THE HRA_{IRC} SOFTWARE FOR ASSESSING THE HUMAN HEALTH RISK FROM WASTE-TO-ENERGY PLANTS

Diana COCÂRȚĂ[1], Marco RAGAZZI[2], Adrian BADEA[3], Tiberiu APOSTOL[4]

The waste incineration processes release substances which can accumulate in various environmental compartments: soils, vegetation, indoor dusts, animals and humans. The studies on the impact on public health from macro and micro pollutants released from significant punctual sources have shown a remarkable development during the last years.

The main aim of the current work was to develop a unique instrument for assessing human health risk that can induce toxically and persistent pollutants from waste incineration plants.

Like first approach, the methodology proposed in 1998 by US EPA (Methodology for assessing health risks associated with multiple pathways of exposure to combustor emissions, US EPA, 1998) together with an application of this methodology, for a waste incineration plant were considered. The EPA document is providing indications for assessments of human health risks that may result from multimedia and multiple pathways of exposure. The inception of multiple pathway assessment occurred in the late 1980's and was first applied to rule-making in the evaluation of multiple pathways of exposure to air pollutants emitted from municipal waste incinerators in 1987.

Moreover, it was developed a software which uses MATLAB as programming language to translate mathematical model (equations) in an instrument. The instrument is able to work in a real time with hundreds of formula and to support different variations as a consequence of the study particularities.

The advantages of having a package which permits to assess in a short period of time the human health risk from waste incineration plants have as consequence some other returns as: I. Decisional criteria on technological investments could be done in real time; II. The impacted area could be classified from agricultural use view; this influence the diet in a practical and sensible way, and is simple to be assessed through the developed software, just modifying some parameters in the input file; III. If the dispersion model used is the appropriate one, it is impossible that the individual risk assessed to not to take into account the climatological conditions that are characterizing the interested area; IV. The application of the present software could be extended to other punctual sources as thermal power plants, but also to linear (highways) or diffuse (landfill) sources.

Keywords: waste incineration, health risk assessment, software.

[1] Researcher Engineer, Power Engineering Faculty, University "Politehnica" of Bucharest, Romania
[2] Associate Prof., Civil and Environmental Engineering Department, University of Trento, Italy
[3] Prof., Department of Energy Production and Use, University "Politehnica" of Bucharest
[4] Prof., Department of Energy Production and Use, University "Politehnica" of Bucharest

1. Introduction

The present work illustrates important aspects on a proposed methodology for assessing the human health risk because of organic and inorganic emissions from waste incineration plants. The most important results from an international PhD thesis are presented. Diet and the ingestion exposure pathway for dioxin human health risk assessment are associated to the proposed approach for human health risk assessment. The instrument for human health risk assessment is presented together with an application on a waste incineration plant under design phase. Interesting results were also obtained with regard to heavy metals concentrations at stack emissions.

2. Human Health Risk Assessment – general methodology

In order to create software able to estimate the human health individual risk from waste-to-energy plants, the methodology proposed in 1998 by US EPA [1] and updated in 2003 by the Office of Environmental Health Hazard Assessment of US (OEHHA) [2] was taken into account. The EPA document is providing indications for assessments of human health risks that may result from multimedia and multiple pathways of exposure and is structured as illustrated in Figure 1. Generally speaking, risk analysis is defined to include risk assessment, risk characterization, risk communication, risk management, and policy relating to risk, in the context of risks of concern to individuals, to public and private sector organizations, and to society at a local, regional, national, or global level [3].

The methodology used in order to develop the HRAIRC software for assessing the individual human health risk is the classical one of the multiple pathways (Figure 1). The methodology for the risk assessment includes four steps: 1. hazard identification; 2. exposure assessment; 3. dose-response evaluation and 4. risk characterization. Finally, the individual risk is counted as expressed bellow:

$$Individual\_Risk_{mp} = Dose_{mp} \times Cancer\_Potency_{mp} \quad (1)$$

where:

Individual_Risk = Potential different pathways excess cancer risk [-];

$Dose_{mp}$ = Doses for multiple exposure pathways [mg/kg – day];

CP_{mp} = Different multiple pathways cancer potency $[mg/kg - day]^{-1}$.

An acceptable human health risk is lower than 10^{-6}.

Once the concentration in soil is counted, the deposition and pollutant concentration at ground level can be estimated by the air dispersion models. The absorbed doses through multiple exposure pathways (inhalation, dermal contact and ingestion) can be assessed through the mathematical model suggested by OEHHA in 2003 [2, 4]. At this point, it is important to underline the fact that the

specific pathway that must be analyzed for each pollutant identified as emitted by the source (in our case a water incineration plant) can be different from a pollutant to another.

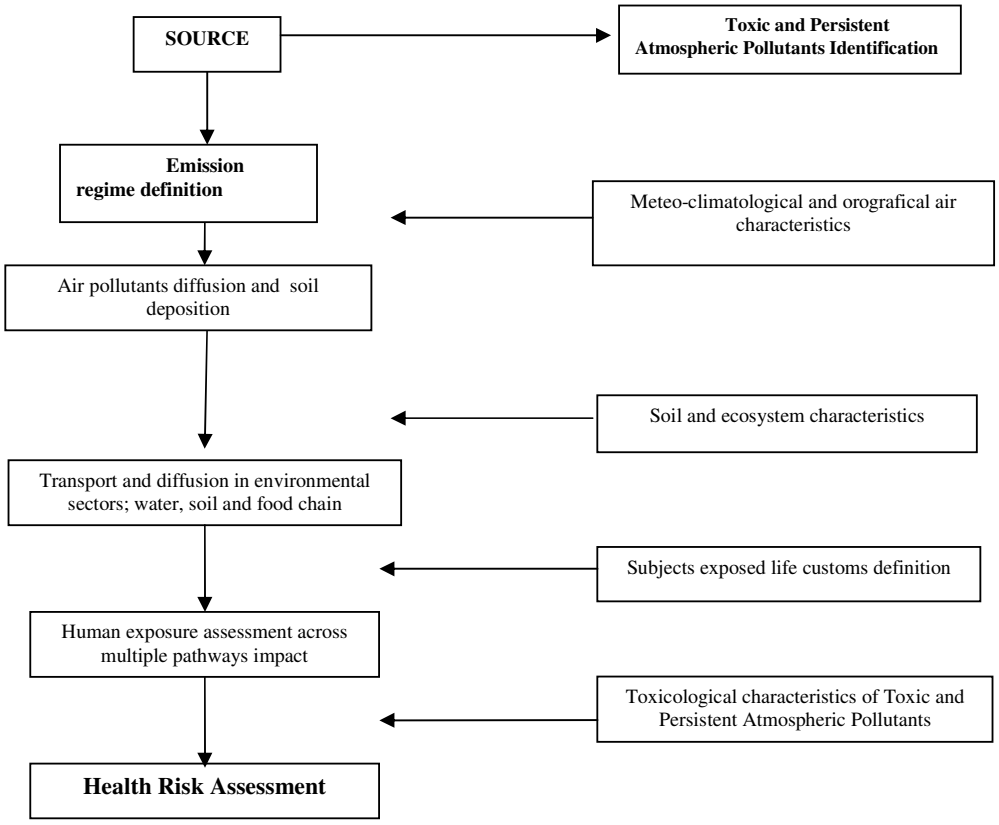

Fig. 1. Risk Assessment methodology – general diagram

Cancer potency (or slope factors) expresses the possible risk of developing cancer per unit of average daily dose over a 70-year lifetime (equation 1.). These values of cancer potency have been determined by OEHHA or EPA and endorse by OEHHA, and are from time to time updated. Table 1 is summarizing cancer potency values for some carcinogenic pollutants possibly emitted by waste incineration plants. Three references were considered and it is about the official site of US Environmental Protection Agency, US Risk Assessment Information System (RAIS), which is realizing a summary of toxicity profiles for some chemicals and the Technical Support Document for Describing Available Cancer Potency Factors, EPA May 2005 [5].

Table 1

Cancer Potency for different exposure pathways and different references

Chemical	Inhalation Cancer Potency			Oral Cancer Potency			Dermal Cancer Potency		
	EPA site	RAIS	CP 2005	EPA site	RAIS	CP 2005	EPA site	RAIS	CP 2005
As	-	5×10^{1}	1.2×10^{1}	1.5	*	1.5	1.5	-	1.5
Cd	-	6.1×10^{1}	1.5×10^{1}	-	-	-	-	-	-
Cr	-	4.1×10^{1}	5.1×10^{2}	-	-	4.2×10^{-1}	-	-	4.2×10^{-1}
BaP	-	-	3.9×10^{1}	7.3	7.3	1.2×10^{1}	7.3	7.3	1.2×10^{1}
PCB	2	-	-	2	-	2	2	-	2
PCDD/F	1.2×10^{5}	-	-	1.6×10^{5}	-	1.3×10^{5}	3.72×10^{5}	-	3.02×10^{5}

The dermal contact slope factors were counted considering an expression suggested in the document from EPA in 2001 [6] (equation 2.).

$$SF_{ABS} = \frac{SF_0}{ABS_{GI}}, \tag{2}$$

where:
SF_{ABS} = dermally adjusted slope factor [mg/kg-d]$^{-1}$;
SF_0 = oral slope factor [mg/kg-d]$^{-1}$;
ABS_{GI} = gastrointestinal absorption factor [-].

Hence, the specialized literature is offering different values of slope factors for the same chemical. In order to evaluate individual risk, it is important that appropriate values are considered; it is not enough to consider the higher cancer potency value in order to consider the worst case because not just the cancer potency has an influence for the assessed human health risk. It is also about the concentration of the pollutant emitted, the meteorology, the geographical characteristics of impacted area and other which have a real contribution on estimated doses. With the aim to point out in which way the human health assessed is changing together with cancer potency, also the calibration of the new instrument has been done along the PhD research.

3. Plant technical characteristics

Some technical characteristics of a proposed waste incineration plant considered for the evaluation of the human health risk are: Plant Capacity = 240 000 t_{MSW}/year; Working days = 315 days/year; Working hours = 7560 hours/year; Stack: • height = 100 m; • diameter = 2.25 m; Release Parameters: • flue gas volume = 150 000 Nm^3/h (ogni linea) = 300 000 Nm^3/h; • flue gas temperature = 140 ˚C = 413.15 K; • flue gas velocity = 20 m/s; Recoverable thermal power = 70 MWt; Electricity: • gross electricity production = 79.6 MWel; • electricity sent out = 70 MWel; Flue gas cleaning system: electrofilter; fabric filter; scrubber; SCR; SNCR.

4. HRA_{IRC} – software

With the aim to evaluate the human health risk from the considered waste incineration plant a software has developed. The software which uses MATLAB as programming language is able to translate mathematical model (equations) in an instrument able to work in a real time with hundreds of formulas and to support different variations as a consequence of the study particularities. The software has two major types of input data from the dispersion model: ground-level concentration (GLC) and deposition on the affected soil area per day, so, first of all, the dispersion model individualizes the impacted area. After the estimation of the pollutants ground level concentrations and depositions, we can run the software. The HRA_{IRC} software was developed as illustrated in Figure 2. The necessary files in order to run the software are listed in Figure 3.

After all the folders with their afferent files were created, it is possible to run the program for the human health risk calculation. The software permits to run the program separately for each pollutant considered for the human health risk assessment and also to run the program one time for all pollutants together with the final individual risk result [4].

The software offers the possibility to choose between the different kind of results representation as risk maps and diagram of risk profile for every gridcell where risk was counted (Figure 4).

5. Results

The reason that the model was applied to a waste incineration plant was to verify if the emissions from the planned incinerator could induce a higher or a minor risk respect to the acceptable one 10^{-6}. The human health individual risk distribution in the considered area is illustrated in Figure 5. The intermediate results from the software application allowed us to make some important remarks: a) Cr^{VI} together with PCDD/F play an important role in HRA from waste

incineration plants; b) it came out the necessity of specific stack air limit emission for Cr^{VI} regulated by a Directive and c) plant with medium or small capacity could be a solution for decreasing the human health risk.

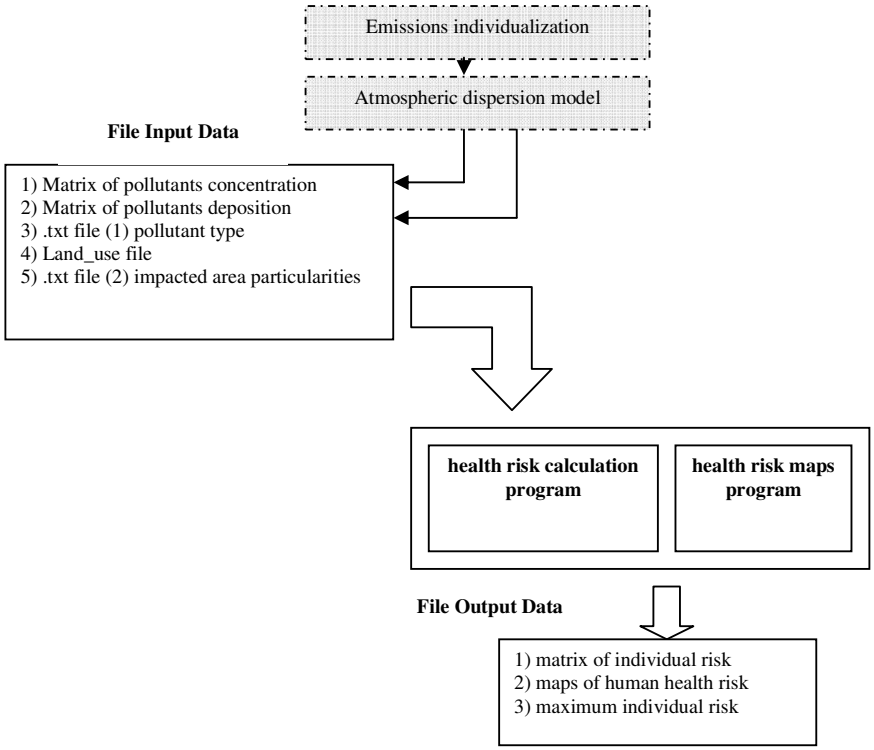

Fig. 2. Modular structure of the HRA_{IRC} instrument for Human Health Risk Assessment

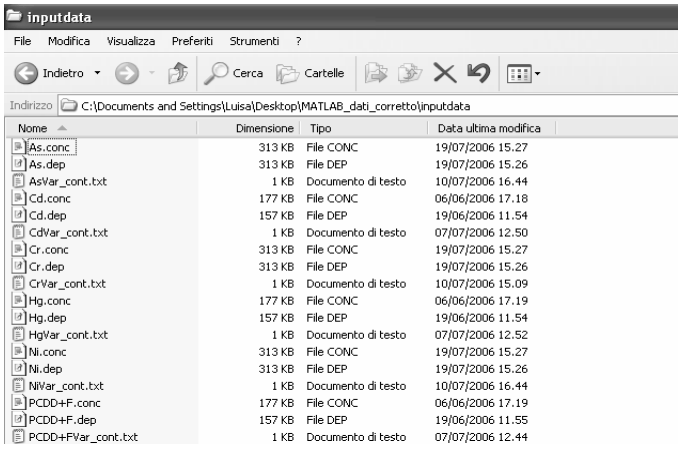

Fig. 3. Files to be generated as input folders

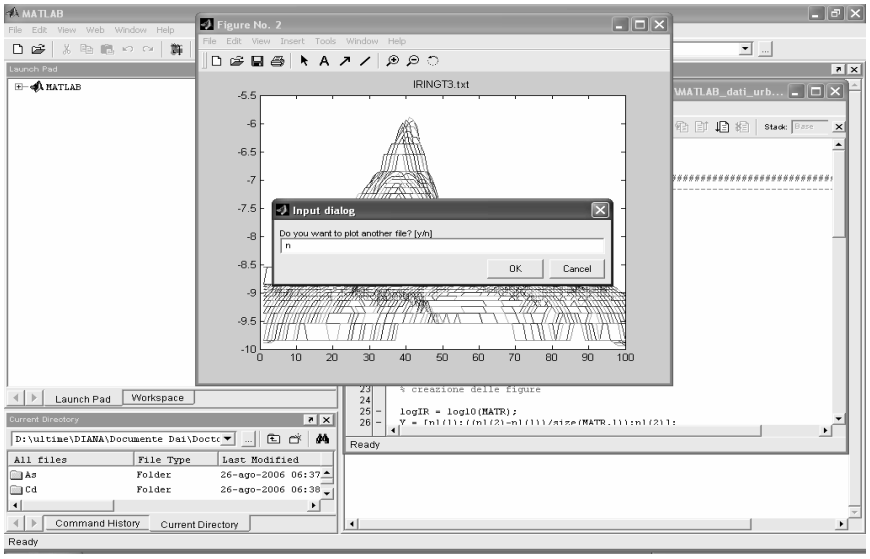

Fig. 4. Different types of results representation choice

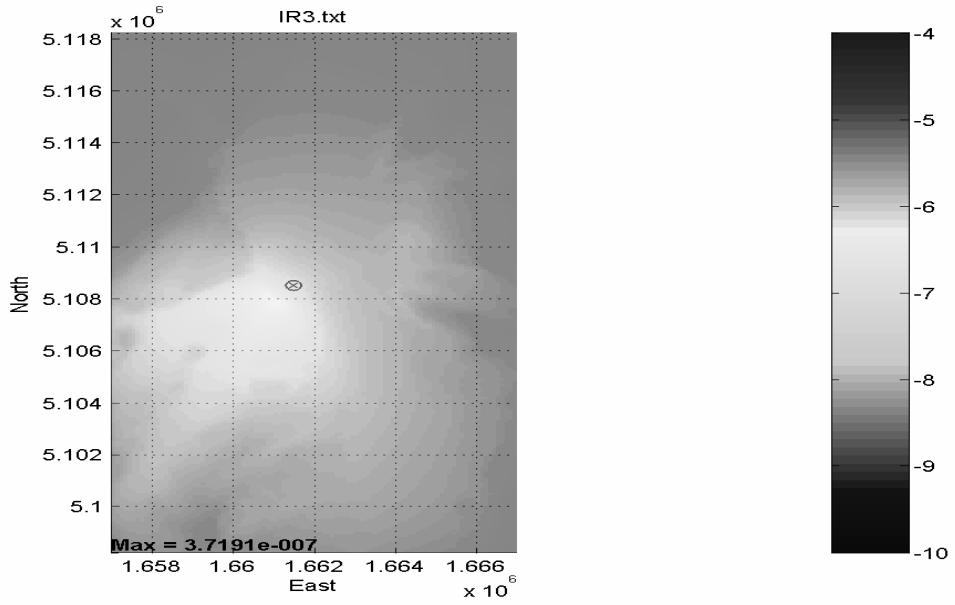

Fig. 5. Individual Risk Assessed (Gauss Boaga coordinated [m]); logarithmical scale

6. Conclusions

The public health impact assessment from a waste-to-energy plant must consider: an appropriate methodology for human health risk assessment, representative pollutants, land use characteristics as well as real and accurate input data from dispersion models (pollutant ground level concentrations and depositions). In this way is becomes possible to assess the human health risk from a source in real time.

The application of the present HRA_{IRC} software could be extended to other punctual sources as thermal power plants, but also to linear (highways) or area (landfill) sources. Additionally, through HRA_{IRC} it is possible to run different scenario simulations and avoid negative consequences. So, the HRA_{IRC} software is a complete and practical tool for the human health risk assessment from waste-to-energy plants.

REFERENCES

[1]. *US EPA*, Methodology for assessing health risks associated with multiple pathways of exposure to combustor emissions, 1998.

[2]. *OEHHA*, The Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments, The Air Toxics Hot Spots Program Risk Assessment Guidelines, California Environmental Protection Agency, August 2003.

[3]. *The Society for Risk Analysis*, SRA mission statement, Switzerland, Europe, 2007 (http://reports.eea.europa.eu/GH-07-97-595-EN-C2/en/iss1c2h.html).

[4]. *Diana M. Cocârță*, Public Health Impact from Waste-to-Energy Plants, International PhD Thesis, Universita degli Studi di Trento, Facolta di Ingegneria - University "POLITEHNICA" of Bucharest, Romania, Power Faculty, Bucharest, April 2007.

[5]. *U.S. EPA**, Air Toxics Hot Spots Program Risk Assessment Guidelines, Part II, Technical Support Document for Describing Available Cancer Potency Factors, California Environmental Protection Agency, May 2005.

[6]. *U.S. EPA***, Basis and background of the soil remediation standards for the combined ingestion and dermal absorption pathway, EPA 2001.