEQ	350	µg I-TEQ/ton	Toolkit factor selected by TNO
6.C	Open burning of agricultural wastes	-	290 000.00	ton	5%	0.44 g I-TEQ	30	µg I-TEQ/ton	Toolkit factor selected by TNO
6.C	Open burning of domestic wastes	-	81 000.00	ton	100%	24.30 g I-TEQ	300	µg I-TEQ/ton	Toolkit factor selected by TNO

Sum for Bulgaria (27 detail records) ***288.81*** g I-TEQ

CountryName *Cyprus*

CRF/NFR	Description	Fuel	Activity		Emission		Emission Factor		Source
1.A.1.a	Public power plants	Heavy Fuel Oil	37 500.00	TJ	100%	0.09 g I-TEQ	2.5	µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.4.b.i	Residential heating in small stoves or centralized heating systems	Gas/Diesel Oil	6 000.00	TJ	100%	0.06 g I-TEQ	10	µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.4.b.i	Residential heating in small stoves or centralized heating systems	Wood and wood waste	1.00	TJ	100%	0.00 g I-TEQ	100	µg I-TEQ/TJ	Toolkit factor selected by TNO
2.A.1	Cement kilns	-	1 400 000.00	ton	100%	0.84 g I-TEQ	0.6	µg I-TEQ/ton	Toolkit factor, confirmed by or consistent with CC Data
2.A.2	Lime production	-	5 500.00	ton	100%	0.00 g I-TEQ	0.07	µg I-TEQ/ton	Toolkit factor, confirmed by or consistent with CC Data
2.C.2	Foundries	-	500.00	ton	100%	0.00 g I-TEQ	1	µg I-TEQ/ton	Data from Candidate Country
2.C.3	(Secondary) aluminium production	-	250.00	ton	100%	0.01 g I-TEQ	35	µg I-TEQ/ton	Toolkit factor, confirmed by or consistent with CC Data
3.D	Fires	-	720 000.00	inhabitant	100%	0.72 g I-TEQ	1	µg I-TEQ/inha	Toolkit factor selected by TNO
3.D	Preservation of wood	-	720 000.00	inhabitant	100%	0.72 g I-TEQ	1	µg I-TEQ/inha	Toolkit factor selected by TNO
6.C	Incineration of hospital waste	-	500.00	ton	100%	1.50 g I-TEQ	3000	µg I-TEQ/ton	Toolkit factor selected by TNO
6.C	Open burning of agricultural wastes	-	61 000.00	ton	5%	0.09 g I-TEQ	30	µg I-TEQ/ton	Toolkit factor selected by TNO
6.C	Open burning of domestic wastes	-	8 600.00	ton	100%	2.58 g I-TEQ	300	µg I-TEQ/ton	Toolkit factor selected by TNO

Sum for Cyprus (12 detail records) ***6.61*** g I-TEQ

CountryName *Czech Republic*

CRF/NFR	Description	Fuel	Activity		Emission		Emission Factor		Source
1.A.1.a	Auto-producer electricity, heat and CHP plants, and public heat plants	Black liquor and other bio wastes	2 800.00	TJ	100%	1.40 g I-TEQ	500	µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.1.a	Public power plants	Brown coal	510 000.00	TJ	100%	5.10 g I-TEQ	10	µg I-TEQ/TJ	Toolkit factor, confirmed by or consistent with CC Data
1.A.1.a	Public power plants	Hard coal coke, brown coal coke and petroleum c	120 000.00	TJ	100%	1.20 g I-TEQ	10	µg I-TEQ/TJ	Toolkit factor, confirmed by or consistent with CC Data

CRF/NFR	Description	Fuel	Activity		Emission		Emission Factor	
1.A.1.a	Public power plants	Heavy Fuel Oil	29 000.00	TJ	100%	0.07 g I-TEQ	2.5 µg I-TEQ/TJ	Toolkit factor, confirmed by or consistent with CC Data
1.A.1.a	Public power plants	Natural Gas	13 000.00	TJ	100%	0.01 g I-TEQ	0.5 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.4.b.i	Residential heating in small stoves or centralized heating systems	Brown coal	52 000.00	TJ	100%	17.94 g I-TEQ	345 µg I-TEQ/TJ	Data from Candidate Country
1.A.4.b.i	Residential heating in small stoves or centralized heating systems	Gas/Diesel Oil	2 900.00	TJ	100%	0.03 g I-TEQ	10 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.4.b.i	Residential heating in small stoves or centralized heating systems	Hard Coal	5 000.00	TJ	100%	0.97 g I-TEQ	193 µg I-TEQ/TJ	Data from Candidate Country
1.A.4.b.i	Residential heating in small stoves or centralized heating systems	Hard coal coke, brown coal coke and petroleum c	6 000.00	TJ	100%	1.16 g I-TEQ	193 µg I-TEQ/TJ	Data from Candidate Country
1.A.4.b.i	Residential heating in small stoves or centralized heating systems	Heavy Fuel Oil	1 100.00	TJ	100%	0.01 g I-TEQ	10 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.4.b.i	Residential heating in small stoves or centralized heating systems	Wood and wood waste	10 000.00	TJ	100%	1.00 g I-TEQ	100 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.B.1.b	Solid fuel transformation | Coke production	-	2 500 000.00	ton	100%	0.75 g I-TEQ	0.3 µg I-TEQ/ton	Toolkit factor selected by TNO
2.A.1	Cement kilns	-	4 800 000.00	ton	100%	24.00 g I-TEQ	5 µg I-TEQ/ton	Toolkit factor selected by TNO
2.A.2	Lime production	-	1 200 000.00	ton	100%	12.00 g I-TEQ	10 µg I-TEQ/ton	Toolkit factor, confirmed by or consistent with CC Data
2.C.1	Steel production | Clean scrap	-	6 000 000.00	ton	100%	18.00 g I-TEQ	3 µg I-TEQ/ton	Data from Candidate Country
2.C.1.2	Iron and steel plants (pig iron)	-	4 700 000.00	ton	100%	47.00 g I-TEQ	10 µg I-TEQ/ton	Data from Candidate Country
2.C.1.3	Iron ore sintering	-	6 500 000.00	ton	100%	130.00 g I-TEQ	20 µg I-TEQ/ton	Toolkit factor, confirmed by or consistent with CC Data
2.C.2	Foundries	-	370 000.00	ton	100%	0.37 g I-TEQ	1 µg I-TEQ/ton	Toolkit factor, confirmed by or consistent with CC Data
2.C.3	(Secondary) aluminium production	-	35 000.00	ton	100%	1.23 g I-TEQ	35 µg I-TEQ/ton	Toolkit factor, confirmed by or consistent with CC Data
2.C.5	Secondary copper	-	12 000.00	ton	100%	0.60 g I-TEQ	50 µg I-TEQ/ton	Toolkit factor, confirmed by or consistent with CC Data
2.C.5	Secondary zinc	-	1 000.00	ton	100%	0.15 g I-TEQ	150 µg I-TEQ/ton	Toolkit factor, confirmed by or consistent with CC Data
3.D	Fires	-	10 000 000.00	inhabitant	100%	10.00 g I-TEQ	1 µg I-TEQ/inha	Toolkit factor selected by TNO
3.D	Preservation of wood	-	10 000 000.00	inhabitant	100%	10.00 g I-TEQ	1 µg I-TEQ/inha	Toolkit factor selected by TNO
6.C	Hazardous waste incineration	-	43 000.00	ton	100%	3.87 g I-TEQ	90 µg I-TEQ/ton	Data from Candidate Country
6.C	Incineration of hospital waste	-	15 000.00	ton	100%	0.21 g I-TEQ	14 µg I-TEQ/ton	Data from Candidate Country

CRF/NFR	Description	Fuel	Activity		Emission		Emission Factor	
6.C	Municipal / industrial waste incineration (legal)	-	370 000.00 ton	100%	0.19 g I-TEQ	0.5 µg I-TEQ/ton	Toolkit factor, confirmed by or consistent with CC Data	
6.C	Open burning of agricultural wastes	-	1 500 000.00 ton	5%	2.25 g I-TEQ	30 µg I-TEQ/ton	Toolkit factor selected by TNO	
6.C	Open burning of domestic wastes	-	100 000.00 ton	100%	30.00 g I-TEQ	300 µg I-TEQ/ton	Toolkit factor selected by TNO	
Sum for Czech Republic (28 detail records)					***319.49*** g I-TEQ			

CountryName	*Estonia*						
1.A.1.a	Auto-producer electricity, heat and CHP plants, and public heat plants	Black liquor and other bio wastes	4 000.00 TJ	100%	2.00 g I-TEQ	500 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.1.a	Public power plants	Brown coal	89 000.00 TJ	100%	0.89 g I-TEQ	10 µg I-TEQ/TJ	Toolkit factor, confirmed by or consistent with CC Data
1.A.1.a	Public power plants	Heavy Fuel Oil	2 900.00 TJ	100%	0.01 g I-TEQ	2.5 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.1.a	Public power plants	Natural Gas	17 700.00 TJ	100%	0.01 g I-TEQ	0.5 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.2.d	Industrial combustion in the paper and pulp industry	Black liquor and other bio wastes	725.00 TJ	100%	0.36 g I-TEQ	500 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.2.f	Industrial combustion in other industrial sectors	Black liquor and other bio wastes	459.00 TJ	100%	0.23 g I-TEQ	500 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.4.b.i	Residential heating in small stoves or centralized heating systems	Brown coal	1 400.00 TJ	100%	0.10 g I-TEQ	70 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.4.b.i	Residential heating in small stoves or centralized heating systems	Gas/Diesel Oil	260.00 TJ	100%	0.00 g I-TEQ	10 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.4.b.i	Residential heating in small stoves or centralized heating systems	Hard Coal	674.00 TJ	100%	0.05 g I-TEQ	70 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.4.b.i	Residential heating in small stoves or centralized heating systems	Wood and wood waste	13 600.00 TJ	100%	1.36 g I-TEQ	100 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.B.1.b	Solid fuel transformation | Coke production	-	40 000.00 ton	100%	0.12 g I-TEQ	3 µg I-TEQ/ton	Toolkit factor selected by TNO
2.A.1	Cement kilns	-	405 000.00 ton	100%	0.24 g I-TEQ	0.6 µg I-TEQ/ton	Toolkit factor, confirmed by or consistent with CC Data
2.A.2	Lime production	-	20 000.00 ton	100%	0.00 g I-TEQ	0.07 µg I-TEQ/ton	Toolkit factor, confirmed by or consistent with CC Data
3.D	Fires	-	1 400 000.00 inhabitant	100%	1.40 g I-TEQ	1 µg I-TEQ/inha	Toolkit factor selected by TNO
3.D	Preservation of wood	-	1 400 000.00 inhabitant	100%	1.40 g I-TEQ	1 µg I-TEQ/inha	Toolkit factor selected by TNO
6.C	Incineration of hospital waste	-	9.50 ton	100%	0.03 g I-TEQ	3000 µg I-TEQ/ton	Data from Candidate Country
6.C	Open burning of agricultural wastes	-	130 000.00 ton	5%	0.20 g I-TEQ	30 µg I-TEQ/ton	Toolkit factor selected by TNO
6.C	Open burning of domestic wastes	-	1 000.00 ton	100%	0.30 g I-TEQ	300 µg I-TEQ/ton	Toolkit factor selected by TNO
Sum for Estonia (18 detail records)					***8.69*** g I-TEQ		

CRF/NFR	Description	Fuel	Activity		Emission		Emission Factor	
CountryName	*Hungary*							
1.A.1.a	Auto-producer electricity, heat and CHP plants, and public heat plants	Black liquor and other bio wastes	220.00 TJ	100%	0.11 g I-TEQ	500 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.1.a	Public power plants	Brown coal	54 500.00 TJ	100%	4.91 g I-TEQ	90 µg I-TEQ/TJ	Data from Candidate Country
1.A.1.a	Public power plants	Hard coal coke, brown coal coke and petroleum c	57 000.00 TJ	100%	8.55 g I-TEQ	150 µg I-TEQ/TJ	Data from Candidate Country
1.A.1.a	Public power plants	Heavy Fuel Oil	44 000.00 TJ	100%	1.10 g I-TEQ	25 µg I-TEQ/TJ	Data from Candidate Country
1.A.1.a	Public power plants	Natural Gas	67 000.00 TJ	100%	0.03 g I-TEQ	0.5 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.2.d	Industrial combustion in the paper and pulp industry	Black liquor and other bio wastes	4.00 TJ	100%	0.00 g I-TEQ	500 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.2.f	Industrial combustion in other industrial sectors	Brown coal	26 000.00 TJ	100%	2.34 g I-TEQ	90 µg I-TEQ/TJ	Data from Candidate Country
1.A.2.f	Industrial combustion in other industrial sectors	Heavy Fuel Oil	21 000.00 TJ	100%	0.48 g I-TEQ	23 µg I-TEQ/TJ	Data from Candidate Country
1.A.4.b.i	Residential heating in small stoves or centralized heating systems	Brown coal	16 000.00 TJ	100%	12.32 g I-TEQ	770 µg I-TEQ/TJ	Data from Candidate Country
1.A.4.b.i	Residential heating in small stoves or centralized heating systems	Gas/Diesel Oil	14 000.00 TJ	100%	0.14 g I-TEQ	10 µg I-TEQ/TJ	Toolkit factor, confirmed by or consistent with CC Data
1.A.4.b.i	Residential heating in small stoves or centralized heating systems	Wood and wood waste	10 000.00 TJ	100%	3.57 g I-TEQ	357 µg I-TEQ/TJ	Data from Candidate Country
1.B.1.b	Solid fuel transformation | Coke production	-	680 000.00 ton	100%	2.04 g I-TEQ	3 µg I-TEQ/ton	Toolkit factor, confirmed by or consistent with CC Data
2.A.1	Cement kilns	-	3 450 000.00 ton	100%	2.07 g I-TEQ	0.6 µg I-TEQ/ton	Toolkit factor, confirmed by or consistent with CC Data
2.A.2	Lime production	-	350 000.00 ton	100%	0.02 g I-TEQ	0.07 µg I-TEQ/ton	Toolkit factor, confirmed by or consistent with CC Data
2.A.6	Asphalt mixing	-	2 900 000.00 ton	100%	0.20 g I-TEQ	0.07 µg I-TEQ/ton	Toolkit factor, confirmed by or consistent with CC Data
2.A.7	Brick and tile production	-	4 200 000.00 ton	100%	0.84 g I-TEQ	0.2 µg I-TEQ/ton	Toolkit factor selected by TNO
2.A.7	Ceramics	-	4 800 000.00 ton	100%	0.96 g I-TEQ	0.2 µg I-TEQ/ton	Toolkit factor, confirmed by or consistent with CC Data
2.A.7	Glass production	-	395 000.00 ton	100%	0.08 g I-TEQ	0.2 µg I-TEQ/ton	Toolkit factor selected by TNO
2.B.5	Production of EDC	-	340 000.00 ton	100%	0.32 g I-TEQ	0.95 µg I-TEQ/ton	Toolkit factor, confirmed by or consistent with CC Data
2.C.1.1	Iron and steel plants (steel)	-	2 000 000.00 ton	100%	6.00 g I-TEQ	3 µg I-TEQ/ton	Data from Candidate Country
2.C.1.2	Iron and steel plants (pig iron)	-	1 350 000.00 ton	100%	2.70 g I-TEQ	2 µg I-TEQ/ton	Data from Candidate Country

CRF/NFR	Description	Fuel	Activity			Emission	Emission Factor	
2.C.1.3	Iron ore sintering	-	500 000.00	ton	100%	2.50 g I-TEQ	5 µg I-TEQ/ton	Toolkit factor selected by TNO
2.C.3	(Secondary) aluminium production	-	35 000.00	ton	100%	12.25 g I-TEQ	350 µg I-TEQ/ton	Toolkit factor, confirmed by or consistent with CC Data
2.C.5	Brass and bronze production	-	2 000 000.00	ton	100%	2.00 g I-TEQ	1 µg I-TEQ/ton	Data from Candidate Country
2.C.5	Secondary copper	-	30 000.00	ton	100%	1.50 g I-TEQ	50 µg I-TEQ/ton	Data from Candidate Country
2.D.1	Pulp and paper mills	-	496 000.00	ton	100%	1.49 g I-TEQ	3 µg I-TEQ/ton	Data from Candidate Country
3.D	Fires	-	10 000 000.00	inhabitant	100%	10.00 g I-TEQ	1 µg I-TEQ/inha	Toolkit factor selected by TNO
3.D	Preservation of wood	-	10 000 000.00	inhabitant	100%	10.00 g I-TEQ	1 µg I-TEQ/inha	Toolkit factor selected by TNO
6.C	Hazardous waste incineration	-	78 000.00	ton	100%	0.06 g I-TEQ	0.75 µg I-TEQ/ton	Data from Candidate Country
6.C	Incineration of hospital waste	-	15 000.00	ton	100%	0.08 g I-TEQ	5 µg I-TEQ/ton	Data from Candidate Country
6.C	Municipal / industrial waste incineration (legal)	-	353 000.00	ton	100%	0.35 g I-TEQ	1 µg I-TEQ/ton	Data from Candidate Country
6.C	Open burning of agricultural wastes	-	1 900 000.00	ton	5%	2.85 g I-TEQ	30 µg I-TEQ/ton	Toolkit factor selected by TNO
6.C	Open burning of domestic wastes	-	100 000.00	ton	100%	30.00 g I-TEQ	300 µg I-TEQ/ton	Toolkit factor selected by TNO

Sum for Hungary (33 detail records) ***121.87*** g I-TEQ

CountryName *Latvia*

1.A.1.a	Public power plants	Hard coal coke, brown coal coke and petroleum c	1 000.00	TJ	100%	0.01 g I-TEQ	10 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.1.a	Public power plants	Heavy Fuel Oil	8 200.00	TJ	100%	0.02 g I-TEQ	2.5 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.1.a	Public power plants	Natural Gas	25 000.00	TJ	100%	0.01 g I-TEQ	0.5 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.1.a	Public power plants	Peat	2 000.00	TJ	100%	1.00 g I-TEQ	500 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.1.a	Public power plants	Wood and wood waste	9 000.00	TJ	100%	0.45 g I-TEQ	50 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.4.b.i	Residential heating in small stoves or centralized heating systems	Gas/Diesel Oil	3 000.00	TJ	100%	0.03 g I-TEQ	10 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.4.b.i	Residential heating in small stoves or centralized heating systems	Hard Coal	1 500.00	TJ	100%	0.11 g I-TEQ	70 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.4.b.i	Residential heating in small stoves or centralized heating systems	Wood and wood waste	30 000.00	TJ	100%	3.00 g I-TEQ	100 µg I-TEQ/TJ	Toolkit factor selected by TNO
2.A.1	Cement kilns	-	200 000.00	ton	100%	0.05 g I-TEQ	0.25 µg I-TEQ/ton	Data from Candidate Country
2.A.2	Lime production	-	14 000.00	ton	100%	0.14 g I-TEQ	10 µg I-TEQ/ton	Toolkit factor selected by TNO
3.D	Fires	-	2 400 000.00	inhabitant	100%	2.40 g I-TEQ	1 µg I-TEQ/inha	Toolkit factor selected by TNO
3.D	Preservation of wood	-	2 400 000.00	inhabitant	100%	2.40 g I-TEQ	1 µg I-TEQ/inha	Toolkit factor selected by TNO
6.C	Incineration of hospital waste	-	200.00	ton	100%	0.60 g I-TEQ	3000 µg I-TEQ/ton	Toolkit factor selected by TNO

CRF/NFR	Description	Fuel	Activity		Emission		Emission Factor	
6.C	Open burning of agricultural wastes	-	180 000.00 ton	5%	0.27 g I-TEQ	30 µg I-TEQ/ton	Toolkit factor selected by TNO
6.C	Open burning of domestic wastes	-	24 000.00 ton	100%	7.20 g I-TEQ	300 µg I-TEQ/ton	Toolkit factor selected by TNO

Sum for Latvia (15 detail records) ***17.69*** g I-TEQ

CountryName *Lithuania*

CRF/NFR	Description	Fuel	Activity		Emission	Emission Factor	
1.A.1.a	Auto-producer electricity, heat and CHP plants, and public heat plants	Black liquor and other bio wastes	1 600.00 TJ	100%	0.80 g I-TEQ	500 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.1.a	Public power plants	Heavy Fuel Oil	21 000.00 TJ	100%	0.05 g I-TEQ	2.5 µg I-TEQ/TJ	Toolkit factor, confirmed by or consistent with CC Data
1.A.1.a	Public power plants	Natural Gas	47 000.00 TJ	100%	0.02 g I-TEQ	0.5 µg I-TEQ/TJ	Toolkit factor, confirmed by or consistent with CC Data
1.A.2.f	Industrial combustion in other industrial sectors	Black liquor and other bio wastes	150.00 TJ	100%	0.08 g I-TEQ	500 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.4.b.i	Residential heating in small stoves or centralized heating systems	Brown coal	570.00 TJ	100%	0.04 g I-TEQ	70 µg I-TEQ/TJ	Toolkit factor, confirmed by or consistent with CC Data
1.A.4.b.i	Residential heating in small stoves or centralized heating systems	Gas/Diesel Oil	51.00 TJ	100%	0.00 g I-TEQ	10 µg I-TEQ/TJ	Toolkit factor, confirmed by or consistent with CC Data
1.A.4.b.i	Residential heating in small stoves or centralized heating systems	Wood and wood waste	21 000.00 TJ	100%	2.10 g I-TEQ	100 µg I-TEQ/TJ	Toolkit factor, confirmed by or consistent with CC Data
1.A.4.b.i	Residential, commercial, institutional and other combustion	Solid and liquid waste fuels, waste tires, slud	220.00 TJ	100%	0.33 g I-TEQ	1500 µg I-TEQ/TJ	Toolkit factor, confirmed by or consistent with CC Data
2.A.1	Cement kilns	-	650 000.00 ton	100%	0.39 g I-TEQ	0.6 µg I-TEQ/ton	Toolkit factor, confirmed by or consistent with CC Data
2.A.2	Lime production	-	88 000.00 ton	100%	0.88 g I-TEQ	10 µg I-TEQ/ton	Toolkit factor selected by TNO
3.D	Fires	-	3 500 000.00 inhabitant	100%	3.50 g I-TEQ	1 µg I-TEQ/inha	Toolkit factor selected by TNO
3.D	Preservation of wood	-	3 500 000.00 inhabitant	100%	3.50 g I-TEQ	1 µg I-TEQ/inha	Toolkit factor selected by TNO
6.C	Incineration of hospital waste	-	5 250.00 ton	100%	15.75 g I-TEQ	3000 µg I-TEQ/ton	Toolkit factor selected by TNO
6.C	Industrial waste	-	27 000.00 ton	100%	9.45 g I-TEQ	350 µg I-TEQ/ton	Toolkit factor selected by TNO
6.C	Open burning of agricultural wastes	-	460 000.00 ton	5%	0.69 g I-TEQ	30 µg I-TEQ/ton	Toolkit factor, confirmed by or consistent with CC Data
6.C	Open burning of domestic wastes	-	35 000.00 ton	100%	10.50 g I-TEQ	300 µg I-TEQ/ton	Toolkit factor, confirmed by or consistent with CC Data
6.C	Open burning of wood	-	4 000.00 ton	100%	0.24 g I-TEQ	60 µg I-TEQ/ton	Toolkit factor, confirmed by or consistent with CC Data

CRF/NFR	Description	Fuel	Activity			Emission	Emission Factor	
Sum for Lithuania (17 detail records)						**48.32** g I-TEQ		
CountryName	*Malta*							
1.A.1.a	Public power plants	Hard Coal	1 300.00	TJ	100%	0.01 g I-TEQ	10 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.1.a	Public power plants	Heavy Fuel Oil	19 000.00	TJ	100%	0.05 g I-TEQ	2.5 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.4.b.i	Residential heating in small stoves or centralized heating systems	Wood and wood waste	1 000.00	TJ	100%	0.10 g I-TEQ	100 µg I-TEQ/TJ	Toolkit factor selected by TNO
2.A.2	Lime production	-	5 000.00	ton	100%	0.05 g I-TEQ	10 µg I-TEQ/ton	Toolkit factor selected by TNO
3.D	Fires	-	390 000.00	inhabitant	100%	0.39 g I-TEQ	1 µg I-TEQ/inha	Toolkit factor selected by TNO
3.D	Preservation of wood	-	390 000.00	inhabitant	100%	0.39 g I-TEQ	1 µg I-TEQ/inha	Toolkit factor selected by TNO
6.C	Incineration of hospital waste	-	585.00	ton	100%	1.76 g I-TEQ	3000 µg I-TEQ/ton	Toolkit factor selected by TNO
6.C	Open burning of agricultural wastes	-	960.00	ton	5%	0.00 g I-TEQ	30 µg I-TEQ/ton	Toolkit factor selected by TNO
6.C	Open burning of domestic wastes	-	3 900.00	ton	100%	1.17 g I-TEQ	300 µg I-TEQ/ton	Toolkit factor selected by TNO
Sum for Malta (9 detail records)						**3.92** g I-TEQ		
CountryName	*Poland*							
1.A.1.a	Auto-producer electricity, heat and CHP plants, and public heat plants	Black liquor and other bio wastes	1 300.00	TJ	100%	0.65 g I-TEQ	500 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.1.a	Public power plants	Brown coal	530 000.00	TJ	100%	1.27 g I-TEQ	2.4 µg I-TEQ/TJ	Data from Candidate Country
1.A.1.a	Public power plants	Hard Coal	910 000.00	TJ	100%	2.18 g I-TEQ	2.4 µg I-TEQ/TJ	Data from Candidate Country
1.A.1.a	Public power plants	Heavy Fuel Oil	6 600.00	TJ	100%	0.02 g I-TEQ	2.5 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.1.a	Public power plants	Natural Gas	110.00	TJ	100%	0.00 g I-TEQ	0.5 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.2.b	Combustion in non-ferous metal	-	1 200.00	TJ	100%	18.00 g I-TEQ	15000 µg I-TEQ/TJ	Data from Candidate Country
1.A.2.d	Industrial combustion in the paper and pulp industry	Black liquor and other bio wastes	15 000.00	TJ	100%	7.50 g I-TEQ	500 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.2.f	Industrial combustion in other industrial sectors	Black liquor and other bio wastes	5 100.00	TJ	100%	2.55 g I-TEQ	500 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.4.b.i	Residential heating in small stoves or centralized heating systems	Hard coal coke, brown coal coke and petroleum c	200 000.00	TJ	100%	140.00 g I-TEQ	700 µg I-TEQ/TJ	Data from Candidate Country
1.A.4.b.i	Residential heating in small stoves or centralized heating systems	Heavy Fuel Oil	8 800.00	TJ	100%	0.09 g I-TEQ	10 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.4.b.i	Residential heating in small stoves or centralized heating systems	Wood and wood waste	100 000.00	TJ	100%	35.00 g I-TEQ	350 µg I-TEQ/TJ	Data from Candidate Country
1.A.4.b.i	Residential, commercial, institutional and other combustion	Solid and liquid waste fuels, waste tires, slud	22 000.00	TJ	100%	33.00 g I-TEQ	1500 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.B.1.b	Solid fuel transformation | Coke production	-	11 500 000.00	ton	100%	34.50 g I-TEQ	3 µg I-TEQ/ton	Toolkit factor selected by TNO
2.A.1	Cement kilns	-	14 000 000.00	ton	100%	0.98 g I-TEQ	0.07 µg I-TEQ/ton	Data from Candidate Country

CRF/NFR	Description	Fuel	Activity		Emission		Emission Factor		
2.A.2	Lime production	-	1 200 000.00	ton	100%	12.00 g I-TEQ	10	µg I-TEQ/ton	Toolkit factor, confirmed by or consistent with CC Data
2.C.1.1	Iron and steel plants (steel)	-	7 000 000.00	ton	100%	14.00 g I-TEQ	2	µg I-TEQ/ton	Data from Candidate Country
2.C.1.2	Iron and steel plants (pig iron)	-	6 500 000.00	ton	100%	13.00 g I-TEQ	2	µg I-TEQ/ton	Data from Candidate Country
2.C.1.3	Iron ore sintering	-	8 000 000.00	ton	100%	12.00 g I-TEQ	1.5	µg I-TEQ/ton	Data from Candidate Country
2.C.3	(Secondary) aluminium production	-	123 000.00	ton	100%	43.05 g I-TEQ	350	µg I-TEQ/ton	Toolkit factor, confirmed by or consistent with CC Data
2.C.5	Primary copper	-	406 000.00	ton	100%	0.00 g I-TEQ	0.01	µg I-TEQ/ton	Toolkit factor selected by TNO
2.C.5	Secondary copper	-	29 000.00	ton	100%	23.20 g I-TEQ	800	µg I-TEQ/ton	Toolkit factor selected by TNO
2.C.5	Secondary lead production	-	15 000.00	ton	100%	1.20 g I-TEQ	80	µg I-TEQ/ton	Toolkit factor selected by TNO
2.C.5	Secondary zinc	-	13 000.00	ton	100%	1.95 g I-TEQ	150	µg I-TEQ/ton	Data from Candidate Country
3.D	Fires	-	39 000 000.00	inhabitant	100%	39.00 g I-TEQ	1	µg I-TEQ/inha	Toolkit factor selected by TNO
3.D	Preservation of wood	-	39 000 000.00	inhabitant	100%	39.00 g I-TEQ	1	µg I-TEQ/inha	Toolkit factor selected by TNO
6.C	Hazardous waste incineration	-	2 100.00	ton	100%	73.50 g I-TEQ	35000	µg I-TEQ/ton	Data from Candidate Country
6.C	Incineration of hospital waste	-	58 500.00	ton	100%	26.33 g I-TEQ	450	µg I-TEQ/ton	Data from Candidate Country
6.C	Industrial waste	-	13 000.00	ton	100%	45.50 g I-TEQ	3500	µg I-TEQ/ton	Data from Candidate Country
6.C	Landfill fires	-	49 000.00	ton	100%	49.00 g I-TEQ	1000	µg I-TEQ/ton	Toolkit factor, confirmed by or consistent with CC Data
6.C	Open burning of agricultural wastes	-	170 000.00	ton	5%	0.26 g I-TEQ	30	µg I-TEQ/ton	Toolkit factor selected by TNO
6.C	Open burning of domestic wastes	-	390 000.00	ton	100%	117.00 g I-TEQ	300	µg I-TEQ/ton	Toolkit factor selected by TNO

Sum for Poland (31 detail records) ***785.72*** g I-TEQ

CountryName *Romania*

1.A.1.a	Auto-producer electricity, heat and CHP plants, and public heat plants	Black liquor and other bio wastes	2 800.00	TJ	100%	1.40 g I-TEQ	500	µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.1.a	Public power plants	Brown coal	250 000.00	TJ	100%	2.50 g I-TEQ	10	µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.1.a	Public power plants	Heavy Fuel Oil	100 000.00	TJ	100%	0.25 g I-TEQ	2.5	µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.1.a	Public power plants	Natural Gas	175 000.00	TJ	100%	0.09 g I-TEQ	0.5	µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.2.d	Industrial combustion in the paper and pulp industry	Black liquor and other bio wastes	2 600.00	TJ	100%	1.30 g I-TEQ	500	µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.2.f	Industrial combustion in other industrial sectors	Black liquor and other bio wastes	6 400.00	TJ	100%	3.20 g I-TEQ	500	µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.4.b.i	Residential heating in small stoves or centralized heating systems	Brown coal	300.00	TJ	100%	0.02 g I-TEQ	70	µg I-TEQ/TJ	Toolkit factor selected by TNO

CRF/NFR	Description	Fuel	Activity		Emission		Emission Factor		
1.A.4.b.i	Residential heating in small stoves or centralized heating systems	Gas/Diesel Oil	4 200.00	TJ	100%	0.04 g I-TEQ	10	µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.4.b.i	Residential heating in small stoves or centralized heating systems	Hard Coal	90.00	TJ	100%	0.01 g I-TEQ	70	µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.4.b.i	Residential heating in small stoves or centralized heating systems	Heavy Fuel Oil	120.00	TJ	100%	0.00 g I-TEQ	10	µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.4.b.i	Residential heating in small stoves or centralized heating systems	Wood and wood waste	73 000.00	TJ	100%	7.30 g I-TEQ	100	µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.4.b.i	Residential, commercial, institutional and other combustion	Solid and liquid waste fuels, waste tires, slud	1 200.00	TJ	100%	1.80 g I-TEQ	1500	µg I-TEQ/TJ	Toolkit factor selected by TNO
1.B.1.b	Solid fuel transformation | Coke production	-	4 700 000.00	ton	100%	14.10 g I-TEQ	3	µg I-TEQ/ton	Toolkit factor selected by TNO
2.A.1	Cement kilns	-	5 700 000.00	ton	100%	28.50 g I-TEQ	5	µg I-TEQ/ton	Toolkit factor selected by TNO
2.A.2	Lime production	-	1 800 000.00	ton	100%	18.00 g I-TEQ	10	µg I-TEQ/ton	Toolkit factor selected by TNO
2.C.1.3	Iron ore sintering	-	4 000 000.00	ton	100%	80.00 g I-TEQ	20	µg I-TEQ/ton	Toolkit factor selected by TNO
2.C.3	(Secondary) aluminium production	-	700.00	ton	100%	0.25 g I-TEQ	350	µg I-TEQ/ton	Toolkit factor selected by TNO
2.C.5	Secondary copper	-	18 000.00	ton	100%	14.40 g I-TEQ	800	µg I-TEQ/ton	Toolkit factor selected by TNO
2.C.5	Secondary zinc	-	770.00	ton	100%	0.12 g I-TEQ	150	µg I-TEQ/ton	Data from Candidate Country
3.D	Fires	-	22 000 000.00	inhabitant	100%	22.00 g I-TEQ	1	µg I-TEQ/inha	Toolkit factor selected by TNO
3.D	Preservation of wood	-	22 000 000.00	inhabitant	100%	22.00 g I-TEQ	1	µg I-TEQ/inha	Toolkit factor selected by TNO
6.C	Incineration of hospital waste	-	33 000.00	ton	100%	99.00 g I-TEQ	3000	µg I-TEQ/ton	Toolkit factor selected by TNO
6.C	Industrial waste	-	250 000.00	ton	100%	87.50 g I-TEQ	350	µg I-TEQ/ton	Toolkit factor selected by TNO
6.C	Municipal / industrial waste incineration (legal)	-	44 000.00	ton	100%	15.40 g I-TEQ	350	µg I-TEQ/ton	Toolkit factor selected by TNO
6.C	Open burning of agricultural wastes	-	170 000.00	ton	5%	0.26 g I-TEQ	30	µg I-TEQ/ton	Toolkit factor selected by TNO
6.C	Open burning of domestic wastes	-	220 000.00	ton	100%	66.00 g I-TEQ	300	µg I-TEQ/ton	Toolkit factor selected by TNO
Sum for Romania (26 detail records)						***485.42*** g I-TEQ			

CountryName	*Slovak Republic*								
1.A.1.a	Auto-producer electricity, heat and CHP plants, and public heat plants	Black liquor and other bio wastes	3 100.00	TJ	100%	1.55 g I-TEQ	500	µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.1.a	Public power plants	Brown coal	43 000.00	TJ	100%	0.43 g I-TEQ	10	µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.1.a	Public power plants	Hard Coal	33 000.00	TJ	100%	0.33 g I-TEQ	10	µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.1.a	Public power plants	Heavy Fuel Oil	5 200.00	TJ	100%	0.01 g I-TEQ	2.5	µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.1.a	Public power plants	Natural Gas	40 000.00	TJ	100%	0.02 g I-TEQ	0.5	µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.2.f	Industrial combustion in other industrial sectors	Black liquor and other bio wastes	2.00	TJ	100%	0.00 g I-TEQ	500	µg I-TEQ/TJ	Toolkit factor selected by TNO

CRF/NFR	Description	Fuel	Activity		Emission		Emission Factor		
1.A.4.b.i	Residential heating in small stoves or centralized heating systems	Brown coal	20 000.00	TJ	100%	1.40 g I-TEQ	70	µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.4.b.i	Residential heating in small stoves or centralized heating systems	Hard Coal	6 300.00	TJ	100%	0.44 g I-TEQ	70	µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.4.b.i	Residential heating in small stoves or centralized heating systems	Hard coal coke, brown coal coke and petroleum c	1 600.00	TJ	100%	0.11 g I-TEQ	70	µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.4.b.i	Residential heating in small stoves or centralized heating systems	Heavy Fuel Oil	1 200.00	TJ	100%	0.01 g I-TEQ	10	µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.4.b.i	Residential heating in small stoves or centralized heating systems	Wood and wood waste	8 000.00	TJ	100%	0.80 g I-TEQ	100	µg I-TEQ/TJ	Toolkit factor selected by TNO
1.B.1.b	Solid fuel transformation | Coke production	-	1 900 000.00	ton	100%	5.70 g I-TEQ	3	µg I-TEQ/ton	Toolkit factor selected by TNO
2.A.1	Cement kilns	-	2 900 000.00	ton	100%	14.50 g I-TEQ	5	µg I-TEQ/ton	Toolkit factor selected by TNO
2.A.2	Lime production	-	800 000.00	ton	100%	8.00 g I-TEQ	10	µg I-TEQ/ton	Toolkit factor selected by TNO
2.C.1.3	Iron ore sintering	-	3 300 000.00	ton	100%	66.00 g I-TEQ	20	µg I-TEQ/ton	Toolkit factor selected by TNO
2.C.3	(Secondary) aluminium production	-	1 400.00	ton	100%	0.49 g I-TEQ	350	µg I-TEQ/ton	Toolkit factor selected by TNO
2.C.5	Primary copper	-	7 000.00	ton	100%	0.00 g I-TEQ	0.01	µg I-TEQ/ton	Toolkit factor selected by TNO
2.C.5	Secondary copper	-	17 000.00	ton	100%	13.60 g I-TEQ	800	µg I-TEQ/ton	Toolkit factor selected by TNO
2.C.5	Secondary zinc	-	1 000.00	ton	100%	0.15 g I-TEQ	150	µg I-TEQ/ton	Data from Candidate Country
3.D	Fires	-	5 400 000.00	inhabitant	100%	5.40 g I-TEQ	1	µg I-TEQ/inha	Toolkit factor selected by TNO
3.D	Preservation of wood	-	5 400 000.00	inhabitant	100%	5.40 g I-TEQ	1	µg I-TEQ/inha	Toolkit factor selected by TNO
6.C	Incineration of hospital waste	-	8 100.00	ton	100%	6.60 g I-TEQ	815	µg I-TEQ/ton	Data from Candidate Country
6.C	Municipal / industrial waste incineration (legal)	-	131 070.00	ton	100%	29.49 g I-TEQ	225	µg I-TEQ/ton	Data from Candidate Country
6.C	Open burning of agricultural wastes	-	700 000.00	ton	5%	1.05 g I-TEQ	30	µg I-TEQ/ton	Toolkit factor selected by TNO
6.C	Open burning of domestic wastes	-	54 000.00	ton	100%	16.20 g I-TEQ	300	µg I-TEQ/ton	Toolkit factor selected by TNO

Sum for Slovak Republic (25 detail records) ***177.69*** g I-TEQ

CountryName *Slovenia*

CRF/NFR	Description	Fuel	Activity		Emission		Emission Factor		
1.A.1.a	Auto-producer electricity, heat and CHP plants, and public heat plants	Black liquor and other bio wastes	110.00	TJ	100%	0.06 g I-TEQ	500	µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.1.a	Public power plants	Brown coal	48 000.00	TJ	100%	0.48 g I-TEQ	10	µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.1.a	Public power plants	Hard coal coke, brown coal coke and petroleum c	16 000.00	TJ	100%	0.16 g I-TEQ	10	µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.1.a	Public power plants	Heavy Fuel Oil	200.00	TJ	100%	0.00 g I-TEQ	2.5	µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.1.a	Public power plants	Natural Gas	50.00	TJ	100%	0.00 g I-TEQ	0.5	µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.2.f	Industrial combustion in other industrial sectors	Black liquor and other bio wastes	2 600.00	TJ	100%	1.30 g I-TEQ	500	µg I-TEQ/TJ	Toolkit factor selected by TNO

CRF/NFR	Description	Fuel	Activity		Emission		Emission Factor	
1.A.4.b.i	Residential heating in small stoves or centralized heating systems	Brown coal	1 500.00 TJ	100%	0.11 g I-TEQ	70 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.4.b.i	Residential heating in small stoves or centralized heating systems	Gas/Diesel Oil	24 000.00 TJ	100%	0.24 g I-TEQ	10 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.4.b.i	Residential heating in small stoves or centralized heating systems	Hard coal coke, brown coal coke and petroleum c	3 100.00 TJ	100%	0.22 g I-TEQ	70 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.4.b.i	Residential heating in small stoves or centralized heating systems	Heavy Fuel Oil	360.00 TJ	100%	0.00 g I-TEQ	10 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.4.b.i	Residential heating in small stoves or centralized heating systems	Sub-Bituminous Coal	700.00 TJ	100%	0.05 g I-TEQ	70 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.4.b.i	Residential heating in small stoves or centralized heating systems	Wood and wood waste	6 000.00 TJ	100%	0.60 g I-TEQ	100 µg I-TEQ/TJ	Toolkit factor selected by TNO
2.A.1	Cement kilns	-	990 000.00 ton	100%	4.95 g I-TEQ	5 µg I-TEQ/ton	Toolkit factor selected by TNO
2.A.2	Lime production	-	150 000.00 ton	100%	1.50 g I-TEQ	10 µg I-TEQ/ton	Toolkit factor selected by TNO
2.C.1.3	Iron ore sintering	-	250 000.00 ton	100%	5.00 g I-TEQ	20 µg I-TEQ/ton	Toolkit factor selected by TNO
2.C.5	Secondary lead production	-	7 500.00 ton	100%	0.60 g I-TEQ	80 µg I-TEQ/ton	Toolkit factor selected by TNO
3.D	Fires	-	2 000 000.00 inhabitant	100%	2.00 g I-TEQ	1 µg I-TEQ/inha	Toolkit factor selected by TNO
3.D	Preservation of wood	-	2 000 000.00 inhabitant	100%	2.00 g I-TEQ	1 µg I-TEQ/inha	Toolkit factor selected by TNO
6.C	Incineration of hospital waste	-	3 000.00 ton	100%	9.00 g I-TEQ	3000 µg I-TEQ/ton	Toolkit factor selected by TNO
6.C	Industrial waste	-	4 800.00 ton	100%	1.68 g I-TEQ	350 µg I-TEQ/ton	Toolkit factor selected by TNO
6.C	Open burning of agricultural wastes	-	75 000.00 ton	5%	0.11 g I-TEQ	30 µg I-TEQ/ton	Toolkit factor selected by TNO
6.C	Open burning of domestic wastes	-	20 000.00 ton	100%	6.00 g I-TEQ	300 µg I-TEQ/ton	Toolkit factor selected by TNO

Sum for Slovenia (22 detail records) ***36.05*** g I-TEQ

CountryName *Turkey*

CRF/NFR	Description	Fuel	Activity		Emission	Emission Factor	
1.A.1.a	Auto-producer electricity, heat and CHP plants, and public heat plants	Black liquor and other bio wastes	12 000.00 TJ	100%	6.00 g I-TEQ	500 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.1.a	Public power plants	Brown coal	400 000.00 TJ	100%	4.00 g I-TEQ	10 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.1.a	Public power plants	Hard Coal	28 000.00 TJ	100%	0.28 g I-TEQ	10 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.1.a	Public power plants	Heavy Fuel Oil	39 000.00 TJ	100%	0.10 g I-TEQ	2.5 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.1.a	Public power plants	Natural Gas	120 000.00 TJ	100%	0.06 g I-TEQ	0.5 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.4.b.i	Residential heating in small stoves or centralized heating systems	Brown coal	67 000.00 TJ	100%	4.69 g I-TEQ	70 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.4.b.i	Residential heating in small stoves or centralized heating systems	Hard Coal	32 000.00 TJ	100%	2.24 g I-TEQ	70 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.4.b.i	Residential heating in small stoves or centralized heating systems	Heavy Fuel Oil	53 000.00 TJ	100%	0.53 g I-TEQ	10 µg I-TEQ/TJ	Toolkit factor selected by TNO
1.A.4.b.i	Residential heating in small stoves or centralized heating systems	Sub-Bituminous Coal	940.00 TJ	100%	0.07 g I-TEQ	70 µg I-TEQ/TJ	Toolkit factor selected by TNO

CRF/NFR	Description	Fuel	Activity		Emission		Emission Factor		
1.A.4.b.i	Residential heating in small stoves or centralized heating systems	Wood and wood waste	180 000.00	TJ	100%	18.00 g I-TEQ	100	µg I-TEQ/TJ	Toolkit factor selected by TNO
1.B.1.b	Solid fuel transformation | Coke production	-	3 100 000.00	ton	100%	9.30 g I-TEQ	3	µg I-TEQ/ton	Toolkit factor selected by TNO
2.A.1	Cement kilns	-	33 000 000.00	ton	100%	165.00 g I-TEQ	5	µg I-TEQ/ton	Toolkit factor selected by TNO
2.A.2	Lime production	-	900 000.00	ton	100%	9.00 g I-TEQ	10	µg I-TEQ/ton	Toolkit factor selected by TNO
2.B	Chemical industry PVC	-	150 000.00	ton	100%	0.02 g I-TEQ	0.1	µg I-TEQ/ton	Data from Candidate Country
2.C.1.3	Iron ore sintering	-	4 300 000.00	ton	100%	86.00 g I-TEQ	20	µg I-TEQ/ton	Toolkit factor selected by TNO
2.C.3	(Secondary) aluminium production	-	70 000.00	ton	100%	24.50 g I-TEQ	350	µg I-TEQ/ton	Toolkit factor, confirmed by or consistent with CC Data
2.C.5	Primary copper	-	80 000.00	ton	100%	0.00 g I-TEQ	0.01	µg I-TEQ/ton	Toolkit factor selected by TNO
2.C.5	Secondary copper	-	9 300.00	ton	100%	7.44 g I-TEQ	800	µg I-TEQ/ton	Toolkit factor selected by TNO
2.C.5	Secondary zinc	-	11 000.00	ton	100%	11.00 g I-TEQ	1000	µg I-TEQ/ton	Toolkit factor, confirmed by or consistent with CC Data
2.D.1	Pulp and paper industry Kraft process	-	1 050 000.00	ton	100%	10.50 g I-TEQ	10	µg I-TEQ/ton	Data from Candidate Country
3.D	Fires	-	67 000 000.00	inhabitant	100%	67.00 g I-TEQ	1	µg I-TEQ/inha	Toolkit factor selected by TNO
3.D	Preservation of wood	-	67 000 000.00	inhabitant	100%	67.00 g I-TEQ	1	µg I-TEQ/inha	Toolkit factor selected by TNO
6.C	Incineration of hospital waste	-	110 000.00	ton	100%	330.00 g I-TEQ	3000	µg I-TEQ/ton	Toolkit factor selected by TNO
6.C	Open burning of agricultural wastes	-	280 000.00	ton	5%	0.42 g I-TEQ	30	µg I-TEQ/ton	Toolkit factor selected by TNO
6.C	Open burning of domestic wastes	-	470 000.00	ton	100%	141.00 g I-TEQ	300	µg I-TEQ/ton	Toolkit factor selected by TNO

Sum for Turkey (25 detail records) ***964.14*** g I-TEQ

Total for dioxins and furans to air ***3 264.44*** g I-TEQ

Part B Emission measurement Program (IUTA)

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IUTA-Report Nr. LP 12/2004 – **Final Report**

Dioxin Emissions in Candidate Countries

Part B: Emission Measurement Program

On behalf of

European Commission
DG Environment
Brussels

Datum: 22.09.2004

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Summary

A dioxin emission measurement program has been carried out at various facilities in 8 of the 13 candidate countries. Major goals of this program were

1) to obtain additional emission data from potentially relevant sources and
2) to assist countries to build or strengthen their capacities of dioxin emission testing

Therefore, sampling and analyses were mainly carried out by CC based institutes. In some cases joint sub-projects were established involving assistance by Western European experts to CC based sampling teams.

Overall 16 of 31 proposed facilities were selected for measurements, which could finally be realised in 13 cases. Among these were iron ore sinter plants, secondary aluminium and zinc recovery, cement works, brown coal and heavy fuel oil power plants and an industrial combustion plant burning residues from pulp and paper production. Those installations belonging to the metallurgical sector proved to have the highest dioxin flue gas concentrations exceeding the limit value set for waste incinerators. However, almost none of the sources had annual emissions above the EPER threshold value of 1 g I-TEQ/year. The comparison of emission factors with those given in the UNEP Toolkit revealed good or acceptable agreement in most cases.

1 Introduction

As part of the project performed for DG Environment, called “Dioxin Emissions in Candidate Countries”, an inventory of emissions to air. Land and water in the 13 countries in Central and Eastern Europe was compiled. These 13 countries were:

1) Bulgaria
2) Cyprus
3) Czech Republic
4) Estonia
5) Hungary
6) Latvia
7) Lithuania
8) Malta
9) Poland
10) Romania
11) Slovak Republic
12) Slovenia
13) Turkey

When the project was commissioned, these countries were referred to as EU candidate member countries. Since June 2004, 10 of these countries are full members of the EU. Bulgaria, Romania and Turkey now are still candidate members.

Besides the emission inventory that is presented in Part A of this report an accompanying emission measurement program was carried out. This report presents the results of this measurement program:

1) Chapter 2 presents the major goals of this part of the project
2) Chapter 3 introduces the approach chosen to select appropriate facilities
3) Chapter 4 shows the measurement results
4) Chapter 5 contains the discussion of results with respect to aspects of current EU regulations
5) Chapter 6 finally gives conclusions and recommendations

Additional data and documentation are presented in Annexes to this report.

2 Goals

At the starting point of the project it was quite obvious that in many of the candidate countries (CCs) no emission measurements of dioxins and furans had ever been carried out. Available measurement data almost exclusively originated from Poland and the Czech Republic. This situation is probably not only due to the political and economical situation in the CCs but may also be effected just by inadequate local availability of sampling teams and analytical laboratories being capable of performing dioxin analysis.

Hence, the measurement program carried out within this project had two major goals:

- To obtain additional dioxin emission data from countries not yet covered so far by dioxin emission measurement activities and for not yet investigated emission sources, respectively

- To help countries with emerging activities in emission control to obtain experience in dioxin emission sampling and – if appropriate laboratories are available – analysis.

3 Approach

CCs experts were asked to support the measurement program by supplying information on potentially relevant emission sources in their countries. For these sources, a questionnaire had to be answered covering plant information and technical data needed for an initial campaign planning and cost calculation. Most importantly, the plant operator's permits for the measurements had to be provided at this early stage, too. No a priori limitations regarding facility type or number of proposals were set except with respect to those plants which already are regulated by the so-called waste incineration directive 2000/76/EC [2] (e.g. municipal, hazardous and hospital waste incinerators). Waste incinerators in particular had to be ignored. However, facilities sometimes used for co-combustion of waste materials like cement works still were accepted.

Moreover, CCs experts were additionally asked to provide information on local companies that might be able to carry out the sampling campaign and/or the analytical work. An overview of the responses is presented in ANNEX A

The measurement program took place in two stages which were agreed on during the first and second project workshop, respectively. From the proposals obtained, facilities to be measured were selected according to their potential relevance. This was assessed by the estimated absolute dioxin emission per year or by its relative importance for the respective CC.

A campaign design was outlined for each of the selected plants, depending on the technical structure of the facility (e.g. number of lines and stacks), and the numbers of stack measurements, blanks and analytical work were set. This outline served as basis for a specific call for offers which was sent to the indicated companies. In case no local company or laboratory existed foreign institutes were asked to take over these tasks.

CC based companies and laboratories were preferred whenever possible with respect to the capacity building goal of the project. In some cases collaborative projects were installed between a CC based sampling team and a foreign, CC or Western European laboratory. A list of the participating companies and institutes can be found in ANNEX B.

Special report templates were provided to the companies committed with emission measurements. This was done to assure a high and equal quality of the results and completeness of data needed to assess the compliance of sampling and analysis methods with current standards (e.g. CEN 1948, 1-3 in connection with ISO 9096). These report forms comprised a spreadsheet form serving to collect all information needed for each sample and a text form to be filled for each campaign (stack). The forms had been developed in

strict relation to the standards mentioned above and taking into account the German rules on reporting emission measurements (so-called “LAI-Musterbericht”). Except for some amendments and minor corrections, the same forms had been previously used within the European Dioxin Inventory project [3, 4].

QA/QC activities further included the draft of general conditions which had to be followed by the contracted institutes. These in particular implied the need for saving backups of each sample and used materials to allow for later cross-check analyses.

4 Results

4.1 Overview of proposed, selected and measured facilities

Overall, 31 facilities located in 10 of the CCs were proposed for emission measurements (see Table 1). No proposals were received from Hungary, Romania and Slovenia. Of the proposed facilities, 16 were selected for measurement campaigns, but finally only 13 of these campaigns could be realised due to insufficient support by some plant operators.

Table 1 Number of proposed, selected and measured facilities by country

Country	***No of facilities***		
	Proposed	***Selected***	***measured***
Bulgaria	1	1	1
Cyprus	2	2	2
Czech Republic	1	-	-
Estonia	2	1	1
Latvia	1	1	-
Lithuania	2	1	-
Malta	1	1	1
Poland	14	5	5
Slovakia	3	2	1
Turkey	4	2	2
TOTAL	**31**	**16**	**13**

The sector split of proposed, selected and measured facilities is shown in Table 2. About 50% belonged to the metallurgical sector.

Table 2 Number of proposed, selected and measured facilities by sector

Sector	NFR group	No. of facilities		
		Proposed	Selected	measured
Power generation	1.A.1.a	5	3	3
Iron and Steel	2.C.1	7	4	2
Non-ferrous metals	2.C.2/2.C.3	14	5	5
Cement	2.A.1	3	3	2
Other	1.A.2.d/3C	2	1	1
TOTAL		**31**	**16**	**13**

In most cases more than 1 emission sample per stack was collected as well as blank samples. Thus, the total amount of sample analyses amounted to 44; in addition 8 blank analyses were reported.

4.2 Detailed information on measured facilities

In Table 3, information has been compiled showing operation conditions and some relevant technical features of the facilities which have been selected for dioxin emission measurements.

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Table 3 Operation features of the measured facilities

Sector	No.	Country	Plant type	Input materials	Operating hours [h/year]	Capacity [Mg/year]	Process temperature [°C]	Flue gas cleaning	Stack height [m]	Remarks
Iron and Steel	1	POL	Iron ore sintering	Iron ore, iron concentrates. Dolomite, lime, additives; fuels: Blast furnace gas, coke, coke gas	Ca. 6,000	1,125,000	1,250-1,400	ESP *)	82	Re-circulation of flue gas to belt (20%)
	2	POL	Iron ore sintering	Iron ore, iron concentrates. Dolomite, lime, additives; fuels: Blast furnace gas, coke, coke gas	7,300	Ca. 2,600,000 (per each strand)	1,250-1,400	ESP *)	250	3 sinter strands, one out of operation during measurements
Non-ferrous metals	3	POL	Zinc oxide ore sintering	Raw zinc oxide from different origins; natural gas heating	1,370 sintered ZnO 730 Zinc/lead oxide	Ca. 3,500	1,300-1,350	Balloon chamber, cyclones, bag-house	86	
	4	POL	Zinc recovery by rotary kiln	Zinc containing wastes and scrap, coke (~40%)	ca. 5,500	13,750 (input Zn containing materials)	1,100-1,250	Precipitation chamber, cyclones, baghouse	76	Continuous operation
	5	POL	Melting of electrolytically produced zinc	Raw zinc cathodes from electrolytic zinc recovery	Ca. 7,000	72,000 (output metallic zinc)	540-560	Baghouse (ZnO powder, 98% efficiency)	30	Continuous operation
	6	TUR	Sec. Aluminium prod.	Waste and raw aluminium	Ca. 3,400	5,040	Not reported	none	120	Discontinuous operation

Table 3 (cont.) Operation features of the measured facilities

Sector	No.	Country	Plant type	Input materials	Operating hours [h/year]	Capacity [Mg/year]	Process temperature [°C]	Flue gas cleaning	Stack height [m]	Remarks
Non-ferrous metals	7	TUR	Sec. Aluminium prod.	Industrial aluminium wastes	7,500	1,500	Not reported	none	18	Discontinuous operation
Power Generation	8a,b	MLT	public power plant, boilers 3,4	Heavy fuel oil	> 8,000	30 MW	Not reported	none	47/47	
	8c,d	MLT	public power plant, boilers 7,8	Heavy fuel oil	> 8,000	60 MW	Not reported	ESP *)	69/85	
	9	BGR	Public power plant	Brown coal	>8,000	500 MW	Not reported	ESP *)	120	
	10	CYP	Public Power plant	Heavy fuel oil	~ 7,700	130 MW	Not reported	Cyclones	125	
Cement	11	EST	Cement wet kiln	Limestone, clay, shale oil, petroleum coke, waste oil from shale oil prod.	Ca. 7,000	650,000 (2 kilns)	1,400	ESP *), dust mainly returned to process	80	2 lines (150 m, 4.5 m diam.), one in repair during measurement
	12	CYP	Cement dry kiln	Limestone, clay	Ca. 8.000	680,000	Not reported	ESP/Bag Filter	47	
Industrial combustion	13	SLK	Bark combustion (Pulp& paper industry)	Waste wood (bark), sludge, non-condensable gases, natural gas	>8,000	96,4 MW (max)	Not reported	ESP *)	204	

*) ESP: Electrostatic precipitator

4.3 Dioxin emission measurement results

The results of the dioxin emission measurements are shown in Table 4. In case of more than one sample per stack all single results and the mean value are presented. Further, to compare the results of different installations the dioxin and furan concentrations have been calculated referring to an oxygen concentration of 11 % in the flue gas. This reference oxygen content was chosen since it is required in the waste incineration directive [2] to check compliance with the emission limit of 0.1 ng I-TEQ/Nm³ applied to waste incinerators. Therefore, re-calculation of the measured flue gas concentrations to 11% oxygen content allows to use the waste incinerator limit value as an orientation value to compare with. It should be noted that given the current European regulations exceedance of this orientation value has no legal implication for any of the sources measured here. It also does not necessarily mean that a facility with higher flue gas concentration is a more significant source of pollution than a waste incinerator since for this aspect the overall flue gas volume, the annual operation time and the stack height must be taken into account.

Table 4 Dioxin emission measurement results

No	Plant type	PCDD/F concentration [ng I-TEQ/Nm³]				
		(operational O_2, dry gas, standard T,p)				11% O_2
		Sample 1	**Sample 2**	**Sample 3**	**Mean**	**Mean**
1	Iron ore sintering	0,37	0,35	0,37	0,363	0,948
2a	Iron ore sintering line 1	1,7457	-[1]	-	1,7457	7,935
2b	Iron ore sintering line 3	1,9843	1,2123	-	1,5983	1,973
3	Zinc oxide ore sintering	6,76	7,83	7,28	7,29	25,14
4	Zinc recovery by rotary kiln	4,44	3,61	2,92	3,66	8,92
5	Melting of electrolytically produced zinc	0,02	0,02	0,02	0,02	0,28
6	Sec. Aluminium prod.	1,56	0,19	-	0,87	2,54

[1] Line 1 accidentially measured only once

Table 4 (cont.) Dioxin emission measurement results

No	Plant type	PCDD/F concentration [ng I-TEQ/Nm³]				
		(operational O_2, dry gas, standard T,p)				11% O_2
		Sample 1	Sample 2	Sample 3	Mean	Mean
7	Sec. Aluminium prod.	0,22	0,80	-	0,51	4,64
8a	public power plant, boiler 3	0,0008	-	-	-	0,001
8b	public power plant, boiler 4	0,0083	-	-	-	0,006
8c	public power plant, boiler 7	0,0037	-	-	-	0,002
8d	public power plant, boiler 8	0,0030	-	-	-	0,002
9	Public power plant	0,008	0,009	0,008	0,008	0,007
10	Public Power plant	0,0142	0,0024	-	0,0083	0,005
11	Cement wet kiln	0,01	0,021	0,024	0,018	0,012
12	Cement dry kiln	0,001	0,0008	-	0,0009	0,001
13	Bark combustion (Pulp& paper industry)	0,012	0,009	0,008	0,010	0,008

5 Discussion

5.1 Relevance of measured emissions compared to the waste incineration emission limit

The PCDD/F measurement data of Table 4 are shown graphically in Figure 1 in the order of decreasing emissions at 11% oxygen. Clearly, a number of facilities, all belonging to the metallurgical sector, exceed the limit set for waste incineration facilities in the directive 2000/76/EC [2].
The highest concentration levels were found at secondary zinc processing facilities. Such findings correspond to similar experiences made in Western European countries (particularly in Germany and France) where secondary zinc producing facilities were among the most important emission sources [4].
However, none of the concentrations measured in the Candidate Countries appear to be surprisingly high when compared to the range of results (Table 5) taken from previous measurement data compilation given in the European Dioxin Inventory [3, 4]. Unexpectedly, the value found for the iron ore sintering plant 1 appears to be quite low. This might be explained by the fact that this facility employs a re-circulation of flue gases (20% by volume) back onto the hot zone of the sintering belt where dioxins and furans (at least partly) are destroyed.

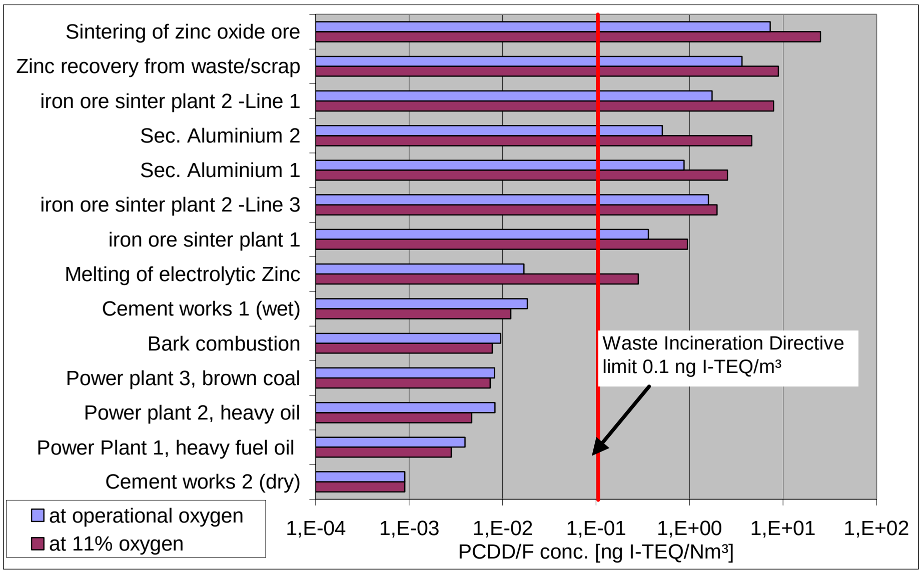


Figure 1: Flue gas concentrations of measured plants compared to waste incineration limit

Table 5 Comparison of measured data with range of concentrations from German facilities (taken from European Dioxin Inventory [3])

	averaged [ngTEQ/Nm3]		Range of emission conc. [ngTEQ/Nm3]
	op. O_2	11% O_2	
Cement works 2 (dry)	0,004	0,003	<0,0001 - 0,1
Cement works 1 (wet)	0,018	0,012	
Power plant, brown coal	0,008	0,007	< 0,0001 - 0,12
Power plant, heavy oil	0,006	0,004	
Bark combustion	0,010	0,008	
iron ore sinter plant 1	0,363	0,948	0,8-14,1
iron ore sinter plant 2	1,600	5,000	
Sec. Aluminium 1	0,875	2,536	0,01-11,6
Sec. Aluminium 2	0,511	4,641	
Melting of electrolytic Zinc	0,017	0,282	< 0,01 - 120
Zinc recovery from waste/scrap	3,657	8,919	
Sintering of zinc oxide ore	7,290	25,138	

5.2 Annual emissions compared to EPER threshold value

The annual emissions of dioxins and furans from the measured facilities may be assessed from the measured flue gas concentrations, the flue gas volume and the annual operation time. It must be noted however that such an assessment based on a single measurement campaign implies considerable uncertainties since only a small fraction of the annual operation time is covered. In particular batch processes that are frequently switched on and off and have input materials of variable compositions might be considerably over – or underestimated by such calculation.

Figure 2 shows the estimated annual emissions for the measured facilities in comparison to the threshold limit of 0.1 g I-TEQ/year set for the European Pollutant Emission Register (EPER) [5]. Obviously, most of the measured facilities would not be subjected to registration in the EPER (unless such registration would be necessary due to emissions of other compounds). Only in case of the zinc recovery plant and one of the iron ore sinter plants the EPER threshold for dioxins and furans might be exceeded.

In view of the flue gas concentrations that were shown to exceed the waste directive limit value this result might be surprising. However, most of these non-ferrous metal facilities are not operated continuously and therefore have quite low operation times. Moreover, in many cases they are small installations with capacities of a few thousand tons per year and hence also have low flue gas flow rates. Both factors combined lead to the low annual emissions shown in Figure 2.

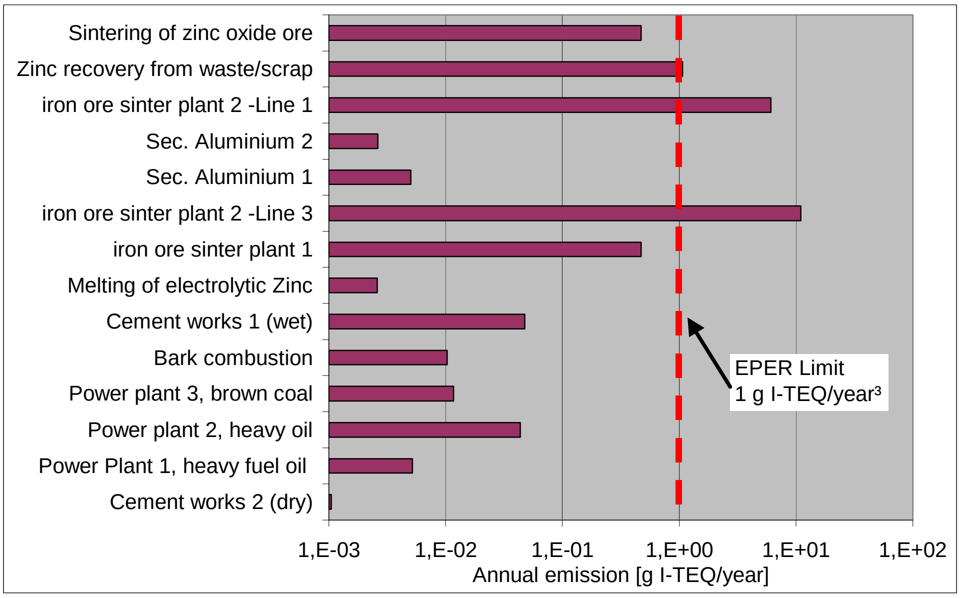


Figure 2 Comparison of annual dioxin and furan emissions with EPER threshold limit for dioxins and furans

5.3 Emission factors compared to UNEP Toolkit values

One of the motivations to carry out an emission measurement program within the project was to obtain some emission factors (EFs) from facilities located in the countries of interest. These emission factors should serve as a check if those EFs taken from other information sources for building the emission inventory are reasonable or not. Therefore, emission factors have been calculated from the measurement results by using typical production or throughput capacities. In some cases the actual production rate during the measurement campaign was known and hence used for this calculation. Otherwise, typical annual production/consumption rates were converted to hourly rates by division with the annual operation time. The emission factor finally is given by the ratio of hourly/annually emission freight and hourly/annually activity rate. The emission factors obtained are shown in Table 6 and compared with the range of emission factors given by the UNEP Toolkit [1] in relation to different flue gas cleaning technologies or input materials.

Table 6 Comparison of emission factors obtained from measurements with UNEP toolkit EFs and those used in the inventory

No	Plant type	Description	EF measured	EF UNEP Toolkit		Dimension
				Based on description	Total range	
1	Iron ore sintering	High technology, emission reduction	0,43	0,3	0,3 - 20	µg I-TEQ/Mg
2	Iron ore sintering (2 lines)	Common technology (ESP)	2,2 - 4,3	5	0,3 - 20	µg I-TEQ/Mg
3	Zinc oxide ore sintering	Hot briquetting/ Rotary furnaces, basic control	110	100	0,3 - 1000	µg I-TEQ/Mg
4	Zinc recovery by rotary kiln	Hot briquetting/ Rotary furnaces, basic control	130	100	0,3 - 1000	µg I-TEQ/Mg
5	Melting of electrolytically produced zinc	Melting (only)	0,04	0,3	0,3 - 1000	µg I-TEQ/Mg
6	Sec. Aluminium prod.	Processing scrap, min input treatment, simple dust control	3,74	150	0,5 - 150	µg I-TEQ/Mg
7	Sec. Aluminium prod.	Processing scrap, min input treatment, simple dust control	0,52	150	0,5 - 150	µg I-TEQ/Mg
8	public power plant (4 boilers)	Heavy Fuel Oil	1,3 – 10,3	2,5	0,5 - 35	µg I-TEQ/TJ
9	Public power plant	Brown coal, ESP	0,81	10	0,5 - 35	µg I-TEQ/TJ
10	Public Power plant	Heavy Fuel Oil	12,1	2,5	0,5 - 35	µg I-TEQ/TJ
11	Cement wet kiln	Electrostatic prec. (ESP) at < 200 ˚C	0,073	0,05	0,05 - 5	µg I-TEQ/Mg
12	Cement dry kiln	Two-Stage preheater, bag filter	0,002*)	0,05	0,05 - 5	µg I-TEQ/Mg
13	Pulp & paper industry (bark combustion)	Bark boiler only	3,78	0,4	0,07-0,4	µg I-TEQ/TJ

In part A of this final report the emission inventory is compiled using the UNEP Toolkit [1] emission factors in most cases. For many emission source types this toolkit contains emission factors (EFs) that are further diversified with respect to the technical level of flue gas cleaning systems. Therefore, to compare these factors with those obtained for the measured facilities additional information on the type and quality of the installed flue gas cleaning systems is necessary. Figure 3 shows the result of the comparison between the emission factors calculated for the measured facilities with toolkit factors which have been chosen according to the technical information provided within the measurement reports. It is obvious that some measured emission factors are in very good agreement with the appropriate toolkit EFs (blue dots); however, there are also large deviations, particularly for low and medium values (red and yellow dots). Pale-coloured dots represent the power generation sources with emission factors related to produced energy (µg I-TEQ/TJ) rather than material input usually given in µg I-TEQ/ton.

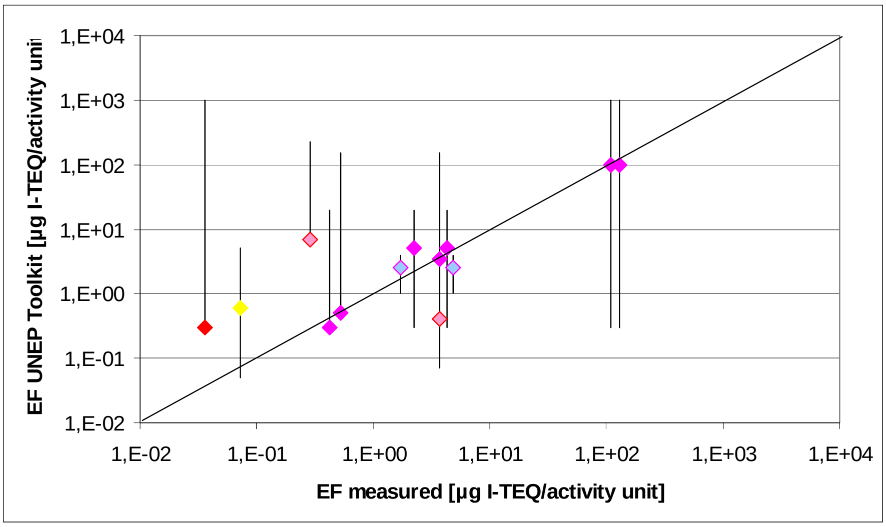


Figure 3 Comparison of emission factors (EFs) derived for the measured facilities with corresponding EFs from UNEP toolkit

Unfortunately, not in every case the technical information was provided in sufficient detail by plant operators or measuring companies. Hence, in such cases choosing the appropriate toolkit factor was difficult. To deal with this uncertainty the comparison of the measured EFs with toolkit EFs shown in Figure 3 is completed by showing the range of emission factors given in the toolkit for the source type which the measured facilities in general belong to ("error bars"). It can be seen that for one of the data points (yellow dot) showing a higher toolkit than measured EF an alternative toolkit factor could be chosen which are in better agreement with the measurements.

Contrarily, in case of the data indicated by red dots the measured emission factors are considerably lower (higher) than even the lowest (highest) factor given in the toolkit. This shall be commented on further:

- The first of these data points represents the zinc melting of zinc electrodes, a process that can be regarded as a “primary” production since pre-cleaned zinc is used as input material. UNEP toolkit includes an emission factor for “zinc melting” of 0.3 µg I-TEQ/ton that was chosen here to be compared with the measured EF. This Ef however does not accurately reflect the process investigated.

- The second pale-red dot (EF = 0,3 µg I-TEQ/Terajoule) indicates the brown-coal fired power plant. For this type of emission source the toolkit EF was based on information taken from Germany, UK and Switzerland for coal fired power plants. The toolkit factor of 10 µg I-TEQ/TJ was derived from a range between 7 and 230 µg I-TEQ/TJ as indicated by the error bar. However, the toolkit document also refers to further data indicating much lower EFs found for coal fired power plants that go down to 0.09 µg I-TEQ/TJ. Therefore the measured EF does not appear implausible. Furthermore, the activity rate used for EF calculation could only be estimated from the electrical power since the actual throughput of coal was not reported.

- Finally, the third pale-red dot corresponds to the bark combustion plant in pulp&paper industry. The toolkit emission factors are lower than the measured one, and even the highest toolkit EF is an order of magnitude below the result obtained. However, the lower EF does not really apply to the installation investigated here as it is assigned to Kraft black liquor burning. The upper toolkit EF was assumed to be the same as derived for wood burning boilers used for power generation. It may be questioned if this assumption is reasonable, since bark combustion uses only a fraction of the wooden fuels usually combusted in biomass burners. Since bark is that part of the trees accumulating environmental air pollutants (e.g. PAHs and heavy metals) a higher dioxin formation potential may be assumed for this type of fuel. As a conclusion, the found emission factor is not implausible.

5.4 Uncertainties

5.4.1 General

As already mentioned, the measurements carried out are spot tests which only represent a short period of the facilities' annual operation time. In case of fluctuating operation conditions the measured concentrations thus do not necessarily provide reliable figures about the average concentration observed on the long term. Such fluctuating operation conditions are more likely to occur at small facilities which are operated discontinuously with batch-type loadings of variable input material. Among the plants investigated here this is the case for the non-ferrous metal plants and the bark combustion installation.
Contrarily, iron ore sintering plants, cement works and power plants usually operate at steady state conditions with well controlled input materials. For these facilities the measurement results may be assessed to have a higher degree of reliability with respect to the long-term emission situation.

5.4.2 Uncertainties of sampling procedure

Besides the general uncertainty that is introduced by the limited number of samples further variance is introduced by the sampling and analysis procedures.

In order to minimise this influence, the European standard EN 1948, 1-3 was developed by CEN. Although this standard leaves considerable freedom with respect to the selection of the sampling method, huge requirements for reporting are included. Concerning sampling the standard to a large degree refers to ISO 9096 (dust sampling) which comprises additional reporting requirements.

To assure a high quality of the measurements carried out within the European Dioxin Inventory standardised reporting form templates were developed reflecting the reporting requirements of these emission measurement standards. Within the course of this project these forms were slightly amended or corrected on recommendation by emission measurement experts from the involved institutes.

However, in practice it is frequently experienced that on-site sampling conditions do not allow to carry out the sampling as exactly as required. Some of the problems that may occur are:

- Location of sampling port does not fit to the requirements regarding the length of straight upstream duct

- Impracticability of carrying out a net sampling over the cross section due to limited space on measurement platform or because rectangular ports are unavailable

Both problems also had to be occasionally faced within the measurements carried out in this project. In any case it is difficult to assess whether these adverse sampling conditions really influence the particular results or not. It might be reasonable to assume however, that at least the order of magnitude of these results is correct.

5.4.3 Uncertainties of analytical procedures

To get reliable analytical results EN 1948 prescribes the usage of HRGC/HRMS methods for the analysis of dioxin emission samples. For this project this requirement was adopted in general. However, since one of the major goals was to support the capacity building process in the Candidate Countries some compromises were made with respect to the analytical procedures. Nevertheless, experience in handling of emission samples and proven comparability to the standard methods was required.

Besides differences in the analytical procedure a further input to uncertainty may be caused by contamination of sampling equipment or reagents. Such influence usually is assessed by analysing blank samples which are obtained from extraction of an unused sampling train. Commonly, one blank sample is taken per each measurement campaign. In Figure 4 the sample-to-blank-ratios (calculated from the I-TEQ results) is shown for those samples such calculation could be made for. Obviously, most samples had higher concentrations than the corresponding blanks by at least a factor of 3 up to more than 300. However, in one case the blank had higher I-TEQ values than the samples (no. 1 to 5 in Figure 4). As both, sample and blank results were in the very low regime of 0,010 ng I-TEQ/m³ this finding indicates that the overall limit of detection for dioxin emission sampling may be stronger influenced by occasionally fluctuating blank contamination than by analytical performance. Note, that sample- to-blank ratios are not presented for all samples obtained since a number of results were reported as blank-corrected values without providing blank concentration values explicitly.

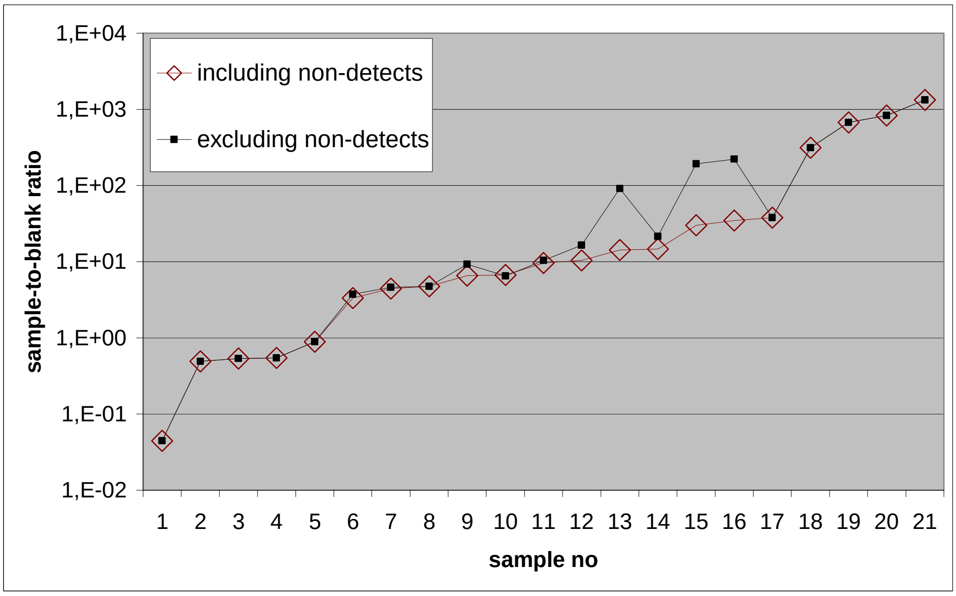


Figure 4 *sample-to blank-ratios (on TEQ basis) for different samples*

For further quality assurance with regard to the analytical values a number of samples have been additionally analysed by another laboratory. In most cases, these samples comprised either the final extract solutions after clean-up in the laboratory that did the first analysis. Hence, only errors made during clean-up could not be identified. A comparison between the single PCDD/F congener concentrations (272 data pairs from 16 samples) found in the both laboratories is shown in Figure 5.

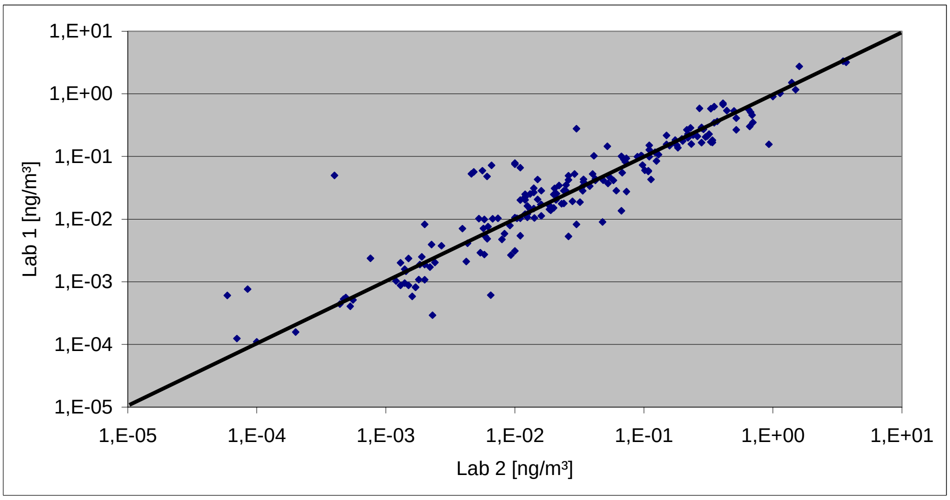


Figure 5 *Comparison of analytical results obtained from two laboratories (single congener data)*

Obviously, wit a few exceptions most results compare well to each other. This is also reflected by the overall I-TEQ values obtained that are shown in Figure 6. The results are highly correlated with a slope slightly below unity. Therefore, within the range of usual errors in this extreme trace analysis the results can be seen as identical.

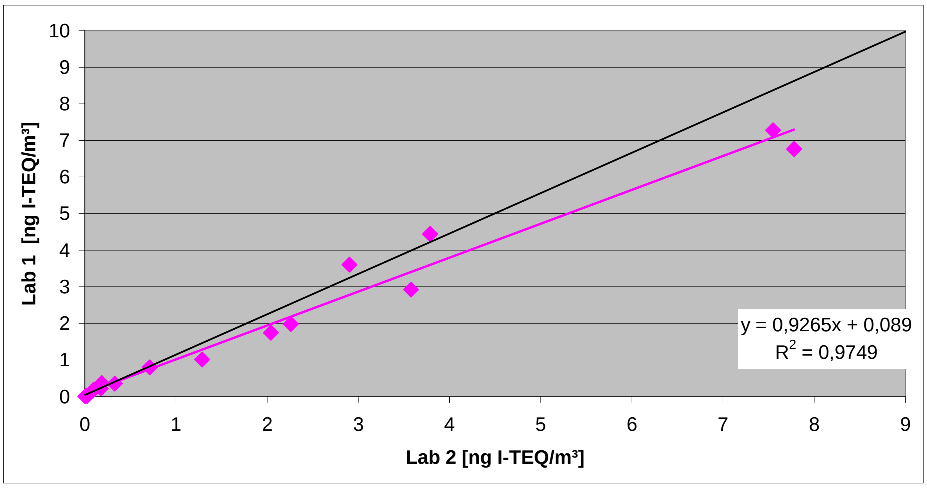


Figure 6 Comparison of analytical results obtained from two laboratories (I-TEQ data)

Additionally, some PUF cartridges used as dilution air filters during samplings with the dilution method were checked for contamination. All these cartridges had PCDD/F values below or near the detection limits. Hence in case of these campaigns no cross contamination of the sampling line by dilution air took place.

6 Conclusions

The emission measurement program embedded in the project "Dioxin emissions in Candidate Countries" comprised a number of potentially relevant sources for dioxins and furans like iron ore sinter plants and facilities in the non-ferrous metal industry. Beside these installations also industrial plants with particular importance for the specific country were investigated.
The measurements and analyses were carried out mostly by companies and institutes located in the area of interest; moreover, some joint sub-projects were established which involved experienced Western European laboratories and less experienced teams of local authorities.

The results have shown again, as already known from the Western European dioxin inventory projects, that metallurgical plants are of particular importance for the release of dioxins and furans to air. Several of the measured facilities exceeded the orientation level of 0.1 ng I-TEQ/m³ that has been set as emission limit for waste incineration. Concerning the annual emissions, however, almost all installations kept the dioxin and furan EPER threshold value of 1 g I-TEQ/year.

With respect to the air emission inventory, facility related emission factors were calculated from the measured flue gas concentrations and plant operation data. These emission factors were compared to the appropriate figures given in the UNEP toolkit. In general, the comparison showed acceptable to good agreement if the range of emission factors underlying the toolkit figures are taken into account. The measurements therefore do not indicate that applying the UNEP toolkit emission factors for releases to air would lead to significant over- or underestimations of the annual emissions. It should be noted however, that only a small fraction of existing emission sources were investigated. Hence, there is a considerable range of uncertainty when conclusions are drawn by scaling up these results to the situation in the entire region of the Candidate Countries.

7 Quotations

1 **Standardized Toolkit** for Identification and Quantification of Dioxin and Furan Releases. 1st Edition May 2003. UNEP Chemicals, Geneva, CH

2 **Directive 2000/76/EC** of the European Parliament and Council of 4th December 2000 on the incineration of waste. Official Journal L332/91

3 **U. Quaß**, M. Fermann, G. Bröker: The European Dioxin Emission Inventory – Stage II; Final Report to European Commission, 3 Volumes, December 2000; published as LUA-Materialien Nr. 59 (2001), Landesumweltamt Nordrhein-Westfalen; electronic version see www.europa.eu.int/comm/environment/dioxin

4 **U. Quaß,** M. Fermann, G. Bröker: „Identification of relevant sources of dioxins and furans in Europe". LUA-Materialien Nr. 43, ISSN 0947-5206, ca. 900 Seiten, 1997. electronic version see www.europa.eu.int/comm/environment/dioxin

5 **Commission Decision** 2000/479/EC of 17. July 2000 on the implementation of a European Pollutant Emission Register (EPER) according to article 15 of Council Directive 96/61/EC concerning integrated pollution prevention and control (IPPC). Official Journal L192/36

Annex A Overview on sampling and analysis labs in the CCs

Here an overview is presented on the responses to the questionnaire submitted to CC experts in the first phase of the project concerning available companies or institutes which are capable of emission sampling and/or analysis for dioxins and furans. Due to this procedure of information gathering the figures given in Table 7 give not necessarily a complete picture of the situation in the CCs. Particularly in case that no proposals for measurements had been made also no indication on laboratories was given.

Table 7 Sampling teams and dioxin laboratories in CC countries according to response from CC experts

Country	**Sampling teams**		**Analysis laboratories**	
	number	*Emission experiences*	*number*	*Emission experiences*
Bulgaria	-		-	
Cyprus	1	No	-	
Czech Republic	1	Yes	1	Yes
Estonia	1	No	-	
Hungary	-		-	
Latvia	1	No	-	
Lithuania	1	No	-	
Malta	-		-	
Poland	3	YES (1)	3	YES (1)
Romania	-		-	
Slovakia	3	YES (1)	1	YES
Slovenia	-		-	
Turkey	1	No	1	No

Annex B Participating companies and institutes

Name	Country	Activity	Co-operation
DEPARTMENT OF LABOUR INSPECTION NICOSIA	Cyprus	Sampling	UBA GmbH, Austria
DK-TEKNIK[2]	Denmark	Sampling assistance for measurements in Estonia	EERC, Estonia; ERGO Forschungs-gesellschaft GmbH, Germany
EMIPRO	Poland	Sampling	Technical University Cracow
ERGO Forschungs-gesellschaft GmbH	Germany	Analyses of Estonia samples	Dk-Teknik
ESTONIAN ENVIRONMENT RESEARCH CENTRE (EERC)	Estonia	sampling	DK-Teknik
IUTA	Germany	Measurement program management, cross check controls	
TECHNICAL UNIVERSITY CRACOW	Poland	Analysis, assistance for measurements in Turkey	EMIPRO, Poland Tubitak, Turkey
TESO	Czech Republic	Sampling and analysis	
TNO-MEP	The Netherlands	Financial management Leading institute for entire project	
TUBITAK MRC	Turkey	Sampling and analysis	Technical University Cracow
UBA GmbH	Austria	Sampling assistance and analyses for measurements in Cyprus	

[2] Company re-named in 2004 to “Force Technology”

Part C Emissions to Land and Water (IOW)

OFFICE INTERNATIONAL DE L'EAU

Développer les compétences pour mieux gérer l'eau

DIOXIN EMISSIONS IN CANDIDATE COUNTRIES

RELEASE OF DIOXINS TO LAND AND WATER

Catherine JUERY

Version February 15th 2005

Content

1. Introduction

As part of a project, performed for DG Environment, called “Dioxin Emissions in Candidate Countries”, an inventory of emissions to water and land in the 13 countries in central and Eastern Europe was compiled. These 13 countries are:

1) Bulgaria
2) Cyprus
3) Czech Republic
4) Estonia
5) Hungary
6) Latvia
7) Lithuania
8) Malta
9) Poland
10) Romania
11) Slovak Republic
12) Slovenia
13) Turkey

When the project was commissioned, these countries were referred to as EU candidate member countries. Since June 2004, 10 of these countries are full members of the EU. Bulgaria, Romania and Turkey now are still candidate members.

This report presents the results of the water and land emissions inventory compilations.

Releases to air are better known and studied than releases to land and water. This is reflected in the fact that bibliographical data on the releases to these media are scarce, specially in the candidate countries. This is due probably to the more numerous sources of dioxin release to air than to water and the fact that exposition to dioxins via air is more direct than via land. It is more common to be contaminated by inhaling air than ingesting lands. Moreover, the levels of release to air are more significant than those to water. In an other way, levels of dioxin in water are quite small, so the importance of these releases did not seem to be a priority for studies and monitoring although some studies have been done using the UNEP toolkit. For example, that was the case for the inventory of dioxin and furan emissions to air, land and water in Ireland (HAYES F.et al) and for New Zealand inventory of dioxin emissions in air, land and water, and reservoir sources (BUCKLAND S et al, March 2000).

2. Procedure and Methods

2.1 General and Data Sources

In the framework of this study, we used only bibliographical data and expert's opinion, no (new) measurements. That means we did not introduce new emission factors in our estimation above the currently existing ones.

No previous inventories of emission to land and/or water have been identified in the 13 studied countries.
Some monitoring networks exist on dioxin concentration in rivers. Direct measurements of releases in relation to processes causing these were not found. An example is the final report of the ELICC project *(Environmental Levels and Human Exposure in Candidate Countries* : ENV.C.2/SER/2002/0085) published in March 2004, monitoring programs in surface waters regarding dioxins contamination levels are described.
According to this study, water monitoring programmes are carried through in the following Accession Countries : Cyprus, Czech Republic, Hungary, Lituania, Poland, Slovak Republic, Slovenia. There is no information about monitoring of dioxins in water in Turkey and Bulgaria. In Latvia, PCDD/Fs and PCBs are not included in the National Monitoring Programme because they were below detection limits during screening measurement in the centralised water supply system. Malta has planned to establish a ground water monitoring programme. No information of release are available.

According to the lack of already available data or inventories about release of PCDD/F to land and water in the 13 studied countries, IOW made an estimate of these releases using existing emission coefficient and activity data on the following basis :

RELEASE in water or land = specific EMISSION FACTOR x ACTIVITY RATE

The first step of this study was to identify the known sources of dioxin release to water and those to land. Once these sources were identified, we tried to find the existing corresponding emission factors. In order to achieve this step, we searched the published and existing inventories on dioxin release to water and land in Europe and in foreign countries.

This approach could present some disadvantages : we used the same emission factor for all the countries even if these countries present particularities in their industrial processes for example. This hypothesis could induce uncertainty in the estimation. In every case, we decided to select the highest emission factors in order to have a pessimist estimation. The reality could be lower. Without any other data on release on the field, we decided to adopt a harmonised approach using the same emission factors in each country.

The only specificity considered here depends on the activity data or when some specific information has been collected. We have contacted national experts (cf.paragraph 2.4) and used our network of national focal points through Aquadoc project (http://www.aquadocinter.org/) in order to collect data. We received comments and complementary information on activity data that were introduced in this report.
A previous important work has been realised on PCDD/F releases to land and water by the European Commission. An inventory report was published in 1999 relating to the Member States (*releases of dioxins and furans to land and water in Europe* – Landesumweltamt Nordrhein-Westfalen, Germany on behalf of European Commission DG Environment). So most of the emission factors used here come from this publication. The UNEP toolkit was

also used in order to compare the coefficients and calculate releases. Emission factors are described in detail in the annex.

The IOW did not use the UNEP toolkit as a reference but only as a comparison and complement. Other publications were also consulted in order to complete the sources. The bibliographical list is available in the annex.

2.2 Emission factors

2.2.1 Releases to water

Table 1 presents the emission factors to water, derived from the information as presented in the Annex. Emission factors were found for seven different processes. For each of these emission factors, a range of values is given in the table. The ranges are one or two orders of magnitude, indicating the high uncertainty in these values.

The highest emission factor is found for “Improper waste oil disposal”. ”Disposal of municipal solid waste to landfill” has also a significant emission coefficient.

Table 1 : known and used emission factors for release to water

Activity sector	**Emission factor to water**		
	Minimum	**Maximum**	**Unit**
Improper waste oil disposal	14	60	µg I-TEQ/T
Disposal of municipal solid waste to landfill	6	15	µg I-TEQ/T
Paper and pulp production	0,077	0,26	µg I-TEQ/T
Incineration of industrial waste	0,062	3,72	µg I-TEQ/T
Coke production	0,06		µg I-TEQ/T
Incineration of sludge from wastewater treatment	0,026	0,2	µg I-TEQ/T d.m.
Wastewater treatment in residential / commercial sector	0,5	5	ng I-TEQ/ m^3

Details about the origin of these factors are given in the annex.

2.2.2 Releases to land

A lot of sources of releases to land have been identified.
Table 2 presents the emission coefficients used. Uncertainty could again be quite important. It is important to note that we took pessimist hypotheses according to the fate of the residues from these different items. We could so consider that the levels of release presented in this report are a maximum.

In some of the cases, we present a minimum and maximum release. These 2 amounts have been calculated as described below :

Minimum releases = activity rate x minimum emission factor

Maximum release = activity rate x maximum emission factor

Table 2 : emission factors for release to land

Activity sector	Emission factor to land		
	Minimum	Maximum	Unit
COMBUSTION			
Combustion of coal – domestic	41,21	5802,65	µg I-TEQ/T
Combustion of coal – power stations	0,789	39,89	µg I-TEQ/TJ
Combustion of coal – industry	0,08	23,26	µg I-TEQ/TJ
Combustion of wood – industry	1,94	21,95	µg I-TEQ/T
Combustion of wood – domestic	0,27	19,21	µg I-TEQ/T
INDUSTRIAL PROCESSES			
Sinter plant	1,45	976	ng I-TEQ/T
Primary copper production	0,34	3,38	µg I-TEQ/T
Secondary lead production	208	1416	µg I-TEQ/T
Secondary zinc production	38,4	1416	µg I-TEQ/T
Secondary copper production	2,06	516	µg I-TEQ/T
Secondary aluminium production	38,4	320	µg I-TEQ/T
Pesticide production	303,4	69085	µg I-TEQ/T
Paper and pulp production	60	4050	ng I-TEQ/T
Cement production	0	1050	ng I-TEQ/T
Lime production	0	1050	ng I-TEQ/T
Electric furnace steel plant	276,9	5802	ng I-TEQ/T
INCINERATION			
Incineration domestic/ municipal waste	0,2	0,95	mg I-TEQ/T
Incineration of industrial waste	0,02	6,8	µg I-TEQ/T
Incineration of sludge from wastewater treatment	11,64		µg I-TEQ/T
Incineration of hospital waste	87	238	µg I-TEQ/T
WASTE TREATMENT AND DISPOSAL			
Disposal of municipal solid waste to landfill	6,3	73	µg I-TEQ/T
Sewage sludge spreading in agriculture	10	100	µg I-TEQ/T
Compost production from waste	1,8	19	µg I-TEQ/T
OTHER ACTIVITES			
Pesticides uses	0,16	8,28	mg I-TEQ/T
Accidental fires	40	190000	µg I-TEQ/T
Bonfires and other incidental fires	37,5	21024	ng I-TEQ/ bonfire

Details on these factors are given in the annex.
For all of these emission factors, hypotheses about the fate of the residues have been made (see annex). When no precision could be found, we choose to consider the worst situation that is to say incorporation of the residues to the soil. All these hypotheses are described coefficient per coefficient in the annex.

An important uncertainty could occur : for example, in sinter production, the emission factor is comprised between 1,45 and 976 ng I-TEQ/T or for cement production, production of dust has been considered between 0 to 35 kg dust per tonne of cement that is to say an emission factor between 0 to 1050 ng I-TEQ/T.

2.3 Activity data

Activity data have been collected in Eurostat, CEPMEIP database http://www.mep.tno.nl/emissions/). , national sources…
When no data were available, some estimation were made by the IOW according to the hypotheses described below. There could be uncertainty due to these estimations.
The different sources of information are identified in the table below.

Table 3 : sources of information about activity data

Activity sector	source of data activity
Power generation and heating	
Combustion of coal - power stations	CEPMEIP
Combustion of coal - industry	CEPMEIP
Combustion of wood - industry	CEPMEIP
Combustion of coal - domestic	CEPMEIP
Combustion of wood - domestic	CEPMEIP
Ferrous and non-ferrous metal production	
Sinter plant	CEPMEIP
Primary copper production	CEPMEIP
Secondary lead production	CEPMEIP
Secondary zinc production	CEPMEIP
Secondary copper production	CEPMEIP
Secondary aluminium production	CEPMEIP
Aluminium production (electrolysis)	CEPMEIP
Coke production	CEPMEIP
Electric furnace steel plant	CEPMEIP
Production and use of chemicals and consumer goods	
Pesticide production	IOW ESTIMATION
Paper and pulp production	National data
Mineral products	
Cement production	CEPMEIP
Lime production	CEPMEIP
Waste incineration	
Incineration of domestic / municipal waste	EUROSTAT
Incineration of industrial waste	EUROSTAT
Incineration of sludge from wastewater treatment	EUROSTAT
Incineration of hospital waste	TNO ESTIMATION
Disposal / landfill	
Improper waste oil disposal	IOW ESTIMATION
Disposal of municipal solid waste to landfill	EUROSTAT
Wastewater treatment in residential / Commercial sector	EUROSTAT
Sewage sludge spreading in agriculture	EUROSTAT
Compost production from waste	EUROSTAT
Pesticide uses	EUROSTAT
Uncontroled combustion processes	
Accidental fires	EUROSTAT
Bonfires and other incidental fires	EUROSTAT

For the last 2 items (accidental fires and bonfires and other incidental fires) and paper and pulp production, it was difficult to obtain activity data. So these sources of dioxin releases have not been evaluated.

Estimations made by the IOW :

In the case of improper waste oil disposal, we made an estimation using the ratio of UK disposal in relation to the population. In 1993, the waste oil generation in UK was about 402000 tonnes. It was estimated that around 10% of this amount were generated by motorists changing their own oil. Less than 20% of this volume was recovered. That means : 0,55 kg of waste oil improperly disposed per habitant Without any other data, this default emission factor was used for all the 13 countries. So the release of dioxin to land from this activity present a high level of uncertainty.

For waste water treatment in residential / commercial sector, we also made an estimation : we supposed that people use an average production of 200 litres of waste water per inhabitant per day (U. Wieland, 2003). We translated this average production in global production using the percentage of population connected to a wastewater treatment for the following countries : Cyprus, Estonia, Hungary, Malta, Slovak republic, Slovenia and Turkey (cf. table below). This activity data could have high uncertainty. So the release estimated also present a high level of uncertainty.

When other sources of information have been used, they are noted in the detail of estimation in annex.

Table 4 : Percentage of population connected to a waste water treatment :

Country	% of population connected
Estonia	69%
Cyprus	35%
Hungary	32%
Malta	13%
Czech republic	68%
Latvia	No data
Lithuania	No data
Poland	55%
Slovenia	30%
Slovak Republic	49%
Bulgaria	38%
Turkey	17%

(source : Eurostat – more recent available year of data)

When no data have been found, estimation of the release has not be made. Population is extracted from Eurostat database

Table 5 : Population in candidate countries

Country	Population (10^3 inhabitants)
Czech republic	10203.3
Estonia	1356
Cyprus	715.1
Latvia	2331.5
Lithuania	3462.6
Hungary	10142.4
Malta	397.3
Poland	38218.5
Slovenia	1995
Republic Slovak	5379.2
Bulgaria	7845.8
Romania	21772.8
Turkey	67803.9

According to pesticide production, we make the hypothesis without any other data that all the pesticides used in the country are produced in it. This is an overall estimation because it is probably not the case.

2.4 Consultation of national experts

We have consulted several experts in each country in order to confirm or comment data and level of emission in water and land.

Country	Contact	E-mail
Bulgaria	Angel Kostov	KostovAngel@moew.government.bg
	Evelina Nikolova	Airmon@NFP-bg.eionet.eu.int
Czech republic	Barbora Cimbalnikova	Barbora_cimbalnikova@env.cz
	Ivan Holoubek	holoubek@chemi.muni.cz
Cyprus	Stelios Georghiades	roc.dli@cytanet.com.cy
Estonia	Ott Roots	Ott@klab.envir.ee
	Margus Kort	margus@klab.envir.ee
Hungary	Akos Fehervary	Fehervary@mail.ktm.hu
	Szabo Gyula	SzaboGyula@vituki.hu
Latvia	Juris Fridmanis	Juris.Fridmanis@lva.gov.lv
Lithuania	Margeriene Aldona	Aldona.mangeriene@nt.gamta.lt
Malta	Charmaine Vassallo	Charmaine.vassallo@mepa.org.mt
Poland	Adam Grochowalski	agrochow@chemia.pk.edu.pl
Romania	Corina Cristea	ccristea@icim.ro
Slovak republic	Gabriela Fischerova	Fischerova.gabriela@enviro.gov.sk
	Anton Kocan	kocan@upkm.sk
Slovenia	Janko Zerjav	janko.zerjav@zzv-mb.si
	Marjan Sajko	Marjan.sajko@zzv-mv.si
Turkey	Kemal Kurusakiz	kurusakiz@yahoo.com

We received answers from most of the countries. But they have no already available data about release to water and land.
Some experts send us publications on levels of contamination of dioxin in water and land, notably from the ELICC-project but no specific emission data has been given.
The experts give us more information on data activities, confirming or not the data used. We indicated the source of data in the annex report country per country when they are different from the sources mentioned in the general table 3.

In the other hand, all the experts refer their comments on the basis of the UNEP toolkit and its emission factors. The emission factors used in this study come from the previous inventory made on “old member states” in 1999. Most of the experts did not adjudge the results.

According to release to land, some experts confirm us that the hypotheses chosen are the worst ones. The reality is probably less than the levels indicated in this report. Without any other concrete data, we preserve the emission factors and data activity available.

3. Results

3.1 Release to land

Estimation of releases in candidate countries to land is suffering from uncertainty, specially about the fate of residues (are they disposed on the soil or recycled? How many of them are recycled?) and lack of data. Despite this we estimate the releases to land in all of these 13 countries as given in Table 6.

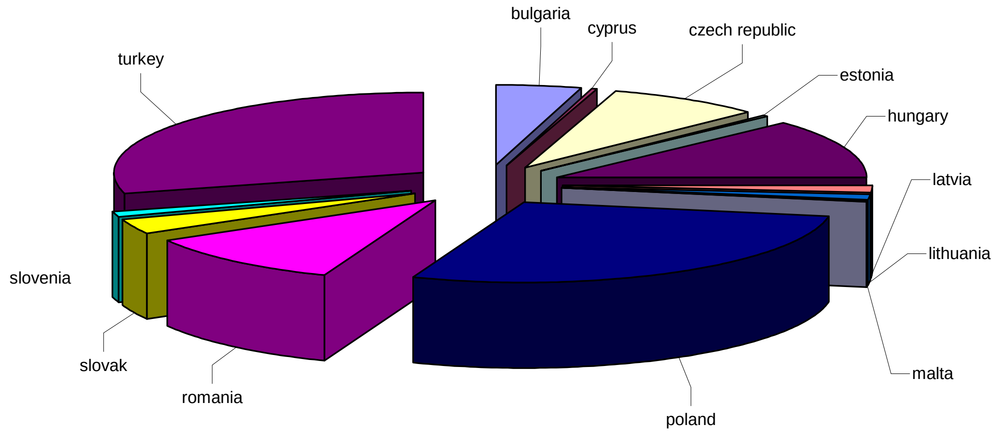
Table 6 : global releases of dioxin to land per country

ntry	Best estimates in g I-TEQ/Year	% of total release to land	Major source of release to land per country
Turkey	2292	29%	disposal of municipal solid waste to landfill
Poland	2212	28%	combustion of coal – domestic and disposal of municipal solid waste to landfill
Hungary	939	12%	incineration of domestic / municipal waste
Romania	844	11%	disposal of municipal solid waste to landfill
Czech republic	630	8%	incineration of domestic / municipal waste
Bulgaria	354	4%	disposal of municipal solid waste to landfill
Slovak republic	249	3%	incineration of domestic / municipal waste
Lithuania	102	1%	disposal of municipal solid waste to landfill
Slovenia	96	1%	disposal of municipal solid waste to landfill
Latvia	96	1%	incineration of industrial waste and disposal of municipal solid waste to landfill
Cyprus	24	0,3%	disposal of municipal solid waste to landfill
Estonia	27	0,3%	disposal of municipal solid waste to landfill
Malta	17	0,2%	disposal of municipal solid waste to landfill
TOTAL FOR ALL THIS REGION	**7 885 g I-TEQ/Year**		

N.B.: The best estimates have been taken as the arithmetic mid-point of the mini-maxi estimates.

The most important release to land could be attributed to Turkey and Poland responsible respectively for 29 and 28% of the total releases to land of this area as shown in the graph 1.

Even with the high level of uncertainty, we could reasonably consider that the distribution of dioxin release between the thirteen studied countries is correct, notably for the major contributors such as Turkey, Poland, Hungary and Romania.



Graph 1 : distribution of global releases of dioxin to land per country

If we detail these results on the studied area (candidate countries) per activity on the whole area, the results are as followed :

Table 7 : releases to land per activity sector on the whole area (candidate countries)

activity sector	Best estimates [(1)] in g I-TEQ/year	% total release
disposal of municipal solid waste to landfill	2190	28%
combustion of coal - domestic	2008	25%
incineration of domestic / municipal waste	563	7%
pesticide uses	319	4%
combustion of coal - power stations	67	1%
electric furnace steel plant	47	1%
secondary lead production	43	1%
cement production	37	0,5%
incineration of hospital waste	28	0,4%
secondary copper production	26	0,3%
sewage sludge spreading in agriculture	18	0,2%
secondary zinc production	17	0,2%
sinter plant	16	0,2%
incineration of industrial waste	5	0,1%
lime production	5	0,1%
combustion of wood - domestic	4	0,05%
compost production from waste	4	0,05%
secondary aluminium production	2	0,02%
primary copper production	1	0,01%
paper and pulp production	1	0,01%
incineration of sludge from wastewater treatment	0,08	-
pesticide production	*2484 (?)(2)*	*32% (?) (2)*

(1) : The best estimates have been taken as the arithmetic mid-point of the min-max estimates.
(2) : this value is a very uncertainty one and could not be considered

The 2 most important sources of releases to land in the 13 candidate countries are :

- Disposal of municipal solid waste to landfill
- Combustion of coal – domestic

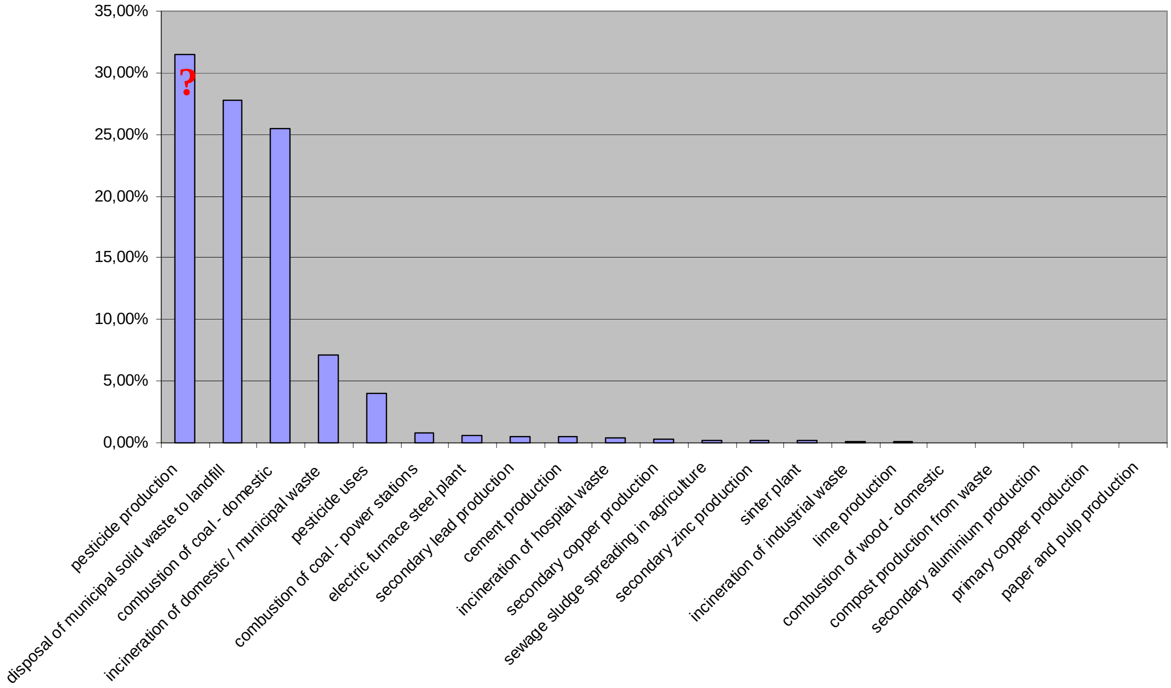
as shown in the graph 2 below.

For disposal of municipal solid waste to landfill, the emission factor presents an uncertainty of a factor 12. But activity data come from EUROSTAT. This estimates could be considered as quite reasonable.

According to releases to land from pesticide production, the value has a great uncertainty. The emission factor used ranges from 303,4 to 69085 µg I-TEQ/T. We also made the hypothesis that all the pesticides used in the country are produced in this country without any distinction between types of pesticide. So this item could not be considered as a major source of release of dioxin to land.

The emission factor used for domestic combustion of coal fluctuates from 41,21 to 5802,65 µg I-TEQ/T. So the uncertainty of releases from this activity could be important.

According to the pessimist hypotheses we made, notably about the fate of residues, we could presume that the real releases to land could be lower



Graph 2 : distribution of global releases of dioxin to land per activity

Details per country are presented in annex.

Even with the uncertainty, the difference of scale between the different activities contribution lets us believe that we could consider the major sources of release to land are disposal of municipal solid waste to landfill, incineration of domestic waste, pesticide production and use, and domestic combustion of coal. These four activities need a strong action in order to decrease their release to land by the European Union.

3.2 Release to land : Comparison with old member states

In the previous inventory made in 1999 (U. Quass et al – 1999), the global release to land in "old member states" have been estimated :

RELEASE to land(g I-TEQ) in "old member states			
	Mini	Maxi	Best estimate
Estimated release to land in "old member states"	3 850	72 600	**38 200**

(Source : U. Quass et al – 1999)

If we consider the European Union as a whole (candidate countries and old member states) and the best estimates in the 2 areas, it means that **the candidate countries contribute for 17% of the total release of dioxin to land and old member states for 83%.**

Regarding the major sources of release to land, U. Quass et al (1999) indicates the situation in old member states as :

Source	Release to land (best estimate) in g I-TEQ in "old member states"	Release to land (best estimate) in g I-TEQ in the 13 studied candidate countries
Pesticide production	13 000	*2 484 (?)*
Accidental fires	7 950	?
Incineration of municipal solid waste	7 200	564
Disposal of municipal solid waste to landfill	4 000	2190
Pesticide use	1 600	319
Secondary lead production	1 200	43
Combustion of wood – domestic	650	4
Secondary copper production	390	26
Electric furnace steel plant	350	47
Secondary aluminium production	310	2
Combustion of coal – domestic	150 (maxi)	2008

(Source : U. Quass et al – 1999)

In the "old member states" of the European Union and in the 13 studied candidate countries, the most important source of release to land seems to be pesticide production. Data used for the "old member states" are from 1994, so the types of pesticides produced could have changed in a decade. Nevertheless, there is nearly a factor 5 between the 2 considered areas for this source.
The second major source in member states is accidental fires. In the candidate countries, because of lack of data, this contribution has not been estimated. It could be considered that this source is significant in the candidate countries as for member states.
On the other side, combustion of coal for domestic uses is a significant source of release to land for candidate countries (third position) whereas it is less than the 10th most important source in member states.
The order of major sources of release to land is almost in accordance in the 2 areas, including the uncertainty of the estimation.

3.3 Release to water

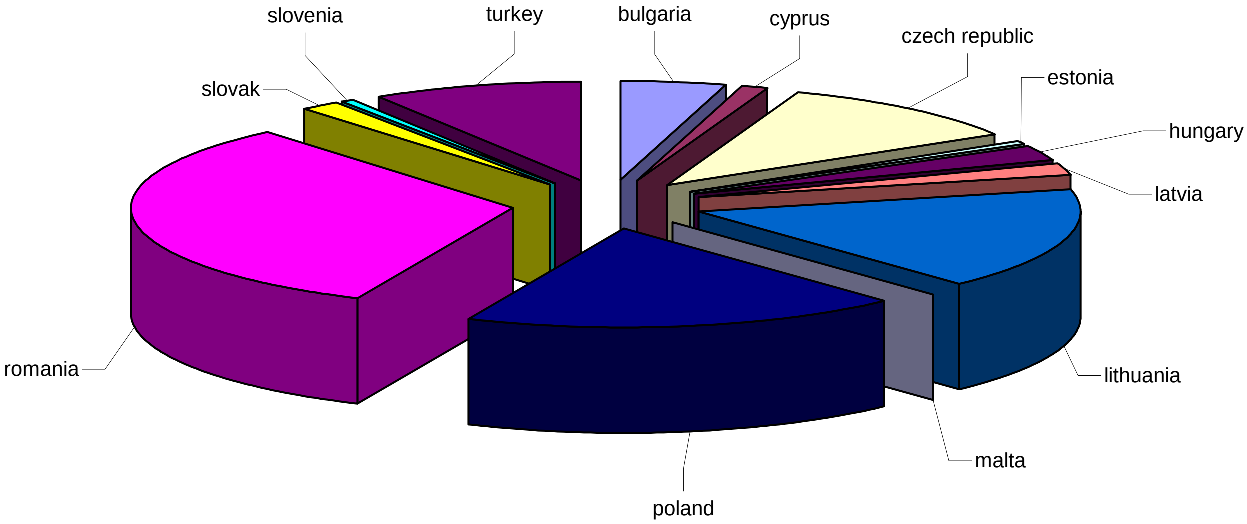
Estimation of releases to water in candidate countries is suffering from lack of data and uncertainty. Very few information on releases to water are known.

Table 8 : : National total releases of dioxin to water per country

ıtry	**Best estimates in g I-TEQ/Year**	**% of total release**	**Major source of release to water**
Romania	14,92	32%	wastewater treatment in residential / Commercial sector
Poland	8,58	18%	wastewater treatment in residential / Commercial sector
Lithuania	7,69	17%	wastewater treatment in residential / Commercial sector
Czech republic	4,96	11%	wastewater treatment in residential / Commercial sector
Turkey	4,14	9%	wastewater treatment in residential / Commercial sector and improper waste oil disposal
Bulgaria	2	4%	wastewater treatment in residential / Commercial sector
Hungary	1,22	3%	wastewater treatment in residential / Commercial sector
Slovak republic	0,76	2%	wastewater treatment in residential / Commercial sector and coke combustion
Latvia	0,88	2%	wastewater treatment in residential / Commercial sector
Cyprus	0,57	1%	incineration of industrial waste
Estonia	0,22	0,5%	wastewater treatment in residential / Commercial sector
Slovenia	0,17	0,4%	wastewater treatment in residential / Commercial sector
Malta	0,02	0,05%	wastewater treatment in residential / Commercial sector
TOTAL FOR ALL THIS REGION	**46,15 g I-TEQ/Year**		

The best estimates have been taken as the arithmetic mid-point of the min-max estimates.

The most important contributors to releases to water in these 13 countries are Romania (32% of total releases to water), Poland and Lithuania (respectively 18 and 17%). We have to note that some sources are missing because of lack of data activity but could be significant: incineration of sludge from wastewater treatment, paper and pulp production



Graph 3 : distribution of global releases of dioxin to water per country

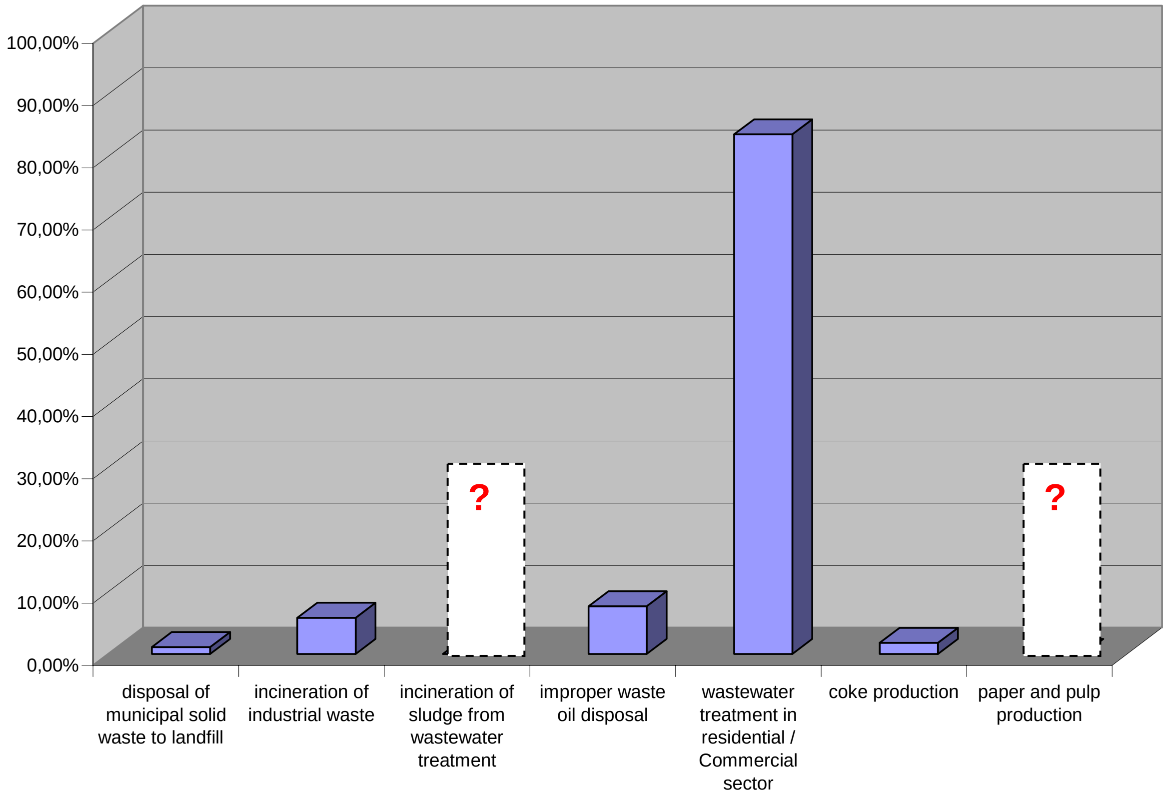
Releases to water per activity point out the major source of dioxin release in these 13 countries.

Table 9 : Sources of dioxin release into water

activity sector	Best estimates in g I-TEQ/year	% total release
wastewater treatment in residential / Commercial sector	37,87 (1)	83% (1)
improper waste oil disposal	3,49	8%
incineration of industrial waste	2,64	6%
coke production	0,82	2%
disposal of municipal solid waste to landfill	0,51	1%
paper and pulp production	No data	?
incineration of sludge from wastewater treatment	Not enough data	?

Note 1 : the release from wastewater treatment in residential / commercial sector are not caused by the treatment itself but by but the contamination of the effluents collected upstream and input in the treatment plant

The best estimates have been taken as the arithmetic mid-point of the min-max estimates



Graph 4 : distribution of global release to water per sources

The main source of dioxin releases to water, according to the data collected, in the area covering the 13 candidate countries is wastewater treatment in residential / commercial sector responsible for around 83% of the estimates. The origin of the dioxins is not the treatment itself but the effluents collected upstream and input in the treatment plant.These release are also influenced by the treatment implemented in the WWTP depending on the presence of a tertiary treatment or not. A certain quantity of dioxins could be retained during the treatment.

We have not enough data about incineration of sewage sludge from wastewater treatment (only available for Poland) and paper and pulp production to point out the contribution of these activity in this area.

3.4 Release to water : comparison with old member states

In the previous inventory made in 1999 (U. Quass et al – 1999), the global release to water in “old member states” has only been estimated as a trend. So it is not possible to compare the 2 areas. Nevertheless, release to water in the two cases are small.

4. Conclusions

There is a high level of uncertainty about this estimation of dioxin releases to water and to land because of :

- uncertainty in emission factors due to the hypotheses we choose and variability of processes and dioxin concentration
- uncertainty in activity data
- lack of data

Nevertheless, estimated dioxin releases to water and to land for the sources for which estimates have been made are as followed :

Releases to land in the 13 candidate countries : 8000 g I-TEQ/Year

Releases to water in the 13 candidate countries : 50 g I-TEQ/Year

The 13 candidate countries contribute for :

17% of total release to land

in the European Union as a whole (old member states and candidate countries)

In the area covered by the 13 candidate countries, the contributors to release to land and water follow the distribution presented below, according to the maximum and minimum estimates.

Table 9 : Percentage of each country contribution to dioxin release in the area

	Releases to land (in %)		**Releases to water (in %)**	
	Mini	Maxi	Mini	maxi
Turkey	26,9	29,2	12,5	8,5
Poland	16,5	28,6	22,1	18,2
Hungary	16,1	11,7	2,6	2,7
Romania	8,3	10,8	28,3	32,8
Czech republic	16,0	7,7	11,1	10,7
Bulgaria	4,1	4,5	4,3	4,4
Slovak republic	6,6	3,0	2,5	1,6
Cyprus	0,5	0,29	0,3	1,4
Lituania	1,2	1,3	13,8	17,0
Slovenia	1,2	1,2	0,4	0,4
Latvia	1,8	1,2	1,4	2,0
Estonia	0,5	0,3	0,5	0,5
Malta	0,2	0,2	0,1	0,05
Total of the area	100%	100%	100%	100%

This table clearly points out the range of uncertainty linked to the estimates.

The major contributor of release of dioxins to land in candidate countries is Turkey (nearly 28% of the total release in this area) followed by Poland (between 17 and 28%) and Hungary (between 11 and 16%).

The major contributor of release to water in studied region is Romania followed by Poland and Lithuania.

The same analysis per activity for the whole 13 countries is presented in table 10.

Table 10 : Percentage of each activity contribution to dioxin release in the area

activity sector	Release to land (in %)		Release to water (in %)	
	Minimum	maximum	Minimum	maximum
Power generation and heating				
combustion of coal - power stations	0,4%	0,9%		
combustion of coal - industry	NA			
combustion of wood - industry	NA			
combustion of coal - domestic	4%	26%		
combustion of wood - domestic	-	-		
Ferrous and non-ferrous metal production				
sinter plant	-	0,2%		
primary copper production	-	-		
secondary lead production	1,7%	0,5%		
secondary zinc production	0,1%	0,2%		
secondary copper production	-	0,3%		
secondary aluminium production	-	-		
aluminium production (electrolysis)				
coke production			16%	-
electric furnace steel plant	0,7%	0,6%		
Production and use of chemicals and consumer goods				
pesticide production	*3% (?)*	*33% (?)*		
paper and pulp production	NA	NA	NA	NA
Mineral products				
cement production	-	0,5%		
lime production	-	-		
Waste incineration				
incineration of domestic / municipal waste	30%	6%		
incineration of industrial waste	-	-	1%	6%
incineration of sludge from wastewater treatment	NA	NA	NA	NA
incineration of hospital waste	2%	0,3%		
Disposal / landfill				
improper waste oil disposal			13%	7%
disposal of municipal solid waste to landfill	54%	27%	3%	1%
wastewater treatment in residential / Commercial sector			67%	86%
sewage sludge spreading in agriculture	0,5%	0,2%		
compost production from waste	0,1%	-		
Agricultural activities				
pesticide uses	2%	4%		
Uncontrolled combustion processes				
accidental fires	NA	NA		
bonfires and other incidental fires	NA	NA		

NA : not available or not enough data available
(grey box) : not relevant

The presented contributions of activities have to be taken with precaution. Percentages could be different if uncertainty of emission factors were more limited and if missing activity rates were available. Thus, the quantity of sewage sludge from wastewater treatment incinerated is only known for one country : Poland. Pulp and paper production could also be a significant source of dioxin release to water but no activity rate could be collected.

According to this estimation, it is not possible to point out a link between emissions and levels of contamination of surface waters or ground waters. First of all, because in this report, we have no indication about the sources of emission (point sources) , and also because levels of uncertainty are too high.

Priorities and actions required to improve completeness and decrease uncertainty of the emission estimations

According to this study and its comparison with “old member states”, it becomes evident that there is a certain similarity in all the European countries. The same major sources of release to land and to water have been identified : pesticide production and use, incineration of municipal solid waste, disposal of municipal solid waste to landfill. Combustion of coal for domestic use seems to be a particularity of the 13 “candidate countries”. Impact of accidental fires have nit been estimated in this area because of lack of data but could be important.

It would be interesting to improve the quality of emission factors to water and land by measurement campaigns on identified point sources of dioxins to water and land, specially for activity sectors which have a high potential of release such as wastewater treatment, incineration of domestic waste, disposal of municipal solid waste in landfill and pesticide production. It could be also essential to obtain activity data in all the potential sources of release. For example, paper and pulp production present a high potential of release but could not have been estimated because of lack of data. The same for accidental fires and bonfires and other incidental fires for which we did not succeed to estimate the release when they could represent an important release. Thus, accidental fires present an emission factor to land between 40 and 190000 µg I-TEQ / Tonne which is quite significant.

According to release to land, it could be important to have a precise idea of the fate of residues in each of the studied countries. We chose to take into account the worst situation which is not representative of the reality in all the cases. Such precision could be useful to clarify the level of release to land and the potential of contamination of ground waters.

On the other hand, it is not possible to analyse or suggest any effects by intake of these waters by human or animals. Further research could be pertinent in order to assess the relevance of this potential way of human and animal contamination.
Direct human contamination through drinking water is not known. Levels of dioxin in water seem to be too low to have a direct impact but this could be demonstrated. But accumulation through food chain is the subject of researches and news that have clearly point out this way of contamination (contamination through milk or chickens) even if it is difficult to separate the ways of contamination between air and water.

Further researches in this areas could be relevant in order to improve this inventory and precise the best ways to decrease the release to land and water.

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DIOXIN EMISSIONS IN CANDIDATE COUNTRIES

RELEASE OF DIOXINS TO LAND AND WATER

ANNEXES

Catherine JUERY

Version February 15th 2005

Contents of annex

1- Emission factors

We present below the emission factors used in the framework of this study according to the activity, source of the pollution.

- **1.1 Combustion of coal – power stations**

No data for liquid waste but release to water seems to be low (PCDD/Fs will be associated with particles)
Emission factor to land : 4,15 tonnes of ash per TJ of energy produced, 19% of which is grate ash and 81% is PFA (pulverised fuel ash) (AEA technology Environment 1997). There are 0,02 – 13,5 ng I-TEQ / kg for grate ash and 0,23 – 8,7 ng I-TEQ /kg for PFA. So : the emission factor to land is **0,789 – 39,89 µg I-TEQ / TJ** (U. Quass et al –1999). The UNEP toolkit indicates a emission factor of 14 µg I-TEQ/TJ (UNEP – 2003) in the ash residue. If all residue is landfilled, these emission factors can be used for emission to land. So we will use the factors boldface noted as an overestimation of land release.

- **1.2 Combustion of coal – Industry**

No data for release in water
Emission factor to land : 1,8 T of ash per TJ of energy produced, 88% of which is grate and 12% is ash from particle control.There are 0,02 – 13,5 ng I-TEQ / kg for grate ash and 0,23 – 8,7 ng I-TEQ /kg for ash particle control (U. Quass et al – 1999) that is to say : **0,08 – 23,26 µg I-TEQ / TJ**

- **1.3 Combustion of wood – industry**

Release to water : not relevant (UNEP – 2003)

Release to land : Treated wood is likely to be contaminated with chemicals that could act as precursors to PCDD/F formation. We supposed that 75% of wood burned is contaminated (same level than in UK in 1997). When wood burns, the production of ash is 3,4 kg/T of waste burned for grade ash and 3,3 kg/T of waste burned for grit ash from gas-cleaning. It is assumed that all ash is released to land (this is an overestimation).

For treated wood, the range of concentrations used for estimating PCDD/F releases are 22,3 – 1090 ng I-TEQ / kg (grate ash) and 722 – 7620 ng I-TEQ / kg (filter or grid ash)
For untreated wood, there are 0,23 – 1,12 ng I- TEQ/kg (grate ash) and 117 – 372 ng I-TEQ /kg (filter or grid ash) (U. QUASS et al – 1999).
That is to say : for treated wood, the PCDD/F emission coefficient to land is : 2,46 – 28,85 µg I-TEQ/T and for untreated wood : 0,38 – 1,23 µg I-TEQ / T.
When the quantity of respectively treated and untreated wood is unknown , we used the following coefficient : **1,94 – 21,95 µg I-TEQ/T** of burned wood.

In the toolkit (UNEP 2003), three emission factors are given for waste wood incineration depending to the furnaces type : between 1000 µg TEQ/t of biomass burned in older furnace, batch type operation without air pollution control equipment to 0,2 µg TEQ/t of biomass burned in modern state-of-art facilities.

- **1.4 Combustion of oil – industry**

No data are available from oil combustion to be estimated but they are expected to be low.

- **1.5 Combustion of refuse – derived fuel**

No data are available from refuse-derived fuel combustion to be estimated but they are expected to be low.

- **1.6 Combustion of coal – domestic**

No data for release to water.
Release to land : The ash content of coal ranges from 5 to 16%. The quantity of soot collected and disposed is estimated to 0,57 kg /T burned.
The emission factors of PCDD/F are : 53 – 10065 ng I-TEQ/kg of soot and 0,22 – 0,41 ng I-TEQ/kg ash (U.Quass et al – 1999). So the global emission factor used is : **41,21 – 5802,65 µg I-TEQ /T burned**

- **1.7 Combustion of wood – domestic**

When no other data is available, we supposed that 11% of wood burned in domestic appliance is treated and 89% untreated like in UK in the 1990s (U.Quass et al – 1999) but this seems to be an overestimation.

Release to water : No arisings of liquid waste.
Release to land :
The ash content of wood ranges from 0,4 to 3,4% (AEA technology Environment, 1997).
From untreated wood, the concentration ranges from 75 – 500 ng I-TEQ /kg for grate ash
From treated wood, the concentration ranges 22,3 – 1090 ng I-TEQ / kg for grate ash like in industrial combustion. (U.Quass et al – 1999).
So the emission coefficients used are :
For treated wood : 0,089 – 37,06 µg I-TEQ /T
For untreated wood : 0,3 – 17 ng I-TEQ / T
If no data are available about the repartition between treated and untreated wood and according to the previous percentage, we assumed to use the following coefficient : **0,27 – 19,21 µg I-TEQ / T** of burned wood .

- **1.8 Non ferrous metal production : hypothesis**

The EU / IPPC, in the BREF relating to non ferrous metal productions (2001) indicated that most of the residues produced in these industries are recycled in Europe :

Residue	Amount of residue reported in tonnes for 1996		
	Recycled or reused	Discharged to a landfill	Total amount
Non-ferrous metal containing dust	6550	1886	8436
Dust	201	13	214
Mineral residues form the abatement system	2638	1752	4390
Sludge	508	4	511
Aluminium containing dust	1477	66	1543

Table : Amount of recycled, reused and discharged residues that have been reported in 1996 for some non-ferrous metals plants in North-Rhine Westphalia (EU / IPPC – 2001)

In the framework of this report, without any other information, we took the hypothesis that all the residues produced are landfilled. This constitues an overestimation

- **1.9 Sinter plant**

No data for release to water. A release to water can occur if there is a wet scrubber used in the process with an effluent discharge but no emission factor is available.
Release to land :
About 0,9 – 15 kg of dust are produced per tonne of sinter (EU – IPPC – 2001). Most dust is recycled. Only a small part is landfilled : for example about 0,05 kg of dust landfilled per tonne of sinter in UK. We used an estimated lanfilled amount to 0,05 - 2 kg of dust per tonne of sinter.
Concentration could range between 29 to 488 ng I-TEQ / kg of dust (UNEP – 2001; U. Quass et al – 1999) that is to say :**1,45 – 976 ng I-TEQ / T** sinter.

- **1.10 Primary lead / zinc production**

Releases to land or water seem to be low (UNEP – 2003).

- **1.11 Primary copper production**

There is only few data on releases of PCDD/F from copper plants. In primary copper production plants, base metal smelters, PCDD/F seem to be very low (UNEP 2003).
Releases to water : no data is available but they are assumed to be low.
Releases to land : According to UNEP 2003, no release to land is expected. Nevertheless, U. QUASS et al (1999) calculated PCDD/F release to land for European member states using emission data from effluent treatment sludge. In the framework of this report, we used the same estimation with a important uncertainty.

About 13,5 to 1,35 T of sludge are produced per tonne of primary copper produced with a concentration of 25 ng I-TEQ / kg that means a release to land of : **0,34 - 3,38 µg / T of primary copper produced** (U. Quass et al– 1999).

- **1.12 Secondary lead production**

No data for <u>release to water</u>
<u>Release to land</u> : dusts and flue gas cleaning residues are potentially contaminated by PCDD/F. We used the same hypothesis than U.Quass et al (1999) : theyare produced at 8% of the secondary lead production. We choose to consider that all the dusts and flue gas cleaning residues are disposed in landfill even if we know that most of the dusts are recycled or used otherwise. So the estimated release to land could be an overestimation of real release.
The concentration range in filter dust is 2600 – 17700 ng I-TEQ/kg (U.Quass et al – 1999) that is to say : **208 – 1416 ng I-TEQ / kg of secondary lead produced**.

- **1.13 Secondary zinc production**

No data for <u>release to water</u>
<u>Release to land</u> : We considered the same hypothesis than in the previous inventory in Europe (U. Quass et al - 1999) : dusts and flue gas cleaning residues, potentially contaminated by PCDD/F, are produced at 8% of the secondary zinc production. We supposed that all the dusts and flue gas are disposed in landfill.
We used the following concentration range in filter dust : 480 – 17700 ng I-TEQ/kg (U.Quass et al –1999) that is to say : **38,4 – 1416 ng I-TEQ / kg of secondary zinc produced**.

- **1.14 Secondary copper production**

There is only few data on releases of PCDD/F from copper plants. In secondary copper production plants. But it seems that PCDD/Frelease could be occasionally high (UNEP 2003).
No data for release to water but it is probably significant when large volumes of effluent are released.
<u>Release to land</u> : we propose to consider that 43 kg of potentially contaminated dusts and residues are disposed to land per tonne of secondary copper produced (AEA Technology environment 1997). The range of emission factors used to estimate the emission is 48 – 12000 ng I-TEQ / kg of dust (U.Quass et al –1999) that is to say **: 2,06 – 516 µg I-TEQ / T of secondary copper produced**.

- **1.15 Primary magnesium production**

No data are available for release to water
<u>Release to land</u> : same factors than for secondary aluminium : see below (U. Quass et al – 1999)

- **1.16 Secondary aluminium production**

Release to water : no data
Release to land : the potentially contaminated with PCDD/F solid waste arising from all aluminium production are dusts from cyclones / bag filters. We assumed that these dusts production represents about 8% of metal produced. Emission factors used for these dusts are : 480 – 4000 ng I-TEQ / kg of dust (U.Quass et al – 1999) that is to say : **38,4 – 320 µg I-TEQ / T of secondary aluminium produced .**

- **1.17 Electric furnace steel plant**

Release to water : no data
Release to land : the most significant contaminated with PCDD/F waste produced are dusts from gas cleaning. Only small part of residues are landfilled (European Commission – IPPC – 2001) : we assumed that 64% of these dusts are recycled that means 36% are landfilled (U. Quass et al - 1999).
Their contamination level is between : 74 and 1470 ng I-TEQ / kg.
When no data is available, we assumed that 10 kg of dust (it is an overestimation) are produced per tonne of steel produced that means an emission coefficient of : 266,4 – 5292 ng I-TEQ/ T of steel produced.
Slags are also produced from the use of lime to collect indesirable components in the steel : 77 – 150 kg of slag per tonne of steel. Between 34 and 100% of these slags are landfilled.
Their contamination level is between : 0,4 and 3,4 ng I-TEQ / kg that is to say **:** 10,47 – 510 ng I-TEQ / T of steel produced**.**
So the global emission factor is **: 276,9 – 5802 ng I-TEQ/ T** of steel produced.

- **1.18 Aluminium production (electrolysis)**

Release to water: no data
Release to land : about 44 kg of spent sludge are produced per tonne of aluminium (de Wit – 1996). These spent sludge may contain : 7,8 – 78 ng I-TEQ / kg (U.Quass et al –1999) that is to say the emission factor used is : **343,2 – 3432 ng I-TEQ / T of aluminium** making the hypothesis that all the spent sludge are landfilled. So this release to land is an overestimation of the reality.

- **1.19 Chemical production – PVC**

No data of production but seems to be significant (U. Quass et al – 1999).

- **1.20 Chemical production – PCE/TCE**

No data of production but seems to be significant when PVC are produced (U. Quass et al – 1999).

- **1.21 Pesticide production**

Release to water : no data
Release to land : The production of pesticides and their active ingredients presents a high potential for releasing PCDD/F to the environment because of the presence of chlorine and aromatic structures.
Waste potentially contaminated represent 0,41% of the pesticide production (we considered solid waste to represent 41% of the production with 1% of these contaminated (AEA Technology Environment - 1997) with a level of contamination : 296 – 67400 ng I-TEQ / T of solid wastes (U.Quass et al –1999). Only 25% of these waste are supposed to be landfilled that is to say : **303,4 – 69085 ng I-TEQ / kg of pesticides produced**. Not a lot of data could be obtained about the production of pesticide in the studied countries. So we assumed that all pesticide used are produced in the country. This hypothesis is an overestimation and the types of pesticides produced have probably changed in a decade. So, the data calculated with this emission factor could be considered as very uncertain.

- **1.22 Chemical production – chlorophenols**

No data for release in water or land.

- **1.23 Paper and pulp production**

Release to water : we used the same estimation than for Sweden (U.Quass et al – 1999) : **0,077 – 0,26 µg I-TEQ /T pulp and paper produced**. In the UNEP toolkit, the emission factor is 0,06 - 4,5 µg I-TEQ / Tonne (UNEP – 2003).
Release to land : the major source of PCDD/F release to land are generated by sludge. We assumed that 25 – 75 kg sludge are produced per tonne of paper or pulp produced and are landfilled.The European commission (EU / IPPC - BREF in paper and pulp processes – 2001) indicates an average of 43 kg of sludge per tonne of pulp in kraft pulp mills and some references to an average 30-60 kg organic wastes (dry basis) per tonne of pulp and 40-70 kg inorganic wastes (dry basis) per tonne of pulp of for bleached kraft pulping.

The UNEP toolkit proposes a production of 50 kg of sludge per tonne of pulp
We considered that the concentration of PCDD/F in sludge is 2,4 – 54 ng I-TEQ /kg sludge (U.Quass et al – 1999).
So we used the emission factor to land : **60 – 4050 ng I-TEQ / T pulp and paper produced**.
No other information is available on candidate countries paper and pulp production processes

- **1.24 Cement and lime production**

Release to water : no data but seems to be not relevant.
Release to land : 0 to 35 kg of dust are generated per tonne of cement produced (UNEP-2003). We made the hypothesis that all these dusts are landfilled. In the IPPC reference document (EU / IPPC – 2001), it is noted that collected dust should be recycled to the production processes whenever practicable but we have no information on practice in candidate countries.

We considered a concentration factor of 0,001 – 30 ng I-TEQ /kg of dust (UNEP – 2003) that is to say an emission factor to land : **0 – 1050 ng I-TEQ/ T of cement** produced.
We assumed that the same emission factor could be relevant for lime production (U. Quass et al – 1999).

- **1.25 Dry cleaning**

Release to water seems to be low but release to land could be significant. But no data could be collected.

- **1.26 PentaChloroPhenol use in wood preservation**

No data available

- **1.27 Incineration of waste : hypothesis**

All kinds of situations could be met in the studied countries. For example, the UE (IPPC - 2004) shows that the fate of bottom ash residues from waste incineration is very constrated in member states : between 0 to 100% are recycled.
So, for this type of activities, when it is not precised, we considered that all residues represent a release to land.

- **1.28 Incineration of domestic / municipal wastes**

<u>Release to water</u> : no data but assumed to be low
<u>Release to land</u> : In the previous inventory of dioxin release in Europe (U. Quass et al – 1999), the following hypotheses were taken: 300 kg of grate residues are produced per tonne of waste with an average concentration of 12 –72 ng I-TEQ / kg. In addition, in older plants, release from particulate controls represent a quantity of 30 kg/ tonne of waste with a concentration of 6600 – 31100 ng I-TEQ/ kg. In new plants, semi-dry system, the release is 38 kg / tonne of waste with a concentration of 810 – 1800 ng I-TEQ/kg that means :
For older plants, an emission factor between : 0,2 and 0,95 mg I-TEQ/T of waste could be applied.
For new plants, an emission factor between : 34,38 and 90 µg I-TEQ/T of waste could be applied.
Sludge represent also a release to land. In plant with wet scrubbing, 10 – 15 kg of sludge are produced per tonne of waste burned with a concentration of 680 – 12200 ng I-TEQ/kg (U QUASS et al, 1999) that is to say : 6,8 – 180 µg I-TEQ/ T of waste.
In the framework of this study and as we have not indication of the proportion between old and new plants, we used the worse coefficient. We also considered that all the disposal ways of these waste represent a release to land.
So, the global emission factor used here is : **0,2 – 0,95 mg I-TEQ / T** of waste incinerated.

In the UNEP tolkit, the emission factors are : between 0,02 and 0,58 mg I-TEQ/T of waste incinerated combining fly ash and bottom ash .
The estimation of release to land we propose could be an overestimation of the reality.

- **1.29 Incineration of industrial waste**

Release to water :we considered that the discharge of liquid waste is 6,2 m^3 per tonne of waste (U.Quass et al –1999) with a PCDD/F concentration level of 0,01 – 0,6 µg I-TEQ / m^3 that is to say : **0,062 – 3,72 µg I-TEQ / T of incinerated waste**.

Release to land : We considered a solid waste production of 20% of the amount of industrial waste incinerated (low technology combustion without APC system) (UNEP - 2003) with a concentration of 0,1 – 34 ng I-TEQ/kg (U.Quass et al –1999) that is to say an emission factor to land of : **0,02 – 6,8 µg I-TEQ/T of industrial waste incinerated**.

- **1.30 Incineration of sludge from waste water treatment**

Release to land : When no data are available, we assumed that 11% of sludge are incinerated (like in the previous inventory in Europe, U. Quass et al – 1999).
In old plants, 430 kg of grate ash with an average concentration of 39 ng I-TEQ / kg of grate ash and 373 kg of ESP ash with an average concentration of 473 ng I-TEQ / kg of ESP ash are produced per tonne of incinerated sludge that is to say : 22,9 µg I-TEQ/T of sludge burned.
For new plants, about 373 kg of ESP ash are produced per tonne of incinerated sludge, with no grate ash, with an average concentration < 0,1 ng I-TEQ/kg that is to say an emission factor <373 ng I-TEQ/T of sludge burned. We used this value as a limit.
Without any other data, we considered that 50% of sludge are burned in new plants and 50% in old plant, so global emission factor is : **11,64 µg I-TEQ/Tonne of sludge burned** (expressed in dry solids) (U. Quass et al - 1999; UNEP - 2003).

Release to water : liquid discharges come from new plants wet scrubbers. It is assumed that 44 – 62 m^3 / tonne of sludge burned is discharged with a concentration of 0,0012 – 0,0065 µg I-TEQ/ m^3 that is to say : **0,026 – 0,2 µg I-TEQ / Tonne of sludge burned** (U. Quass et al - 1999)

- **1.31 Incineration of hospital waste**

No data for release to water

Release to land : without any other data, we assumed that 50% of new plants have dry scrubbers and produced 80 kg of solid residues per tonne of hospital waste burned with a concentration of 1800 – 4500 ng I-TEQ/kg.
The last 50% of new plants have wet scrubbers and produced 40 kg of solid residues per tonne of hospital waste burned with a concentration of 680 ng I-TEQ/kg.
Incineration of hospital waste also produce 150kg of grate ash per tonne of waste burned whatever is the plant with a concentration of 15 – 300 ng I-TEQ/kg.
So the global emission factor used here is : **87 – 238 µg I-TEQ/T of hospital waste burned** (U. Quass et al - 1999) with the hypothesis that all these residues are landfilled (it is an overestimation).
The UNEP toolkit proposes emission factors between 20 to 920 µg I-TEQ/Tonne of medical waste burned.

- **1.32 Improper waste oil disposal**

Release to water : It is assumed that the concentration of PCDD/F in waste oil is **14 – 60 ng I-TEQ/kg** (based on the same hypothesis than the European Inventory – U. Quass et al – 1999).
No data could be obtained relating to waste oil produced.
In UK, about 402000 Tonnes have been collected in 1993. 10% of arisings come from motorists who change their own oil and only 20% of this volume is recovered (U.Quass et al –1999) that is to say 0,550 kg of improper waste oil disposed per inhabitant. We used this ratio for all the countries to estimate waste oil production.

No release to land

- **1.33 Disposal of municipal solid waste to landfill**

Release to land : all the municipal solid waste landfilled are considered as a release to land. The concentration used is **6,3 – 73 ng I-TEQ/kg** wet basis (U. Quass et al – 1999).

Release to water : we used 30 pg I-TEQ /l of lixiviat (UNEP - 2003). Even if it is very variable, we assumed that 200 – 500 l of leachate discharge are produced per tonne of waste (Noma Y. et al – 1999) that is to say : **6 – 15 ng I-TEQ/T of waste**.

- **1.34 Open burning of agricultural wastes**

No data available

- **1.35 Waste water treatment in residential / commercial sector**

release to water : the used emission factor is **0,5 – 5 ng I-TEQ/m^3** of wastewater (UNEP 2003). The emission is not due to the treatment itself but to the effluents collected in the plant such as runoff on roads, commercial activites.... No details could be obtained in order to distinguish the different sources of dioxin emission collected in wastewater treatment plants.
release to land : sludge from wastewater treatment plant are incinerated or spread in agriculture or landfilled. They are so included in other categories.

- **1.36 Sewage sludge spreading in agriculture**

release to land : we assumed that sewage sludge content about **10 to 100 ng I-TEQ/kg** (UNEP – 2003).
No release to water

- **1.37 Compost production from waste**

Release to land : we used a range of **1,8 – 19 µg I-TEQ / T of compost produced** (U. Quass et al – 1999). The UNEP toolkit suggests an emission level of 5 – 100 µg I-TEQ / T dry product (UNEP – 2003).
No data relating to release to water

- **1.38 Pesticides uses**

Release to land : we supposed that only 4,73% of the pesticide used are potentially contaminated with PCDD:F (U. Quass et al – 1999). We assumed that all the pesticides used are contaminated at a level 3,5 – 175 mg I-TEQ / T that is to say an emission factor of **0,16 – 8,28 mg I-TEQ / T of pesticide used**.
Release to water : there is a high potential for release to water courses from open use of chemicals but no data is available.

- **1.39 Accidental fires**

Release to land : It is estimated that solid material from accidental fires content a concentration of PCDD/F within the range : **40 – 190000 µg I-TEQ / Tonne** (U.Quass et al – 1999).
But it is difficult to have activity data about this item.

- **1.40 Bonfires and other incidental fires**

Release to land : we considered that 0,5 kg of residue is produced per bonfire with a concentration of 75 – 42048 ng I-TEQ / kg that is to say : **37,5 – 21024 ng I-TEQ/ bonfire** (U.Quass et al – 1999).
But it is difficult to have activity data about this item.

- **1.41 Coke production**

Release to water : we applied the worst emission factor from the UNEP toolkit : **0,06 µg I-TEQ/T** of production (UNEP –2003)

Release to land : no data

2 – Releases estimations

- **2.1 - Release to land**

Here are summarised the emission coefficient used for estimation according to the different sources of dioxins. Uncertainty could be quite important. The estimated emissions are indications on the level of releases.

Activity sector	Emission factor to land		
	Mini	**Maxi**	**Unit**
Combustion of coal – power stations	0,789	39,89	µg I-TEQ/TJ
Combustion of coal – industry	0,08	23,26	µg I-TEQ/TJ
Combustion of wood – industry	1,94	21,95	µg I-TEQ/T
Combustion of coal – domestic	41,21	5802,65	µg I-TEQ/T
Combustion of wood – domestic	0,27	19,21	µg I-TEQ/T
Sinter plant	1,45	976	ng I-TEQ/T
Primary copper production	0,34	3,38	µg I-TEQ/T
Secondary lead production	208	1416	µg I-TEQ/T
Secondary zinc production	38,4	1416	µg I-TEQ/T
Secondary copper production	2,06	516	µg I-TEQ/T
Secondary aluminium production	38,4	320	µg I-TEQ/T
Pesticide production	303,4	69085	µg I-TEQ/T
Paper and pulp production	60	4050	ng I-TEQ/T
Cement production	0	1050	ng I-TEQ/T
Lime production	0	1050	ng I-TEQ/T
Electric furnace steel plant	276,9	5802	ng I-TEQ/T
Incineration domestic/ municipal waste	0,2	0,95	mg I-TEQ/T
Incineration of industrial waste	0,02	6,8	µg I-TEQ/T
Incineration of sludge from wastewater treatment	11,64		µg I-TEQ/T
Incineration of hospital waste	87	238	µg I-TEQ/T
Disposal of municipal solid waste to landfill	6,3	73	µg I-TEQ/T
Sewage sludge spreading in agriculture	10	100	µg I-TEQ/T
Compost production from waste	1,8	19	µg I-TEQ/T
Pesticides uses	0,16	8,28	mg I-TEQ/T
Accidental fires	40	190000	µg I-TEQ/T
Bonfires and other incidental fires	37,5	21024	ng I-TEQ/ bonfire

- **2.2 – Release to water**

Here are presented the different emission factors to water : comparing to land, there are only few known significant sources of release to water. Improper waste oil disposal presents the most important level of PCDD / F release to water per tonne.

Activity sector	**Emission factor to water**		
	Mini	**Maxi**	**Unit**
Paper and pulp production	0,077	0,26	µg I-TEQ/T
Incineration of industrial waste	0,062	3,72	µg I-TEQ/T
Incineration of sludge from wastewater treatment	0,026	0,2	µg I-TEQ/T d.m.
Improper waste oil disposal	14	60	µg I-TEQ/T
Disposal of municipal solid waste to landfill	6	15	µg I-TEQ/T
Wastewater treatment in residential / commercial sector	0,5	5	ng I-TEQ/ m^3
Coke production	0,06		µg I-TEQ/T

3 – Results per country

Here are presented the results for each country and the major source of release to land and water according to the maximum release estimations.

3.1 – Bulgaria

- 3.1.1 – Activity data in Bulgaria

activity sector	activity value	unit
combustion of coal - power stations	216000	TJ
combustion of coal - industry		
combustion of wood - industry		
combustion of coal - domestic	17000	TJ
combustion of wood - domestic	25000	TJ
sinter plant	2500000	T
primary cooper production	27500	T
secondary lead production	10000	T
secondary zinc production	5500	T
secondary cooper production	5000	T
secondary aluminium production		
aluminium production (electrolysis)		
pesticide production	3907	T
paper and pulp production	No data	
cement production	2070000	T
lime production	804000	T
electric furnace steel plant	960000	T
incineration of domestic / municipal waste	no data	
incineration of industrial waste	109040	T
incineration of sludge from wastewater treatment	no data	
incineration of hospital waste	13000	T
improper waste oil disposal	4315	T
disposal of municipal solid waste to landfill	3188200	T
wastewater treatment in residential / Commercial sector	556,9	mio m^3
sewage sludge spreading in agriculture	no data	
compost production from waste	no data	
pesticide uses	3907	T
accidental fires	8100000	inhabitant
bonfires and other incidental fires	no data	
coke production	1237000	T

- 3.1.2 - Release to land in Bulgaria

activity sector	release to land		
	mini	maxi	unit
combustion of coal - power stations	0,17	8,62	g I-TEQ
combustion of coal - industry			
combustion of wood - industry			
combustion of coal - domestic	0,70	98,65	g I-TEQ
combustion of wood - domestic	0,01	0,48	g I-TEQ
sinter plant	0,004	2,44	g I-TEQ
primary cooper production	0,01	0,09	g I-TEQ
secondary lead production	2,08	14,16	g I-TEQ
secondary zinc production	0,21	7,79	g I-TEQ
secondary cooper production	0,01	2,58	g I-TEQ
secondary aluminium production			
aluminium production (electrolysis)			
pesticide production (?)	*1 (?)*	*270 (?)*	g I-TEQ
paper and pulp production			
cement production	0	2,17	g I-TEQ
lime production	0	0,84	g I-TEQ
electric furnace steel plant	0,27	5,57	g I-TEQ
incineration of domestic / municipal waste	No data		
incineration of industrial waste	0,002	0,74	g I-TEQ
incineration of sludge from wastewater treatment			
incineration of hospital waste	1,13	3,09	g I-TEQ
disposal of municipal solid waste to landfill	20,09	232,74	g I-TEQ
sewage sludge spreading in agriculture	No data		
compost production from waste	No data		
pesticide uses	0,63	32,35	g I-TEQ

The total of release to land represents : 26 – 682 g I-TEQ / year with the major source for disposal of municipal solid waste to landfill for 34% of all the release to land in Bulgaria and, with the high level of uncertainty pesticide production.

- 3.1.3 – Release to water in Bulgaria

activity sector	release to water		
	mini	maxi	unit
paper and pulp production	No data		
incineration of industrial waste	0,01	0,41	g I-TEQ
incineration of sludge from wastewater treatment	No data		
improper waste oil disposal	0,06	0,26	g I-TEQ
disposal of municipal solid waste to landfill	0,02	0,05	g I-TEQ
wastewater treatment in residential / Commercial sector	0,28	2,78	g I-TEQ
coke production	0,07		g I-TEQ

The total estimated release to water in Bulgaria represents : 0,44 – 3,57 g I-TEQ / Year. The part of waste water treatment in residential and commercial sector is nearly 78% of these releases.

- **3.2 Cyprus**

- 3.2.1 – Activity data in Cyprus

activity sector	activity value	unit
combustion of coal - power stations		
combustion of coal - industry		
combustion of wood - industry		
combustion of coal - domestic		
combustion of wood - domestic	2000	TJ
sinter plant		
primary cooper production		
secondary lead production		
secondary zinc production		
secondary cooper production		
secondary aluminium production		
aluminium production (electrolysis)		
pesticide production		
paper and pulp production	No data	
cement production	1431709	T
lime production	5500	T
electric furnace steel plant		
incineration of domestic / municipal waste	no data	
incineration of industrial waste	266000	T
incineration of sludge from wastewater treatment	no data	
incineration of hospital waste	1200	T
improper waste oil disposal	393	T
disposal of municipal solid waste to landfill	450000	T
wastewater treatment in residential / Commercial sector	17	mio m^3
sewage sludge spreading in agriculture	no data	
compost production from waste	no data	
pesticide uses	975	T
accidental fires	No data	
bonfires and other incidental fires	No data	
coke production		

Waste water treatment in residential and commercial sector is an estimation from IOW. This estimation has been confirmed by the Department of labour Inspection in Cyprus which indicated, from the year 2002 : 3000 m^3/day for industrial effluent and 42000 m^3/day for domestic effluent.
Data for pesticides consumption, cement production, incineration of hospital waste and lime production have been collected by the Department of labour Inspection in Cyprus. There is not pesticide production in Cyprus.

- 3.2.2 - Release to land in Cyprus

activity sector	release to land		
	mini	maxi	unit
combustion of coal - power stations			
combustion of coal - industry			
combustion of wood - industry			
combustion of coal - domestic			
combustion of wood - domestic	0,001	0,04	g I-TEQ
sinter plant			
primary cooper production			
secondary lead production			
secondary zinc production			
secondary cooper production			
secondary aluminium production			
aluminium production (electrolysis)			
pesticide production			
paper and pulp production			
cement production	0	1,50	g I-TEQ
lime production	0	0,006	g I-TEQ
electric furnace steel plant			
incineration of domestic / municipal waste	No data		
incineration of industrial waste	0,01	1,81	g I-TEQ
incineration of sludge from wastewater treatment	No data		
incineration of hospital waste	0,04	0,12	g I-TEQ
disposal of municipal solid waste to landfill	2,835	32,85	g I-TEQ
sewage sludge spreading in agriculture	No data		
compost production from waste	No data		
pesticide uses	0,156	8,073	g I-TEQ

The total of release to land represents : 3,04 – 44,40 g I-TEQ / year. The major sources of seem to be disposal of municipal solid waste to landfill (considering the maximum release) representing 74% of total release to land and pesticide use for 18% of all the release to land in Cyprus (if we consider the minimum release level, this source is the major one).

- 3.2.3 – Release to water in Cyprus

activity sector	release to water		
	mini	maxi	unit
paper and pulp production	No data		
incineration of industrial waste	0,02	0,99	g I-TEQ
incineration of sludge from wastewater treatment	No data		
improper waste oil disposal	0,01	0,02	g I-TEQ
disposal of municipal solid waste to landfill	0,003	0,01	g I-TEQ
wastewater treatment in residential / Commercial sector	0,009	0,085	g I-TEQ
coke production			

The total estimated release to water in Cyprus represents : 0,03 – 1,1 g I-TEQ / Year.
The part of incineration of industrial waste is nearly 90% of these releases.

- **3.3 Czech republic**

- 3.3.1 – Activity data in Czech republic

activity sector	activity value	unit
combustion of coal - power stations	508900	TJ
combustion of coal - industry		
combustion of wood - industry		
combustion of coal - domestic	39400	TJ
combustion of wood - domestic	31000	TJ
sinter plant	6500000	T
primary cooper production		
secondary lead production	15000	T
secondary zinc production	1000	T
secondary cooper production		T
secondary aluminium production		
aluminium production (electrolysis)		
pesticide production	4090	T
paper and pulp production	No data	
cement production	4825000	T
lime production	1186000	T
electric furnace steel plant	942000	T
incineration of domestic / municipal waste	402200	T
incineration of industrial waste	266000	T
incineration of sludge from wastewater treatment	no data	
incineration of hospital waste	17000	T
improper waste oil disposal	5612	T
disposal of municipal solid waste to landfill	2000000	T
wastewater treatment in residential / Commercial sector	1422,6	moi m^3
sewage sludge spreading in agriculture	159300	T
compost production from waste	2000	T
pesticide uses	4090	T
accidental fires	No data	
bonfires and other incidental fires	No data	
coke production	5270000	T

- 3.3.2 - Release to land in Czech republic

activity sector	release to land		
	mini	maxi	unit
combustion of coal - power stations	0,40	20,30	g I-TEQ
combustion of coal - industry			
combustion of wood - industry			
combustion of coal - domestic	1,62	228,62	g I-TEQ
combustion of wood - domestic	0,01	0,60	g I-TEQ
sinter plant	0,01	6,34	g I-TEQ
primary cooper production			
secondary lead production	3,12	21,24	g I-TEQ
secondary zinc production	0,04	1,42	g I-TEQ
secondary cooper production			
secondary aluminium production			
aluminium production (electrolysis)			
pesticide production (?)	*1,24 (?)*	*282,6 (?)*	*g I-TEQ*
paper and pulp production	No data		
cement production	0	5,07	g I-TEQ
lime production	0	1,25	g I-TEQ
electric furnace steel plant	0,26	5,47	g I-TEQ
incineration of domestic / municipal waste	80,44	382,09	g I-TEQ
incineration of industrial waste	0,01	1,81	g I-TEQ
incineration of sludge from wastewater treatment	No data		
incineration of hospital waste	1,48	4,05	g I-TEQ
disposal of municipal solid waste to landfill	12,60	146,00	g I-TEQ
sewage sludge spreading in agriculture	1,59	15,93	g I-TEQ
compost production from waste	0,004	0,04	g I-TEQ
pesticide uses	0,65	33,87	g I-TEQ
accidental fires	No data		
bonfires and other incidental fires	No data		

The total of release to land represents : 103,48 – 1156,63 g I-TEQ / year with the major source for incineration of domestic / municipal waste representing nearly 33% of all the release to land in Czech republic.

- 3.3.3 – Release to water in Czech republic

activity sector	release to water		
	mini	maxi	unit
paper and pulp production	No data		
incineration of industrial waste	0,02	0,99	g I-TEQ
incineration of sludge from wastewater treatment	No data		
improper waste oil disposal	0,08	0,34	g I-TEQ
disposal of municipal solid waste to landfill	0,01	0,03	g I-TEQ
wastewater treatment in residential / Commercial sector	0,71	7,11	g I-TEQ
coke production	0,32		g I-TEQ

The total estimated release to water in Czech republic represents : 1,13 – 8,79 g I-TEQ / Year.
The part of waste water treatment in residential and commercial sector is nearly 81 % of these releases.

- **3.4 Estonia**

- 3.4.1 – Activity data in Estonia

activity sector	activity value	unit
combustion of coal - power stations	95000	TJ
combustion of coal - industry		
combustion of wood - industry		
combustion of coal - domestic	1600	TJ
combustion of wood - domestic	12000	TJ
sinter plant		
primary cooper production		
secondary lead production		
secondary zinc production		
secondary cooper production		
secondary aluminium production		
aluminium production (electrolysis)		
pesticide production	84	T
paper and pulp production		
cement production	417000	T
lime production	17000	T
electric furnace steel plant	2000	T
incineration of domestic / municipal waste	960	T
incineration of industrial waste	no data	
incineration of sludge from wastewater treatment	no data	
incineration of hospital waste	2300	T
improper waste oil disposal	746	T
disposal of municipal solid waste to landfill	402960	T
wastewater treatment in residential / Commercial sector	68	mio m^3
sewage sludge spreading in agriculture	no data	
compost production from waste	11080	T
pesticide uses	84	T
accidental fires		
bonfires and other incidental fires		
coke production	40000	T

Wastewater treatment volume is estimated by IOW

- 3.4.2 - Release to land in Estonia

activity sector	release to land		
	mini	maxi	unit
combustion of coal - power stations	0,07	3,79	g I-TEQ
combustion of coal - industry			
combustion of wood - industry			
combustion of coal - domestic	0,07	9,28	g I-TEQ
combustion of wood - domestic	0,003	0,23	g I-TEQ
sinter plant			
primary cooper production			
secondary lead production			
secondary zinc production			
secondary cooper production			
secondary aluminium production			
aluminium production (electrolysis)			
pesticide production (?)	*0,03 (?)*	*5,80 (?)*	*g I-TEQ*
paper and pulp production	No data		
cement production	0	0,44	g I-TEQ
lime production	0	0,02	g I-TEQ
electric furnace steel plant	0,001	0,01	g I-TEQ
incineration of domestic / municipal waste	0,19	0,91	g I-TEQ
incineration of industrial waste	No data		g I-TEQ
incineration of sludge from wastewater treatment	No data		
incineration of hospital waste	0,20	0,55	g I-TEQ
disposal of municipal solid waste to landfill	2,54	29,42	g I-TEQ
sewage sludge spreading in agriculture	No data		
compost production from waste	0,02	0,21	g I-TEQ
pesticide uses	0,01	0,70	g I-TEQ
accidental fires	No data		
bonfires and other incidental fires	No data		

The total of release to land represents : 3,13 – 51,36 g I-TEQ / year with the major source for disposal of municipal solid waste to landfill representing nearly 57% of all the release to land in Estonia.

- 3.4.3 – Release to water in Estonia

activity sector	release to water		
	mini	maxi	unit
paper and pulp production	No data		
incineration of industrial waste	No data		
incineration of sludge from wastewater treatment	No data		
improper waste oil disposal	0,01	0,04	g I-TEQ
disposal of municipal solid waste to landfill	0,002	0,01	g I-TEQ
wastewater treatment in residential / Commercial sector	0,034	0,34	g I-TEQ
coke production	0,002		g I-TEQ

The total estimated release to water in Estonia represents : 0,05 – 0,39 g I-TEQ / Year. The part of waste water treatment in residential and commercial sector is nearly 87 % of these releases.

A previous inventory was realised using the UNEP toolkit and estimated :
Release to land : more than 0,12 g I-TEQ/Year
Release to water : more than 0,15 g I-TEQ/year (UNEP – 2003)

The great difference between these 2 estimations come from the hypotheses we made. We could consider the present estimation as an overestimation but the UNEP estimation seems to be quite low.

- **3.5 Hungary**

- 3.5.1 – Activity data in Hungary

activity sector	activity value	unit
combustion of coal - power stations	185000	TJ
combustion of coal - industry		
combustion of wood - industry		
combustion of coal - domestic	22950	TJ
combustion of wood - domestic	32000	TJ
sinter plant	500000	T
primary copper production	5880	T
secondary lead production		
secondary zinc production		
secondary copper production	30000	T
secondary aluminium production	5900	T
aluminium production (electrolysis)	35000	T
pesticide production	12701	T
paper and pulp production	496000	T
cement production	3452000	T
lime production	355000	T
electric furnace steel plant	109000	T
incineration of domestic / municipal waste	352900	T
incineration of industrial waste	148860	T
incineration of sludge from wastewater treatment	no data	
incineration of hospital waste	9081	T
improper waste oil disposal	5578	T
disposal of municipal solid waste to landfill	3906540	T
wastewater treatment in residential / Commercial sector	237	mio m^3
sewage sludge spreading in agriculture	27100	T
compost production from waste	47000	T
pesticide uses	12701	T
accidental fires	No data	
bonfires and other incidental fires	No data	
coke production	682000	T

Wastewater treatment volume is estimated by IOW.
Some data have been provided by Akos FEHERVARY and used in a previous estimation of PCDD / F emissions to air in 2001 using the UNEP toolkit: coke production, pulp and paper production, sinter plant, secondary copper production, cement production, lime production, incineration of domestic / municipal waste and incineration of medical waste .

- 3.5.2 - Release to land in Hungary

activity sector	release to land		
	mini	maxi	unit
combustion of coal - power stations	0,15	7,38	g I-TEQ
combustion of coal - industry			
combustion of wood - industry			
combustion of coal - domestic	0,95	133,17	g I-TEQ
combustion of wood - domestic	0,01	0,61	g I-TEQ
sinter plant	0,001	0,49	g I-TEQ
primary copper production	0,002	0,02	g I-TEQ
secondary lead production			
secondary zinc production			
secondary copper production	0,06	15,48	g I-TEQ
secondary aluminium production	0,23	1,89	g I-TEQ
aluminium production (electrolysis)			
pesticide production (?)	*3,85 (?)*	*877,45 (?)*	*g I-TEQ*
paper and pulp production	0,03	2,01	g I-TEQ
cement production	0	3,62	g I-TEQ
lime production	0	0,37	g I-TEQ
electric furnace steel plant	0,03	0,63	g I-TEQ
incineration of domestic / municipal waste	70,58	335,26	g I-TEQ
incineration of industrial waste	0,003	1,01	g I-TEQ
incineration of sludge from wastewater treatment	No data		
incineration of hospital waste	0,79	2,16	g I-TEQ
disposal of municipal solid waste to landfill	24,61	285,18	g I-TEQ
sewage sludge spreading in agriculture	0,27	2,71	g I-TEQ
compost production from waste	0,08	0,89	g I-TEQ
pesticide uses	2,03	105,16	g I-TEQ
accidental fires	No data		
bonfires and other incidental fires	No data		

The total of release to land represents :103,68 – 1775,50 g I-TEQ / year with the major source for incineration of domestic / municpal waste representing nearly 68% of all the release to land in Hungary.
Release to land from pesticide presents a high level of uncertainty.

- 3.5.3 – Release to water in Hungary

activity sector	release to water		
	mini	maxi	unit
paper and pulp production	No data		
incineration of industrial waste	0,01	0,55	g I-TEQ
incineration of sludge from wastewater treatment	No data		
improper waste oil disposal	0,08	0,33	g I-TEQ
disposal of municipal solid waste to landfill	0,02	0,06	g I-TEQ
wastewater treatment in residential / Commercial sector	0,1185	1,185	g I-TEQ
coke production	0,04		g I-TEQ

The total estimated release to water in Hungary represents : 0,27 – 2,17 g I-TEQ / Year. The part of waste water treatment in residential and commercial sector is nearly 54 % of these releases.

3.6 Latvia

- 3.6.1 – Activity data in Latvia

activity sector	activity value	unit
combustion of coal - power stations	1000	TJ
combustion of coal - industry		
combustion of wood - industry		
combustion of coal - domestic	1500	TJ
combustion of wood - domestic	30000	TJ
sinter plant		
primary cooper production		
secondary lead production		
secondary zinc production		
secondary cooper production		
secondary aluminium production		
aluminium production (electrolysis)		
pesticide production	1000	T
paper and pulp production	No data	
cement production	203000	T
lime production	14000	T
electric furnace steel plant	4000	T
incineration of domestic / municipal waste	27250	T
incineration of industrial waste	116400	T
incineration of sludge from wastewater treatment	no data	
incineration of hospital waste	200	T
improper waste oil disposal	1282	T
disposal of municipal solid waste to landfill	910730	T
wastewater treatment in residential / Commercial sector	220,9	mio m^3
sewage sludge spreading in agriculture		
compost production from waste	16300	T
pesticide uses	1000	T
accidental fires	No data	
bonfires and other incidental fires	No data	
coke production		

Some activity data have been collected from other sources than those indicated in chapter 3.

Data about combustion of coal in power stations and for domestic uses, combustion of wood for domestic uses, pesticide consumption come from Central Statistical bureau of Latvia.

Tonnes of hospital waste incinerated come from the Latvian Environmental Agency.

- 3.6.2 - Release to land in Latvia

activity sector	release to land		
	mini	maxi	unit
combustion of coal - power stations	0,001	0,04	
combustion of coal - industry			
combustion of wood - industry			
combustion of coal - domestic	0,06	8,70	g I-TEQ
combustion of wood - domestic	0,008	0,58	g I-TEQ
sinter plant			
primary cooper production			
secondary lead production			
secondary zinc production			
secondary cooper production			
secondary aluminium production			
aluminium production (electrolysis)			
pesticide production (?)	*0,30 (?)*	*69,09 (?)*	*g I-TEQ*
paper and pulp production	No data		
cement production	0	0,21	g I-TEQ
lime production	0	0,01	g I-TEQ
electric furnace steel plant	0,001	0,02	g I-TEQ
incineration of domestic / municipal waste	5,45	25,89	g I-TEQ
incineration of industrial waste	0,002	0,79	g I-TEQ
incineration of sludge from wastewater treatment	No data		
incineration of hospital waste	0,02	0,05	g I-TEQ
disposal of municipal solid waste to landfill	5,74	66,48	g I-TEQ
sewage sludge spreading in agriculture			
compost production from waste	0,03	0,31	g I-TEQ
pesticide uses	0,16	8,28	g I-TEQ
accidental fires	No data		
bonfires and other incidental fires	No data		

The total of release to land represents : 11,77 – 180,46 g I-TEQ / year and the major source is disposal of municipal solid waste to landfill representing nearly 38% of all the release to land in Latvia. Pesticide production has a high level of uncertainty.

- 3.6.3 – Release to water in Latvia

activity sector	release to water		
	mini	maxi	unit
paper and pulp production	No data		
incineration of industrial waste	0,01	0,43	g I-TEQ
incineration of sludge from wastewater treatment	No data		
improper waste oil disposal	0,02	0,08	g I-TEQ
disposal of municipal solid waste to landfill	0,01	0,01	g I-TEQ
wastewater treatment in residential / Commercial sector	0,11	1,10	g I-TEQ
coke production			

The total estimated release to water in Latvia represents : 0,14 – 1,63 g I-TEQ / Year. The part of waste water treatment in residential and commercial sector is nearly 67 % of these releases.

A previous inventory was realised with the UNEP toolkit (2003) and estimated :
Release to water more than 0,18 g I-TEQ/year (reference year 2000)
Release to land more than 0,24 g I-TEQ/ year. This is quite different from the present estimation probably because of the hypotheses we made which induce an overestimation.

- **3.7 – Lithuania**

- 3.7.1 – Activity data in Lithuania

activity sector	activity value	unit
combustion of coal - power stations		
combustion of coal - industry		
combustion of wood - industry		
combustion of coal - domestic	8650	TJ
combustion of wood - domestic	11000	TJ
sinter plant		
primary cooper production		
secondary lead production		
secondary zinc production		
secondary cooper production		
secondary aluminium production		
aluminium production (electrolysis)		
pesticide production	928	T
paper and pulp production	No data	
cement production	649000	T
lime production	88000	T
elctric furnace steel	0	
incineration of domestic / municipal waste	no data	
incineration of industrial waste	27230	T
incineration of sludge from wastewater treatment	no data	
incineration of hospital waste	5800	T
improper waste oil disposal	1904	T
disposal of municipal solid waste to landfill	1000000	T
wastewater treatment in residential / Commercial sector	2747	mio m^3
sewage sludge spreading in agriculture	no data	
compost production from waste	no data	
pesticide uses	928	T
accidental fires	No data	
bonfires and other incidental fires	No data	
coke production		

- 3.7.2 - Release to land in Lithuania

activity sector	release to land		
	mini	maxi	unit
combustion of coal - power stations			
combustion of coal - industry			
combustion of wood - industry			
combustion of coal - domestic	0,36	50,19	g I-TEQ
combustion of wood - domestic	0,003	0,21	g I-TEQ
sinter plant			
primary cooper production			
secondary lead production			
secondary zinc production			
secondary cooper production			
secondary aluminium production			
aluminium production (electrolysis)			
pesticide production	*0,28 (?)*	*64,11 (?)*	*g I-TEQ*
paper and pulp production	No data		
cement production	0	0,68	g I-TEQ
lime production	0	0,09	g I-TEQ
elctric furnace steel			
incineration of domestic / municipal waste	No data		
incineration of industrial waste	0,001	0,19	g I-TEQ
incineration of sludge from wastewater treatment	No data		
incineration of hospital waste	0,50	1,38	g I-TEQ
disposal of municipal solid waste to landfill	6,30	73,00	g I-TEQ
sewage sludge spreading in agriculture	No data		
compost production from waste	No data		
pesticide uses	0,15	7,68384	g I-TEQ
accidental fires	No data		
bonfires and other incidental fires	No data		

The total of release to land represents : 7,59 – 197,54 g I-TEQ / year with the major source for disposal of municipal solid waste to landfill representing nearly 37% of all the release to land in Lithuania.

A previous inventory was realised with the UNEP toolkit and estimated :
Release to land more than 0,29 g I-TEQ/ year
Release to water more than 0,1 g I-TEQ/Year (reference year 2000). This is quite different from the present estimation probably because of the hypotheses we made which induce an overestimation.

- 3.7.3 – Release to water in Lithuania

activity sector	release to water		
	mini	maxi	unit
paper and pulp production	No data		
incineration of industrial waste	0,002	0,10	g I-TEQ
incineration of sludge from wastewater treatment	No data		
improper waste oil disposal	0,03	0,11	g I-TEQ
disposal of municipal solid waste to landfill	0,01	0,02	g I-TEQ
wastewater treatment in residential / Commercial sector	1,37	13,74	g I-TEQ
sewage sludge spreading in agriculture	No data		
coke production			

The total estimated release to water in Lithuania represents : 1,41 – 13,97 g I-TEQ / Year. The part of waste water treatment in residential and commercial sector is nearly 98 % of these releases.

- **3.8 – Malta**

- 3.8.1 – Activity data in Malta

activity sector	activity value	unit
combustion of coal - power stations	1300	TJ
combustion of coal - industry		
combustion of wood - industry		
combustion of coal - domestic		
combustion of wood - domestic	1000	TJ
sinter plant		
primary cooper production		
secondary lead production		
secondary zinc production		
secondary cooper production		
secondary aluminium production		
aluminium production (electrolysis)		
pesticide production	228	T
paper and pulp production	No data	
cement production		
lime production	5000	T
electric furnace steel plant		
incineration of domestic / municipal waste	no data	
incineration of industrial waste	no data	
incineration of sludge from wastewater treatment	no data	
incineration of hospital waste	640	T
improper waste oil disposal	219	T
disposal of municipal solid waste to landfill	184710	T
wastewater treatment in residential / Commercial sector	3,8	mio m^3
sewage sludge spreading in agriculture	no data	
compost production from waste	31200	T
pesticide uses	228	T
accidental fires	No data	
bonfires and other incidental fires	No data	
coke production		

The value of wastewater treatment in residential and commercial sector is an estimation of IOW.

- 3.8.2 - Release to land in Malta

activity sector	release to land		
	mini	maxi	unit
combustion of coal - power stations	0,001	0,05	g I-TEQ
combustion of coal - industry			
combustion of wood - industry			
combustion of coal - domestic			
combustion of wood - domestic	0,000	0,02	g I-TEQ
sinter plant			
primary cooper production			
secondary lead production			
secondary zinc production			
secondary cooper production			
secondary aluminium production			
aluminium production (electrolysis)			
pesticide production	*0,07 (?)*	*15,75 (?)*	*g I-TEQ*
paper and pulp production	No data		
cement production			
lime production	0	0,005	g I-TEQ
electric furnace steel plant			
incineration of domestic / municipal waste	No data		
incineration of industrial waste	No data		
incineration of sludge from wastewater treatment	No data		
incineration of hospital waste	0,06	0,15	g I-TEQ
disposal of municipal solid waste to landfill	1,16	13,48	g I-TEQ
sewage sludge spreading in agriculture	No data		
compost production from waste	0,06	0,59	g I-TEQ
pesticide uses	0,036	1,89	g I-TEQ
accidental fires	No data		
bonfires and other incidental fires	No data		

The total of release to land represents : 1,38 – 31,94 g I-TEQ / year with the major source for disposal of municipal solid waste to landfill in Malta.
Pesticide production presents a high level of uncertainty.

- 3.8.3 – Release to water in Malta

activity sector	release to water		
	mini	maxi	unit
paper and pulp production	No data		
incineration of industrial waste	No data		
incineration of sludge from wastewater treatment	No data		
improper waste oil disposal	0,003	0,01	g I-TEQ
disposal of municipal solid waste to landfill	0,001	0,003	g I-TEQ
wastewater treatment in residential / Commercial sector	0,002	0,02	g I-TEQ
coke production			

The total estimated release to water in Malta represents : 0,006 – 0,03 g I-TEQ / Year.

- **3.9 – Poland**

- 3.9.1 – Activity data in Poland

activity sector	activity value	unit
combustion of coal - power stations	1440000	TJ
combustion of coal - industry		
combustion of wood - industry		
combustion of coal - domestic	463700	TJ
combustion of wood - domestic	36000	TJ
sinter plant	8800000	T
primary cooper production	405708	T
secondary lead production	15000	T
secondary zinc production	13000	T
secondary cooper production	29000	T
secondary aluminium production		
aluminium production (electrolysis)	55700	T
pesticide production	8699	T
paper and pulp production	No data	
cement production	13914000	T
lime production	2526000	T
electric furnace steel plant	2676000	T
incineration of domestic / municipal waste	36000	T
incineration of industrial waste	208000	T
incineration of sludge from wastewater treatment	6900	T
incineration of hospital waste	64000	T
improper waste oil disposal	21020	T
disposal of municipal solid waste to landfill	10142000	T
wastewater treatment in residential / Commercial sector	2402,4	mio m^3
sewage sludge spreading in agriculture	49300	T
compost production from waste	215000	T
pesticide uses	8699	T
accidental fires	No data	
bonfires and other incidental fires	No data	
coke production	11579000	T

- 3.9.2 - Release to land in Poland

activity sector	release to land		
	mini	maxi	unit
combustion of coal - power stations	1,14	57,44	g I-TEQ
combustion of coal - industry			
combustion of wood - industry			
combustion of coal - domestic	19,11	2690,69	g I-TEQ
combustion of wood - domestic	0,01	0,69	g I-TEQ
sinter plant	0,01	8,59	g I-TEQ
primary cooper production	0,14	1,37	g I-TEQ
secondary lead production	3,12	21,24	g I-TEQ
secondary zinc production	0,50	18,41	g I-TEQ
secondary cooper production	0,06	14,96	g I-TEQ
secondary aluminium production			
aluminium production (electrolysis)			
pesticide production	*3 (?)*	*601 (?)*	*g I-TEQ*
paper and pulp production	No data		
cement production	0	14,61	g I-TEQ
lime production	0	2,65	g I-TEQ
electric furnace steel plant	0,74	16	g I-TEQ
incineration of domestic / municipal waste	7,20	34,20	g I-TEQ
incineration of industrial waste	0,004	1,41	g I-TEQ
incineration of sludge from wastewater treatment	0,08		
incineration of hospital waste	5,57	15,23	g I-TEQ
disposal of municipal solid waste to landfill	63,89	740,37	g I-TEQ
sewage sludge spreading in agriculture	0,49	4,93	g I-TEQ
compost production from waste	0,39	4,09	g I-TEQ
pesticide uses	1,39	72,03	g I-TEQ
accidental fires	No data		
bonfires and other incidental fires	No data		

The total of release to land represents : 106 – 4319 g I-TEQ / year with the major source for combustion of coal for domestic uses representing nearly 63% of all the release to land in Poland.

- 3.9.3 – Release to water in Poland

activity sector	release to water		
	mini	maxi	unit
paper and pulp production	No data		
incineration of industrial waste	0,01	0,77	g I-TEQ
incineration of sludge from wastewater treatment	0,0002	0,001	g I-TEQ
improper waste oil disposal	0,29	1,26	g I-TEQ
disposal of municipal solid waste to landfill	0,06	0,15	g I-TEQ
wastewater treatment in residential / Commercial sector	1,20	12,01	g I-TEQ
coke production	0,69		g I-TEQ

The total estimated release to water in Poland represents : 2,26 – 14, 09 g I-TEQ / Year.
The major source of release to water in Poland is waste water treatment representing 81% of total release to water in Poland.

A previous inventory was realised, reference year 2000, presented in the UNEP toolkit (2003), and estimated :
release to land more than 6,6 g I-TEQ/year
release to water more than 1,2 g I-TEQ/ year

- **3.10 – Romania**

- 3.10.1 – Activity data in Romania

activity sector	activity value	unit
combustion of coal - power stations	288600	TJ
combustion of coal - industry		
combustion of wood - industry		
combustion of coal - domestic	970	TJ
combustion of wood - domestic	31000	TJ
sinter plant	6200000	T
primary cooper production	22013	T
secondary lead production	4000	T
secondary zinc production	2300	T
secondary cooper production	1000	T
secondary aluminium production	3400	T
aluminium production (electrolysis)	140500	T
pesticide production	14000	T
paper and pulp production	No data	
cement production	6842000	T
lime production	1763000	T
electric furnace steel plant	1499000	T
incineration of domestic / municipal waste	no data	
incineration of industrial waste	250000	T
incineration of sludge from wastewater treatment	no data	
incineration of hospital waste	37000	T
improper waste oil disposal	11975	T
disposal of municipal solid waste to landfill	6695000	T
wastewater treatment in residential / Commercial sector	5018,2	mio m^3
sewage sludge spreading in agriculture	no data	
compost production from waste	no data	
pesticide uses	14000	T
accidental fires	No data	
bonfires and other incidental fires	No data	
coke production	3384000	T

- 3.10.2 - Release to land in Romania

activity sector	release to land		
	mini	maxi	unit
combustion of coal - power stations	0,23	11,51	g I-TEQ
combustion of coal - industry			
combustion of wood - industry			
combustion of coal - domestic	0,04	5,63	g I-TEQ
combustion of wood - domestic	0,01	0,60	g I-TEQ
sinter plant	0,01	6,05	g I-TEQ
primary cooper production	0,01	0,07	g I-TEQ
secondary lead production	0,83	5,66	g I-TEQ
secondary zinc production	0,09	3,26	g I-TEQ
secondary cooper production	0,002	0,52	g I-TEQ
secondary aluminium production	0,13	1,09	g I-TEQ
aluminium production (electrolysis)			
pesticide production	*4 (?)*	*967 (?)*	*g I-TEQ*
paper and pulp production	No data		
cement production	0	7,18	g I-TEQ
lime production	0	1,85	g I-TEQ
electric furnace steel plant	0,42	8,70	g I-TEQ
incineration of domestic / municipal waste	No data		
incineration of industrial waste	0,01	1,7	g I-TEQ
incineration of sludge from wastewater treatment	No data		
incineration of hospital waste	3,22	8,81	g I-TEQ
disposal of municipal solid waste to landfill	42,18	488,74	g I-TEQ
sewage sludge spreading in agriculture	No data		
compost production from waste	No data		
pesticide uses	2,24	115,92	g I-TEQ
accidental fires	No data		
bonfires and other incidental fires	No data		

The total of release to land represents : 53,65 – 1634,47 g I-TEQ / year with the major source for disposal of municipal solid waste to landfill representing nearly 30% of all the release to land in Romania.
Release to land from pesticide production has a high level of uncertainty.

- 3.10.3 – Release to water in Romania

activity sector	release to water		
	mini	maxi	unit
paper and pulp production	No data		
incineration of industrial waste	0,016	0,93	g I-TEQ
incineration of sludge from wastewater treatment	No data		
improper waste oil disposal	0,17	0,72	g I-TEQ
disposal of municipal solid waste to landfill	No data		
wastewater treatment in residential / Commercial sector	2,51	25,09	g I-TEQ
coke production	0,20		g I-TEQ

The total estimated release to water in Romania represents : 2,90 – 26,94 g I-TEQ / Year. The major source of release to water is waste water treatment representing 93% of total release to water in Romania.

- **3.11 – Slovak republic**

- 3.11.1 – Activity data in Slovak republic

activity sector	activity value	unit
combustion of coal - power stations	76000	TJ
combustion of coal - industry		
combustion of wood - industry		
combustion of coal - domestic	27900	TJ
combustion of wood - domestic	8000	TJ
sinter plant	3300000	T
primary cooper production	7870	T
secondary lead production		
secondary zinc production	1000	T
secondary cooper production	17000	T
secondary aluminium production		
aluminium production (electrolysis)	25133	T
pesticide production	3079	T
paper and pulp production	No data	
cement production	2902000	T
lime production	803000	T
electric furnace steel plant	266000	T
incineration of domestic / municipal waste	156450	T
incineration of industrial waste	no data	
incineration of sludge from wastewater treatment	no data	
incineration of hospital waste	8900	T
improper waste oil disposal	2959	T
disposal of municipal solid waste to landfill	1192410	T
wastewater treatment in residential / Commercial sector	192	mio m^3
sewage sludge spreading in agriculture	84400	T
compost production from waste	39310	T
pesticide uses	3079	T
accidental fires	No data	
bonfires and other incidental fires	No data	
coke production	1910000	T

Waste water treatment volume has been estimated by IOW.

- 3.11.2 - Release to land in Slovak republic

activity sector	release to land		
	mini	maxi	unit
combustion of coal - power stations	0,06	3,03	g I-TEQ
combustion of coal - industry			
combustion of wood - industry			
combustion of coal - domestic	1,15	161,89	g I-TEQ
combustion of wood - domestic	0,002	0,15	g I-TEQ
sinter plant	0,005	3,22	g I-TEQ
primary cooper production	0,003	0,03	g I-TEQ
secondary lead production			
secondary zinc production	0,04	1,42	g I-TEQ
secondary cooper production	0,04	8,77	g I-TEQ
secondary aluminium production			
aluminium production (electrolysis)			
pesticide production			
paper and pulp production	No data		
cement production	0	3,05	g I-TEQ
lime production	0	0,84	g I-TEQ
electric furnace steel plant	0,07	1,54	g I-TEQ
incineration of domestic / municipal waste	31,29	148,63	g I-TEQ
incineration of industrial waste	No data		
incineration of sludge from wastewater treatment	No data		
incineration of hospital waste	0,77	2,12	g I-TEQ
disposal of municipal solid waste to landfill	7,51	87,05	g I-TEQ
sewage sludge spreading in agriculture	0,84	8,44	g I-TEQ
compost production from waste	0,07	0,75	g I-TEQ
pesticide uses	0,49	25,49	g I-TEQ
accidental fires	No data		
bonfires and other incidental fires	No data		

The total of release to land represents : 42,35 – 456,42 g I-TEQ / year with the major source for pesticide production representing nearly 32% of all the release to land in Slovak republic. There is no production of pesticide in Slovak republic.

- 3.11.3 – Release to water in Slovak republic

activity sector	release to water		
	mini	maxi	unit
paper and pulp production	No data		
incineration of industrial waste	No data		
incineration of sludge from wastewater treatment	No data		
improper waste oil disposal	0,04	0,18	g I-TEQ
disposal of municipal solid waste to landfill	0,01	0,02	g I-TEQ
wastewater treatment in residential / Commercial sector	0,10	0,96	g I-TEQ
coke production	0,11		g I-TEQ

The total estimated release to water in Slovak republic represents : 0,26 – 1,27 g I-TEQ / Year.
The major source of release to water is waste water treatment representing 76% of total release to water in Slovak republic.

- **3.12 – Slovenia**

- 3.12.1 – Activity data in Slovenia

activity sector	activity value	unit
combustion of coal - power stations	64000	TJ
combustion of coal - industry		
combustion of wood - industry		
combustion of coal - domestic	4600	TJ
combustion of wood - domestic	6000	TJ
sinter plant	250000	T
primary cooper production		
secondary lead production	7425	T
secondary zinc production		
secondary cooper production		
secondary aluminium production		
aluminium production (electrolysis)	57575	T
pesticide production	1091	T
paper and pulp production		
cement production	991000	T
lime production	149000	T
electric furnace steel plant	394000	T
incineration of domestic / municipal waste	4770	T
incineration of industrial waste	no data	
incineration of sludge from wastewater treatment	no data	
incineration of hospital waste	3300	T
improper waste oil disposal	1097	T
disposal of municipal solid waste to landfill	699200	T
wastewater treatment in residential / Commercial sector	44	mio m^3
sewage sludge spreading in agriculture	500	T
compost production from waste	11300	T
pesticide uses	1091	T
accidental fires	No data	
bonfires and other incidental fires	No data	
coke production		

Waste water treatment volume has been estimated by IOW.

- 3.12.2 - Release to land in Slovenia

activity sector	release to land		
	mini	maxi	unit
combustion of coal - power stations	0,05	2,55	g I-TEQ
combustion of coal - industry			
combustion of wood - industry			
combustion of coal - domestic	0,19	26,69	g I-TEQ
combustion of wood - domestic	0,002	0,12	g I-TEQ
sinter plant	0,0004	0,24	g I-TEQ
primary cooper production			
secondary lead production	1,54	10,51	g I-TEQ
secondary zinc production			
secondary cooper production			
secondary aluminium production			
aluminium production (electrolysis)			
pesticide production	*0,33 (?)*	*75,37 (?)*	*g I-TEQ*
paper and pulp production	No data		
cement production	0	1,04	g I-TEQ
lime production	0	0,16	g I-TEQ
electric furnace steel plant	0,11	2,29	g I-TEQ
incineration of domestic / municipal waste	0,95	4,53	g I-TEQ
incineration of industrial waste	No data		
incineration of sludge from wastewater treatment	No data		
incineration of hospital waste	0,29	0,79	g I-TEQ
disposal of municipal solid waste to landfill	4,40	51,04	g I-TEQ
sewage sludge spreading in agriculture	0,005	0,05	g I-TEQ
compost production from waste	0,02	0,21	g I-TEQ
pesticide uses	0,17	9,03	g I-TEQ
accidental fires	No data		
bonfires and other incidental fires	No data		

The total of release to land represents : 8,07 – 184,63 g I-TEQ / year with the major source for disposal of municipal solid waste to landfill representing nearly 28% of all the release to land in Slovenia.
Release to land from pesticide production present a high level of uncertainty.

- 3.12.3 – Release to water in Slovenia

activity sector	release to water		
	mini	maxi	unit
paper and pulp production	No data		
incineration of industrial waste	No data		
incineration of sludge from wastewater treatment	No data		
improper waste oil disposal	0,02	0,07	g I-TEQ
disposal of municipal solid waste to landfill	0,004	0,010	g I-TEQ
wastewater treatment in residential / Commercial sector	0,02	0,22	g I-TEQ
coke production			

The total estimated release to water in Slovenia represents : 0,04 – 0,30 g I-TEQ / Year. The major source of release to water is waste water treatment representing 73% of total release to water in Slovenia.

- **3.13 – Turkey**

- 3.13.1 – Activity data in Turkey

activity sector	activity value	unit
combustion of coal - power stations	428000	TJ
combustion of coal - industry		
combustion of wood - industry		
combustion of coal - domestic	99000	TJ
combustion of wood - domestic	180000	TJ
sinter plant	4300000	T
primary cooper production	80300	
secondary lead production	2000	T
secondary zinc production		
secondary cooper production	20000	T
secondary aluminium production		
aluminium production (electrolysis)	61513	T
pesticide production	24870	T
paper and pulp production	No data	
cement production	33153000	T
lime production	897000	T
electric furnace steel plant	8501000	T
incineration of domestic / municipal waste	no data	
incineration of industrial waste	4000	T
incineration of sludge from wastewater treatment	no data	
incineration of hospital waste	11000	T
improper waste oil disposal	37292	T
disposal of municipal solid waste to landfill	24471090	T
wastewater treatment in residential / Commercial sector	841	mio m^3
sewage sludge spreading in agriculture	no data	
compost production from waste	no data	
pesticide uses	24870	T
accidental fires	No data	
bonfires and other incidental fires	No data	
coke production	3131000	T

Waste water treatment volume has been estimated by IOW.

- 3.13.2 - Release to land in Turkey

activity sector	release to land		
	mini	maxi	unit
combustion of coal - power stations	0,34	17,07	g I-TEQ
combustion of coal - industry			
combustion of wood - industry			
combustion of coal - domestic	4,08	574,46	g I-TEQ
combustion of wood - domestic	0,05	3,46	g I-TEQ
sinter plant	0,01	4,20	g I-TEQ
primary cooper production	0,03	0,27	g I-TEQ
secondary lead production	0,42	2,83	g I-TEQ
secondary zinc production			
secondary cooper production	0,04	10,32	g I-TEQ
secondary aluminium production			
aluminium production (electrolysis)			
pesticide production	*8 (?)*	*1718 (?)*	*g I-TEQ*
paper and pulp production	No data		
cement production	0	34,81	g I-TEQ
lime production	0	0,94	g I-TEQ
electric furnace steel plant	2,35	49,32	g I-TEQ
incineration of domestic / municipal waste	No data		
incineration of industrial waste	0	0,03	g I-TEQ
incineration of sludge from wastewater treatment	No data		
incineration of hospital waste	0,957	2,618	g I-TEQ
disposal of municipal solid waste to landfill	154,17	1786,39	g I-TEQ
sewage sludge spreading in agriculture	No data		
compost production from waste	No data		
pesticide uses	3,98	205,92	g I-TEQ
accidental fires	No data		
bonfires and other incidental fires	No data		

The total of release to land represents : 174 – 4411 g I-TEQ / year with the major source for disposal of municipal solid waste to landfill representing nearly 40% of all the release to land in Turkey. Release to land from pesticide production could represent 39% of all release to land but this value has a high level of uncertainty.

- 3.13.3 – Release to water in Turkey

activity sector	release to water		
	mini	maxi	unit
paper and pulp production	No data		
incineration of industrial waste	0,0002	0,01	g I-TEQ
incineration of sludge from wastewater treatment	No data		
improper waste oil disposal	0,52	2,24	g I-TEQ
disposal of municipal solid waste to landfill	0,15	0,37	g I-TEQ
wastewater treatment in residential / Commercial sector	0,42	4,21	g I-TEQ
coke production	0,19		g I-TEQ

The total estimated release to water in Turkey represents : 1,28 – 7,01 g I-TEQ / Year.
The major source of release to water is wastewater treatment representing 60% of total release to water in Turkey.

4 – Conclusions

- **4.1 - Release to land**

Estimation of releases in candidate countries to land is suffering from uncertainty, specially about the fate of residues (are they disposed on the soil or recycled? How many of them are recycled?) and lack of data. Despite this we estimate the releases to land in all of these 13 countries as given in the following Table

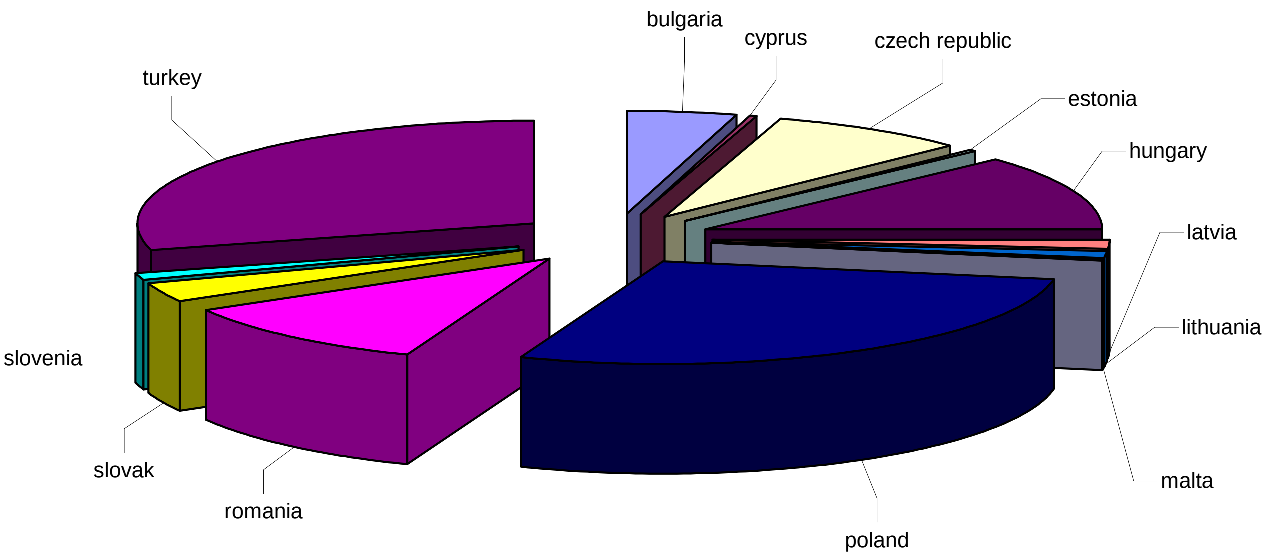
Table : global releases of dioxin to land per country

Country	**Best estimates in g I-TEQ/Year**	**% of total release to land**	**Major source of release to land per country**
Turkey	2292	29%	disposal of municipal solid waste to landfill
Poland	2212	28%	combustion of coal – domestic and disposal of municipal solid waste to landfill
Hungary	939	12%	incineration of domestic / municipal waste
Romania	844	11%	disposal of municipal solid waste to landfill
Czech republic	630	8%	incineration of domestic / municipal waste
Bulgaria	354	4%	disposal of municipal solid waste to landfill
Slovak republic	249	3%	incineration of domestic / municipal waste
Lithuania	102	1%	disposal of municipal solid waste to landfill
Slovenia	96	1%	disposal of municipal solid waste to landfill
Latvia	96	1%	incineration of industrial waste and disposal of municipal solid waste to landfill
Cyprus	24	0,3%	disposal of municipal solid waste to landfill
Estonia	27	0,3%	disposal of municipal solid waste to landfill
Malta	17	0,2%	disposal of municipal solid waste to landfill
TOTAL FOR ALL THIS REGION	**7 885 g I-TEQ/Year**		

N.B.: The best estimates have been taken as the arithmetic mid-point of the mini-maxi estimates.

The most important release to land could be attributed to Turkey and Poland responsible respectively for 29 and 28% of the total releases to land of this area as shown in the graph 1.

Even with the high level of uncertainty, we could reasonably consider that the distribution of dioxin release between the thirteen studied countries is correct, notably for the major contributors such as Turkey, Poland, Hungary and Romania.



Graph 1 : distribution of global releases of dioxin to land per country

If we detail these results on the studied area (candidate countries) per activity on the whole area, the results are as followed :

Table : releases to land per activity sector on the whole area (candidate countries)

activity sector	Best estimates [(1)] in g I-TEQ/year	% total release
disposal of municipal solid waste to landfill	2190	28%
combustion of coal - domestic	2008	25%
incineration of domestic / municipal waste	563	7%
pesticide uses	319	4%
combustion of coal - power stations	67	1%
electric furnace steel plant	47	1%
secondary lead production	43	1%
cement production	37	0,5%
incineration of hospital waste	28	0,4%
secondary copper production	26	0,3%
sewage sludge spreading in agriculture	18	0,2%
secondary zinc production	17	0,2%
sinter plant	16	0,2%
incineration of industrial waste	5	0,1%
lime production	5	0,1%
combustion of wood - domestic	4	0,05%
compost production from waste	4	0,05%
secondary aluminium production	2	0,02%
primary copper production	1	0,01%
paper and pulp production	1	0,01%
incineration of sludge from wastewater treatment	0,08	-
pesticide production [(2)]	*2484 (?)*	*32% (?)*

(1) The best estimates have been taken as the arithmetic mid-point of the min-max estimates.
(2) : this value is a very uncertainty one and could not be considered

The 3 most important sources of releases to land in the 13 candidate countries are :

- Disposal of municipal solid waste to landfill
- Combustion of coal – domestic
- The importance of pesticide production is overestimated

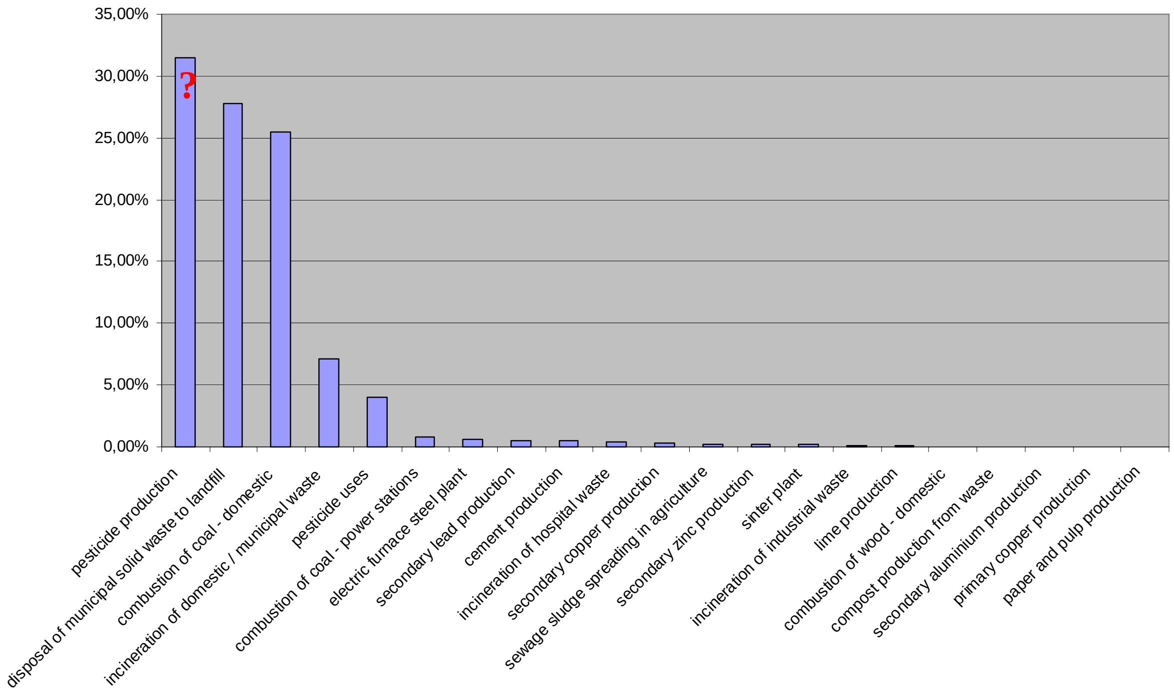
as shown in the graph 2 below.

For disposal of municipal solid waste to landfill, the emission factor presents an uncertainty of a factor 12. But activity data come from EUROSTAT. This estimates could be considered as quite reasonable.

According to releases to land from pesticide production, the value has a great uncertainty. The emission factor used ranges from 303,4 to 69085 µg I-TEQ/T. We also made the hypothesis that all the pesticides used in the country are produced in this country without any distinction between types of pesticide. So this item could not be considered as a major source of release of dioxin to land.

The emission factor used for domestic combustion of coal fluctuates from 41,21 to 5802,65 µg I-TEQ/T. So the uncertainty of releases from this activity could be important.

According to the pessimist hypotheses we made, notably about the fate of residues, we could presume that the real releases to land could be lower.



Graph 2 : distribution of global releases of dioxin to land per activity

Even with the uncertainty, the difference of scale between the different activities contribution lets us believe that we could consider the major sources of release to land are disposal of municipal solid waste to landfill, incineration of domestic waste, pesticide production and use,

and domestic combustion of coal. These four activities need a strong action in order to decrease their release to land by the European Union.

- **4.2. - Release to land : Comparison with old member states**

In the previous inventory made in 1999 (U. Quass et al – 1999), the global release to land in "old member states" have been estimated :

RELEASE to land(g I-TEQ) in "old member states			
	Mini	Maxi	Best estimate
Estimated release to land in "old member states"	3 850	72 600	**38 200**

(Source : U. Quass et al – 1999)

If we consider the European Union as a whole (candidate countries and old member states) and the best estimates in the 2 areas, it means that **the candidate countries contribute for 17% of the total release of dioxin to land and old member states for 83%.**

Regarding the major sources of release to land, U. Quass et al (1999) indicates the situation in old member states as :

Source	Release to land (best estimate) in g I-TEQ in "old member states"	Release to land (best estimate) in g I-TEQ in the 13 studied candidate countries
Pesticide production	13 000	2 484
Accidental fires	7 950	?
Incineration of municipal solid waste	7 200	564
Disposal of municipal solid waste to landfill	4 000	2190
Pesticide use	1 600	319
Secondary lead production	1 200	43
Combustion of wood – domestic	650	4
Secondary copper production	390	26
Electric furnace steel plant	350	47
Secondary aluminium production	310	2
Combustion of coal – domestic	150 (maxi)	2008

(Source : U. Quass et al – 1999)

In the "old member states" of the European Union and in the 13 studied candidate countries, the most important source of release to land seems to be pesticide production. Data used for the "old member states" are from 1994, so the types of pesticides produced could have changed in a decade. Nevertheless, there is nearly a factor 5 between the 2 considered areas for this source.

The second major source in member states is accidental fires. In the candidate countries, because of lack of data, this contribution has not been estimated. It could be considered that this source is significant in the candidate countries as for member states.

On the other side, combustion of coal for domestic uses is a significant source of release to land for candidate countries (third position) whereas it is less than the 10th most important source in member states.
The order of major sources of release to land is almost in accordance in the 2 areas, including the uncertainty of the estimation.

- **4.3. - Release to water**

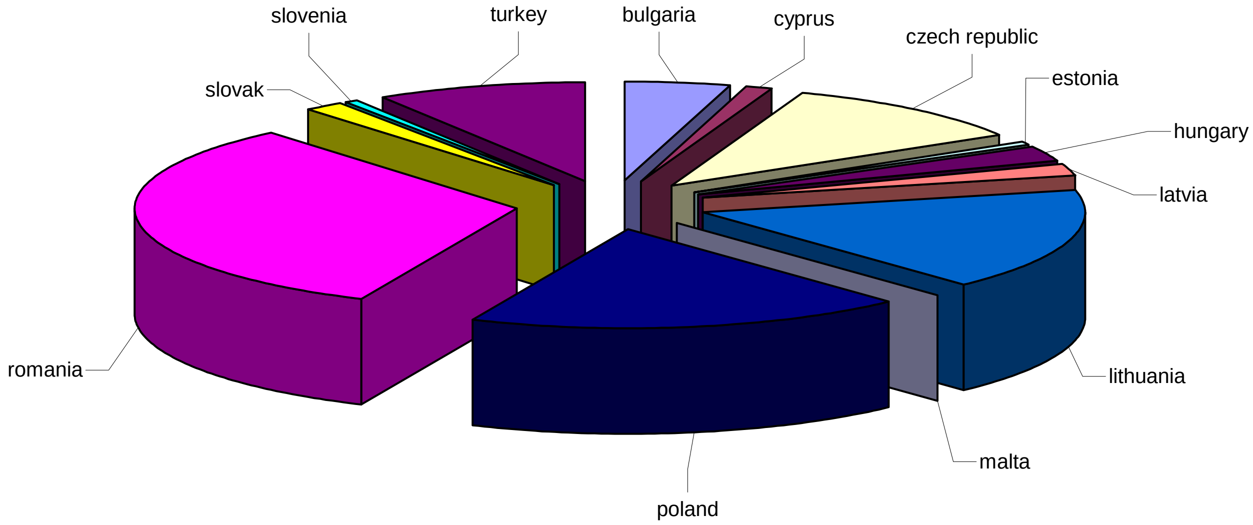
Estimation of releases to water in candidate countries is suffering from lack of data and uncertainty. Very few information on releases to water are known.

Table: : National total releases of dioxin to water per country

Country	**Best estimates in g I-TEQ/Year**	**% of total release**	**Major source of release to water**
Romania	14,92	32%	wastewater treatment in residential / Commercial sector
Poland	8,58	18%	wastewater treatment in residential / Commercial sector
Lithuania	7,69	17%	wastewater treatment in residential / Commercial sector
Czech republic	4,96	11%	wastewater treatment in residential / Commercial sector
Turkey	4,14	9%	wastewater treatment in residential / Commercial sector and improper waste oil disposal
Bulgaria	2	4%	wastewater treatment in residential / Commercial sector
Hungary	1,22	3%	wastewater treatment in residential / Commercial sector
Slovak republic	0,76	2%	wastewater treatment in residential / Commercial sector and coke combustion
Latvia	0,88	2%	wastewater treatment in residential / Commercial sector
Cyprus	0,57	1%	incineration of industrial waste
Estonia	0,22	0,5%	wastewater treatment in residential / Commercial sector
Slovenia	0,17	0,4%	wastewater treatment in residential / Commercial sector
Malta	0,02	0,05%	wastewater treatment in residential / Commercial sector
TOTAL FOR ALL THIS REGION	**46,15 g I-TEQ/Year**		

The best estimates have been taken as the arithmetic mid-point of the min-max estimates.

The most important contributors to releases to water in these 13 countries are Romania (32% of total releases to water), Poland and Lithuania (respectively 18 and 17%). We have to note that some sources are missing because of lack of data activity but could be significant: incineration of sludge from wastewater treatment, paper and pulp production



Graph 3 : distribution of global releases of dioxin to water per country

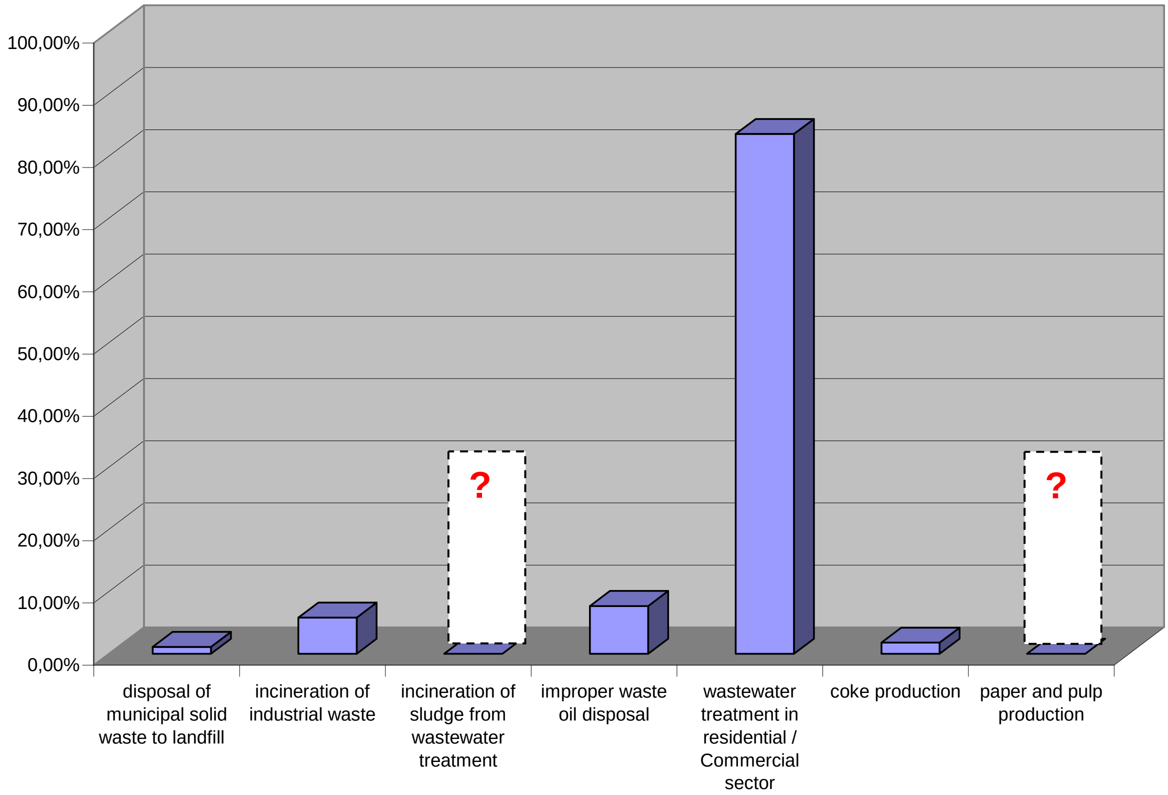
Releases to water per activity point out the major source of dioxin release in these 13 countries.

Table : Sources of dioxin release into water

activity sector	Best estimates in g I-TEQ/year	% total release
wastewater treatment in residential / Commercial sector	37,87 (1)	83% (1)
improper waste oil disposal	3,49	8%
incineration of industrial waste	2,64	6%
coke production	0,82	2%
disposal of municipal solid waste to landfill	0,51	1%
paper and pulp production	No data	?
incineration of sludge from wastewater treatment	Not enough data	?

Note 1 : the release from wastewater treatment in residential / commercial sector are not caused by the treatment itself but by but the contamination of the effluents collected upstream and input in the treatment plant

The best estimates have been taken as the arithmetic mid-point of the min-max estimates



Graph 4 : distribution of global release to water per sources

The main source of dioxin releases to water, according to the data collected, in the area covering the 13 candidate countries is wastewater treatment in residential / commercial sector responsible for around 83% of the estimates. The origin of the dioxins is not the treatment itself but the effluents collected upstream and input in the treatment plant.These release are also influenced by the treatment implemented in the WWTP depending on the presence of a tertiary treatment or not. A certain quantity of dioxins could be retained during the treatment.
We have not enough data about incineration of sewage sludge from wastewater treatment (only available for Poland) to point out the contribution of this activity in this area. Release from pulp and paper production could berelevant but have not be evaluated becasue of lack of data.

- **4.4. - Release to water : comparison with old member states**

In the previous inventory made in 1999 (U. Quass et al – 1999), the global release to water in “old member states” has only been estimated as a trend. So it is not possible to compare the 2 areas. Nevertheless, release to water in the two cases are small.

- **4.5 - Conclusion**

There is a high level of uncertainty about this estimation of dioxin releases to water and to land because of :

- uncertainty in emission factors due to the hypotheses we choose and variability of processes and dioxin concentration
- uncertainty in activity data
- lack of data

Nevertheless, estimated dioxin releases to water and to land for the sources for which estimates have been made are as followed :

Releases to land in the 13 candidate countries : 8000 g I-TEQ/Year

Releases to water in the 13 candidate countries : 50 g I-TEQ/Year

The 13 candidate countries contribute for :

17% of total release to land

in the European Union as a whole (old member states and candidate countries)

In the area covered by the 13 candidate countries, the contributors to release to land and water follow the distribution presented below, according to the maximum and minimum estimates.

Percentage of each country contribution to dioxin release in the area

	Releases to land (in %)		Releases to water (in %)	
	Mini	Maxi	Mini	maxi
Turkey	26,9	29,2	12,5	8,5
Poland	16,5	28,6	22,1	18,2
Hungary	16,1	11,7	2,6	2,7
Romania	8,3	10,8	28,3	32,8
Czech republic	16,0	7,7	11,1	10,7
Bulgaria	4,1	4,5	4,3	4,4
Slovak republic	6,6	3,0	2,5	1,6
Cyprus	0,5	0,29	0,3	1,4
Lituania	1,2	1,3	13,8	17,0
Slovenia	1,2	1,2	0,4	0,4
Latvia	1,8	1,2	1,4	2,0
Estonia	0,5	0,3	0,5	0,5
Malta	0,2	0,2	0,1	0,05
Total of the area	100%	100%	100%	100%

This table clearly points out the range of uncertainty linked to the estimates.
The major contributor of release of dioxins to land in candidate countries is Turkey (nearly 28% of the total release in this area) followed by Poland (between 17 and 28%) and Hungary (between 11 and 16%).

The major contributor of release to water in studied region is Romania followed by Poland and Lithuania.

The same analysis per activity for the whole 13 countries is presented below.

Percentage of each activity contribution to dioxin release in the area

activity sector	Release to land (in %)		Release to water (in %)	
	Minimum	maximum	Minimum	maximum
Power generation and heating				
combustion of coal - power stations	0,4%	0,9%		
combustion of coal - industry	NA			
combustion of wood - industry	NA			
combustion of coal - domestic	4%	26%		
combustion of wood - domestic	-	-		
Ferrous and non-ferrous metal production				
sinter plant	-	0,2%		
primary copper production	-	-		
secondary lead production	1,7%	0,5%		
secondary zinc production	0,1%	0,2%		
secondary copper production	-	0,3%		
secondary aluminium production	-	-		
aluminium production (electrolysis)				
coke production			16%	-

electric furnace steel plant	0,7%	0,6%		
Production and use of chemicals and consumer goods				
pesticide production	*3% (?)*	*33% (?)*		
paper and pulp production	NA	NA	NA	NA
Mineral products				
cement production	-	0,5%		
lime production	-	-		
Waste incineration				
incineration of domestic / municipal waste	30%	6%		
incineration of industrial waste	-	-	1%	6%
incineration of sludge from wastewater treatment	NA	NA	NA	NA
incineration of hospital waste	2%	0,3%		
Disposal / landfill				
improper waste oil disposal			13%	7%
disposal of municipal solid waste to landfill	54%	27%	3%	1%
wastewater treatment in residential / Commercial sector			67%	86%
sewage sludge spreading in agriculture	0,5%	0,2%		
compost production from waste	0,1%	-		
Agricultural activities				
pesticide uses	2%	4%		
Uncontrolled combustion processes				
accidental fires	NA	NA		
bonfires and other incidental fires	NA	NA		

NA : not available or not enough data available
[grey box] : not relevant

The presented contributions of activities have to be taken with precaution. Percentages could be different if uncertainty of emission factors were more limited and if missing activity rates were available. Thus, the quantity of sewage sludge from wastewater treatment incinerated is only known for one country : Poland. Pulp and paper production could also be a significant source of dioxin release to water but no activity rate could be collected.

According to this estimation, it is not possible to point out a link between emissions and levels of contamination of surface waters or ground waters. First of all, because in this report, we have no indication about the sources of emission (point sources) , and also because levels of uncertainty are too high.

- **4.6. - Priorities and actions required to improve completeness and decrease uncertainty of the emission estimations**

According to this study and its comparison with “old member states”, it becomes evident that there is a certain similarity in all the European countries. The same major sources of release to land and to water have been identified : pesticide production and use, incineration of municipal solid waste, disposal of municipal solid waste to landfill. Combustion of coal for domestic use seems to be a particularity of the 13 “candidate countries”. Impact of accidental fires have nit been estimated in this area because of lack of data but could be important.

It would be interesting to improve the quality of emission factors to water and land by measurement campaigns on identified point sources of dioxins to water and land, specially for activity sectors which have a high potential of release such as wastewater treatment, incineration of domestic waste, disposal of municipal solid waste in landfill and pesticide production. It could be also essential to obtain activity data in all the potential sources of release. For example, paper and pulp production present a high potential of release but could not have been estimated because of lack of data. The same for accidental fires and bonfires and other incidental fires for which we did not succeed to estimate the release when they could represent an important release. Thus, accidental fires present an emission factor to land between 40 and 190000 µg I-TEQ / Tonne.

According to release to land, it could be important to have a precise idea of the fate of residues in each of the studied countries. We chose to take into account the worst situation which is not representative of the reality in all the cases. Such precisions could be usefull to clarify the level of release to land and the potential of contamination of ground waters.

On the other hand, it is not possible to analyse or suggest any effects by intake of these waters by human or animals. Further research could be pertinent in order to assess the relevance of this potential way of human and animal contamination.
Direct human contamination through drinking water is not known. Levels of dioxin in water seem to be too low to have a direct impact. But accumulation through food chain is the subject of researches and news that have clearly point out this way of contamination (contamination through milk or chickens) even if it is difficult to separate the ways of contamination between air and water.

BIBLIOGRAPHY

❖ **BAWDEN K.,**
National dioxin program – technical report n°3 – Inventory of dioxin emission in Australia – 2004
May 2004
As posted : http://www.deh.gov.au/industry/chemicals/dioxins/pubs/report-3.pdf

❖ **BUCKLAND S, ELLIS H.K., DYKE P.**
New Zealand inventory of dioxin emissions in air, land and water, and reservoir sources
March 2000
As posted : http://www.mfe.govt.nz/publications/hazardous/dioxin-emissions-inventory-mar00.pdf

❖ **CEPMEIP** data base http://www.mep.tno.nl/emissions/

❖ **European Commission**
Dioxins & PCBs: Environmental Levels and Human Exposure in Candidate Countries
Final report – March 2004 (REFERENCE: ENV.C.2/SER/2002/0085)

❖ **European Commission**
Statistical yearbook on candidate countries
Data 1997 – 2001
2003 Edition

❖ **European Commission - IPPC**
Best available techniques reference document on the production of iron and steel
December 2001

❖ **European Commission - IPPC**
Reference document on Best available techniques reference document on the production of the pulp and paper production
December 2001

❖ **European Commission - IPPC**
Reference document on Best available techniques in the cement and lime manufacturing industries
December 2001

❖ **European Commission – IPPC**
Reference document on Best available techniques in the non ferrous metals industries
December 2001

❖ **European Commission – IPPC**
Reference document on best available techniques in common waste water and waste gas treatment / management systems in chemical sector
February 2003

❖ **European Commission – IPPC**
Draft reference document on best available techniques for waste incineration
Draft March 2004

❖ **Eurostat**
A selection of environmental pressure indicators for the EU and Candidate Countries
April 2004

❖ **Eurostat**
A selection of environmental pressure indicators for the EU and Acceding countries
2003 edition

❖ **FIEDLER Heidelore**
Sources and Environmental Impact of PCDD/PCDF
As posted : http://www.chem.unep.ch/pops/POPs_Inc/proceedings/slovenia/FIEDLER1.html

❖ **HAYES F., MARNAME I.**
Inventory of dioxin and furan emissions to air, land and water in Ireland for 2000 and 2010
Final report - As posted : http://www.epa.ie/EnvironmentalResearch/ReportsOutputs/FileUpload,1957,en.pdf

❖ **NOMA Y., MATSUFUJI Y., TAKATA M. and TOMODA K.**
Study on the mass flow of dioxins in a landfill site disposed of municipal solid waste incinerator ash
Leachate, gas, operation and health effects in landfills – Volume II
Proceedings Sardinia 99, seventh international waste management and landfill symposium
4 – 8 October 1999

❖ **Ulrich QUASS, Michael FERMANN, Günter BRÖKER**
Landesumweltamt nordrhein-Westfalen – DG ENV
Releases of dioxins and furans to land and water in Europe
– September 1999
as posted : http://europa.eu.int/comm/environment/dioxin/

❖ **Ulrich QUASS, Michael FERMANN, Günter BRÖKER**
Landesumweltamt nordrhein-Westfalen – DG ENV
European dioxin emission inventory Stage II
December 2000
As posted : http://europa.eu.int/comm/environment/dioxin/

❖ **Republic of Slovenia**
State of the environment Report - Ljubljana december 2002
Sur internet : http://www.gov.si/mop/en/podrocja/pso_summary.pdf

❖ **UNEP**
Standardized toolkit for identification and quantification of dioxin and furan releases
Draft –- January 2001

❖ **UNEP**
Regionally based assessment of persistent toxic substances
Global environment facility
December 2002

❖ **UNEP**
Inventaire des dioxines et des furannes – émissions nationales et régionales des PCDD/PCDF
Mai 1999

❖ **WIELAND U.**
Utilisations de l'eau et traitement des eaux usées dans l'UE et les pays candidats
Eurostat – Statistiques en bref – Environnement et Energie - 2003