



2-FUN

*Full-chain and UNcertainty Approaches for Assessing Health Risks in
FUture ENvironmental Scenarios*

**FP6 Project-2005-Global-4
Integrated Project - Contract n°: 036976**

– CRITICAL ANALYSIS OF PREVIOUS STUDIES RELATED TO THE CASE STUDIES AND INTERNAL COLLECTION OF DATASETS FOR FURTHER USE IN THE CASE STUDIES –

Due date of delivery: *30/04/2008*

Actual submission date: *10/10/2008*

Start date of the project: *01/02/2007*

Duration: *48 Months*

Lead contractor organisation name for this deliverable: *IETU*

Project co-funded by the European Commission within the Sixth Framework Programme (2002-2006)	
Dissemination Level	
PP	Restricted to other programme participants (including the Commission Services)

PROPRIETARY RIGHTS STATEMENT

This document contains information, which is proprietary to the 2-FUN Consortium. Neither this document nor the information contained herein shall be used, duplicated or communicated by any means to any third party, in whole or in parts, except with prior written consent of the 2-FUN consortium.

Date: 10/10/08
Security: PP



Document Information

Document Name Critical analysis of previous studies related to the case studies and internal collection of datasets for further use in the case studies
ID D4.2_Case_studies_literature_review.doc
Revision Version 3
Revision Date 06/05/2008
Author J. GZYL / IETU
Co-Authors S. MAURAU / EDF; E. CASIMIRO / FFCUL; A.BUBAK / IETU, P. CIFFROY / EDF; S. ALMEIDA / FFCUL

Approvals

	Name	Company	Date	Visa
Author	J. GZYL	IETU	16/09/2008	J. Gzyl
Co-Author	S. MAURAU	EDF	16/09/2008	S. Maurau
Co-Author	E. CASIMIRO	FFCUL	16/09/2008	E. Casimiro
Co-Author	A. BUBAK	IETU	16/09/2008	A. Bubak
Co-Author	P. CIFFROY	EDF	16/09/2008	P. Ciffroy
Co-Author	S. ALMEIDA	FFCUL	16/09/2008	S. Almeida
WP Leader	J. GZYL	IETU	16/09/2008	J. Gzyl
Coordinator	F. BOIS	INERIS	10/10/2008	F. Bois

Documents history

Revision	Date	Modification	Author
Version 0	18/01/2008	Template made available to the WP leaders	F. BOIS
Version 1	30/05/2008	First version (CS3)	J. GZYL
Version 2	19/06/2008	Second version (CS3+CS2)	J. GZYL
Version 3	15/09/2008	Third and final version (CS3+CS2+CS1)	J. GZYL



Contents

<u>INTRODUCTION</u>	4
<u>1. CASE STUDY 1: EVOLUTION OF AIR POLLUTANTS AND THERMAL STRESS IN PORTUGAL AND IMPLICATIONS FOR FUTURE HEALTH RISK</u>	6
<u>1.1 Data Sources</u>	6
<u>1.2 Summary of Data Collected</u>	7
<u>1.2.1 Demographics</u>	7
<u>1.2.2 Mortality Dataset</u>	9
<u>1.2.3 Climate Dataset</u>	10
<u>1.2.5 Observed daily weather</u>	12
<u>1.2.5 Ambient Air Pollutants</u>	13
<u>2. CASE STUDY 2: MANAGEMENT OF A RIVER WATERSHED IN FRANCE</u>	15
2.1 Data sources	15
<u>2.1.1 Seine-Normandy Water Management Agency</u>	15
<u>2.1.2 GIS Piren Seine Program</u>	15
<u>2.1.3 GIP Seine Aval (Seine-Downstream)</u>	15
2.2 Presentation of data collected on the SNWA's database	16
<u>2.2.1 Contacts with the main actors</u>	16
<u>2.2.2 Examples of data</u>	17
<u>3. CASE STUDY 3: LAND MANAGEMENT IN A HEAVY INDUSTRY REGION</u> ...	24
3.1 Sources of environmental and biomonitoring data.....	24
3.2 Brief description of available data for the substances of concern	24
<u>3.2.1 Lead in the environment</u>	24
<u>3.2.2 Lead in biomonitoring samples</u>	25
<u>3.2.3 Cadmium in the environment</u>	27
<u>3.2.4 Cadmium in biomonitoring samples</u>	27
<u>3.2.5 Polycyclic aromatic hydrocarbons(PAHs) in the environment</u>	28
<u>3.2.6 Polycyclic aromatic hydrocarbons(PAHs) in biomonitoring samples</u>	29
<u>3.2.7 Health outcomes</u>	30
<u>REFERENCES</u>	33



INTRODUCTION

The European project 2-FUN (Full-chain and UNcertainty approaches for assessing health risks in FUture eNvironmental scenarios) must provide methods and tools for the assessment of health risks generated by environmental stressors, especially chemical substances. The 2-FUN's developments will contribute to the "toolbox" built by complementary projects (in particular HEIMSTA) and aiming at allowing integrated full-chain assessments.

2FUN project focuses on the following four issues:

- Construction of long term environmental and socio-economic scenarios;
- Evaluation of the exposure profiles and toxic effects in multi-stress contexts (mixtures of chemical stressors);
- Assessment of the exposure and health effects of sensitive individuals, especially children;
- Establishment of margins of uncertainty and analyses of sensitivity.

This will result primarily in the development, then the implementation, of mechanistic models simulating the transfer of pollutants in the environment (*cf.* 2-FUN's WP2) and the human organism (*cf.* 2-FUN's WP3), in order to provide answers in term of risks of pathologies. Besides, 2-FUN's WP1 develops methods helping the construction of scenarios: (i) ranking of relevant scenarios to be investigated in priority through multi-criteria approaches; (ii) improvement of input data treatment (e.g. values below the limit of detection, outliers); (iii) downscaling methods to generate local scenario from global input data.

These tools will be tested in three case studies, which were selected according to the following criteria covering:

- covering different sectorial and environmental policies (e.g. Water Framework Directive, Soil Framework Directive, Climate Change policies);
- covering different stressors sources and typology (e.g. metals, pesticides, PAHs, particles);
- covering different spatial and temporal scales relevant for future cost-benefit analysis.

Two other major criteria were also considered for the selection of case studies:

- the availability of datasets (regarding emissions, distribution of stressors in the environment, environmental and health monitoring networks) that can be used for initiating the case study as well as to validate some intermediate results (*e.g.* accumulation of pollutants in environmental compartments an/or in human body);
- the existence of previous risk assessments, performed according to current methodologies. Such previous studies can give a 'background' level of risk assessment methodologies and will allow to measuring the improvements allowed by the 2-FUN approach.

Three case studies were selected to cover a wide range of situations:

1. Evolution of air pollutants and thermal stress in Portugal and implications for future health risk scenarios;
2. Health risk assessment at a river watershed scale (Seine River – France);
3. Land management in a heavy industry region (Upper Silesia Region – Poland).

Because the investigated regions can be contaminated by a wide range of stressors, a pre-selection of substances that should be studied in priority was established during the 2-FUN's first annual meeting. This selection was based on three criteria:

- the investigated substances must be of interest for the European policies related to human health risks. An analysis of relevant policies at the regional (e.g. Agreements for the



management of a specific watershed, like the Danube or Rhine watersheds¹), European (Water Framework Directive (WFD), Soil Framework Directive) and international levels (e.g. OSPAR convention²) allowed to list the priority substances of interest (cf detailed analysis provided in D 2.3)

- during the first year of the 2-FUN project, the WPs in charge of the development of assessment tools (exposure multi-media models simulating the transfer of substances to environmental compartments of concern for man, and pharmacokinetic models (PBPK) simulating the distribution of chemicals in human body) converged towards an objective of chaining these tools. Taking into account the advance of their work, it is now possible to define certain pollutants for which this coupling is accessible in a realistic way over the three years to come;
- the choice of substances of concern was established in such a way to cover a wide range of chemical 'families' (i.e. metals, lipophilic non polar organics (e.g. PAHs), Volatile Organic Compounds (VOC, like BTEX), polar compounds (like some pharmaceuticals)) in order to demonstrate the capability of the 2-FUN tools to conduct homogeneous assessments for various chemicals.

Crossing these three criteria, it was proposed to focus the case studies on the following pollutants:

- 3 metals: lead ; cadmium ; arsenic ;
- 2 PAHs (representing the 'neutral hydrophobic' family: benzo(a)pyrene, (BaP); benzo(a)anthracene (BaA) and/or dibenzo(a,h)anthracene (DahA);
- 1 pesticide: Atrazine ;
- one pharmaceutical substance (representing the 'ionisable' family).
- Benzene
- Particulate matter (PM10) and ozone
- Heat-stress (as a physical agent)

The first stage of WP4 was to collect existing datasets for initiating CSs, for testing intermediate prototypes of the methods and models provided by the other WPs, and for validating intermediate results. Partners in charge of the CS gathered all the input information that are needed for initiating the risk assessment process (*i.e.* emission datasets and/or population data and/or contamination levels datasets and/or meteorological datasets and/or 'upstream' models outputs, etc) and that can be further used for validating some step of the assessment (*e.g.* concentrations data of pollutants in the environment, biomonitoring studies). This report describes in detail the datasets thus collected for each of the CSs.

¹ Danube River Protection Convention (DRPC), International Commission for the Protection of Rhine (ICPR)

² International convention for the protection of marine systems



1. CASE STUDY 1: EVOLUTION OF AIR POLLUTANTS AND THERMAL STRESS IN PORTUGAL AND IMPLICATIONS FOR FUTURE HEALTH RISK

1.1 Data Sources

In this case study present (2000-2004) and future health impacts from ambient pollutants and thermal stress will be assessed using the 2FUN tool box as well as the epidemiology methods developed in the PHEWE and EUROHEAT projects. Future climate and socio-economic data generated in WP1 will be used to assess the future health impacts.

In order to test the full potential of the downscaling tool developed in WP1, in this case study, we will focus on health impacts in Lisbon. As Lisbon has never been included in previous EU research projects that addressed health and air pollution (i.e. ExternE, APHEIS, PHEWE, etc.) or heat-stress (EUROHEAT) the results from this case study will be of obvious scientific value.

Six datasets required to conduct this case study are:

1. Observed demographics
2. Future demographics
3. Mortality data
4. Observed climate
5. Future climate data
6. Ambient air pollutant concentrations

Datasets 2 (future demographics) and 5 (future climate) will be produced in task 1.2 within the 2FUN project and will be available to WP4 as from M25. Data from the remaining databases have been collected and are discussed in this document.

All demographic data was obtained from the National Statistics Institute. This data is publically available from their website (www.ine.pt).

Observed annual and monthly mortality for Portugal was obtained from the Health Ministry, while the daily mortality data for Lisbon for the period 2000-2004 from the National Statistics Institute. The monthly data was publicly available on the Ministry of Health annual reports. On the other hand, daily mortality data is not publically available. It was obtained as a result of a formal request to the National Statistics Office. The daily mortality data obtained can only be used for the research goals described in this request.

Parallel to the mortality data, an attempt to obtain daily hospital emergency visits data was unsuccessful because this data is not in electronic format and assess to all Lisbon hospitals paper patient records was not possible for confidentially reasons. Nevertheless, data form previous research projects that use only one hospital data indicate that more than one third of all daily hospital emergency visits in children hospitals are due to respiratory complaints.

General indicators of the observed climate for Portugal were obtained from the Portuguese Weather Institute. This data is freely available from their website (www.meteo.pt). Daily time series data is not freely available from the Weather Institute, hence they were obtained from

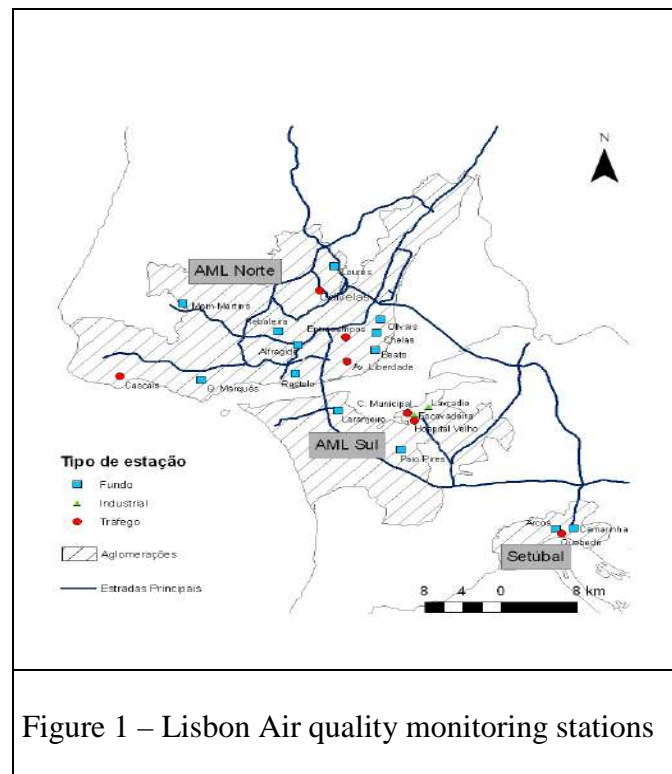
Date: 10/10/08

Security: PP



the European Climate Assessment & Dataset (<http://eca.knmi.nl>) and the Portuguese Water Institute (<http://snirh.pt/>).

Ambient air pollution data was obtained from the Portuguese Environmental Agency. This data is publically available from their website (www.iamambiente.pt). Hourly data is obtained which then needs to be processed into daily and monthly values and checked for quality. The air pollution network in the Lisbon Metropolitan Area consists of 24 monitoring stations (figure 1). In this study we used data from stations belonging to the area above the Tagus Delta (AML Norte) which geographical corresponds to the district of Lisbon.



1.2 Summary of Data Collected

1.2.1 Demographics

During 2000-2004, Portugal had an average population of 10.4 million of which 15.8% were below the age of 15 and 16.7% above the age of 65. As most job opportunities are located along the coastal urban areas, the percentage of elderly population increases towards the interior. The average birth, mortality, and infant mortality rates (‰) during the same period were 11, 10.2, and 4.8 respectively. Although currently infant mortality in Portugal is on par with the EU average, it has improved significantly and constantly over the past decades, from rates of 70‰ in the 1960s, to 40‰ in the 1970s, 17‰ in the 1980s and 8‰ in the 1990s. The number of expected life years at birth has increases continuously over the past decade. In 2004, the expected life years at birth is estimated to be 77.8 years (74.5 years for males and 81.0 years for females).



The percentage of public spending on health in Portugal for 2000-2004, fluctuated from 6.7% to 7.2 %. Total (public and private) health spending ranged from 9.3% to 10% in relation to the GDP. It has one of the highest total health spending in the EU when compared to the national GDP. Consequently, it has a low adaptive capacity potential in the case of unexpected health impacts.

The case study area of Lisbon is composed of 9 municipalities which collectively are grouped into what is termed “Grande Lisboa”. This area is approximately identical to one of the Portuguese agglomerations, defined according to the criteria of the EU Directive 1999/30/CE. The area and resident population of each location in 2001 is listed in Table 1.

The average population in “Grande Lisboa” during 2000-2004 was approximately 2 million, with about 15.3% of the population below the age of 15 and 16.9% above 65 years. The average birth rate (11.4‰) in this region is above the national average, while the average mortality (9.3‰) and infant mortality (3.8‰) are below the national average.

Table 1 – Municipalities of district of Lisbon, area and resident population

Municipalities	Area 2001 (km ²)	Resident population 2001
Grande Lisboa	1084	1.947.261
Amadora	23,8	175.872
Cascais	97,3	170.683
Lisboa	84,6	564.657
Loures	167,9	199.059
Mafra	256,1	54.358
Odivelas	26,6	133.847
Oeiras	45,8	162.128
Sintra	319,5	363.749
Vila Franca de Xira	318,5	122.908

Lisbon is the capital and largest city of Portugal. Due to its economic output, standard of living and market size, Grande Lisboa is considered the second most important financial and economic center of the Iberian Peninsula. The region produces 45% of the Portuguese GDP. It is also the political centre of the country, as seat of government and residence of the Head of State.

Lisbon’s public transport network is considerably far-reaching and has its Metro as its main artery, connecting the city centre with the upper and eastern districts, and now reaching the suburbs. Bus, funicular, tram, and train services constitute the secondary network. The city is connected to the far side of the Tagus River by two bridges. Lisbon International Airport is located within the city limits. It is estimated that there are 2.3 million trips realized to and from Lisbon daily. The correspondent modal shift is constituted by 49% of trips by collective transport, 35% by private vehicle and 11% pedestrian trips.



1.2.2 Mortality Dataset

1.2.2.1 Annual mortality data

Similar to other EU countries, the main causes of death in Portugal are from cardiovascular diseases and tumors. In 2004, the main causes of deaths were from: cardiovascular diseases (36%), tumors (22%), respiratory diseases (8.5%), and external causes (5%).

Data from 2000 indicate that in the adult population the most common type of malignant tumor cases are: Colon and rectal cancers (16%), Breast cancer (12%), Stomach cancer (10%), Lung cancer (8.5%) and Prostrate (8%). Apart from breast cancer, these cancer types affect males more than females. For the population group 0-14 years, the most common malignant tumor cases are: cancers of the central nervous system (23%), leukemia (21%), and Hodgkin's lymphoma (7%).

1.2.2.2 Daily mortality data

Daily mortality data was grouped by cause of death, age and sex. Cause of death was classified based on the ICD-9 and ICD-10 codes. Data was grouped into the following classifications:

- All causes (ICD-9 codes < 800 or ICD-10 codes A00-R99)
- Cardiovascular diseases (ICD-9 codes 390-459 or ICD-10 codes I00-I99)
- Respiratory diseases (ICD-9 codes 460-519 or ICD-10 codes J00-J98).

The data obtained was of excellent quality with no data gaps during the entire period. This time series is summarized in figures 2 and 3. The sharp increase in mortality in the summer of 2003 is evident in figure 2. Table 2 lists a summary of the mortality values for the study period.

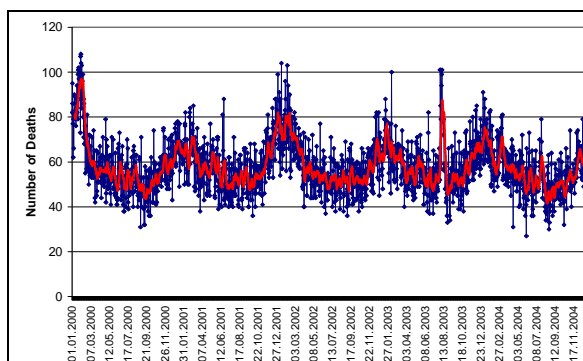


Figure 2 – Daily deaths (all causes) in Lisbon during 2000-2004. Red line is a 10 day running average.

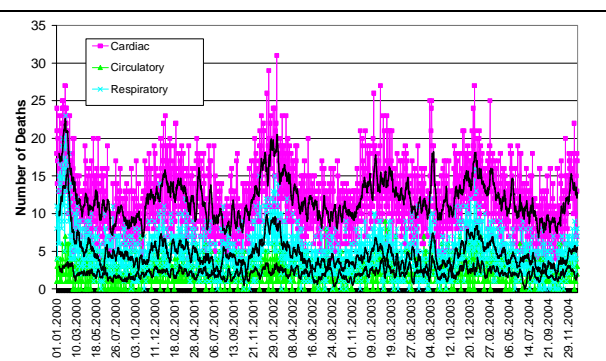


Figure 3– Daily cardiovascular and respiratory deaths in Lisbon. Black lines are 10 day running average.



Table 2 – Summary of daily mortality cases in Lisbon, 2000-2004

Number of cases	Causes of Death			
	All causes	Cardiac	Circulatory	Respiratory
Average	58	12	2.1	4.8
Maximum	108	31	9	23
25 th Percentile	50	9	1	3
50 th Percentile	56	12	2	4
75 th Percentile	65	15	3	6
Sex (%)				
Male	51.1	47.1	39.4	53.8
Female	48.9	52.9	60.6	46.2

1.2.3 Climate Dataset

Mainland Portugal has a mild Mediterranean climate which is strongly influenced by the Atlantic Ocean. The mean annual air temperatures vary between 7°C in the inner highlands of the central region to 18°C in the southern coastal area. Mean annual precipitation is slightly above 900 mm with much spatial variability. In the northwest mountains the mean annual precipitation is above 3 000mm while in the southeast Alentejo it is approximately 500mm. Figure 4 shows the mean monthly temperatures and precipitation for selected locations in Portugal.

The SIAM project (<http://www.siam.fc.ul.pt/>) results clearly showed that the climate in Portugal has changed over the past century. During 1931-2000, the mean annual air temperature in Portugal shows an increasing trend since the 1970s with an increase of 0.47°C/decade in the maximum temperature and an increase of 0.48°C/decade during 1975-2000. For Lisbon from 1975-2000, there was an increase of 0.59°C/decade and 0.29°C/decade for annual mean minimum and maximum temperatures respectively. Relative humidity in Lisbon during 1940-2002 increased at a rate of 1.0%/decade attaining the highest recorded values in 2002.

The same project also showed that there were significant changes in the climatic indices used to describe extreme events. For example, during 1975-2002, the number of nights with temperatures above 20°C (called tropical nights) increased at a rate of 4.2 nights/decade. Similarly, the number of days with temperatures above 25°C (called summer days), increased at a rate of 3.9 days/decade. During this period there has also being a significant reduction in total annual precipitation associated with more frequent precipitation extreme events (both drought and flooding) in Lisbon.

Figures 5 and 6 show the temperature and precipitation monthly means for Lisbon during 1971-2000. The annual maximum mean temperature during this period was 20.9°C while the minimum mean temperature was 13.1°C. For the same period, the absolute maximum temperature recorded in heat-wave of 1981 was 41.5°C. During the entire period, the absolute minimum temperature recorded was 0.4°C.

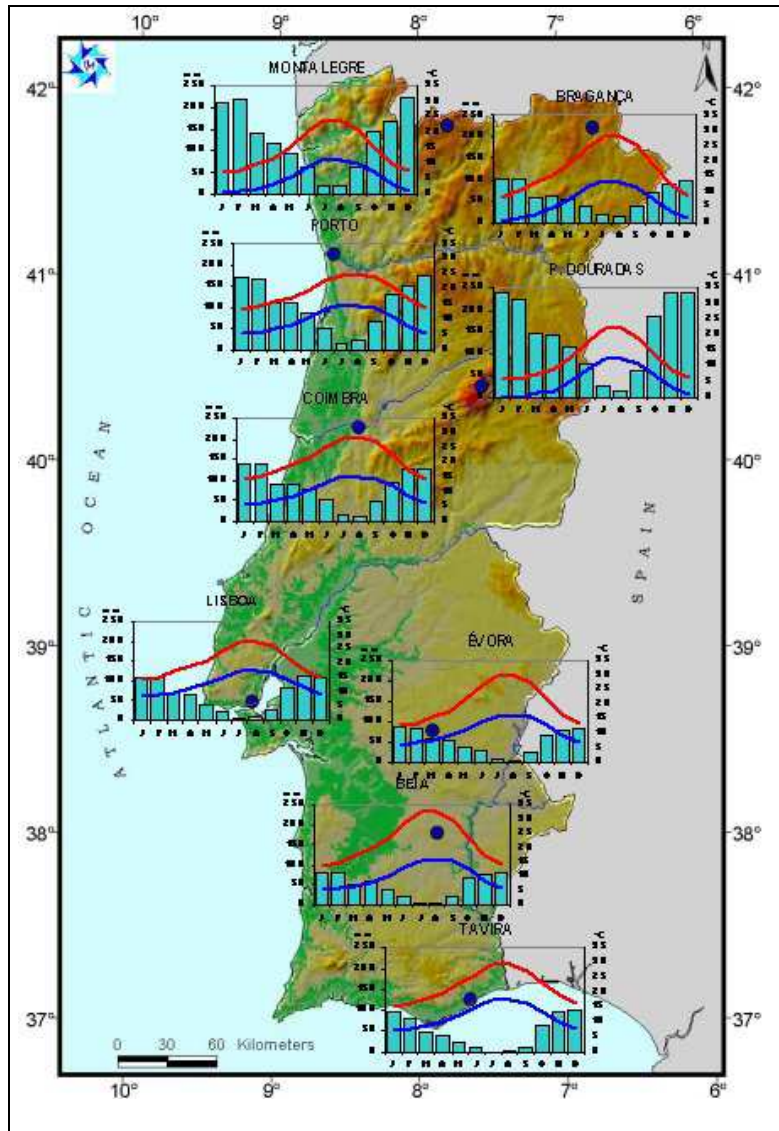


Figure 4 – Mean monthly temperatures and precipitation for selected locations in Portugal (1961-1990). Red lines are for maximum temperature, blue lines for minimum temperatures and blue bars total precipitation.

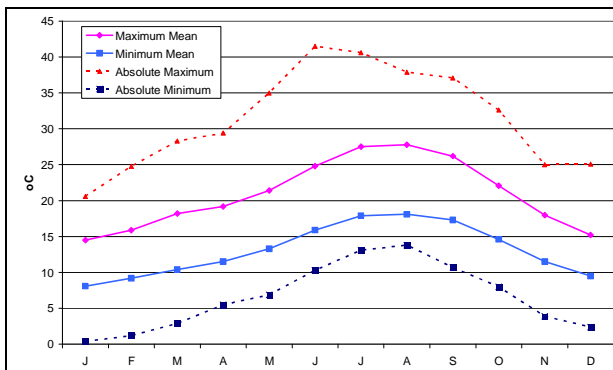


Figure 5 – Monthly temperature in Lisbon (1971-2000).

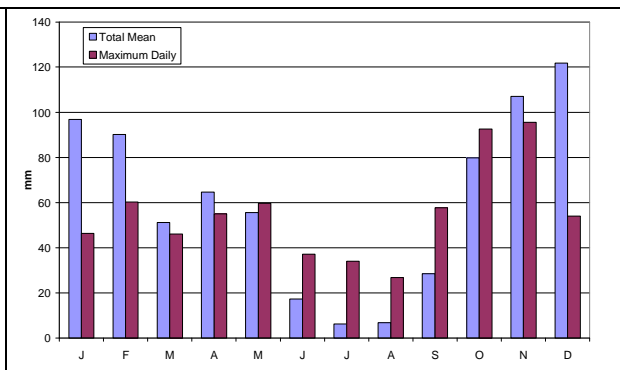


Figure 6 – Monthly precipitation in Lisbon (1971-2000).



1.2.5 Observed daily weather

Daily and hourly data was obtained from 3 stations in Lisbon during 2000-2004 for the following variables: temperature, dew point, wind speed, precipitation, and relative humidity. This data was of good quality. Time-series plots for some of these variables are presented in figures 7-10.

During this period, the average daily temperature was 17°C and the average maximum temperature 21.3°C. The absolute maximum daily temperature was 43.0°C, recorded during the 2003 heat-wave. Daily maximum temperature 50th, 75th, 90th, and 95th percentiles of 20°C, 26°C, 30°C, and 32°C were recorded for 2000-2004.

The average daily dew point in Lisbon (2000-2004) was 11.8°C and the average daily maximum 21°C. For the same period, the average daily wind speed was 15.5 km/hr indicative of a gentle breeze, while the daily maximum average was 43.1 km/hr indicative of a strong breeze.

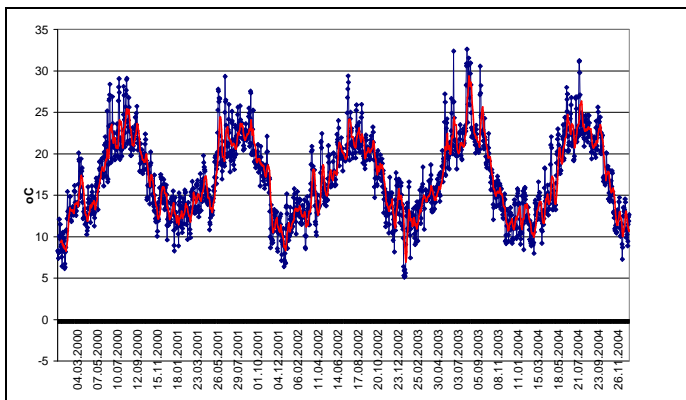


Figure 7 – Daily mean temperature in Lisbon (2000-2004). The red line is a 10 day running average.

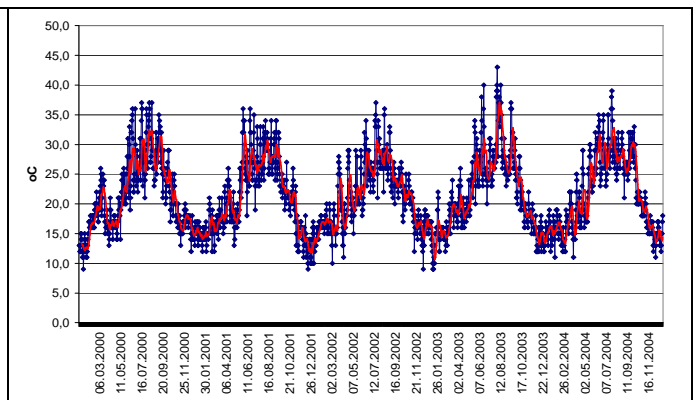


Figure 8 – Daily maximum temperature in Lisbon (2000-2004). The red line is a 10 day running average.

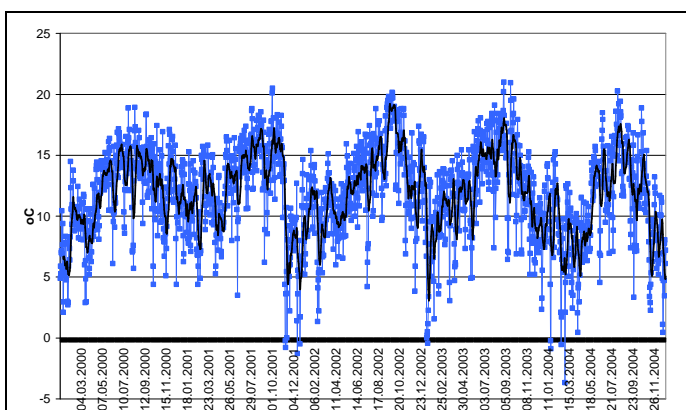


Figure 9 – Daily mean dew point in Lisbon (2000-2004). The black line is a 10 day running average.

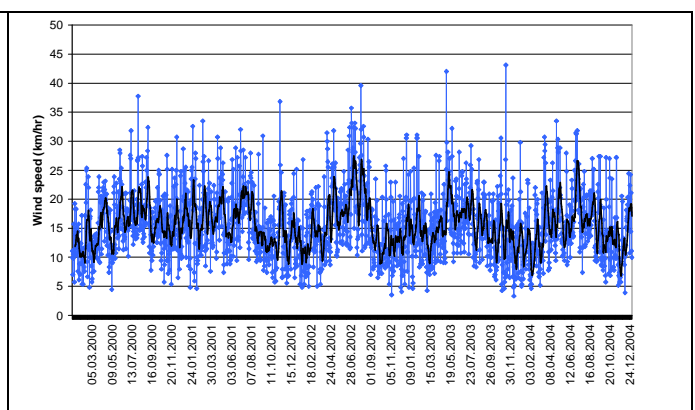


Figure 10 – Daily mean windspeed in Lisbon (2000-2004). The black line is a 10 day running average.



1.2.5 Ambient Air Pollutants

The main source of air pollution in Lisbon is urban traffic. The road transport sector contributes with both vehicle exhaust particles and re-suspension of road dust (mineral dust of street surface and abrasion of tires, brakes and the road surface). Due to its geographical location, dust particles from the Sahara also contribute significantly (on average two thirds) to the PM10 levels in Portugal.

1.2.5.1 PM10

Data from nine monitoring stations are available. Five are background stations (Olivais, Loures, Reboleira, Mem-Martins and Quinta do Marques) and four traffic stations (Entrecampos, Av. Liberdade, Odivelas and Cascais). For all nine stations the data is of good quality with efficacy of measurements above 75%. Figures 11 and 12 are time series plots of this data.

For the background stations the annual average during 2000-2004 was $32\mu\text{g}/\text{m}^3$ and the maximum daily $192\mu\text{g}/\text{m}^3$. Results for the traffic stations were significantly higher than background. No obvious seasonal pattern is noticeable.

PM2.5 is measured at the Entrecampos (traffic station) and in the Olivais monitoring stations (background station) since 2002 and 2004 respectively. Results are of good quality and above 80% efficacy. During 2002-2004, the annual PM2.5 value at the Entrecampos station was $21.3\mu\text{g}/\text{m}^3$ and the annual average for 2004 at the Olivais station was $15.4\mu\text{g}/\text{m}^3$. The average PM2.5/PM10 ratio was 0.52.

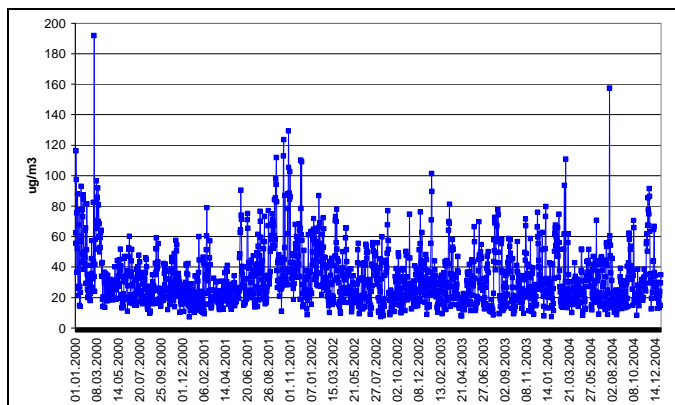


Figure 11 - Daily PM10 for background stations in Lisbon (2000-2004)

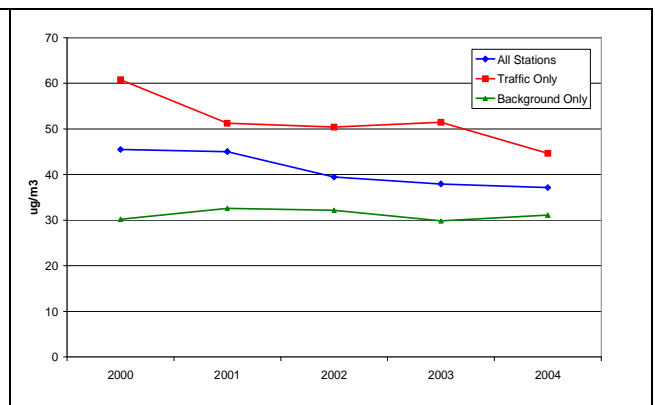


Figure 12 – PM10 Annual average in different station types in Lisbon.

1.2.5.2 Ozone

Data available is from 8 background stations (Olivais, Beato, Restelo, Loures, Alragide, Reboleira, Mem-Martins and Quinta do Marques) and one traffic station (Entrecampos). This data is of good quality with efficacy of measurements above 75% in all stations. Only data from the background stations was used. The time-series for this data is summarized in figures 13 and 14. These figures show the clear seasonal pattern of this pollutant as well as the

Date: 10/10/08

Security: PP



increased levels in 2003 which are probably due with the summer 2003 heatwave and related wildfires.

During 2000-2004, the ozone 1 hour average was $81\mu\text{g}/\text{m}^3$ and reached a maximum value of $226\mu\text{g}/\text{m}^3$. For the same time period, the ozone 8 hour average was $67\mu\text{g}/\text{m}^3$ and the maximum $165\mu\text{g}/\text{m}^3$.

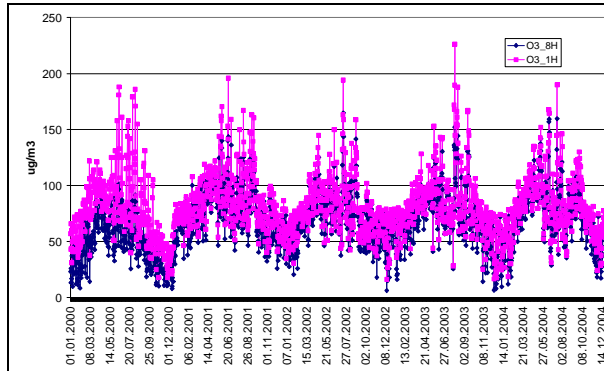


Figure 13 – Daily ambient ozone concentrations at background stations in Lisbon

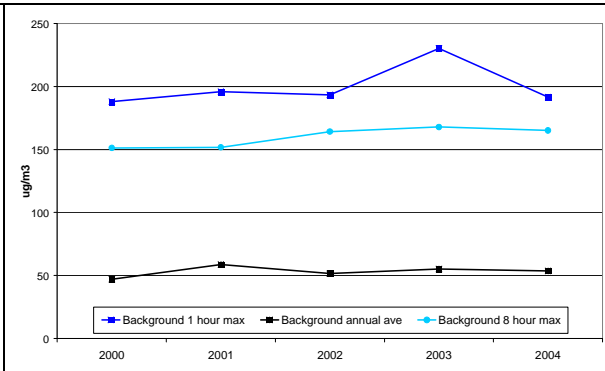


Figure 14 – Ambient ozone annual average values in background stations in Lisbon

1.2.5.3 Benzene

Benzene is monitored in two stations in Lisbon namely: the stations of Entrecampos and Beato. The available data is summarized in Table 3. The data from both stations is however of poor quality with measurement efficacies below 75%.

Table 3 – Summary of ambient benzene concentrations in Lisbon

Station/Year	Type	Efficacy (%)	Annual average ($\mu\text{g}/\text{m}^3$)
Entrecampos	Traffic		
2003		63	2
2004		67	1
2005		56	1,5
Beato	Background		
2003		61	0,8
2004		58	0,4
2005		32	0,8



2. CASE STUDY 2: MANAGEMENT OF A RIVER WATERSHED IN FRANCE

2.1 Data sources

2.1.1 Seine-Normandy Water Management Agency

The Seine Normandy Water Agency (SNWA) is a publicly-owned establishment. Its mission is to preserve the water resources, monitor water systems, stimulate the reduction of pollutions, and restore the aquatic environments. Users (e.g. industry) which are responsible for pollutant releases into aquatic bodies must pay taxes to the Agency; these taxes are then redistributed to fund actions, projects and studies able to improve the quality of water bodies. The Agency missions are planned by a multi-annual program elaborated by various actors (e.g. consumers, industry, State representatives).

Among its missions, the SNWA is responsible for the design of monitoring networks covering all the rivers of the watershed. The database resulting from the monitoring network constitutes an unique source of data because of its spatial coverage, and because a wide range of substances were investigated over long-term periods.

Recently, the SNWA financially contributed to 3 research programs, that could complete the database, especially for some emerging substances or for materials not routinely monitored by the SNWA :

- **Piren-Seine:** interdisciplinary research program on the environment of the Seine watershed (see 3.1.2) ;
- **Seine-Aval Program:** research program focused on the Seine estuary;
- **Europol'Agro:** program for the valorization of the agro-resources in the Champagne-Ardenne area.

2.1.2 GIS Piren Seine Program

The Piren-Seine research program was created about 20 years ago. The PIREN-Seine is a network of research institutes (e.g. *CNRS*, *ENSMP*, *INRA*, *CEMAGREF*, *CEREVE*) aiming at developing an overall vision of the Seine watershed system, including: (i) the monitoring of agricultural, industrial and urban pollutant sources; (ii) the inventory of classical and emerging pollutants levels in air, surface waters, groundwater and soils; (iii) modeling work simulating the transfer of pollutants among the various components of the watershed system; (iv) socio-economic retrospective and prospective works in relation with the quality of waters.

Various models were developed by the PIREN-Seine program and allow the simulation of ecological and biochemical variations in the hydro-system, from the streams to the estuarine limit.

The Piren-Seine program developed its own databases for the capitalization of datasets collected by its various actors. Some of these database are based on 'easy-to-use' interfaces and can be a source of data in the frame of the Seine case study.

2.1.3 GIP Seine Aval (Seine-Downstream)

The Seine Aval program is a research program created in 1995 and is focused on the estuarine and coastal continuum of the Seine river. It is structured around 3 main axes :

1. observation systems;
2. remediation and restoration ;
3. health and environmental risks.



The program aims also at developing decision-making tools for the future management of the estuarine and coastal Seine area.

The Seine-Aval Program is organized on two pillars :

- a scientific pillar carrying out research projects for a better understanding of the estuarine ecosystem and its interactions with anthropogenic activities. It is coordinated by a Scientific Committee and gathered about 160 scientists who have worked on the Seine estuary for more than 10 years;
- an operational pillar which carrying out valorization and transfer actions towards end users. It is coordinated by the technical team of the GIP (Grouping of Public Interest) which associates many specialized technical organizations.

2.2 Presentation of data collected on the SNWA's database

2.2.1 *Contacts with the main actors*

The SNWA's database contains chemical analyses river water and groundwater of the watershed.

The monitoring network allowing the collection of data in waters, called 'Watershed National Network', as well the 'network of subsoil waters' (LMBO), are funded by the SNWA and the Environment Ministry. The data are available since 1971 for surface waters and 1997 for subsoil waters. Measured parameters are used to evaluate the quality of aquatic environments and their evolution. In addition to the 'traditional' physicochemical parameters (dissolved oxygen, nitrates, phosphates...), measurements of pesticides, toxics, metals and hydro-biologic indices are accessible. It must be noted that the whole of these data are public and accessible via SNWA Internet site.

However, these networks did not completely satisfy the objectives and criteria required for the implementation of the WFD. Consequently, a new network, called 'WFD network', was recently designed. For each monitoring station, an intake point was defined: (i) in the middle of the principal channel for raw water; (ii) in the surface layer (first centimetres) of the delivery points for sediments. Water and/or sediments will be measured according to the following criteria: (i) only water if $\log K_{ow} < 3$; (ii) water and sediments if $3 \leq \log K_{ow} < 5$; (iii) only sediments if $\log K_{ow} \geq 5$. For measurements of organics carried out on water, raw water will be considered, except for non-volatile organic substances and high SPM loads, (dissolved and particulate concentrations will be distinguished in this latter case). For metals, only the dissolved concentration is measured (0.45 mm cut-off and mineralization). It should be noted that some 'old' monitoring stations, followed in historical networks, were also included in this new network, thus allowing the data acquisition on long-term periods.

The 'Seine Aval' and the 'Piren-Seine' research programs also expressed their interest for the 2-FUN project study. Even if the data collected in these programs are more recent, but certainly more frequent in some stations, they could supplement the SNWA's data. Besides, 'socio-economic' research activities conducted in these programs could help the definition of exposure scenarios³.

³ A meeting aiming at defining the possible collaborations and exchange of data will be organized June 2008.



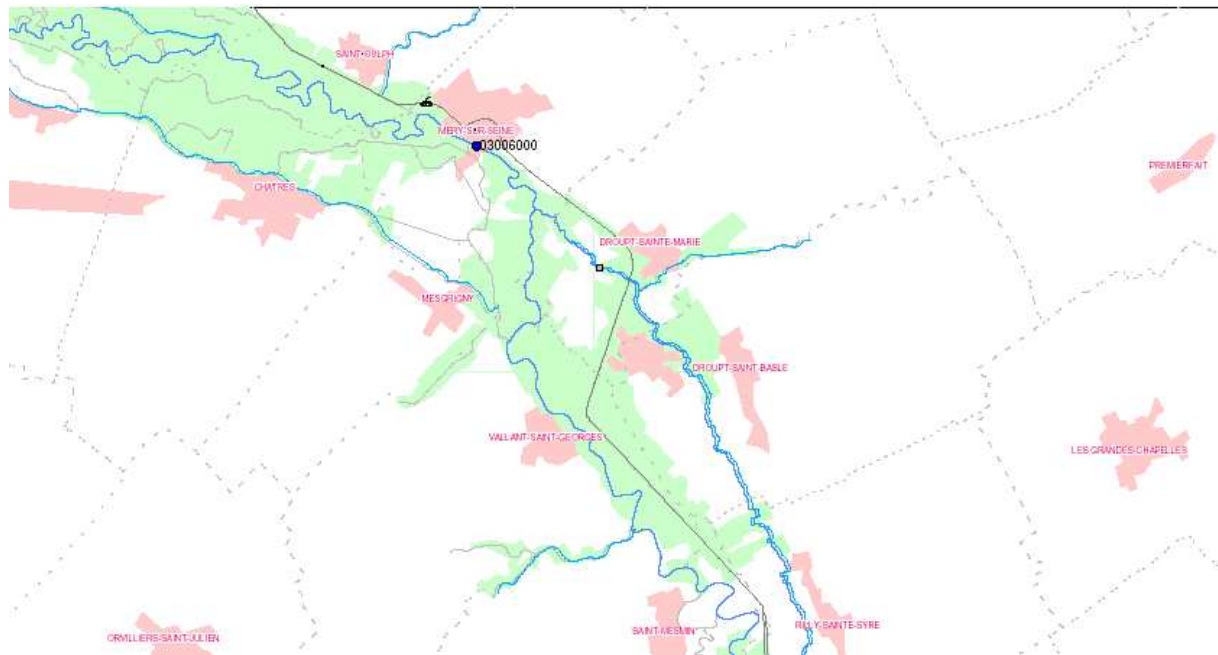
2.2.2 Examples of data

To illustrate the ‘format’ of data that could be extracted from the SNWA’s database, some examples are given below. Stations included in the recent ‘WFD network’ were preferred to guarantee that the 2-FUN’s tools can be used on data collected over a long term periods.

It must however be noted that pharmaceuticals (ionized substances) are not routinely monitored in this networks.

Three contrasted stations are presented here, differing according to the pollutant sources (e.g. not submitted to urban discharges vs submitted to the Paris megacity discharges), the agricultural coverage and the population density. The following maps present the situation of these three regions.

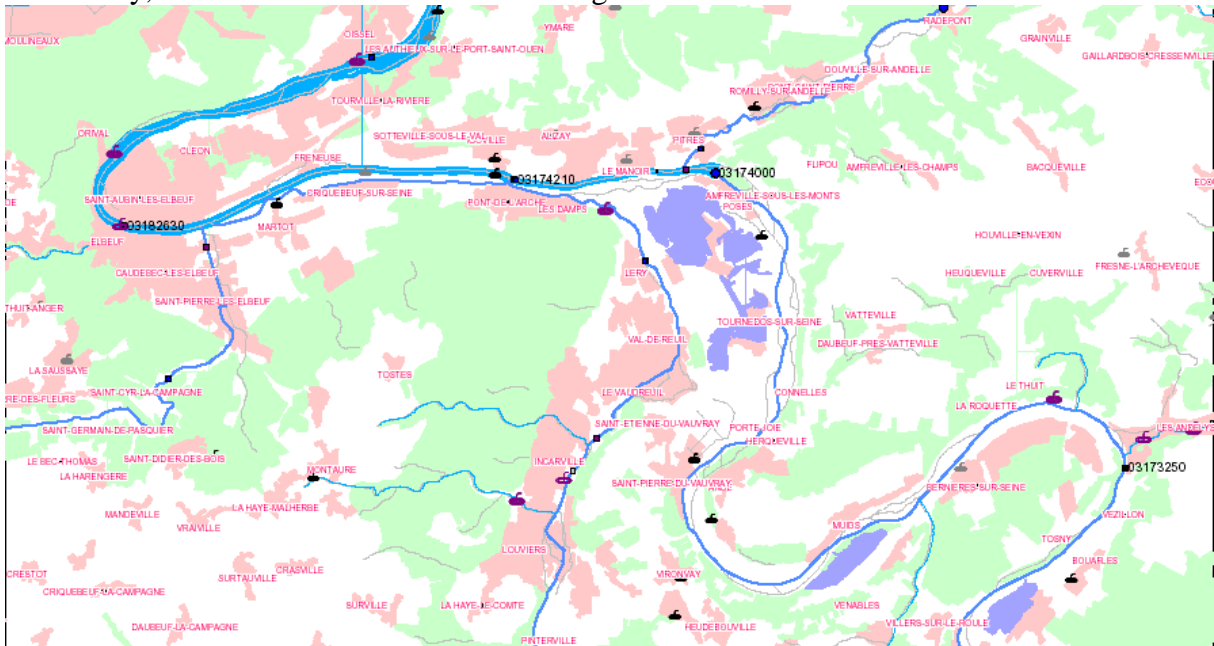
Station “upstream – basin” : the station of Méry sur Seine is not submitted to significant urban or industrial influences :



Station “downstream town of Paris “ : the station of Carrières sous Poissy is situated downstream of the Paris megacity and is particularly submitted to discharges from the Achères waste treatment plant (one of the biggest in the world):



Station “downstream – basin” : the station d’Amfreville sous les Monts is situated just before the transition zone towards the Seine estuary (Poses dam). Located downstream of the Rouen city, this station is submitted to a strong urban and industrial influence.



The selected stations belong to the new ‘WFD network’ and will thus be regularly followed in the future. These stations were also monitored in the frame of the ‘old’ networks previously described and log term series are thus available.

The following table presents the materials monitored for each of the substance of concern in the future ‘WFD network’.



Substance	Family	N° Chemical Abstract Services	Code SANDRE	Most relevant support	Percentage of sites indicated in the WFD network
Arsenic and minerals compounds	Metals	7440-38-2	1369	Eau - Sédiments	25%
Atrazine	Pesticides	1912-24-9	1107	Eau	100%
Benzo(a)pyrene	PAH	50-32-8	1115	Sédiment	100%
Benzo(a)anthracene	PAH	56-55-3	1082	Sédiment	25%
Cadmium	Metals	7440-43-9	1388	Eau - Sédiments	100%
Dibenzo(ah)anthracene	HAP	53-70-3	1621	Sédiments	25%
Lead	Metals	7439-92-1	1382	Eau - Sédiments	100%

In the following tables, some examples are presented to illustrate the kind of information (format, periods, frequency, support of measurement, unit, related information...) that can be extracted from the SNWA's database. Data were extracted for the Amfreville sous les Monts.

Lead at Amfreville sous les Monts (« Poses »)

	Unit	Period	Number of values over the period	Number of values noted " < with the threshold of detection "	Years without values
Concentration in dissolved of water	µg/l	1990-2007	298	7	1993-1994
Concentration in SPM	mg/kg	1990-2007	279	0	1991 1993-1994
Concentration in sediments	mg/kg	1985-2007	28	0	1995

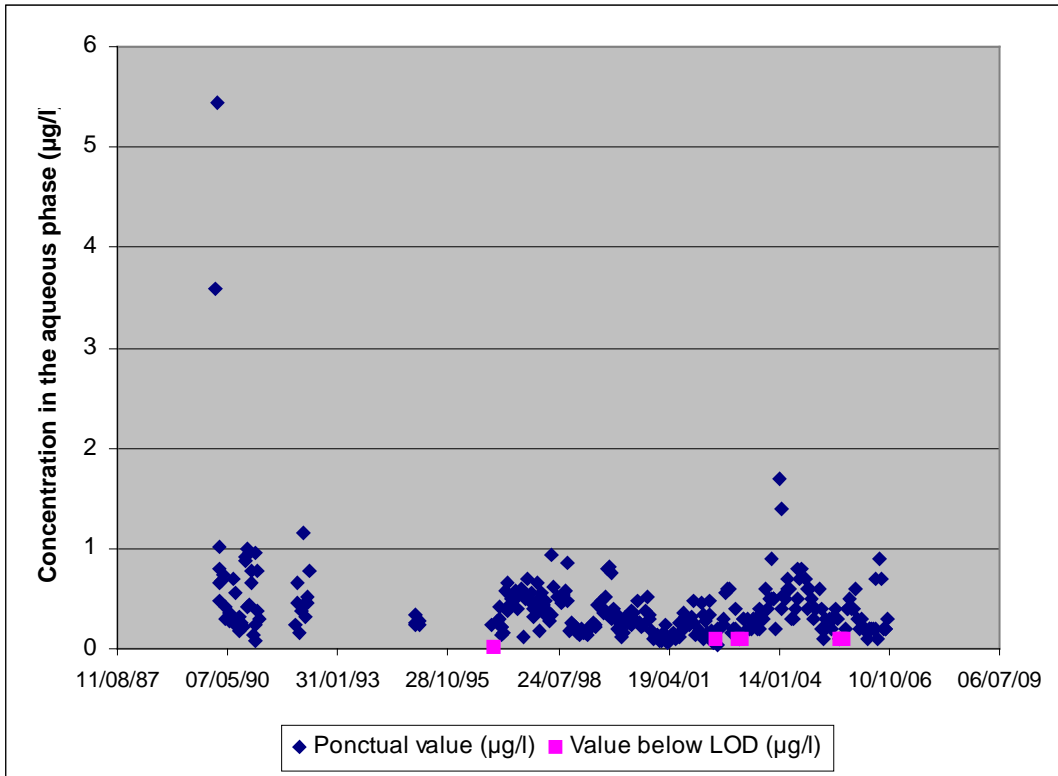


Figure 1: Lead in dissolved water

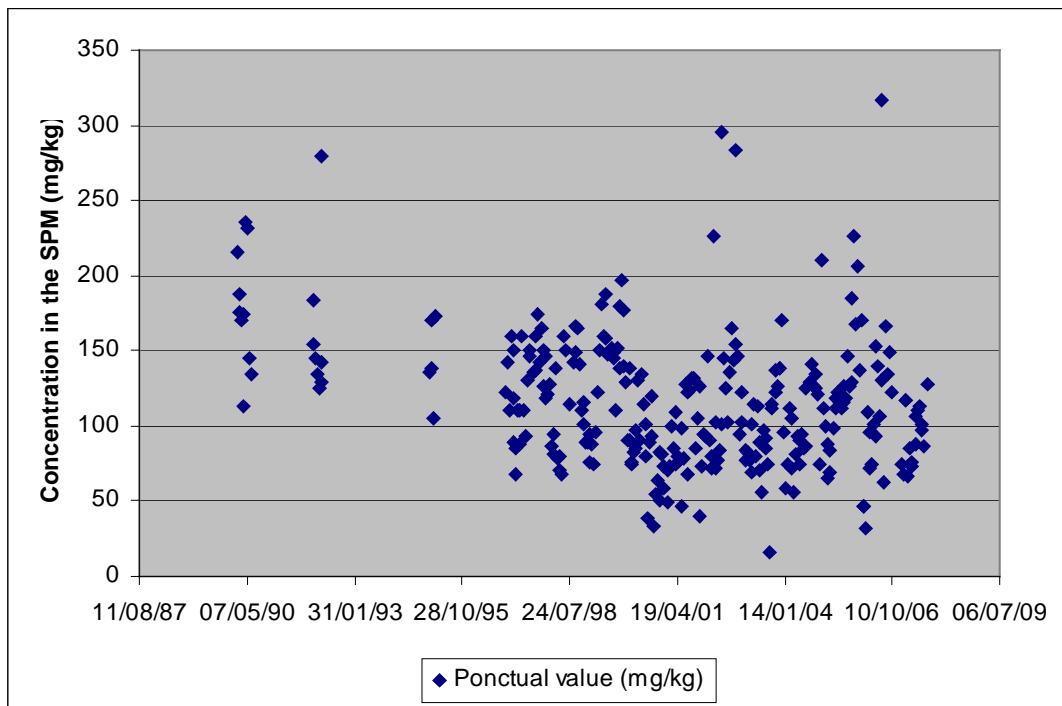


Figure 2 : Lead in SPM

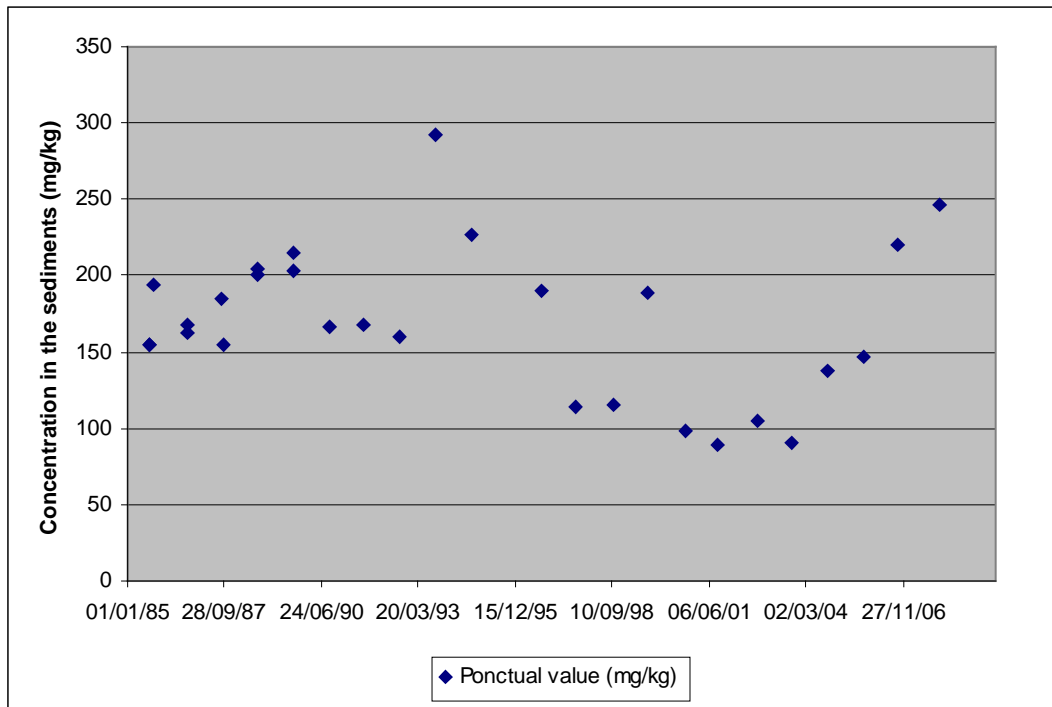


Figure 3 : Lead in sediments

Atrazine at Amfreville sous les Monts (« Poses »)

	Unit	Period	Number of values over the period	Number of values noted " < with the threshold of detection "	Years without values
Concentration in raw water	µg/l	1996-2007	193	68	/

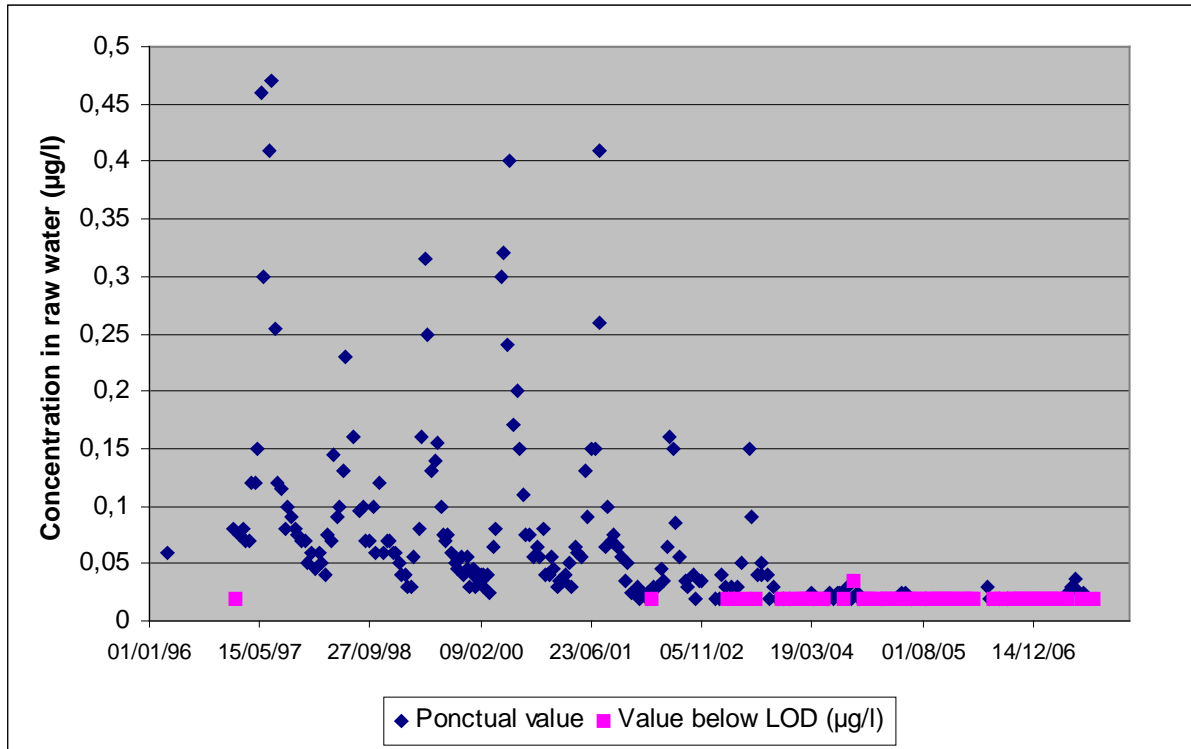


Figure 4 : Atrazine in raw river water

Benzo(a)pyrene at Amfreville sous les Monts (« Poses »)

	Unit	Period	Number of values over the period	Number of values noted " < with the threshold of detection "	Years without values
Concentration in raw water	µg/l	2007	12	4	/
Concentration in the sediments	mg/kg	1991-2007	14	1	1995

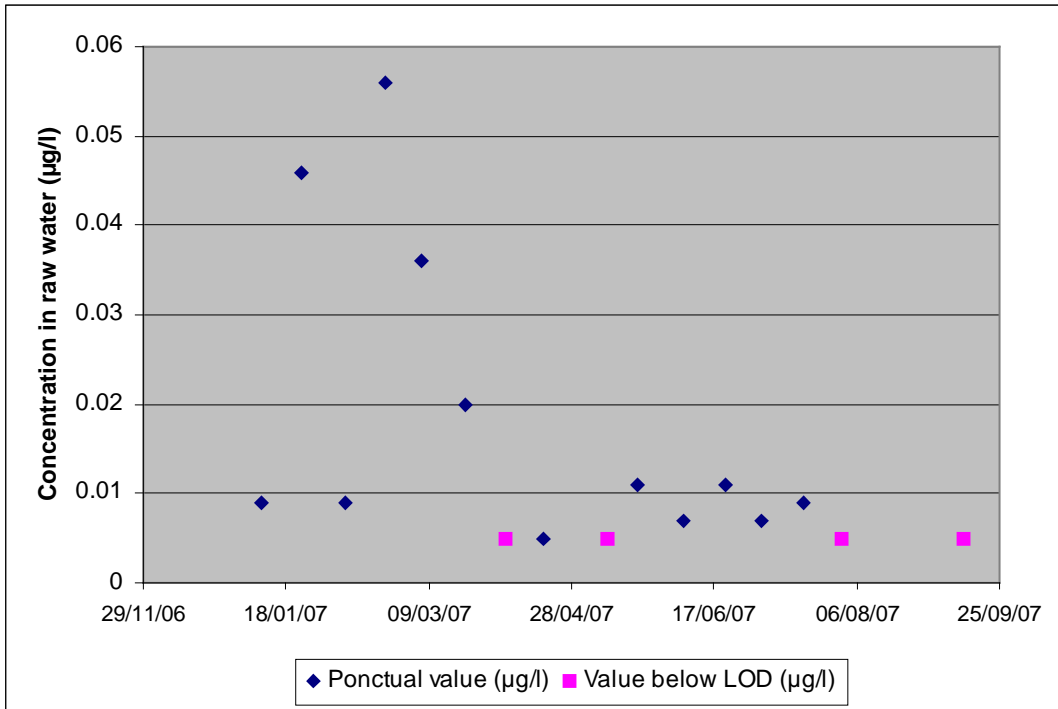


Figure 5 : BaP in raw water

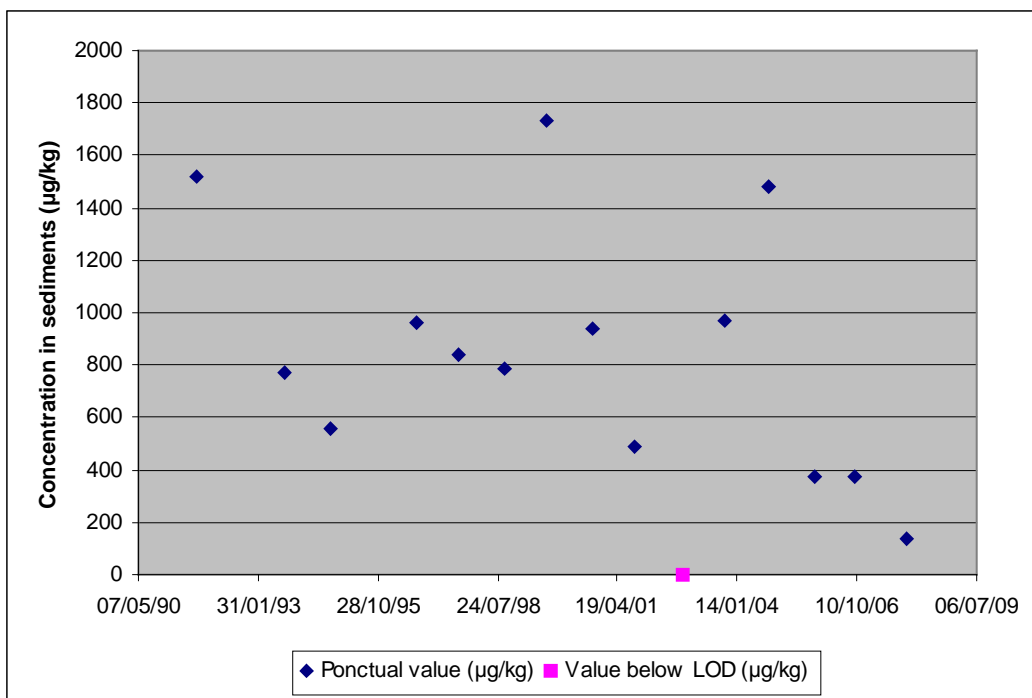


Figure 6 : BaP in sediments



3. CASE STUDY 3: LAND MANAGEMENT IN A HEAVY INDUSTRY REGION

3.1 Sources of environmental and biomonitoring data

Case study data contain environmental and biological monitoring results (lead, cadmium and polycyclic aromatic hydrocarbons) from Upper Silesia Region, the most industrialised and urbanised region in Poland. Case study includes published and unpublished data from 1990 to 2008.

Environmental data were selected according to their importance for interpretation of biomonitoring data. The Upper Silesia Region is covered by regular monitoring system of environmental pollutants which is a part of nationwide monitoring networks carried by governmental agencies. The information about pollutant concentrations in Poland has been primarily developed on the basis of analyses of data collected and processed at a national level. There are two kinds of network:

1. national network of base stations (also called the base network), subordinated to the State Inspectorate for Environmental Protection (PIOŚ);
2. the network subordinated to the State Sanitary Inspectorate (PIS).

Long-term results of monitoring indicate a very strong differentiation of concentrations of the above-mentioned environmental contaminants. The most contaminated part of the Region is its central part in which the majority of industrial plants are located and road density is the highest.

The described part of biological monitoring was related to determination of children exposure to Pb, Cd and PAHs. The majority of these investigations took place in the vicinity of Pb-Zn mining and smelting plants. The investigation were carried out by research centres as well as by non-governmental organisations like Foundation for Safety of Silesian Children. The total number of investigated children amounted to 20.000. Lead blood level was the most frequent parameter determining children exposure. Investigations included pre-school (age 2 to 6) and school children (7 to 15) of both sexes. The majority of studies concern the centres of Pb-Zn ores mining and smelting plants: Miasteczko Śląskie, Piekary Śląskie, Bukowno, Bytom, Katowice, Chorzów. In a few studies statistical correlation was found. The scientists correlated levels of pollutants or their metabolites in blood, hair, urine with different factors like age, sex, socio-economic status and eating of home-grown vegetables. In some biomonitoring investigations authors presented limited results of environmental monitoring (pollutant), and did not calculate correlations between results of both kind of data.

3.2 Brief description of available data for the substances of concern

3.2.1 Lead in the environment

Air

The lowest value of arithmetic mean was detected in the outskirts of the Upper Silesia Region ($0.049 \mu\text{g}/\text{m}^3$). The highest value was detected in Bukowno, where Pb-Zn ore mining and smelting complex is located ($0.88 \mu\text{g}/\text{m}^3$). Due to dramatically diminishing dust emission since 1990s the values have systematically went down. It should be mentioned that the number of studies concerning environmental contamination have also strongly decreased (Chłopicka et al, 1998 B; Bubak, 1998; Osman et al, 1998; Zejda et al, 1998; Kulka et al, 2003).



Soil

Lead concentration in industrial soil samples [mg/kg], collected in the towns located in the central part of the region, varied in a very broad range, even in contaminated areas. Arithmetic mean and range of lead concentration in rural soil samples [mg/kg] (in the outskirts of the Upper Silesia Region) were much lower than in samples collected in the central part of the region (Chłopecka, 1996; Verner et al, 1996; Chłopicka et al, 1998 B; Zejda et al, 1998; Ullrich et al 1999; Kulka et al, 2000 A; Kulka et al, 2000 B; Kulka, 2001; Kulka et al, 2003; Loska et al, 2004; Baranowska et al, 2005; Kulka & Krajewska, 2007). Some examples are provided in the following Table.

Location	Type of soil	Number of samples	Arithmetic mean (mg.kg ⁻¹)	Range (mg.kg ⁻¹)
Bukowno	Industrial soil	137		42 to 3570
Piekary Śląskie	Industrial soil	16	455.8	64.2 to 1546
Bytom	Industrial soil	122	627.0	69 to 5260
Piekary Śląskie	Industrial soil	20	894.9	97.2 to 9301
Katowice Szopienice	Industrial soil	14	740.7	115.8 to 1987.7
Suszec	Rural soil	1228	39.8	17.8 to 212.9

3.2.2 Lead in biomonitoring samples

Blood

As a consequence of high lead content in different environmental compartments, a lot of studies were focused on human health. The biological monitoring results (e.g. lead blood level PbB) showed high exposure to lead, especially among children. The studies were carried out mainly in the vicinity of Pb-Zn ores mining and smelting plants. The Pb levels in children blood exceeded (even several times) the reference value of Pb in blood.

Blood lead level concentrations analysed until the year 2000 were generally expressed as arithmetic means (sometimes also as geometric means). In the last years, scientists reported PbB concentrations mainly as geometric means. Comparison of blood lead for the whole investigation period shows that PbB concentrations were systematically diminishing (Dutkiewicz et al, 1993; Norska-Borówka & Śliwa, 1994; Osman et al, 1994; Skiba, 1995; Zejda et al, 1995; Zejda et al, 1996; Bursa, 1996; Zejda et al, 1997; Chłopicka et al, 1997; Osman et al, 1998 A; Osman et al, 1998 B; Zejda et al, 1998; Chłopicka et al, 1998 B; Kulka, 1999; Osman et al, 1999; Kulka et al, 2003; Kulka, 2004).

It is quite evident that PbB levels reported in last years were significantly lower than reported in 1990 - 2000. The potential reason for that is: (i) decreasing of pollutant emissions; (ii) arising of ecological awareness; (iii) undertaking of preventive measures. After 2000, the PbB levels are lower than the reference value (10 µg/dl).

Some results of blood lead levels measured until year 2000 and expressed as arithmetic means [µg/dl] are reported in the following table.

Location	Number of samples	Arithmetic mean (µg.dl ⁻¹)	Range (µg.dl ⁻¹)
Mysłowice	31	2.98	1.5 to 6.3
Tarnowskie Góry	48	4.08	1.5 to 9.8
Piekary Śląskie	453	13.3	3.9 to 49.5
Piekary Śląskie	575	16.8	4.4 to 50
Chorzów	12	27.33	14.5 to 43.6

.....
Date: 10/10/08

Security: PP



In case of the geometric mean Pb levels [$\mu\text{g}/\text{dl}$] were different before and after the year 2000: until 2000:

	Location	Number of samples	Geometric mean ($\mu\text{g}\cdot\text{dl}^{-1}$)	Range ($\mu\text{g}\cdot\text{dl}^{-1}$)
Before 2000	Miasteczko Śląskie	192	14.71	5.38 to 28.3
	Miasteczko Śląskie	158	13.74	5.38 to 26.5
	Piekary Śląskie	575	15.1	4.4 to 50
After 2000	Olkusz	78	4.0	1.9 to 14.4

The results of the large-scale blood lead levels test and surveys in pre-school urban children living in the industrial area of Poland (Katowice Voivodship, Upper Silesian Region) were presented. The occurrence of PbB above $10 \mu\text{g}/\text{dl}$ (14,2%-17,2%) was associated with the floor on which the apartment was located, number of siblings, apartment's quality, presence of a carpet in a child's room and frequent trips outside the region. The occurrence of PbB above $15 \mu\text{g}/\text{dl}$ (2.5%-4.2%) was associated with the same variables and, also with the place of residence and intensity of vehicle traffic. From a statistical point of view, mean PbB concentrations differ significantly between locations (both sexes, all age groups: $P=0.00002$); the effect of location is statistically significant in each sex (boys: $P=0.01$; girls $P=0.0009$); and the age groups (both sexes, all locations: $P=0.00003$); and in each sex (boys $P=0.006$; girls $P=0.01$) (Zejda et al, 1997).

Seven-year study (1993-1999) assessed children's exposure to lead and associations of blood lead levels (PbB) with season of sampling, questionnaire data and environmental levels of lead. The geometric mean PbB was $6,6 \mu\text{g}/\text{dl}$, and over 13% of children had PbB $>10 \mu\text{g}/\text{dl}$. There was a significant increase in the mean PbB with increasing lead concentrations in air. Poor housing, two or more siblings in the family, lack of recreational trips outside the region, time the child spent outdoors and consumption of home-grown vegetables were associated with elevated PbB (Jarosińska et al, 2004).

Blood lead was positively correlated with haematocrit ($r=0.16$; $p=0.048$) and Pb and Cd were significantly correlated ($r=0.38$, $p<0.001$). PbB was also correlated with family income ($r=-0.30$, $p=0.014$, $n=69$). Moreover, there were no significant correlations between family incomes and haematological parameters. Sufficient dietary intake of iron may protect against the absorption of both lead and cadmium in children environmentally exposed to those metals (Osman et al, 1998 A).

The objective of one of the studies was to investigate the contribution of environmental exposures to lead in the development of cytogenetic damage detected as the frequency of micronuclei (MN) in children. Results suggest that the exposure to lead may be associated with an increased frequency of MN; however, the influence of other factors (vitamins, and minerals in the diet) cannot be excluded. Environmental exposure to lead resulted in significantly increased levels of PbB, although the average level was much below the value of the biological exposure limit = $10\mu\text{g}/\text{dl}$. There is no significant influence of gender or ETS exposure on the concentration of lead in blood (Kapka et al, 2007).

The hearing threshold was elevated in children with higher blood lead level. The hearing defects stepped up with the increasing of PbB. Higher hearing defects were observed among girls (Zejda et al, 1996; Osman et al, 1999).

Hair

Results of lead in hair (PbH) were reported in five studies carried out in the highly contaminated areas of the region (Piekary Śląskie, Miasteczko Śląskie, Chorzów) (Zachwieja et al, 1993; Kasznia-Kocot et al, 1996; Chłopicka et al, 1997; Chłopicka et al, 1998 A;



Chłopicka et al, 1998 B). Arithmetic mean and the range of the analysed concentration [$\mu\text{g/g}$] were as follows:

Location	Number of samples	Arithmetic mean ($\mu\text{g.g}^{-1}$)	Range ($\mu\text{g.g}^{-1}$)
Bolesław	155	3.14	
Chorzów	69	4.41	0.81 to 15.91
Miasteczko Śląskie	216	8.31	0.56 to 37.42
Piekary Śląskie	168	20.03	

All these studies were conducted by a scientific team and all results were very well statistically elaborated. Hair of children living in Miasteczko Śląskie contains the elevated amount of Pb. The level of Pb in blood and hair were determined in groups of children selected after previous screening ($>10\mu\text{g/dl}$). Blood level of Pb does not differ significantly among girls and boys. There was a correlation between PbB and PbH ($r=0.306$, $p<0.0001$) (Chłopicka et al, 1997). The average levels of Pb and Cd in hair of boys were higher of girls ($p<0.001$ for Pb and $p<0.05$ for Cd). The average level of PbB of boys was higher than that in the blood of girls ($p<0.001$) (Chłopicka et al, 1998). A slight correlation between Pb and Cd ($r=0.3593$, $p=0.002$) in children hair was also observed (Kasznia-Kocot et al, 1996).

3.2.3 Cadmium in the environment

Air

The lowest value of arithmetic mean was detected in the outskirts of the Upper Silesia Region ($0.0013 \mu\text{g/m}^3$). The highest value of arithmetic mean amounted to $0,0544 \mu\text{g/m}^3$ was detected in Tarnowskie Góry, with maximum of $1.0732 \mu\text{g/m}^3$. Due to dramatically diminishing dust emission since 1990s, the number of studies concerning environmental contamination have also strongly decreased (Sokal et al, 1995; Chłopicka et al, 1998 B; Kulka et al, 2003).

Based on cadmium concentrations in air, cancer risk for humans was estimated. For the highest values it reached respectively 1.09×10^{-4} and 2.15×10^{-3} (Sokal et al, 1995).

Soil

industrial soil

Cadmium concentrations in industrial soil samples [mg/kg], expressed as arithmetic mean and range of cadmium concentration, which were measured in the towns located in the central part of the region, varied in a very broad range even in contaminated areas. Arithmetic mean and range of cadmium concentration in rural soil samples [mg/kg] (in the outskirts of the Upper Silesia Region) were much lower than in samples collected in the central part of the region (Chłopicka, 1996; Verner et al, 1996; Chłopicka et al, 1998 B; Kulka et al, 2000 A; Kulka et al, 2000 B).

Location	Type of soil	Number of samples	Arithmetic mean (mg.kg^{-1})	Range (mg.kg^{-1})
Bukowno	Industrial soil	137		2 to 73.2
Piekary Śląskie	Industrial soil	20	41.66	2.46 to 507.3
Bytom	Industrial soil	122	19.6	0.75 to 106
Piekary Śląskie	Industrial soil	16	14.77	1.30 to 48.49
Katowice Szopienice	Industrial soil	14	21.72	2.62 to 87.34
Suszec	Rural soil	1228	0.8	0.2 – 2.07

3.2.4 Cadmium in biomonitoring samples

Blood

The number measurements related to Cd concentration in blood (CdB) is much lower than for Pb (about 14 times) and they were carried out mainly until 2000 (Osman et al, 1994;

Date: 10/10/08

Security: PP



Jakubowski, 1995; Bursa, 1996; Chłopicka et al, 1998 B; Osman et al, 1998 A; Osman et al, 1998 B; Kulka et al, 2003; Kulka, 2004). CdB expressed as arithmetic means [$\mu\text{g}/\text{dl}$] were:

Location	Number of samples	Arithmetic mean ($\mu\text{g}.\text{dl}^{-1}$)	Range ($\mu\text{g}.\text{dl}^{-1}$)
Chorzów, Bytom, Sosnowiec	157	0.039	0.0124 to 0.326
Tarnowskie Góry	21	0.022	0.013 to 0.05
Miasteczko Śląskie	98	0.55	0.08 to 0.98
Miasteczko Śląskie	60	0.48	0.13 to 0.94
Bytom	211	0.042	0.012 to 0.46

Urine

There are limited data originated only from one study concerning cadmium level in children urine (Jakubowski, 1995). Only geometric mean in this study were presented and there are as follows:

Location	Number of samples	Geometric mean ($\mu\text{g}.\text{dl}^{-1}$)
Zyglin	35	10.32
Miasteczko Śląskie	84	9.78
Lasowice	105	5.4

3.2.5 Polycyclic aromatic hydrocarbons(PAHs) in the environment

Air

Three PAHs – benzo(a)pyrene (BaP), benzo(a)anthracene (BaA) and dibenzo(a,h)anthracene (DahA) – were chosen for the 2-FUN's exposure tool prototype. Range of arithmetic means of these PAHs were expressed as ng/m^3 . The lowest value of arithmetic mean was detected in the outskirts of the Upper Silesia Region. The highest values of BaP were detected in more industrialised and urbanised cities like Zabrze, Bytom, Wodzisław, Mysłowice and Chorzów. High concentration of BaA and DahA in winter and summer samples were found in the outskirts of the Upper Silesia Region (Zebrzydowice, Toszek) (Bodzek et al, 1993; Siwińska et al 1995; Sokal et al, 1995; Bubak, 1998; Siwińska et al 1999).

The lowest concentrations of selected PAHs detected in the outskirts of the Upper Silesia Region in winter and summer were as follows:

Season	Location	PAH substance	Lowest PAHs concentrations ($\text{ng}.\text{m}^{-3}$)
Winter	Grzegorzowice	BaP	7.12
	Dąbrowa Górnicza-Błędów	BaA	3.8
	Grzegorzowice	DahA	1.78
Summer	Kidów	BaP	0.356
	Dąbrowa Górnicza-Błędów	BaA	0.616
	few places	DahA	not detected

The highest concentrations of selected PAHs were as follows:

Season	Location	PAH substance	Highest PAHs concentrations ($\text{ng}.\text{m}^{-3}$)		
Winter	Mysłowice	BaP	173.8		
	Wodzisław		206.2		
	Bytom		222.9		
	Zabrze		225.8		
	Olkusz	Katowice	BaA	68.1	
				69.4	
				72.2	
				80.6	
	Zebrzydowice	Dąbrowa Górnicza	DahA	9.9	
				Mysłowice	11.7
				Chorzów	13.6
	Toszek			14.9	
	Season	Location	PAH substance	Highest PAHs concentrations ($\text{ng}.\text{m}^{-3}$)	

Date: 10/10/08

Security: PP



Summer	Mysłowice	BaP	98.7
	Wodzisław		119.2
	Zabrze		124.9
	Bytom	BaA	132.7
	Łaziska		10.9
	Zebrzydowice		13.3
	Bytom	DahA	16.5
	Mysłowice		30.4
	Olkusz		10.5
	Zebrzydowice		18.4
	Łaziska		23.6
	Bytom	26.0	

Soil

Arithmetic mean and a range of PAHs sum concentration were presented for industrial and rural soil samples [mg/kg], while BaP was reported only for industrial soil of the Upper Silesia Region (Maliszewska-Kordybach, 1999):

Location	Type of soil	Substance(s)	Number of samples	Arithmetic mean (mg.kg ⁻¹)	Range (mg.kg ⁻¹)
Zabrze	Industrial soil	PAHs	25	7.364	0.7 to 29
Tarnowskie Góry	Industrial soil	PAHs	68	1.852	0.062 to 12.76
Zabrze	Industrial soil	BaP	25	0.716	0.04 to 4
Tarnowskie Góry	Rural soil	PAHs	52	1.92	0.064 to 12.76

3.2.6 Polycyclic aromatic hydrocarbons (PAHs) in biomonitoring samples

Urine

1-Hydroxypyrene, a major metabolite of pyrene, was used as a biological marker for the measurement of human PAH exposure. The majority of the studied populations were exposed to environmental tobacco smoke (ETS) at home. The level of 1-HP [nmol/l] was expressed as median and a range of this metabolite (Siwińska et al 1995; Siwińska et al 1998; Siwińska et al 1999).

The lowest levels of urinary 1-hydroxypyrene were as follows:

Location	ETS exposure	Number of samples	Arithmetic mean (nmol.l ⁻¹)	Range (nmol.l ⁻¹)
Dąbrowa Górnicza	yes	96	1.63	n.d. to 18.82
Dąbrowa Górnicza	no	32	1.02	n.d. to 6.6
Dąbrowa Górnicza	yes	82	3.21	0.71 to 18.82
Bytom	yes	108	5.6	0.71 to 74.14
Sosnowiec	yes	19	6.41	
Sosnowiec	no	11	3.66	
Pilica	no	66	3.66	0.5 to 17.4
Bytom	no	27	4.08	0.7 to 25.8

The data showed high levels of urinary 1-HP in children from the Silesia Region. The uptake of PAH varied significantly among the examined areas. The urinary 1-HP concentration were strongly influenced by indoor heating with coal-fired stoves. Generally, children exposed to ETS do not show significantly increased levels of the urinary 1-HP (Siwińska et al, 1995; Siwińska et al, 1999).

The day-to-day variability of 1-hydroxypyrene levels is connected with home microenvironment, including behavioural and dietary factors as well as with outdoor activities of the children (Siwińska et al, 1998).

.....
Date: 10/10/08

Security: PP



3.2.7 Health outcomes

The following health outcomes were studied as an indicators of children health status and are biological response on environmental contaminants: hemoglobin, hematocrit, erythrocytes, mean corpuscular volume, mean corpuscular haemoglobin concentration, platelets, erythrocyte zinc protoporphyrin, peak expiration flow, delta-aminolevulinic acid in urine, hearing threshold.

Haemoglobin

The hemoglobin (Hb) level in children blood was analysed in 9 studies and expressed in [g/l] (Kulka, 1999, Grabecki et al, 1993; Norska-Borówka & Śliwa, 1994; Skiba, 1995; Osman et al, 1998 A; Osman et al, 1998 B; Zejda et al, 1998; Kulka et al, 2003; Kulka, 2004). The lowest value of arithmetic mean and range was:

72.9	n=17	range from 63.2 to 87.0	Chorzów ⁴ ,
------	------	-------------------------	------------------------

The highest value of arithmetic mean and range was as follows:

129.4	n=50	range from 114.0 to 148.0	Mysłowice,
-------	------	---------------------------	------------

Hematocrit

Hematocrit (HCT) level in children blood was presented in 7 studies and expressed in % (Norska-Borówka & Śliwa, 1994; Skiba, 1995; Osman et al, 1998 A; Zejda et al, 1998; Kulka et al, 2003; Kulka, 2004). The lowest value of arithmetic mean and range was:

34	n=17	range from 3 to 41	Chorzów ³ ,
----	------	--------------------	------------------------

The highest value of arithmetic mean and range was:

39.56	n=50	range from 34.9 to 44.9	Mysłowice.
-------	------	-------------------------	------------

Erythrocytes

The number of erythrocytes (RBC) in children blood was presented in 6 studies (Kulka, 1999, Grabecki et al, 1993; Norska-Borówka & Śliwa, 1994; Skiba, 1995; Zejda et al, 1998; Kulka et al, 2003; Kulka, 2004). The number of erythrocytes was expressed as ($\times 10^{12}/l$). The lowest value of arithmetic mean and range was:

3.62	n=17	range from 3.15 to 4.2	Chorzów ³ ,
4.02	n=192	max 4.43	Bukowno ⁵ ,

The highest value of arithmetic mean and range was:

4.66	n=46	range from 3.96 to 5.25	Miasteczko Śląskie ⁶ ,
3.65	n=368		Bytom ⁷ ,

⁴ The aim of the study was to assay health condition and mental maturity of children with increased blood lead level above 20 $\mu\text{g}/\text{dl}$. In 12 of children, with blood lead level over 14 $\mu\text{g}/\text{dl}$, 5-day medical-prevention with the aid of Ca Na₂ EDTA was implemented. After that action (4 month later), blood lead level in children was measured again - it was lower. Eight from the examined children showed lateralisation disorders.

⁵ The increased absorptions of Pb were found in all of the examined groups. The highest levels of PbB were detected in children population living in Piekary Śląskie (Pb mine and smelter plant "White Eagle"). Slight biochemical changes of blood and urine were observed and there are no basis to consider them as a early, preclinical effects of lead

⁶ The highest levels of PbB were detected in children population living in Piekary Śląskie and Miasteczko Śląskie and there were statistically significant differences between two sexes, but only in the industrial areas (industrial lead emitters). 8% of the total population had more than 10 $\mu\text{g}/\text{dl}$ PbB, 22,5% in Piekary Śląskie and 13,6% in Miasteczko Śląskie, respectively. CdB results for 98 percentile of population were below the reference limits, excluding two kindergarten from Piekary Śląskie and Miasteczko Śląskie.

⁷ Mean PbB and SD in 9 years' old children population was larger than 9,9 $\mu\text{g}/\text{dl}$ found in 32 children (8,7%) or larger than 15 $\mu\text{g}/\text{dl}$ was found in 5 children (1,4%). Mean PbB in boys was statistically significant higher than mean PbB in girls. Pb values were associated with parental smoking, housing conditions and apartment's



Mean corpuscular volume

Mean corpuscular volume (MCV) was reported in 6 investigations concerning 7 areas located in the centre of the Upper Silesia Region and 5 located in the outskirts (Kulka, 1999; Skiba, 1995; Osman et al, 1998 A; Zejda et al, 1998; Kulka et al, 2003; Kulka, 2004). The lowest level of MCHC [fl] arithmetic mean with the standard deviation was:

81.0 n=368 SD=3.1 Bytom⁶,

The highest level of MCHC [fl] arithmetic mean with the standard deviation was:

87.83 n=31 SD=3.32 Mysłowice.

Mean corpuscular haemoglobin

Mean corpuscular haemoglobin concentration (MCHC) was reported in the above-mentioned investigations (Kulka, 1999; Skiba, 1995; Osman et al, 1998 A; Zejda et al, 1998; Kulka et al, 2003; Kulka, 2004). The lowest level of MCHC [g/dl] arithmetic mean with the standard deviation was:

32.22 n=37 SD=0.68 Tarnowskie Góry,

The highest level of MCHC [g/dl] arithmetic mean with the standard deviation was:

33.4 n=368 SD=1.1 Bytom⁶.

Platelets

The number of platelets (PLT) in children blood was presented only in 4 investigations and all of them were conducted in Bytom (Skiba, 1995; Osman et al, 1998 A; Zejda et al, 1998). The number of platelets was expressed as ($\times 10^9/l$). The lowest value of arithmetic mean was:

263 n=368 Bytom⁶,

The highest value of arithmetic mean and range was:

375.39 n=112 range from 71 to 458 Bytom.

Erythrocyte zinc protoporphyrin

Erythrocyte zinc protoporphyrin (ZnPP) was determined only in one study (total number of population was 492 children) (Grabecki et al, 1993). The lowest value of geometric mean of ZnPP [ug/g Hb] with geometric standard deviation was:

0.96 n=195 GSD=1.38 Bukowno⁴,

The highest value of geometric mean of ZnPP [ug/g Hb] with geometric standard deviation was:

1.39 n=169 GSD=1.76 Piekary Śląskie⁴.

Peak expiration flow

Peak expiration flow (PEF) expressed as litre of air per minute was analysed only in one paper but 561 children (4, 5 and 6 years old) from two investigated sites were tested (Kaszniak-Kocot J. & Buszman Z., 1995). The lowest PEF value of arithmetic mean with standard deviation was:

54 n=31 SD=13,2 Chorzów

The highest PEF value of arithmetic mean with standard deviation was:

133,1 n=32 SD=27,2 Pszczyna

In all age groups and in both sexes PEF values were inversely proportional to the degree of atmospheric pollution. PEF in studied population demonstrate a significant decrease if this parameter in children coming from more polluted areas. (PbB of children from 1976-1990).

location. Children with PbB>10 $\mu\text{g}/\text{dl}$ had statistically significant lower values of the haemoglobin concentration, haematocrit, mean corpuscular volume and mean corpuscular haemoglobin.

Date: 10/10/08

Security: PP



Delta-aminolevulinic acid in urine

Delta-aminolevulinic acid in urine (acid ALA) was analysed only in one investigation carried out in three different places (Grabecki et al, 1993). The lowest value of arithmetic mean [mg/l] with standard deviation was:

4.7	n=168	SD=2.28	Bukowno ⁴
-----	-------	---------	----------------------

The highest value of arithmetic mean [mg/l] with standard deviation was:

5.4	n=115	SD=2.33	Chorzów ⁴ .
-----	-------	---------	------------------------

Hearing thresholds

Hearing thresholds for the children from Katowice Voivodeship were determined in one investigation in the following frequencies 0.5, 1, 2, 4, 6 and 8 kHz and expressed in dB/ear (Osman et al, 1999). The lowest value of arithmetic mean was:

10.3	n=155	left ear	Katowice Voivodeship,
------	-------	----------	-----------------------

The highest value of arithmetic mean was:

15.1	n=115	right ear	Katowice Voivodeship.
------	-------	-----------	-----------------------

The hearing thresholds increased significantly with increasing blood lead levels at all investigated frequencies. The audiometric results clearly indicate that auditory function in children is impaired at blood lead concentration even below 10 µg/dl.



REFERENCES

1. Baranowska I., Barchańska H., Pryszyk A. 2005: Distribution of pesticides and heavy metals in trophic chain, *Chemosphere*. 2005: 60, 1590-1599
2. Bodzek D., Luks-Betlej K., Warzecha L. 1993: Determination of particle associated polycyclic aromatic hydrocarbons in ambient air from Upper Silesia Region of Poland, *Atmospheric Environment*, Vol. 27A, No 5: 759-764, 1993
3. Bubak A., 1998: Szczepy *Salmonella typhimurium* o różnicowanym poziomie nitroreduktazy i O-acetylotransferazy jako indykatory efektu mutagennego zanieczyszczeń powietrza (*Salmonella typhimurium* strains with different nitroreductase i O-acetylotransferase levels as indicators of mutagenic effect induced by air pollutants), doctor's dissertation, abstract in English
4. Bursa J. 1996: Lead and Cadmium Concentrations in Whole Maternal Blood and Cord Blood of their Newborns with Different Birth Weight (<1500>1500g), *Child Health: Critical Needs and Issues for Central and Eastern Europe*. International conference. Sosnowiec, 8-10 May, conference proceeding
5. Environmental Pollution and Circulaire du 13 juillet 2006 relative à la constitution et à la mise en œuvre du programme de surveillance pour les eaux douces de surface en application de la directive 2000/60/CE du 23 octobre 2000 du Parlement et du Conseil établissant un cadre pour une politique communautaire dans le domaine de l'eau
6. Chłopecka A. 1996: Assessment of form of Cd, Zn and Pb in contaminated calcareous and gleyed soils in Southwest Poland, *The Science of the Total Environment*. 188, 253-262
7. Chłopicka J., Barton H., Zachwieja Z., Schlegel-Zawadzka M., Fołta M., Krośniak M. 1998 A: Ołów we włosach dzieci mieszkających w pobliżu trzech ośrodków przemysłowych w Polsce południowej (Lead content in hair of children living near the three industrial centers at southern Poland), *Lead in environment- ecological and methodical problems. Scientific workbooks of committee "The Human and the Environment" PAN*. 21, 411-418
8. Chłopicka J., Zachwieja Z., Frydrych J., Słota P., Krośniak M. 1997: Stężenie ołowiu, magnezu i cynku w krwi i we włosach dzieci z Miasteczka Śląskiego (Concentration of lead, magnesium and zinc in the hair and blood of children from Miasteczko Śląskie), *Dziecko w skażonym środowisku, Problemy ekologiczne i zdrowotne, Materiały Konferencji Naukowej, Legnica 6-8.06.1997*, 269-273
9. Chłopicka J., Zachwieja Z., Zagrodzki P., Frydrych J., Słota P., Krośniak M., 1998 B: Lead and cadmium in the hair and the blood of children from a highly industrial area in Poland, *Biological Trace Element Research*, Vol. 62, 229-234
10. Dutkiewicz T., Sokołowska D., Kulka E. 1993: Health risk assessment in children exposed to lead compounds in the vicinity of Mine-Smelter Plant "Orzeł Biały", *Polish Journal of Occupational Medicine and Environmental Health*. 6, No 1, 71-78
11. Grabecki J., Jarkowski M., Knapek R., Zejda J.E., Król B., Skiba M. 1993: Monitorowanie zagrożeń i skutków zdrowotnych narażenia na metale ciężkie (ołów i kadm) w populacji województwa katowickiego (Monitoring of hazards and health effects as a consequence of exposure to heavy metals (lead and cadmium) in the population of Katowice province), unpublished report
12. Jakubowski M. 1995: Poziomy biologiczne kadmu u mieszkańców Polski (Biological levels of cadmium in the population of Poland), *Medycyna Pracy*. XLVI, 5. Supplement 5
13. Jarosińska D., Peddada S., Rogan S. 2004: Assessment of lead exposure and associated risk factors in urban children in Silesia, Poland, *Environmental Research*. 2004: 95, 133-142

Date: 10/10/08

Security: PP



14. Kapka L., Baumgartner A., Siwińska E., Knudsen L.E., Anderson D., Mielżyńska D. 2007: Environmental lead exposure increases micronuclei in children, *Mutagenesis*. 1-7
15. Kasznia-Kocot J., Buszman Z. 1995: The influence of pollution on children's health in Chorzów, *Polish Journal of Environmental Studies* Vol. 4, No 2, 29-32
16. Kasznia-Kocot J., Zachwieja Z., Chłopicka J., Krośniak M. 1996: Zawartość wybranych mikroelementów i metali ciężkich we włosach dzieci z Chorzowa (The content of certain trace elements and heavy metals in the hair of children from Chorzów), *Pediatr. Pol.* 71 (1), 31-36
17. Kulka E. 1999: Ograniczenie narażenia środowiskowego dzieci poprzez realizację inwestycji proekologicznych w przedszkolach (Mitigation of environmental children exposure by undertaking proecological actions in kindergardens), unpublished report
18. Kulka E. 2001: Ocena zanieczyszczenia metalami toksycznymi (Pb, Cd) przedszkolnych placów zabaw w Piekarach Śląskich (The assessment of soil contamination of kindergarden playgrounds with toxic metals in Piekary Śląskie), unpublished report
19. Kulka E. 2004: Opracowanie i wdrożenie modelowego, lokalnego planu działań na rzecz środowiska i zdrowia. Etap III. Załącznik 3. Ocena narażenia na ołów i kadm dzieci uczęszczających do przedszkoli w Olkuszu (Development and implementation of a model Local Environmental Health Action Plan. Stage III. Annex 3. Assessment lead and cadmium exposure of children attending kindergardens in Olkusz), unpublished report
20. Kulka E., Dyduch B., Krajewska J., 2003: Ocena jakości środowiska miejscowości uzdrowiskowych, wypoczynkowych w województwie śląskim, w aspekcie ich przydatności jako ośrodków profilaktyki zdrowotnej i rekreacji (Environmental quality assessment of spa and recreation areas in Silesia, in the context of their applicability as health prevention and recreation centers), unpublished report
21. Kulka E., Gzyl J., Krajewska J. 2000 A: Ocena zanieczyszczenia metalami gleby i roślin w strefie oddziaływania Zakładów Górniczo - Hutniczych „Orzeł Biały” w Piekarach Śląskich (Assessment of soil and plant contamination with heavy metals in the vicinity of Coal Mining-Steel Industry "White Eagle" in Piekary Śląskie), unpublished report
22. Kulka E., Gzyl J., Krajewska J. 2000 B: Ocena zanieczyszczenia metalami ciężkimi kompleksów ogrodów działkowych zlokalizowanych w Piekarach Śląskich (Assessment of soil and plant contamination of allotments with heavy metals in Piekary Śląskie), unpublished report
23. Kulka E., Krajewska J. 2007: Ocena zanieczyszczenia metalami toksycznymi (Pb, Cd) placów zabaw na obszarze oddziaływania emisji z huty metali nieżelaznych (Assessment of playgrounds soil contamination with toxic metals (Pb, Cd) in the area affected by non-ferrous plant), unpublished report
24. Loska K., Wiechuła D., Korus I. 2004: Metal contamination of farming soils affected by industry, *Environment International*. 30, 159-165
25. Maliszewska-Kordybach B. 1999: Persistent organic contaminants in the environment: PAHs as a case study, Ph. Baveye et al. (eds.), *Bioavailability of Organic Xenobiotics in the Environment*. 1999: 3-34
26. Norska-Borówka I., Śliwa F. 1994: Diagnostyka, leczenie doraźne i profilaktyka zatrucia ołowiem u dzieci w wieku 0-7 lat (Diagnostics, casual curing and prevention of lead poisoning of 0-7 years old children), unpublished report



27. Osman K., Bjorkman L., Mielzynska D., Lind B., Sundstedt K., Palm B., Nordberg M. 1994: Blood levels of lead, cadmium and selenium in children from Bytom, Poland, *International Journal of Environmental Health Research*, 4, 223-235
28. Osman K., Pawlas K., Schütz A., Gazdzik M., Sokal J. A., Vahter M. 1999: Lead Exposure and Hearing Effects in Children in Katowice, Poland, *Journal Environmental Research Section A* 80, 1-8
29. Osman K., Schütz A., Akesson B., Maciag A., Vahter M. 1998 A: Interactions between essential and toxic elements in lead exposed children in Katowice, Poland, *Clinical Biochemistry*, Vol. 31, No. 8, 657-665
30. Osman K., Zejda J. E., Schütz A., Mielzynska D., Elinder C. G., Vahter M. 1998 B: Exposure to lead and other metals in children from Katowice district, Poland, *International Archives of Occupational and Environmental Health* Volume 71, Number 3 / April, 180-186
31. Siwińska E., Mielżyńska D., Bubak A., Braszczyńska Z., Smolik E., Cimander B. 1995: Urinary 1-hydroxypyrene as a biomarker of environmental exposure to polycyclic aromatic hydrocarbons, *Proceedings of the Workshop "Monitoring of Exposure to Genotoxic Substances*, pp: 75-81, Sosnowiec
32. Siwińska E., Mielżyńska D., Smolik E., Bubak A., Kwapuliński J. 1998: Evaluation of intra- and interindividual variation of urinary 1-hydroxypyrene, a biomarker of exposure to polycyclic aromatic hydrocarbons, *The science of the Total Environment*. 1998: 217, 175-183
33. Siwińska E., Mielżyńska E., Bubak A., Smolik E. 1999: The effect of coal stoves and environmental tobacco smoke on the level of urinary 1-hydroxypyrene, *Mutation Research*. 445, 147-153
34. Skiba M. 1995: Ocena wpływu narażenia środowiskowego na ołów na stan rozwoju psychofizycznego dzieci zamieszkałych w Bytomiu (Assessment of environmental lead exposure and its impact on psychophysical development of children in Bytom), unpublished report
35. Sokal J.A., Knappek R., Zejda J.E., Pastuszka J., Dębowski M., Smolik E., Bobula A. 1995: Ocena wielkości ryzyka nowotworowego w Polsce (The health risk assessment in Poland), unpublished report
36. SNWA's database (<http://www.eau-seine-normandie.fr/index.php?id=1627>)
37. Ullrich S.M., Ramsey M.H., Helios-Rybicka E. 1999: Total and exchangeable concentrations of heavy metals in soils near Bytom, an area of Pb/Zn mining and smelting in Upper Silesia, Poland, *Applied Geochemistry*. 14, 187-196
38. Verner J.F., Ramsey M.H., Helios-Rybicka E., Jędrzejczyk B. 1996: Heavy metals contamination of soils around a Pb-Zn smelter in Bukowno, Poland, *Applied Geochemistry*. 11, 11-16
39. Zachwieja Z., Chłopicka J., Wypchło J. 1993: Analiza zawartości kadmu i ołowiu we włosach dzieci mieszkających na terenach uprzemysłowionych (Analysis of cadmium and lead concentrations in the hair of children living in highly industrialized areas), *Polska Akademia Nauk-Oddział w Krakowie. Komisja Nauk Mineralogicznych. Prace Mineralogiczne*. 1993: 83, 99-101
40. Zejda J.E., Grabecki J., Król B., Panasiuk Z., Jędrzejczak A., Jarkowski M. 1997: Blood lead levels in urban children of Katowice voivodship, Poland: Results of the population-based biomonitoring and surveillance program, *Centr. Eur. J. Publ. Hlth* 5. No 2, 60-64
41. Zejda J.E., Skiba M., Król B., Jędrzejczak A., Bubak A. 1998: Stężenie ołowiu i parametry hematologiczne krwi w populacji dzieci zamieszkałych w Bytomiu (Blood

.....
Date: 10/10/08

Security: PP



- lead concentration and hematological parameters in population of children in Bytom), *Pediatr. Pol.* 73 (4), 297-304, abstract in English
42. Zejda J.E., Skiba M., Mielżyńska D. 1996: Wpływ narażenia środowiskowego na ołów na rozwój psychofizyczny dzieci z Bytomia. Zadanie w zakresie oceny wpływu narażenia na ołów na stan układu nerwowego z uwzględnieniem stanu narządu słuchu (Assessment of environmental lead exposure and its impact on psychophysical development of children in Bytom. Relation between lead exposure, neurotoxicity and hearing effects), unpublished report
43. Zejda J.E., Sokal J.A., Grabecki J., Panasiuk Z., Jarkowski M., Skiba M. 1995: Blood lead concentrations in school children of Upper Silesian Industrial Zone, Poland, *Centr. Eur. J. Publ. Hlth* 3. No 2, 92-96