ATMOSPHERIC IMPACT ASSESSMENT AND MONITORING OF DIOXIN EMISSIONS OF MUNICIPAL SOLID WASTE INCINERATORS IN PORTUGAL

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Abstract

In Portugal two municipal solid waste (MSW) incinerators are under construction in the metropolitan areas of Lisbon and Porto. During the development of the Environmental Impact Assessment (EIA) studies of these units the authors found several limitations and uncertainties associated to the assessment of the environmental impact. Uncertainties were particularly felt on the assessment of the environmental impacts associated with the atmospheric emissions of PCDD and PCDF. At present an External Monitoring Plan is under design. ©1998 Elsevier Science Ltd. All rights reserved

1. Municipal solid wastes in Portugal

During the last decade waste production in Portugal increased at a higher rate than the capacity available in the waste treatment and elimination systems. A fast economic development and a significant change of consuming patterns caused this substantial increase. The problem of waste treatment is also affected by the accumulation of a large number of uncontrolled waste discharges and the existence of old small and medium industries that use polluting technologies;

Important efforts were put in the creation and development of efficient municipal solid waste collection systems. Next steps will be the implementation of adequate treatment and disposal solution that require large financial investments mainly provided by the European Union (EU) Cohesion Fund.
Presently, Portugal is one of the EU countries with the lowest municipal solid waste *per capita* production. Nevertheless, economic development caused an increase on waste production of *circa* 40% between 1985 and 1993 (see Figure 1). Data from 1993 show that waste treatment was performed in 34 controlled landfill facilities that served 67 municipalities. More than 300 uncontrolled waste disposal sites are still present around the country. A significant part of the wastes (approximately 10%) is treated in four composting plants.

At the moment, seven municipal solid waste (MSW) management plans are under implementation gathering wastes produced in several municipalities. These management plans will take care of the wastes produced by 43.8% of the Portuguese population. In the MSW management plans adopted for the metropolitan areas of Lisbon and Porto it was decided to build two MSW incinerators with the capacity of 600 000 and 400 000 tons yr\(^{-1}\). Lisbon and Porto are the two most populated regions of Portugal, with respectively 1 850 000 and 900 000 inhabitants.

![Figure 1 - Evolution of *per capita* municipal solid waste production in Portugal [1].](image)

At present, both Lisbon and Porto MSW incinerator's projects Environmental Impact Assessment (EIA) process are concluded. IDAD participated in both Environmental Impact Studies either as coordinator [2] or as responsible for the analysis of the impact on air quality [3].

Within Portugal, the EIA procedure is regulated by the transposition of the EC Directive 85/337/EEC on the national Decree-Law 186/90. More recently the need of performing an EIA for MSW incinerators was clearly stated in the national Decree-Law 310/95.
2. Uncertainties of environmental impact assessment

Marchlik [4] analyzed the uncertainties in health risk estimates for MSW combustors based in the similarities with the methodology followed in probabilistic risk assessment for nuclear plants. A similar methodology can also be used to identify the uncertainties associated with the EIA of MSW incinerators.

The sources of uncertainty can be divided into parameter uncertainty, model uncertainty and completeness uncertainty. Parameter uncertainty refers to the variability inherent in the input variables or in the measurement of these variables. Model uncertainty pertains to uncertainty about the form of the mathematical equations used to represent the process of interest. Completeness uncertainty considers whether all sources of risk have been accounted for and adequately described. In the case of dioxin impact assessment, completeness uncertainties become particularly significant for research is still very active in this field. As a result of this it is not obvious how to operationalize a methodology to fully assess dioxin environmental impact for a specific industrial process and location.

Moreover, most EIA are performed within a timeframe of circa 3 to 6 months which is bounded by the complex process of industrial licensing. This period is relatively short and most of the time available is dedicated to the collection of data to characterize the environmental reference level. This fact is particularly significant in Portugal where the environmental monitoring networks are quite incipient in most regions.

2.1 Emissions and meteorology

No information concerning measurements or specific emission factors for the most significant activities on this subject is published in Portugal. In order to apply the dispersion models it was necessary to develop an inventory of dioxin emissions using emission factors determined by researchers in Europe and in the USA. These emissions factors must be applied to very specific data that is difficult to find in most cases.

As a result of this limitation, source types considered in this study were limited to traffic, oil combustion on generic industrial processes, incineration of landfill gas, hospital and municipal waste incineration.

Figure 2 compares the relative importance of the five source types considered in the analysis. It can be seen that hospital waste incineration has the greater contribution on the atmospheric emissions with almost 85% of the total emission. Fuel combustion and MSW incineration represent respectively 7.4% and 4.6%. It is important to refer that as municipal waste incinerators have not yet been built the information used corresponds to the project data. Moreover emission data used in the EIA does not consider any difference between PCDD and PCDF species, so the emissions are calculated in terms of equivalent toxicity of
2,3,7,8-PCDD (TEQ). The use of TEQ carries uncertainties because no information about the homologue profile of PCDD and PCDF was considered.

There are others uncertainties associated to the dioxin inventory which were transferred to the EIA. The most important refers to the completeness of the emission estimates. In fact some relevant activities were not considered, such as the burning of electric cables, asphalt-mixing installations, combustion of coal, wood and other fuels and several industrial processes due to the absence of the statistical data necessary to apply the emission factors. In the other hand the emission factors used are the only available but may not be the most appropriate for some of the activities and industrial processes present in Portugal. Emissions factors were determined under specific conditions, that do not always exactly correspond to the practical operating conditions.

The other set of data required to perform atmospheric transport and dispersion modeling concerns the meteorological characterization of a site. On the case-studies of Lisbon and Porto, the dispersion model was run with input of one year of hourly meteorological data, including air temperature, wind speed and direction. On each case study data from a single meteorological measuring station was introduced in a gaussian dispersion model. These facts introduce uncertainties on the dispersion simulations because meteorological spatial variation along the domain were not considered. However it is necessary to stress that this assumption is not specific to projects involving dioxin emissions and is currently applied in most EIA studies.
2.2 Modeling

The dispersion model used to estimate ground-level atmospheric dioxin concentrations was the Industrial Source Complex - ISC [5]. Dioxins were simulated as gas, because the emission information of the MSW incinerator projects does not include the rate of dioxin emission associated to particulate matter, neither its concentration nor its granulometric distribution. Thus, it was not possible to calculate dry or wet deposition of dioxins that enabled the estimate of atmospheric input to the soil and to the ecosystem. Analogies with previous international studies had to be established to overcome this limitation.

Modeling results obtained with ISC show average and peak environmental dioxin levels of respectively 150 and 2000 fg.m\(^{-3}\). Emissions from the MSW incinerators would cause an increase of average and peak concentrations of respectively 2 and 40 fg.m\(^{-3}\). These results suggest that the MSW incinerator activity does not significantly alters the atmospheric dioxin concentrations. Anyway the most important is to adequately estimate the relative increase of dioxin concentration and not only the absolute value. This fact decreases the error associated with the uncertainties already indicated.

2.3 Assessment of impact on human health

In the Lisbon and Porto EIA’s the atmospheric impact assessment was done using the statistical values of percentile 50 and percentile 98, for the medium and maximum atmospheric conditions. These statistical parameters are specified in the Portuguese legislation for the “classical” atmospheric pollutants such as SO\(_2\) and NO\(_X\). It is important to refer that there are no references or guidance values on the Portuguese legislation to compounds such as dioxins.

It is however possible to find several exposure criteria which are applied in different countries. Two main approaches are frequently used: the comparison of predicted values with Acceptable Daily Intakes and the estimation of excess of cancer cases on the population, through lifetime exposure. Nevertheless criteria differing by several orders of magnitude can be found [6].

Problems on the characterization of the exposed population and on exposure modes lead to the assumption of conservative hypothesis. Individuals are considered to be exposed continuously to the highest airborne concentrations, disregarding population movements and sheltering effects of buildings. Moreover complete absorption of inhaled dioxins is assumed and all dioxins are considered to be in the gaseous form. The application of this set of conservative assumptions tends to overestimate the true risk to the public.
3. External Monitoring Program

IDAD is preparing the External Monitoring Program (EMP) for the Porto Project. The main objective of the EMP will be to follow the evolution of the several environmental mesological elements around the site of LIPOR II. Within this Program the potential effects over the environmental, public health and human behaviour will be systematically tracked. The Monitoring Program will start its activities before the beginning of operation of the incineration plant.

The EMP will have the following objectives:

- assess the "real" environmental impact of the construction and operation of LIPOR-II;
- to follow the evolution of public health;
- to follow the psycho-social reactions of the population;
- to provide an integrated toll for the collection and treatment of environmental data.

This Program will integrate three partial monitoring plans (see Figure 3):
- Environmental Monitoring Plan;
- Public Health Monitoring Plan;
- PsychoSocial Monitoring Plan.

![Figure 3- Structure of the External Monitoring Program](image)

The three Monitoring Plans will be organized independently taking into account the inter-relations that exist between the different sectors. The direct relation between potential environmental nuisances and public
health problems such as the appearance of physiological stress symptoms in the more sensitive population is a good example of this complex set of inter-relations.

The Environmental Monitoring Plan will include the monitoring and assessment of the construction and operation of LIPOR-II over the atmosphere, surface and underground water, soil, biota and noise. A biomonitoring plan will also be developed which main objective will be to study contaminants transfer through the several environmental media.

4. Conclusions

In this paper, we present some of the difficulties and limitations found in the assessment of the atmospheric impact of dioxin emissions from the MSW incinerators. Classical methodologies used in EIA of atmospheric pollutants that are regulated by legal reference values are not directly applicable to EIA involving dioxins. Under these circumstances dispersion studies were used as input to other scientific disciplines.

This analysis was based on human exposure to the predicted values and, in the other hand, by comparison with typical atmospheric concentrations on urban, rural and industrial zones [7]. Either the average scenarios as well as the peak values were considered. Peak values were analyzed as accident scenarios with shorter exposure period.

As a consequence of the Environmental Impact Assessment study, an External Monitoring Plan will be implemented in the region of Porto to follow the potential effects of the incinerator.

References

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