HUMAN HEALTH RISK ASSESSMENT FROM THE EMISSIONS OF A ROMANIAN THERMOELECTRIC POWER PLANT

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The present paper is illustrating a case study concerning toxic and persistent emissions from a Romanian power plant running on coal. After modeling emissions of pollutants as Cd, Cr, Ni, Pb, Hg, PCDD/F and PAH emitted from the analyzed power plant, the associated human health risk assessment was developed. The main aim of the paper was to identify the individual risk related to human health as a consequence of the power plant emissions.

Keywords: risk assessment, thermoelectric power plant, human health, air pollution.

1. Introduction

Generally pollutants as NOx, SOx, CO and PM are taken into account for the assessment of health impact from energy production; nevertheless, attention should also be drawn on toxic organic emissions and heavy metals. Chemical species belonging to this category of pollutants, after dispersion in the atmosphere and after soil deposition processes can reach plants, animal, food and human beings. Effects on human health are different as a consequence of the pollutant type and multiple exposure pathways duration [1]. The present paper is illustrating a case study concerning toxic and persistent emissions from a Romanian power plant running on coal. After modeling emissions of pollutants as Cd, Cr, Ni, Pb, Hg, PCDD/F and PAH emitted from the analyzed power plant, the associated human health risk assessment was developed. The main aim of the paper was to identify the individual risk related to human health as a consequence of the power plant emissions.

2. Human Health Risk Assessment: method and software tool

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The proposed methodology for the health risk assessment is identifying the additional number of cancer cases given by a specific pollutant concentration due to the considered plant; this methodology has been proposed by the United States Environmental Protection Agency (US EPA) in 1998 [2] and further updated in 2003 by OEHHA [3].

The acceptable individual risk, integrated over the whole set of micro-pollutants, is conventionally set to a value of 10^{-6}. Once identified the pollutants that are characterizing the emissions of the considered source, the individual risk is assessed and this should be lower than the acceptable one. The pathways for which the exposure is calculated are the soil ingestion, dermal contact and inhalation. For the individual risk evaluation, a software for assessing human health risk (HRA_{IRC}) was taken into account. This software was developed in the frame of a co-supervised PhD research. The assessment of the uncertainty of the model is addressed in "The Air Toxics Hot Spots Programme Guidance Manual for Preparation of Health Risks Assessments, 2003" [3]. The parameters categories used for the dose estimations are presented in Table 1. The illustrated results were obtained across a research supported by the Romanian National Research Council.

Table 1

Parameters categories used for the dose estimations

Parameter category	Parameter	Value
Soil concentration	time deposition (y^{-1})	30
Soil concentration	soil elimination constant (y^{-1})	0.06
Soil concentration	soil density (kg m^3)	1 500
Exposure	total exposure time (y)	30
Exposure	adults total exposure time (y)	21
Exposure	children total exposure time (y)	9
Exposure	exposure frequency (d y^{-1})	350
Exposure	total days of exposure period (d)	2 550
Exposure	adults body weight (kg)	70
Exposure	children body weight (kg)	30
Dermal Absorbtion exposure	surface area of exposed skin (m^2 kg_{bw}^{-1})	0.0489
Dermal Absorbtion exposure	soil loading on skin (mg_{soil} cm^{-2} d^{-1})	0.52
Dermal Absorbtion exposure	fraction absorbed across skin (%)	0.5
Soil ingestion exposure	adults soil ingestion rate (mg_{soil} d^{-1})	50
Soil ingestion exposure	adults soil ingestion rate (mg_{soil} d^{-1})	85
Soil ingestion exposure	oral absorbtion factor (%)	100
Vegetable ingestion exposure	BCFsoil plant, PCDD/F [(mg/g_{dry})/(mg/g_{soil})]	0.033
Vegetable ingestion exposure	BCFair plant, PCDD/F [(mg/g_{dry})/(mg/g_{air})]	10 200
Vegetable ingestion exposure	air density (g m^{-3})	1 290
Vegetable ingestion exposure	vegetable daily consumption (g_{dry} d^{-1})	60

Parameter category	Parameter	Value
Vegetable ingestion exposure	apples daily consumption (g_{dry} d^{-1})	5
Vegetable ingestion exposure	vegetable fraction from contaminated area (%)	10
Vegetable ingestion exposure	apples fraction from contaminated area (%)	50
Mother's milk ingestion exposure	half-life of contaminant in mother (d)	2117
Mother's milk ingestion exposure	exposure time (y)	1
Mother's milk ingestion exposure	fraction of contaminant that partitions to mother's fat (%)	80
Mother's milk ingestion exposure	fraction of mother's weight that is fat (kg_{fat} kg_{bw}^{-1})	0.04
Mother's milk ingestion exposure	fraction of fat of mother's milk (kg_{fat} kg_{milk}^{-1})	0.33

3. The case study

The considered thermoelectric power plant has a capacity of over 1 000 MW_{el} and the fuel used is coal. The plant has two stacks. The stack height is 220 m with a flow gas velocity of about 20 m s^{-1} for every single stack. The micro-pollutants emissions from the thermoelectric power plant and used for the pollutants dispersion are illustrated in the Table 2.

Table 2

Melting points and elemental analyses

Pollutant	Concentration		UM
	Stack 1	Stack 2	
Cd	0.000221	0.000221	mg/Nm^3
Pb	0.0589	0.0589	mg/Nm^3
Ni	0.00284	0.00284	mg/Nm^3
Cr	0.00395	0.00395	mg/Nm^3
Hg	0.000028	0.000028	mg/Nm^3
PCDD/F	0.001	0.001	ng/Nm^3
HPA	1.01	1.01	mg/Nm^3

4. Results

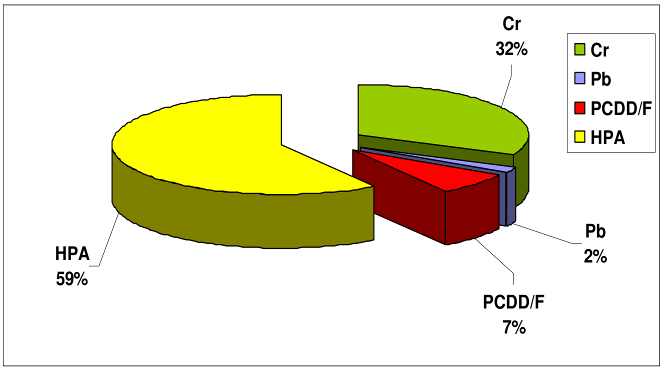
In order to apply the approach for the human health risk assessment, two kinds of parameters are requested from the dispersion model: pollutant concentration in the air at ground level and deposition. Additionally, parameters as shown in Table 1 were used. To solve the pollutants dispersion issue, cooperation between University POLITEHNICA of Bucharest and a research centre from Italy was established (Centro di Ingegneria e Sviluppo di Modelli per l'Ambiente). A suitable dispersion model was applied and this leads to provide necessary information for the human health assessment. Results identify the most important pollutants emissions from the power plant and the related consequences on human health. The significance of every single pollutant concentration was pointed out, in order to identify the best strategies for risk minimization. The Human Health Individual Risks from the thermoelectric power plant considering the illustrated toxic and persistent emissions are presented in Table 3.

Table 3

Melting points and elemental analyses

Pollutant	IR Oral exposure	IR Dermal Contact	IR Inhalation	**IR**
Cd	2.8E-09	8.03E-12	2.84E-09	**2.96E-09**
Cr	5.05E-08	1.44E-09	1.72E-06	**1.78E-06**
Hg	0.00E+00	0.00E+00	0.00E+00	**0.00E+00**
Ni	0.00E+00	0.00E+00	2.21E-09	**2.21E-09**
Pb	1.04E-07	2.98E-09	2.12E-09	**1.07E-07**
PCDD/F	3.06E-07	7.12E-08	3.03E-08	**4.07E-07**
HPA	0.00E+00	0.00E+00	3.34E-06	**3.34E-06**

Figure 1 is presenting the pollutants contribution to the assessed Individual Risk. It must be specified that for the PAHs Individual risk assessment the cancer potencies of Benzo[a]pyrene were taken into account, as (B(a)P) is considered the most potent carcinogen in PAH mixtures [4]. The distribution of the individual risk from the power plant emissions is illustrated in Fig. 2. (x- and y-axes represent the UTM geographic coordinate system expressed in m).



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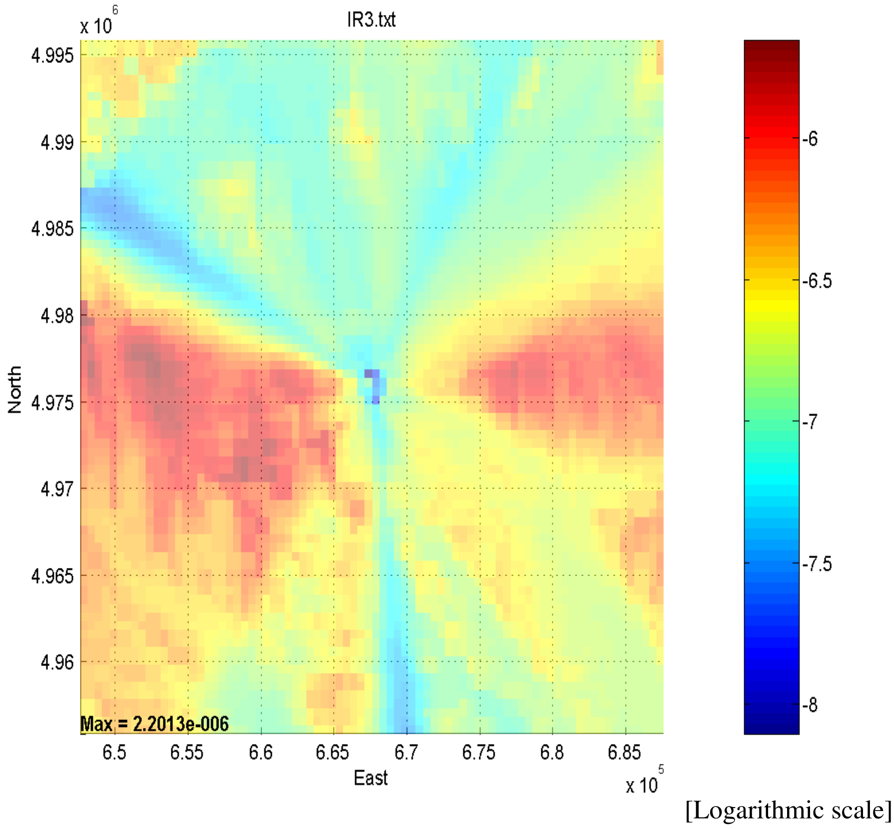

Fig. 2. Individual Risk
(grid-cell representation with horizontal spatial resolution of 500 × 500 m)

5. Conclusions

Assuming the pollutants emission due to the plant as initial hypothesis, the target was to check by means of the health risk model if the expected risk was lower with respect of the acceptable threshold of 10^{-6}. The area of interest was subdivided into smaller areas using a regular grid system [5].

For each grid-cell, ground level concentrations and pollutant depositions were obtained from the dispersion model. Furthermore, the human individual risk was computed in every cell.

The total impact area considered has a surface of 40 × 40 km^2 and a horizontal grid resolution of 500 × 500 m^2. The maximum individual risk, reported in Fig. 1, presents maximum values larger than the threshold value 10^{-6}, approximately two times higher than the threshold. Furthermore, it was assessed which of the pollutants was the main responsible for the individual risk. The individual risk for every single pollutant was evaluated and the main results were underlined. Besides the results related to the individual risk, the presented approach could be also adopted for optimizing the flue gas cleaning system and this only becomes possible after that the most important pollutants concentration in the atmosphere and, consequently, the related effects on human health are known, as shown before.

R E F E R E N C E S

[1]. *Diana Cocârță,* Public Health Impact from waste-to-energy plants, PhD Thesis, University POLITEHNICA of Bucharest, Romania and University of Trent, Italy, 2007.

[2]. US Environmental Protection Agency - Methodology for Assessing Health Risks Associated with Indirect Exposure to Combustor Emissions, EPA 600/R-98/137, Methodology for Assessing Health Risks Associated with Multiple Pathways of Exposure to Combustor Emissions, Update to EPA/600/6-90/003, 1998.

[3]. 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, 2003.

[4]. *D. James Fitzgerald, Neville I. Robinson and Beverly A. Pester,* "Application of Benzo(a)pyrene and coal tar tumour dose-response data to a modified benchmark dose method of guideline development", in Environmental Health Perspectives **vol. 112**, no. 14, 2004, pp. 1341-1346.

[5]. *D. Cocârță, E. C. Rada, M. Ragazzi, A. Badea, T. Apostol*, "A contribution for a correct vision of health impact from municipal solid waste treatments", Environmental Technology, Vol. 30 Issue 9, ISSN 1479-487X (electronic), 0959-3330 (paper), 2009, pp. 963-968.