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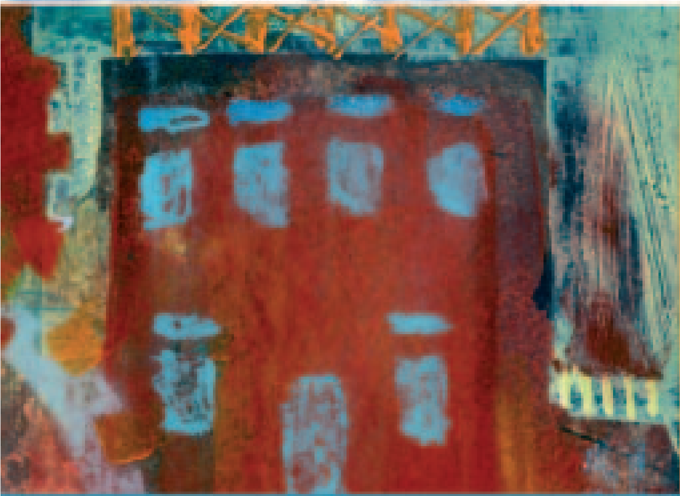
Project part financed by the European Union EUROPA

Comune di Forlì

ENHance HEALTH



"Enhance Health: environmental health surveillance system in urban areas near incinerators and industrial premises", op. n.2E0040I, INTERREG III C East Programme

Guidelines - January 2004/March 2007

Project Partners:

- Italy: Municipality of Forlì, Welfare Policies Department and Environment Department
- Italy: ARPA Emilia-Romagna District Branch of Forlì-Cesena
  Environmental Epidemiologic Structure- Modena
- Italy: Local Health Authority of Forlì, Public Health Department
- Poland: National Institute of Hygiene -Warsaw
- Greece: Computer Technology Institute - Patras
- Hungary: "Fodor József" National Centre of Public Health- Budapest
- Austria: Regional Government of Lower Austria, Department of Environmental Health- St. Polten
- Spain: University of Valladolid-ITAP

Municipality of Forlì, Lead Partner, (Italy): Environment Department: Pier Sandro Nanni – Person in charge of the Project and Financial Management, Francesca Bacchiocchi, Emanuela Buscemi; Welfare Policies Department: Rossana Giacomoni – Project Coordinator.

ARPA-Regional Agency for the Prevention and the Environment of Emilia-Romagna (Italy): Operating units: Arpa Forlì-Cesena: Franco Scarponi, Simona Rossi, Andrea Mecati; Environmental Epidemiology Thematic Unit: Paolo Lauriola, Andrea Ranzi, Laura Erspamer.

Local Sanitary Service Office of Forlì, National Health Service (Italy): Romana Bacchi, Aligi Gardini, Morena Cantarelli, Andrea Bolognesi, Oscar Mingozzi, Rosalba Ricci.

National Institute of Hygiene (Poland): Jan K. Ludwicki, Pawel Gorynski, Janusz_wi_tczak, Krzysztof Kanclerski.

Computer Technology Institute (Greece): Paul Spyrakis, John Garofalakis, Andreas Koskeris, Sotiris Michalopoulos.

National Centre for Public Health "Fodor Jozsef" (Hungary): Gyorgy Ungvary, Peter Brunner, Peter Rudnai, Anna Paldy, Gyula Dura, Dr. Mihály J. Varró, Dr. Éva Vaskövi

Government of Lower Austria, Environmental Health Department (Austria): Emil Schabl, Ulrike Schauer.

Advanced Production Technologies Institute – UVA, ITAP and CARTIF (Spain): Emilio Suárez de la Torre, Ruben Irusta, Dolores Hidalgo, Marta Gómez.

We wish to thank ERVET S.p.A. for their advice on planning and support to the project management

We also wish to thank all members of the Scientific Committee for their valuable contribution both to project management and Guidelines drafting:

Pietro Comba, Stefania Trinca	Istituto Superiore di Sanità, Department of Environment and Primary Prevention Department, Rome
Fabrizio Bianchi	Research National Council, Epidemiology Department - IFC, Pisa
Francesco Forastiere,	Epidemiology Department, ASL RM/E – Rome
Elisabetta Chellini	Operating Unit of Environmental and Occupational Epidemiology, Centre for Cancer Research and Prevention, Florence
Fabio Barbone	Professor of Hygiene and Epidemiology, University of Udine
Dino Amadori, Fabio Falcini	Oncology Institute of Romagna
Lorenzo Tomatis	International Society Doctors for Environment

We also thank:
Pierluigi Macini and Alba Carola Finarelli of National Health Service, Emilia-Romagna Region, for their valuable hints on the project's results
Valeria Fano, Alessandra Ravaioli, Massimo Ventrucci, for their contribution to the epidemiological investigations carried out on the Italian site.

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FOREWORD

Approved on January 19 2004, the individual project "Enhance Health. Environmental Health Surveillance System in urban areas near incinerators and industrial premises", under the EU Interreg IIIC East Programme (European Regional Development Fund: ERDF) aims to promote the exchange and dissemination of experience and competence acquired through interventions carried out under urban development programmes of regional Innovative Actions.
The name chosen for the project is *ENHance health (Environmental health surveillance system in urban areas near incinerators and industrial premises).*
This document gives a summary of the texts drafted and approved by the Italian partners.

PROJECT BACKGROUND

The project stems from the "Environmental and Territorial Study of an urban industrial area, namely Forlì-Coriano in Italy, Dorog in Hungary and Warsaw in Poland".
Before kicking off the European project, a few studies on air quality were conducted on the Coriano area, promoted by the Province of Forlì-Cesena, practically carried out by Arpa Forlì-Cesena and Arpa Emilia Romagna – Environmental epidemiology, which saw the involvement of the University of Bologna, the Istituto Superiore di Sanità and the Italian National Research Centre. Thanks to this study, an environmental status investigation methodology was specifically designed for a composite productive area, close to the town and hosting many types of economic activities and two waste incinerators: one for solid urban waste and one for hospital waste.
The wide area being studied is mainly agriculture oriented and encompasses some industrial parks – Coriano, Villa Selva and Pieve Acquedotto – and an urban district of the town of Forlì (Ronco district).
Within the framework of the Environmental Action Plan, the Emilia-Romagna region launched the transformation process of productive areas into "Ecologically equipped areas".
In this respect, the town of Forlì proposed and obtained the inclusion of the project "Environmental regeneration of Coriano industrial park" among the 2001-2003 interventions envisaged in the Environmental Action Plan.

EXPECTED RESULTS OF THE EU INTERREG IIIC PROJECT ENHANCE HEALTH

During the preliminary environmental and health evaluation phase within the territory of Forlì, the following overall objectives were identified:

ENVIRONMENTAL AND HEALTH SURVEILLANCE SYSTEM DEFINITION

The project's main objective was to define guidelines for the development of environmental and health surveillance systems designed to assess the health status of the population exposed to risk factors due to the presence of incineration plants.

RISK PERCEPTION

In this field, we intended to:
- precisely define the communication process purposes;
- identify all the subjects involved, taking into account their knowledge, needs, values, languages and interpretation methods;
- define specific messages;
- choose adequate contexts and strategies;
- jointly assess the outcomes with the subjects involved and disseminate them;
- implement wide participation processes;
- ensure equality to all involved subjects.

DATA COMMUNICATION AND DISSEMINATION

A major objective of the project was to communicate and disseminate data among the population, through the participation of all stakeholders:
- ♦ experts working in the environmental field
- ♦ citizens
- ♦ public administration

INTERNATIONAL PARTNERSHIP

The project was characterized by the close co-operation of a wide international partnership made up as follows:
- ❑ Municipality of Forlì (lead partner)
- ❑ Local Sanitary Service Office of Forli (AUSL) - Italy
- ❑ Regional Agency for Prevention and the Environment of Emilia-Romagna (Arpa) – Italy (Forlì-Cesena section and EPAM)
- ❑ National Institute of Hygiene - Poland
- ❑ Computer Technology Institute - Greece

- ❑ National Centre for Public Health - Hungary
- ❑ Government of Lower Austria - Austria
- ❑ Advanced Production Technologies Institute (ITAP) - Spain

The pilot activities were carried out by the Hungarian and Polish partners, Italian ARPA and AUSL, which ensured consistent results for the project's "transferability" and scientific rigour.
The Hungarian partner was in charge of defining the environmental and health surveillance methodology to be implemented within the project.
AUSL and ARPA (Italian Partners) collaborated to the implementation of an environmental and health surveillance system on the Coriano pilot site.
The Polish partner was entrusted with risk perception investigation.
The Austrian partner gave a huge contribution in the field of risk communication.
The Greek partner was responsible for the implementation and management of the project's information systems and computerized procedures.
The Spanish partner applied specific pollution dispersion models on the basis of the data provided for by the other partners.

PROJECT'S PURPOSES AND OBJECTIVES

The project's main objectives were to define Guidelines and Good Practices for the implementation of a communication-oriented Environmental and Health Surveillance System, based on a model's transferability criterion.

SURVEILLANCE SYSTEM'S OBJECTIVES AND POTENTIAL USES

An environmental and health surveillance system shall allow the user to[5]:

- monitor environmental risks so as to plan adequate prevention interventions;
- monitor disease *trends* on populations at risk or within geographic areas under study to seek for possible variations over time;
- integrate information on environmental risks, exposure data and disease *reports* to back environmental epidemiology research;
- provide information on trends and assess the effectiveness of environmental protection programmes and health prevention policies;
- facilitate public access to information on environmental pollution health effects.

The operating tool is the setting up of an integrated environment-health database consisting of:

- health-relevant environmental parameters, classified into air, surface and underground water, and soil matrices;
- health harmful effects specifically linked to short, medium and long term exposure and typical of polluted sites, according to site type;
- non-health factors affecting health (e.g. variables of socioeconomic status, demographic features) [6].

SCOPE OF THE DOCUMENT

This document is the final outcome of the experiences carried out under the European Interreg IIIC project "ENHance Health" which, as previously said, was designed to define guidelines for the implementation of environmental and health surveillance systems aimed at assessing the health status of the population exposed to risk factors due to the presence of incineration plants.
Information from literature and the experiences conducted under the project allowed us to identify a set of useful elements for the definition of environmental and health surveillance investigations in areas where important environmental pressure factors act.
This document is therefore intended to be a methodological contribution at the disposal of the European Community for the environmental and health monitoring in the said areas.
It should be however pointed out that the indications provided herein should always be referred to and/or adjusted to different local realities.
The document is divided into theme-specific chapters with sections focusing on methodology and local experiences conducted under the project.

ENVIRONMENTAL INVESTIGATIONS

INTRODUCTION

By “environmental investigation” it is meant a set of variables defining an environmental, social, economic, demographic and health context.
Several approaches could be adopted to achieve the said objectives, however environmental assessment combining available methods seems to be the most effective one, say “periodically gathering data to define environmental resources’ conditions”. It is possible to get such data from either regional or national monitoring networks or ad hoc campaigns.
It is proposed to link polluting emissions with concentrations measured in the matrices involved in the dispersion process (air, dry and wet depositions, soil, water, vegetation) so as to identify cause-effect relationships.
This implies the integrated use of data and emission models, dispersion models and field data.
Studying the territory’s main features is critical to sampling and analysis activities and their subsequent interpretation: it is the starting point for environmental investigations.
The site’s environmental characterization is of the outmost importance in order to detect and assess human and environment risks and define the actions to be implemented.

SITE GEOGRAPHIC LOCATION AND STUDY AREA DEFINITION

First of all, the area where the industrial plant is located shall be defined on the basis of the plant’s technological characteristics, the position of main pollution sources within the area and the potentially exposed population density.
Such evaluations lead to the definition of a study area, usually a circle centred on the incinerator, to which several investigation procedures are directed.
The following activities are aimed at assessing various pressure levels (environmental, anthropic, etc.) acting on the area identified and characterized by the presence of incinerators and other productive and non-productive activities that contribute to air emissions.

ENVIRONMENT AND TERRITORY CHARACTERIZATION

The environment, territory and study area characterization envisages the analysis of important territory’s features and the acquisition of environmental, urban and demographic data.

Among the first ones, say territory's features, we can mention:

- Environmental restrictions (such as: hydrogeological restriction, seismic restriction, etc.)
- Hydrology and hydrography
  - Surface water quality
  - Underground water quality
- Soil geology and pedology
- Local flora and fauna
- Meteorology
- Air quality
- Soil quality
- Evaluation of pressure factors:
  - Productive activities
  - Incinerators
  - Landfills
  - Housing areas sources
  - Traffic
  - Total emissions framework
  - High voltage transmission network
  - Use of pesticides in agriculture
  - Mud spreading on soil
  - State of primary sanitation facilities (water pipelines, sewage)

Among the urban and demographic characteristics there are:

- Geographical location – area topography
- Administrative borders (census sections, districts, municipal borders, etc.)
- Anthropic and demographic development
- Settlements (residential, commercial, recreational facilities etc.)
- Population subgroups exposed to greater risk due to higher sensitivity (children, the elderly, pregnant women etc.) in private hospitals, kindergartens, schools, rest homes, behaviour patterns (exposed workers), individual factors of susceptibility (ethnic origin, etc.)
- Use of territory with respect to productive activities (agriculture, stock farming, craftsmanship, industry, trade).

Potential sources for such information include:
- Photogrammetry, topographic, demographic and urban maps (describing the territory's present and future use);
- Photographic documentation and satellite images;
- Census data of productive, commercial, recreational activities, hotel and restaurant, etc.
- Inspection reports on the site and surrounding territory.

PRESSURE FACTORS APPRAISAL

The purpose of this activity is to identify, characterize and quantify air-polluting emissions caused by anthropic activities in area under study.
As to pressure factors appraisal, incinerators must be accurately characterized, taking into account all plant's specifications and other information given below:
- year of construction, renovation and revamping;
- total capacity (t/y);
- number and capacity of burning lines;
- burning temperature and pressure;
- abatement systems;
- energy production;
- production of ash (t/y), sludge, dangerous waste (dust) and activated carbon;
- amount and type of waste burnt in the incinerator;
- air emissions;
- residues.

ENVIRONMENTAL MODELLING

Calculating pollutants' air concentrations caused by waste incineration, as well as deposition rates in areas surrounding incinerators is integral part of the evaluation process of potential risks to human health associated with this kind of activity. Air concentrations and deposition rates are usually measured by means of air dispersion models. Dispersion models are based on mathematical algorithms capable of describing the impact of physical processes occurring in the atmosphere on dispersion rates of emissions from a point source (like incinerators)[8].
Dispersion models require information on polluting emissions' rates, source technical specifications (among which the emission point height), meteorological data such as temperature, wind strength and direction; they predict pollutants' air concentration levels at soil height.
Most available models allow to measure maximum concentration levels over short and long time periods within the area surrounding the emission point. They can also detect maximum and minimum fallout points for the emissions analysed (incinerator only or other sources). The models' accuracy is nonetheless considerably affected by input data quality. However, validation studies based on a comparison between measured levels and estimated concentrations show that air pollutants' dispersion models are reliable, mainly when it comes to long-term measurements[9,10].
Recent models refer to GIS (Geographic Information System) software packages' standards for easy and effective results display.

ENVIRONMENTAL SURVEILLANCE ACTIVITY

By environmental monitoring it is meant the repeated observation over time of pollutants' concentrations in environmental matrices (air, water, soil…) through measurements and evaluations.
Environmental monitoring can be done either through the regional (or national) monitoring network or ad hoc campaigns in the view of specific target studies. It may be focused on geographical areas or a specific site, as it is the case in our study.

The environmental surveillance activity to be carried out includes:
- Monitoring and controls set by environmental regulations
- Additional monitoring and controls based on scientific knowledge.

MONITORING AND CONTROLS SET BY ENVIRONMENTAL REGULATIONS

An incinerator's (waste-to-energy plant) monitoring and control plan envisages a set of actions to be performed by the plant's managing company and the supervising authority, which allow for an effective monitoring of the plant's environmental impact, at different stages of its lifespan, say environmental emissions and their impact on receptor bodies, thus providing the cognitive basis to firstly check their compliance with the requirements set out in authorization/s and European regulations in force.
The European regulation provides for a few instruments that can be divided into two categories:
GENERAL INSTRUMENTS (for plants in general):
Procedure EIA (85/337/EC) (97/11/EC),
Procedure IPPC (96/61/EC) and
Recommendations 2001/331/CE ("minimum criteria for environmental inspections")
SPECIFIC INSTRUMENTS (waste plants)
Directive (99/31/EC) Landfills
Directive (00/76/EC) Incineration/co-incineration of waste

In Italy, for instance, all incinerators are subject to the IPPC Directive *(Integrated Pollution Prevention and Control):*
• transposed into Italian legislation by Legislative Decree n. 372/99 which regulates the issuing of Integrated Environmental Authorisation (IEA)
the main objective of which is:
• to achieve a high level of environmental protection by coordinating authorisation issuing procedures, so as to prevent separate approaches in water, soil and air emissions control due to transferring pollution from one environmental sector to another
The Integrated Environmental Authorisation (IEA) entails, among others:
- The adoption of BAT (Best Available Techniques) in activity management
- Air and water emission limit values
- An adequate monitoring and control plan

The incinerator's monitoring and control plan envisages all actions designed to effectively monitor its environmental impact, by ensuring compliance with the requirements set out in authorisations and regulations in force.

The Legislative Decree n. 133 of May 11 2005, which is the most recent transposition of the European IPPC Directive, sets measures and procedures intended to avoid and reduce as much as possible the environmental impact of incineration and the related risks for human health.

Based on this Directive, pollutants and frequency of controls on incinerators' stack emissions are identified (see table below):

Pollutant or process parameter	Daily limit value (mg/Nmc)	Limit value half-hourly (mg/Nmc)	Frequency
Carbon monoxide	50	100	Continuous measurement
Particulate matter	10	30	Continuous measurement
Volatile organic compounds	10	20	Continuous measurement
Hydrochloric acid	10	60	Continuous measurement
Sulphur oxides	50	200	Continuous measurement
Nitrogen oxides	200	400	Continuous measurement
Hydrofluoric acid	1	4	Continuous measurement (discontinuous)
Discharge, Temperature and Chimney pressure			Continuous measurement
Oxygen and Percentage of water			Continuous measurement
Heavy metals Mercury Cadmium+Thallium Dioxins - PAH	0.5 mg/Nmc -0.05mg/Nmc -0.05mg/Nmc 0.1ng/Nmc -0.01 mg/Nmc	1 hour sample 1 hour sample 8 hour sample	Discontinuous measurement 1 measure/4 months (3 months)

By transposing these instruments and directives, Member States set up **Monitoring and Control Plans** in order to ensure plants' compliance with the requirements set upon authorisation issuing, over their whole lifespan.

ADDITIONAL MONITORING AND CONTROLS BASED ON SCIENTIFIC KNOWLEDGE

Monitoring several matrices (air, water, soil etc.) within the areas surrounding incinerators is mainly aimed to define an environmental scenario useful for the health status assessment of potentially exposed population.
The general objectives are the following:

- To obtain air quality results for some traditional pollutants potentially attributable to incinerators, through a monitoring activity in locations of possible maximum and minimum fallouts calculated by modelling analysis;
- Speciation of PM_{10} and $PM_{2.5}$ particles with respect to:
  - o organic micropollutants (PCDD, PCDF, PAH, PCB),
  - o metals in $PM_{2.5}$: cadmium (Cd), lead (Pb), vanadium (V), nickel (Ni), manganese (Mn), arsenic (As), mercury (Hg), cobalt (Co), zinc (Zn), chromium (Cr), hexavalent chromium (Cr VI), thallium (Tl), antimony (Sb), copper (Cu).
- Possible monitoring campaigns of water courses within the area and in soil;
- Definition and feasibility of a biomonitoring system for environmental and individual parameters (exposure biomarkers).

The monitoring activity in areas surrounding incinerators is not regulated by ad hoc directives, but it relies on monitoring strategies for air quality and other environmental matrices (water and soil). Therefore the modelling analysis of maximum and minimum fallout points can provide us with useful information on sites to be chosen for matrices' sampling.
Sector standards indicate analysis methods, sampling techniques and maximum allowed concentrations in different matrices.
Therefore, besides the monitoring linked to locally existing networks, data from literature and considerations related to potential health effects suggest the assessment of parameters falling into the following categories:

- particulate matter,
- volatile organic compounds,
- PCBs,
- metals,
- dioxins and furans,
- polycyclic aromatic hydrocarbons.

For example, the environmental monitoring analytical methods used for the Italian site of Coriano (FC) under the ENHance Health project are the following:

Measurement	Reference	Methodology
CO	ISO 4224:2000	Ambient air – Determination of carbon monoxide – Non-dispersive infrared spectrometric method
NOx	ISO 7996:1985	Ambient air - Determination of the mass concentration of nitrogen oxides – Chemiluminescence method
Pb	ISO 9855:1993	Ambient air – Determination of the particulate lead content of aerosols collected on filters - Atomic absorption spectrometric method
PTS and PM10	ISO 10473:2000	Ambient air - Measurement of the mass of particulate matter on a filter medium - Beta-ray absorption method
Particulate matter samples (PM10)	UNI EN 12341:2001	Air quality – Determination of the suspended particulate PM10 – Reference method and procedure in campaign measurements to show the equivalence of measurement methods towards the reference one.
SO2	ISO 10498:2004	Ambient air - Determination of sulfur dioxide - Ultraviolet fluorescence method
O3	ISO 13964:1998	Air quality - Determination of ozone in ambient air - Ultraviolet photometric method
PAH	/	Determination of PAH in PM10 particulate through HPLC analysis with UV detector
PCDD and PCDF	EPA 8280	The Analysis of Polychlori nated Dibenzo-p-Dioxins and Polychlorinated Dibenzofuran s by High Resolution Gas Chromatography/Low Resolution Mass Spectrometry (HRGC/LRMS)
PCB	UNICHIM 825:89	Gasiform flows convoyed – Organic micro pollutant sampling and determination: PAH, PCDD+PCDF, PCB (EM/23)
CO	ISO 4224:2000	Ambient air – Determination of carbon monoxide – Non-dispersive infrared spectrometric method

Measurement	Reference	Methodology
Wet and dry Deposition		
Soil and atmospheric deposition of PCDD and PCDF	EPA 1613/94	Tetra- through Octa-Chlorinated Dioxins and Furans by Isotope Dilution HRGC/HRMS
Heavy metals (Al, Cd, Cr, Hg, Ni, Pb)		Mineralization in microwave oven and analysis in spectrophotometry of atomic absorptiometer.
Passive sampler		
NO2		Detection with Griess-Saltzman reactive and spectrophotometric analysis UV/VIS.
C6H6		Extraction with carbon disulphide and determination gas-cromatography with detector FID.
Vegetables and soil		
Heavy metals (Al, Cd, Cr, Hg, Ni, Pb)		Mineralization in microwave oven and analysis in spectrophotometry of atomic absorptiometer.
PCDD and PCDF	EPA 1613/94	Tetra- through Octa-Chlorinated Dioxins and Furans by Isotope Dilution HRGC/HRMS
Bioindicators (bees and lichens)		
Heavy metals (Al, Cd, Cr, Hg, Ni, Pb)		Mineralization in microwave oven and analysis in spectrophotometry of atomic absorptiometer.
Radionuclides		Laboratory radiochemistry method of UCI, Chemistry Radiochemistry and Metallurgical Sciences of Bologna University – spectrometry range at high resolution
Benzo(a)pyrene		HPLC determination by fluorescence detector

The monitoring of several matrices needs to be planned taking into account various aspects, ranging from the characteristics of the area in which the plant is located, the availability of instruments and funds up to political and communication factors.
Such monitoring activities integrated with information from literature and a few local experiences can help us improve the definition of human exposure to incinerators' impact.
Exposure assessment can be perfected by means of human biomonitoring measurements, which are meant to give a more reliable quantification of exposure to specific substances, such as heavy metals.
All this can contribute to the definition of environmental and biological-health indicators specifically linked to incinerators' pollution.

EXPOSURE ASSESSMENT

INTRODUCTION

The exposure to an environmental factor is defined as the contact between a potentially harmful factor existing in an environmental matrix (such as air, water or food) and a human body surface (like skin or digestive or respiratory tract walls)[12,13].

The main exposure assessment methods are classification, measurement, modelling.
Classification refers to the definition of subject subgroups according to ordinal exposure categories; the most common is dichotomous classification (e.g. exposed and not exposed).
Exposure measurement is mainly using an instrument which measures the value of an exposure variable. Exposure modelling relies on mathematical models to foresee an exposure variable's value. Models are based on the knowledge of factors determining or affecting the variable, and on the quantitative relationship between such factors and exposure[14].

Ideally, an etiological and epidemiological study is intended to assess the risk of illness with respect to the amount of noxious factor (or one of its metabolites) reaching the body's target organ, but the said amount can be hardly calculated. When it comes to environmental epidemiological studies, it is very often replaced by the concentration measurement of the mostly present factor in the environment with respect to the entry pathway to the body.

A first notion which needs to be clarified, is that measuring a factor's environmental concentration levels does not represent the population exposure to such a factor, but one of its indicators *(proxy)*, the validity of which depends upon several elements. Concerning air pollutants, for example, human exposure can be influenced by localization and house type with respect to emissions source, population mobility, the transport means used, the time spent indoors or outdoors. Additionally, in this example as in many others, further important factors affecting exposure can be age, socioeconomic level, health status and meteorological and environmental parameters[9].

Different complexity-level models shall be used in analytical studies on polluted areas focusing on long-latency illness etiological hypothesis, whose objective is to measure exposure which occurred at a previous time. As people usually spend most of the day at home, when assuming an exposure point source, the exposure surrogate measurement will be the distance between source and house, possibly including in the model a few wind direction indicators. Generally speaking, the presence of such a relationship between source distance and risk excess suggests a causal relationship, whereas its absence may simply express estimates' inaccuracy or databases' low statistical significance[15.]

A recent step forward in environmental epidemiology has been the introduction of pollutants' dispersion models to characterize individual exposure; such approach brings about quite a powerful tool which is certainly more reliable than estimates based on the mere distance from emission source.

EXPOSURE ASSESSMENT IN SMALL AREA STUDIES THROUGH ENVIRONMENTAL DATA

When designing and managing epidemiological studies, the assessment of environmental exposures and their interactions is one of the most important aspects contributing to the definition of the role environment has in affecting human health, under a cause-effect perspective.
Geographical information is increasingly used in exposure assessment and, generally speaking, in epidemiological studies both during study design phase and data analysis.
The use of dispersion models to characterize individual exposure has been introduced quite recently in epidemiology and provides quite a powerful instrument which is certainly more reliable than distance-from-source based estimates.
Maps' reliability shall be evaluated considering how the obtained datum will be used for. From an absolute quantity point of view, approximation level is significant and depends upon the quality of *input* data. Things are different when it comes to quality, say defining different territory's exposure levels to the modelled pressure factor: this datum is used to identify subgroups with different exposure levels under an epidemiological study.

Within the framework of the ENHance project, the methodological pathway for assessing the exposure of a population living in a pilot area has been defined, by using the dispersion models applied within the project itself.
Phases can be summed up as follows:

- Area environmental characterization on digital data and maps
- Definition and localization of the population being studied
- Reconstruction of resident population's residential history
- Area socioeconomic characterization based on census data
- Definition and localization of other exposure sources

- Definition of specific tracers for incinerators and other sources
- Definition of exposure levels and tracers' environmental mapping according to the levels defined to identify different exposure sub-areas
- Data joint analysis

The area has been defined by applying a modified three-dimensional Gaussian dispersion model, ADMS-Urban[18]. Such identified area has been environmentally characterized following the guidelines indicated in this document with respect to environmental aspects.
The definition, localization and reconstruction of residential history of the population living within the study area has been done by using the Registry records managed by the local Information Office which has also provided the database with geographic coordinates of address numbers within the study area.
The *linkage* between information has allowed for the geocoding of each residence of cohort population, by using GIS software[19].
Starting from census data and through census sections' geocoding, it has been possible to assign to each subject living in the area a socioeconomic characterization indicator, according to the section he/she belongs to.
On the basis of the pressure factors acting on the area (traffic, industry, civil sources, incinerators), the dispersion model described above has been applied to simulate pollutants' fallout, due to different source types (point, linear, areal, diffuse). Two environmental tracers have been defined: one for incinerators and one for global pollution.
Such geocoded information *layers* all together contributed to the definition of an exposure index following address number, to be applied in epidemiological surveys on the health status of the population living in the area.

THE USE OF BIOMARKERS IN AREAS WITH INCINERATORS[20, 6]

Over the last few years, environmental epidemiology focusing on polluting sources and namely incinerators has seen the clear dominance of cross-wise and geographic studies relying on biomonitoring (BM) to assess individual exposure and the link between pollutants and early adverse effects, by possibly investigating vulnerability as well.

A few examples of substances present in the environment and for which exposure biomarkers have been developed are given in the table below.

Examples of polluting substances for which exposure biomarkers have been developed

Substances	**Biomarkers**
Lead	Blood lead concentration
Cadmium	Cadmium in urine
Chromium	DNA-protein cross-links
Mercury	Mercury in urine
Poly Chlorinated Biphenyls (PCB)	Serum PCB concentration
Volatile organic compounds (VOC)	Blood VOC concentration
Organochlorinated pesticides	Pesticide levels in maternal milk
Polycyclic aromatic hydrocarbons (PAH)	PAH-adducted DNA
DDT	DDE and other methanols in the adipose tissue

Exposure or dose assessment actions through biomarkers may be varied, although two main types can be identified:
– periodic sample surveys or large-scale population monitoring, where individual monitoring costs may be a problem;
– small-scale studies to document individual exposure and dose before and after a specific intervention (sample surveys).
Adopting biomarkers should be however thoroughly evaluated, after deeply considering costs and benefits plan compared to traditional systems such as questionnaires.
Sometimes questionnaires are as information-providing as the more complex and expensive measurement of PCB concentration in umbilical cord blood. It is also worth pointing out that sometimes standardizing data obtained from questionnaires (variability between observers, inaccuracy in transforming first-level variables into second-level variables, etc.) turns out to be even more arduous than lab methods standardization, which is by the way necessary. However estimates' accuracy and validity should be carefully assessed.

INTEGRATED ANALYTICAL APPROACH[9]

For the purpose of completeness, it is briefly described herein a recent *risk assessment*-oriented approach of exposure evaluation.
The different ways people are exposed to many pollutants where they live can be represented through specific “exposure scenarios”. In a recently published document, the U.S. Environmental Protection Agency (EPA) names “exposure sce-

nario" a set of information, data, assumptions and interferences, and in some cases experts' opinions, which allow to assess, calculate or quantify human exposure. This document follows a previous publication *(Exposure Factors Handbook)* where data on physiological parameters, lifestyles and activity patterns necessary to set up exposure scenarios (drinking water consumption; consumption of fruit and vegetables, fish, meats; soil ingestion; inhalation rates; ingestion and absorption, body weight, etc.) where widely described.
It should be stressed, however, that the scenarios presented by the U.S. EPA refer to single factors and exposure ways, although more emphasis has been recently placed on analysis, characterization and quantification of risks associated with multiple exposures and complex mixes. The U.S. EPA has for instance identified a platform which allows for multiple risks assessment, say the global risk associated with various multiple-exposure pathways and ways. Examples of potential exposure scenarios provided by the U.S. EPA rely on determinism (single values for each parameter *(e.g. point estimates)*). Using probabilistic methods, unlike the point-estimate based approach, allows for an improved characterization of variability level and/or uncertainty in exposure estimates/doses with quantification of likelihood of exposure potential effects.

ENVIRONMENTAL EPIDEMIOLOGY INVESTIGATIONS

INTRODUCTION

The purpose of an environmental epidemiology survey is to assess the connection between environmental exposure and health effects. To do so, it is necessary to compare the occurrence of health effects on subjects with different exposure levels.
When exposures cannot be clearly defined and/or monitored, the first step to take is to carry out a descriptive study which can be useful to set hypothesis for a further analytical study.
This chapter is aimed at examining steps and problems of an epidemiological study carried out in small areas where incineration plants are located; it provides additional information which cannot be neglected when defining environmental, biological and health indicators to be included in the integrated information system, as the basis for the environmental and health surveillance system.

HOW TO CHOOSE THE STUDY POPULATION

The choice of the study population stems from the notion of area delimitation, according to the estimated or measured pollutant fallout area caused by incinerators. By using geographic information to spatially define the population residence, we can first of all make a distinction between at-risk and not-at-risk population.
Choosing the study population is challenging. Ideally, the reference population of a polluted site is equal, with respect to socioeconomic, cultural, ethnic, climate and historical characteristics, but actually these conditions are hardly achieved. In the case of present polluted sites located on the outskirts of a region or a province, for instance, it's better to make a comparison with the population of the neighbouring region or province.

THE USE OF CURRENT DATA

Processing health statistics from current data sources should follow established methods, in order to **increase the possibility to compare them** with similar experiences.

MORTALITY DATA

The availability of current statistics quantifying the occurrence of diseases within a set population allows us to carry out ecological-type studies, in order to compare the population living in the polluted site with a reference population.
In most European Community countries, mortality statistics ranged per cause, statistics on some pathologies incidence and hospital admissions classified per cause, are available.
The advantage of mortality statistics is that they concern the whole national population and cover many decades, and can be separated and ranged per residence municipality (with the possibility to further separate them into population groups corresponding to census units, that are made up of a few hundred people). On the other hand, the major drawback is that non-lethal pathologies are excluded and thus the range of environmental pollutants' health effects – which can be analyzed through an epidemiological study – is reduced. Basic documentation is characterized by lower diagnostic accuracy than statistics based on clinical diagnosis, although for various pathologies occurrence inaccuracy has been measured. If lethal effects of environmental pollution are assumed, analysing mortality statistics is the first easiest and cheapest way to back such an assumption (not to demonstrate it, though) and to quantify the potential risk, although not definitely. A further advantage of mortality statistics is that they allow for risk measurement not only per place of residence but also per place of birth (surveys on migrants).

As many epidemiological studies conducted in Italy and abroad demonstrated it, the mortality analysis carried out on multi-annual periods and interpreted on the basis of available knowledge allows us to check for significant differences in health status compared to not-at-risk areas, and to identify situations which may need further analysis.

MORBIDITY DATA

As hospital discharge sheets have been significantly improved in many countries since the nineties, it is nowadays possible to use them to evaluate health services and carry out assessment epidemiological studies.
The use of hospital discharge data in environmental epidemiology is quite recent. Its main applications refer to European multi-centre studies (HEAPSS [23], APHEA [24]).
When it comes to environmental epidemiology geographical analysis, hospital discharge sheets are mainly used within the framework of investigation studies aimed at setting etiological hypothesis to be further analyzed through analytical studies (case control or cohort studies). This data source is of course useful every time a given pathology is characterized by low mortality and related hospital admission is frequent.
In literature there are only few examples of the use of hospital admission records in environmental epidemiology studies on small areas and the studies being published are mainly English. Wilkinson *et al.* [27] carried out a case-control study in London to investigate the connection between children's hospital admissions for respiratory diseases and residence in high traffic density areas.

Limitations:

- **Case selection**: it depends on illness severity, on the possibility of making a diagnosis and providing necessary treatment outside hospital, on the accessibility of hospital services or other socioeconomic factors.
- **Multiple admissions:** hospital data usually reflect hospitalization of cases rather than persons, thus differences in rates may be linked to multiple admissions of persons (for the same disease) and not to a larger number of people being hospitalized.

Data quality: if our purpose is to assess hospitalization frequency with respect to environmental exposure, it is fundamental to know data detection accuracy and the information system's suitability to collect necessary information for proper case identification and patient's severity description. To properly evaluate these aspects, clinical documentation must be examined and, taking this as a *gold standard*, the accuracy of data from hospital discharge sheets must be checked. This type of analysis is known in literature under the name of *re-abstract study* [32].

The (daily) number of requests for emergency medical care, in hospitals or out-patient clinics, can provide useful information for environmental epidemiology when acute health outcomes are considered. This number tends to reflect the unplanned occurrence of symptoms or diseases, and is used to investigate connections with short-term variations in pollution.

- **Routinely collected data:** Data from hospitalization and/or hospital discharge records are usually considered;
- **Non-routinely collected data:** to make indicator associated with specific pathologies of interest and/or given vulnerable population subgroups more sensitive, important information on air pollutants' potential noxious effects on health can be provided by specialists and general practitioners.

Morbidity data were examined to assess multiple effects on health. Adequately connected to mortality data, they have been recently used to study the daily frequency of lethal and non-lethal coronary events[33].
Other experiences, also conducted under the ENHance project, were intended to investigate air pollutants' harmful health effects in the short term, by using paediatricians' reports on children's acute respiratory morbidity.
Besides social, economic and emotional aspects, children are considered to be an appropriate sentinel population for the assessment of environmental pollutants' health effects as they are more sensitive to toxic effects than adults, due to their higher metabolic needs with respect to body weight and to their usually less risky lifestyles (they do not smoke and are not exposed to workplace contaminants).
In this respect, the daily morbidity of children aged 0-14 can be reported by paediatricians. The effects on the respiratory system can be grouped into 3 main categories: upper respiratory diseases (and their complications), lower respiratory infections (bronchitis and pneumonia) and diseases involving some allergic reactions (obstructive bronchitis, allergic rhinitis).
Separating the various parts of the respiratory tract involved can be useful also with respect to air pollutants which may have different sizes and penetrate the respiratory tract at various levels. Associations between air pollutants' daily levels and respiratory diseases' daily incidence can be mainly evaluated through time-series analysis.

DATA ON CANCER INCIDENCE

The pathologies most frequently taken into account in surveys on population living in the proximity of incineration plants are neoplasms and congenital malformations. Compared to mortality statistics, diagnosis accuracy of reports for such pathologies is higher, and low mortality pathologies (such as many congenital malformations) as well as some cases of non lethal pathologies are included in the system - thanks to therapeutic standards. It is nonetheless known that cancer and malformation registers are not exhaustive nor homogeneous when it comes to large territories.

It may seem that studies on the geographical heterogeneity of areas for which cancer registers are available are the natural step forward of cancer registration. In Italy as in other countries, "maps" and descriptive studies were created on the basis of various registers, although they did not add that much to mortality analysis, as regards problems concerning surveys in small areas. With only a few exceptions, confirming the existence of potential incident (or lethal) cancer clusters turned out to be far more difficult than first expected[35].

CLASSIFICATION OF PATHOLOGIES PER CAUSE

A list of pathologies ranged per cause is given below. Such list can be used when carrying out epidemiological surveys of sites affected by environmental pressure factors such as incinerators.
The table only refers to three health data sources: mortality, hospital admissions and cancer incidence.

Causes	Codes ICD-9/ICD-9-CM	Data source
All causes	0-999	ReM
Total amount of cancers	140-239	RTRO
Stomach Cancer	151	RTRO
Colorectal Cancer	153-154	RTRO
Larynx Cancer	161	RTRO
Trachea, Bronchi and Lungs Cancer	162	RTRO
Pleura Cancer	163	RTRO
Soft Tissues Sarcoma	171	RTRO
Bladder Cancer	188	RTRO
Central Nervous System Cancer	191-192;225	RTRO
Non-Hodgkin lymphomas	200,202	RTRO
Hodgkin Disease	201	RTRO
Leukemias	204-208	RTRO
Thyroid Diseases	240-246	ReM/SDO
Diabetes Mellitus	250	ReM/SDO
Cardiovascular Diseases	390-459	ReM/SDO
Ischemic Diseases	410-414	ReM/SDO
Respiratory Diseases	460-519	ReM/SDO
Acute Respiratory Diseases	460-466;480-487	ReM/SDO
Chronic Lung Diseases	490-496	ReM/SDO
Bronchial Asthma	493	ReM/SDO
Bronchial Asthma 0-14 years old	493	SDO
Pneumoconiosis	500-505	ReM/SDO
Kidney Diseases	580-589	ReM/SDO

STUDY DESIGN

It is important to point out what contribution different types of surveys can bring and therefore distinguish epidemiological, descriptive and analytical studies.
In epidemiological studies, populations rather than individuals are used as analysis units (populations' mortality rates per cause are compared).
Descriptive studies, on the other hand, investigate variables distribution (smoking, mortality per cause) within a given population, without considering any hypothesis, either causal or not.
Analytical studies are aimed at testing hypothesis and measuring risk at individual level with the well known cohort, control-case or transversal models, which – whether properly planned and conducted – allow to take into account potential confounders and thus provide a "strong" result.
The connections measured in ecological studies – within aggregates of individuals – do not necessarily reflect the connections existing at individual level and thus the possibility to control confounders[15] is more limited.
The analysis methods described below represent an overview of the methods described in literature[36] integrated with the experiences carried out under the ENHance project.

DESCRIPTIVE ANALYSES

a) Standardized mortality rates per age;
b) Standardized Mortality Ratios (SMR) per age;
c) SMRs per age and index of socioeconomic deprivation at municipal level created on the basis of several census variables;
d) Standardized Proportionate Mortality Ratios (SPMR) per stable residents; this ratio is used to detect potential effects linked to migratory flows.

GEOGRAPHIC STUDIES

Role of geographic studies: The role played by geographic studies in environmental epidemiology has been frequently discussed in literature[37-40].

Geographic localization: the geographic localization of cases being studied (usually place of residence) can be seen as a substitute for the exposure of interest in descriptive studies designed to provide a preliminary analysis investigation of a given population.

Integration of varied knowledge: generally speaking, it is suggested to use geographic studies as an integration to biological, pathogenic and clinical information on suspected risk factors. Epidemiological data on populations are crucial to the public health sector and allow for the detection of situations which need *ad hoc* analytical epidemiological studies.

To sum up, the aim of these studies is to detect potential differences in the health status of populations living in differently exposed areas and thus propose hypothesis to be tested through analytical studies. The contribution of such studies can be significant to the public health sector, but universally valid knowledge will be hardly acquired (although a few examples do exist).

Types of spatial analyses

- **Spatial heterogeneity assessment:** Objective: to detect irregularities in the spatial distribution of health outcomes, which may provide information on the existence of specific risk factors.
- **Risk mapping:** Should the spatial analysis give risk spatial heterogeneity, then the risk mapping of the said area is realised in order to identify the areas where risk is higher. In these cases, SMRs and Bayesian estimators are usually calculated, the latter correcting the estimates of the former, taking into account the problem linked to the few numbers available.
- **Analysis of spatiotemporal clusters:** it refers to the use of epidemiological methods to find out a potential high incidence or predominance of disease in time and space. Most cluster studies are focused on small areas and very few cases. Thus data analysis is very complex and various statistical methods have been specifically developed for it.

ANALYTICAL STUDIES

Under the ENHance project, a study taking into account a retrospective cohort with data collected on an individual basis has been carried out, unlike most geographical surveys conducted in the proximity of incinerators. Thanks to the availability of an exhaustive cohort of people living in the area and their full follow-up through the investigation of many health databases (mortality, cancer incidence, hospital admissions) we managed to integrate demographic information, residential history, exposure data, occurrence of health events, by exactly measuring the contribution of each individual to the calculation of years-person at risk and the risk estimates through a comparison within the study area. This turned out to be an important advantage compared to traditional geographic studies based on aggregated data, when no individual information is available. Concerning exposure measurement, in this type of study as in many environmental epidemiology studies, when personal measurements are not available, residence is taken into consideration at the beginning of follow-up in order to define the indicators to be used for exposure (surrogate) estimate. In this case – unlike what is usually done in other studies – thanks to the availability of estimates on pollutants' concentrations based on dispersion models and to the possibility to use a geographic software for information processing, we managed to identify pollutant-specific isoconcentration areas, so as to associate each individual with an exposure level. Such a study design let us evaluate in details incinerators' contamination impact and at the same time take into consideration the presence of sources (i.e. car traffic) other than the incinerator.

Studies on short and long-term effects

When designing an epidemiological study on small areas characterized by important environmental pressure factors, it is crucial to define the pathologies to be investigated and to divide health effects into short and long-term ones.
The impact of such a choice on epidemiological studies is illustrated below.

Study design

Short-term studies

time series or *case-crossover* analysis, panel studies to assess worsening of pathologies

Long-term studies

mortality studies, retrospective and prospective cohorts, population cross-section, case-control studies for selected pathologies.

Measurement of exposure and surrogates

The issue of exposure assessment is widely discussed in these guidelines. As it has been already said, this is a key element of epidemiological studies.
The creation and use of an exposure datum varies following the effect taken into account:

Acute effects: daily measurement of environmental tracers;
Chronic effects: there is a qualitative gradient of exposure surrogates that ranges from the mere residence in an area up to the estimate of area/individual exposure through environmental and geographic modelling applied to the areas.

Temporal dimension

The long-term analysis brings problems linked to exposure duration, latency of first exposure and selection of the related time window.

Confounding factors

Short-term effects: factors connected to temporal variations
Long-term effects:

- other environmental pressure factors (traffic emissions, industrial emissions)
- individual factors:
  - lifestyle
  - individual vulnerability conditions (age, sex, ethnic origin…)
  - socioeconomic status

Creating a socioeconomic index of the population living in small areas on the basis of census data

Under the ENHance project, the cohort considered in the epidemiological survey has been characterized through an indicator taking into account the population's socioeconomic status.

Objective. Creating a socioeconomic indicator to characterize the population living in various census sections of Forlì.

Design and setting. 1116 census sections with at least 20 inhabitants have been considered (average rate of inhabitants: 96). Census variables have been selected so as to represent several aspects of social disadvantage: education, employment, housing condition, family composition. A factor-related analysis has been carried out to define a composite indicator of socioeconomic status, by algebraically combining the indicators emerged from the analysis weighed on factor scores. Quintiles of composite indicator's distribution within sections were considered and a 5-level socioeconomic indicator was established.

STATISTICAL ANALYSIS:

Within the framework of statistical analysis protocol, the following needs to be clarified:

- Definition of *a priori* hypotheses
- Distinction between *a priori* and *a posteriori* choices
- Preference of individual-based modules
- Limited model building
- Easily understandable indicators
- Definition of *record linkage* methods with special emphasis on problems and limitations

The significance of a study protocol

A study protocol shall be drafted for each epidemiological study; it shall encompass a detailed description of all activities to be performed during the preparatory phase and the real study phase. To sum up, a study protocol should be made up of the following components:

- rationale;
- study objectives;
- problem definition;
- state-of-the-art
- study design and methods to be applied;
- study timetable;
    - necessary resources;
    - ethical considerations;

During study design phase, it is important to take into account the data analysis you wish to carry out. The reasons for that and its main aspects are the following:

- specific considerations on data analysis plan will tell you if key objectives have been identified;
- the data analysis plan may identify critical variables that have not been adequately considered in the data collection plan. At the same way, it may happen to find out that variables included in data collection design are not relevant to the study's objectives achievement.

The persons in charge of the analysis are therefore fundamental during the planning phase and when it comes to examine the whole protocol from a statistical point of view.

INTEGRATED INFORMATION SYSTEM

INTRODUCTION

The integrated information system is used as the basis for the environmental and health assessment and surveillance system in areas at risk.
The general aim of a surveillance system is to assess the health impact of pollution within areas where incineration plants are located.
To integrate environment and health data, we need to work on three levels of complexity:
a) to harmonize the spatial and temporal reference levels of environmental parameters (*background* values) with the ones of health parameters (*baseline* values);
b) to develop the integrated system by moving from separate data to common matrix data;
c) to develop the set environment-health indicators' system, both for *ex post* assessment and the setting up of the environmental and health surveillance system.
The last point is fundamental if we want the information system to perform an effective surveillance action within the study area. (For further information on the indicators' choice refer to the dedicated chapter).
A prerequisite is the existence of environmental and health databases suitable for integrated evaluation.
The integration operational tool is the integrated environment-health database made of:
– relevant environmental parameters under the health perspective, divided according to environmental matrices (air, surface and underground water, soil);
– hazardous health events linked to short, medium and long-term exposure, according to site type;
– non-health factors having an impact or affecting health (e.g. variables of socioeconomic status, demographic features).

ENVIRONMENTAL AND HEALTH DATA

The environmental data to be used in an integrated system can be the following:

- Data of monitoring networks on air quality (or other matrices, if any)
- Data on emissions controls
- *Output* data of models' applications
- Data obtained from *ad hoc* monitoring

As to health data, an indicative list of information sources is given below. Through them it is possible to get data on pathologies which may be connected to exposure to incinerators:

- mortality data;
- cancer registries;
- hospital admissions/discharges;
- Emergency Department admissions;
- congenital malformations registers;
- notifiable diseases registries;
- data obtained from general practitioners;
- biological data on human tissues/liquids;
- drug administration records.

Data availability and quality at local level affect information choice.

Besides environmental and health information, data on population should also be taken into consideration, whether possible (in compliance with the Privacy Act): address, street number, sex, age of resident people, socioeconomic data and population mobility.

DATA INTEGRATION

Surveillance systems gathering data on public health effects and monitoring systems that collect environmental data currently exist. They are however separate systems, often developed by different agencies/institutions and for different purposes, making it difficult to track environmental hazards and investigate possible associated health effects.
There is a lack of common standards on data collection methods, frequency and data features and formats. Therefore, linking health surveillance and environmental monitoring systems can be very complex and time-consuming (but not only).
Thus we need to implement a completely *new* system based on identified indicators and using a geographically-structured common matrix.

GEOGRAPHIC INFORMATION SYSTEMS (GIS) AND THEIR USE IN EPIDEMIOLOGY

Despite their quite different features, the types of data described in these guidelines can be analyzed together if they refer to the same geographical location. To collect, manage and process very heterogeneous data (cartographic, alphanumerical, images) special information systems are now available, as previously said: GIS *(Geographic Information System).*
In the field of environmental epidemiology, GIS are used in geographic studies to trace health effects distribution maps

(mortality/incidence per specific cause) and to compare such maps with the geographic distribution of exposure indicators. In analytical studies, these tools are mainly used to map the spatial distribution of subjects being studied (control-cases) with respect to the risk source. Other applications have been recently experimented to better characterize risk sources, by associating data from different sources, thus allowing for improved exposure estimates[7].

GIS STRUCTURE AND POTENTIALS

Technically speaking, GIS are software products made up of several components, each one having a specific function and operating in a combined way:

1. *Graphic:* to manage digital mapping and images;
2. *Database:* to manage information;
3. *Analytical:* to analyse spatial and statistical data.

These tools enable us to implement a geographic database including all previously gathered information which is interconnected from a spatial and logical point of view.
One of the primary purposes of environmental and health data geocoding is to perform joint analyses on them.
With respect to studies on small areas where plants such as incinerators are located, through GIS it is possible to process data in various ways[7]:

- By associating data and digital maps on territories' basic features (administrative boundaries, orography, hydrography, vegetation, soil use, communication and technological networks, etc.) it is possible to sketch a first picture of the study area that will be the scenario on which environmental and health events' distribution will be studied.
- Data on risk sources (plants, stacks, landfills, etc.) and chemical and physical data on environmental matrices (water, air, land), represented by synthetic exposure and/or risk indicators, can be used to set up maps of risk spatial distribution and define exposure areas.
- Similarly, it is also possible to analyse the spatial distribution of health events; this not only enables us to identify areas of major interest, but also to detect potential *clusters* of mortality or morbidity for specific pathologies and evaluate risk according to distance from source.
- By comparing thematic maps we can get helpful information to develop correlation studies, as we can connect health indicators to exposure ones and thus identify further explanation elements for the effects detected within the study areas, by using for instance socioeconomic indicators.

A FEW REMARKS ON THE USE OF GEOGRAPHIC INFORMATION SYSTEMS (GIS) IN ENVIRONMENT AND HEALTH INVESTIGATIONS

The examples illustrated above on how to use GIS in environment-health correlation studies show the major contribution they can give to the definition of new indicators, even connected to spatial parameters, and the varied inputs they can bring in terms of data joint analysis methods; such analysis need to be further developed by means of these tools and other software as well, so as to perform even more sophisticated investigations. It should be however pointed out that all this implies the need for checking cartographic data quality following a few criteria that define:

1. *global quality:* of digital map, characterized by:
   1. *exhaustiveness:* measurement of excess or lack of information ;
   2. *up-to-dateness:* percentage of changes occurred between detection date and present time;
   3. *genealogy:* set of information on sources and treatments;
2. *local quality:* of each map item, characterized by:
3. *metric accuracy:* difference between a point's position on the map and its real position in the reference cartographic system used;
4. *resolution:* to be seen from the size of the smallest detail represented;
5. *semantic accuracy:* defined as correspondence between reality and qualitative name associated with the object;
6. *geometric congruence:* absence of any form or position error which cannot be detected unless an on-site investigation is conducted.

The introduction of GIS applications in environment-health correlation studies led to the development of a new working method based on multi-disciplinary competence (geographic, environmental, epidemiological, data management and processing, knowledge of information sources, etc.), which goes beyond the mere use of the information tool.
Despite the advantages offered by such approach, we should not forget that the validity of these investigations relies on scientific rigour applied to the choice of a suitable study design, correct data analysis and accurate control of the validity of system's *input* data.

INVESTIGATIONS ON RISK PERCEPTION

INTRODUCTION

Within the framework of the "ENHance Health" project, the activity carried out under component 4 was aimed at investigating risk perception as the starting point, in order to define effective communication strategies.
At first, the idea was to assess risk perception in each pilot project, through mainly quantity methods (questionnaires) to be repeatedly presented over time, thus measuring potential changes resulting from the communication strategies adopted. Actually, right from the first meetings with the European project partners, it was clear how difficult it would be to identify common survey plan and detection tools, with respect to epidemiological and environmental investigations, to study very different realities like the **three pilot study areas in Italy, Hungary and Poland.** If this is true of biological variables, it is even more true of perception-related aspects where social, psychological and cultural factors get involved.
Defining common research methods and tools was one of the ultimate goals to be achieved, by therefore letting researchers involved in the projects more freely choose the most suitable investigation tools, with respect to each territory's features. As a consequence, we will not illustrate a common research design and set of tools applied to all contexts, but rather a set of criteria, methodological instructions and types of tools which can be possibly used to investigate risk perception.

WHY WE SHOULD ADDRESS RISK PERCEPTION

In modern societies every single choice on technological issues has also a social and political impact, and requires a careful technical evaluation and assessment of the impact of the environment on health, to be performed by various institutional and social subjects with different roles and responsibilities.
Understanding how the involved subjects perceive risk is thus crucial if we wish to properly manage technical evaluation and decision-making processes. Knowing the opinions and attitudes of the people we talk to, is also a key prerequisite to effective communication: we shall adjust every message, tool and communication strategy to the recipients' needs.

RISK PERCEPTION AND FACTORS AFFECTING PERCEPTION OF RISK

There is a large literature on how the "objective" characteristics of risks and the "subjective" elements of the people perceiving them affect perception.
Communication is therefore fundamental to achieve common risk appraisal by putting together different subjective perceptions, but on the other hand it can also bring paradoxes or exacerbate disagreements and conflicts.

THE SUBJECTS INVOLVED

When talking about the subjects involved, we can refer to subjects, people carrying out the research, people ordering it or the recipients the research is addressed to.

TARGET SUBJECTS OF PERCEPTION INVESTIGATION

The problem of subjectivity of perception does not only concern population, but all institutional and social actors.
One of the first things to do when defining a communication research project is to identify the subjects to be involved.
Local level is the priority: in each reality, names, roles, opinions and specific stories correspond to the theoretically identified categories.
In particular the following is outlined:

- **a.** the crucial role played by decision-makers, as major communication players;
- **b.** the experts may have different responsibilities, roles, interests (technicians of administrations and public authorities involved in decision-making processes, professional communities, technicians from the companies managing the plants);
- **c**. the need for a clearer classification of *targets*, as to population, both in terms of participation in decision-making and contribution to communication (subgroups of people as recipients of varied communication actions, *opinion leaders*, information mediators, competent citizens, among whom, in particular, environmental associations).

SURVEY COMMISSIONING PEOPLE, RECIPIENTS, OPERATORS CARRYING OUT RISK PERCEPTION SURVEYS

Generally speaking, survey commissioning people are all those who have responsibilities in technical assessment and decision-making processes and thus want to identify useful elements to understand what criticalities they'll have to manage, who will react and how, how to structure and foster public participation to the process and communication.
As to the role played by researchers, it is worth outlining that we cannot achieve strong results, unless close collaboration and exchange of views between survey commissioning people, scientific experts and experts of social research methods are ensured.

INVESTIGATING PERCEPTION

As far as **methods and tools** are concerned, the need for a dialogue between different subjects and the participation of all the actors involved, so as to better understand needs and assess choices, force us to use research integrated methods combining quality and quantity data, through different reliable and sustainable tools suitable for purposes and context.
The best available model seems to be action research which let you activate participation processes to make problems and solutions arise from the community context, thus justifying subjective perceptions and allocating resources to solve problems.
To improve our knowledge on a phenomenon where psychological, cultural and social aspects are involved, as previously said, sociological research provides for three types of tools:

a. reading, interpreting and comparing documentation sources (paper and online ones);
b. observing deeds and behaviours;
c. collecting information on knowledge, opinions and attitudes (by using quantity and quality methods).

It is recommended to use varied tools suitable for the purposes and operating context, but also reliable and sustainable from an economic and organizational point of view.

RESEARCH STAGES

Literature review

We wish to stress how important it is to carry out a preliminary analysis on existing documents, in order to better define the subject of study. Taking into account the different problem components (technical evaluation, political decision, social context) and the categories of actors identified (experts, decision-makers, citizens), we can understand the complex system of principles, values, knowledge, rules, procedures etc. they may or should refer to.
The literature review also showed us risk communication's significance and purposes, so as to properly manage the evaluation process, and provided helpful information on methods and *best practices* on how to plan and implement effective communication; finally many cases on what may happen if such rules are not applied emerged.

LOCAL RETROSPECTIVE STUDY

In our experience, the preliminary study of the areas in question through retrospective investigations turned out to be equally important in order to define a reference framework where the project and future research activities can be better identified, and mainly to:

- get more precise information on risk perception in the reference territory and on the factors, among those described in literature, which are present and which mostly affect risk perception;
- map the subjects involved and get data on knowledge, levels of perception and attitudes;
- get to know the territory’s demographic and socio-cultural characteristics, which can better guide our definition of communication strategies;
- get useful elements to interpret the context and the relationships between subjects capable of affecting communication processes (environmental sensitivity, social climate, etc.).

Documents on administrative and technical activities of the institutional subjects involved, and *articles from local newspapers and socio-demographic* data about the Coriano area, were gathered.
Documentary data of local situation can be integrated with *interviews to relevant witnesses and focus groups.*
In our project, the documentary study coupled with evidence from local subjects and observers (councillors, public experts, etc.) represented a very rich and valuable source of information characterized by remarkable consistency.

PERCEPTION INVESTIGATIONS

The on-site survey carried out by using both quantity and quality materials was useful to both confirm the results of the retrospective study and further investigate how risk is perceived by the subjects involved, namely:

- groups representing the most involved subjects and stakeholders (decision-makers, experts, citizens);
- specific *targets (opinion leaders,* competent citizens, journalists) who may play an important role in the project’s next steps;
- subgroups or population samples.

Within the Italian context, namely in Forlì, the questionnaire was submitted to two target groups:

- a small group of operators from Public Health Departments;
- a sample of about 250 university students.

In Poland and Hungary, it was used to assess the knowledge and opinions of 2 population samples living close to incineration plants.

ADOPTED METHODS

Due to the nature of the problems to be investigated and in order to properly manage organizational aspects, our experience relied on the use of quality and quantity measurement tools (statistical and documentary sources, interviews and in-depth discussions, *focus groups*, questionnaire).
Each study stage and course of enquiries provided useful elements to base our choices on in the following phases; the meth-

ods adopted turned out to be complementary and led to consistent results.
The **documentary study** is, as far as our experience is concerned, one of the most exhaustive and easy-to-manage investigation tools; it is also cheap and easily accessible. During the preliminary phase, it certainly played a critical role in steering the research and further studies both in terms of issues to be dealt with, subjects to be involved and investigation methods, and with respect to the problems to be addressed and intervening variables, not to mention the opportunity to learn from other people's stories and experiences. At local level, by gathering newspapers' articles, official documents (administrative documents, programmatic plans, etc.) and unofficial ones (leaflets, brochures, minutes, etc.) it is possible to follow how a situation progresses over time.
Quality methods turned out to be useful and effective in order to study this type of problems. They played a critical role in on-site surveys due to methodological and organizational reasons and greatly contributed to both the retrospective study and the real survey on perception.

a. **Interviews to witnesses:** they can be used both in the retrospective study as a contribution to story reconstruction and to investigate the knowledge and perception of some subjects representing important target groups.
b. **Focus groups:** they are even more interesting, as they allow us to focus also on the interaction between various subjects; sometimes, however, they are difficult to be organized and managed.
c. **Observation of events and communication dynamics:**
   - among the most important information sources, there is participation to various communication events (contents, relational dynamics, reactions, development over time, etc.);
   - equally important are observations, contacts, comments within the reference environments and communities, both in the professional and social field; attention to news conveyed by media – not only local ones – which can hardly be quantified but effectively used to confirm and interpret what is pointed out by other researches.

The use of **quantity methods** was far more present in our original research plan, but later on we had to face some difficulties:

- to define a standard investigation method, as the situations in the three study areas were very different from each other;
- to interpret the results achieved, identify and examine potential sources of bias and confounders, and reach certain and univocal conclusions: perception can easily be defined in general terms, but its components are hard to be analysed and "measured";
- logistic, organisational and economic problems.

Additionally we found it hard to balance decision-making, communication and observation times, thus making it impossible to perform a deviation assessment of the results by repeatedly submitting the same investigation tool over time.

ENVIRONMENTAL COMMUNICATION

FOREWORD

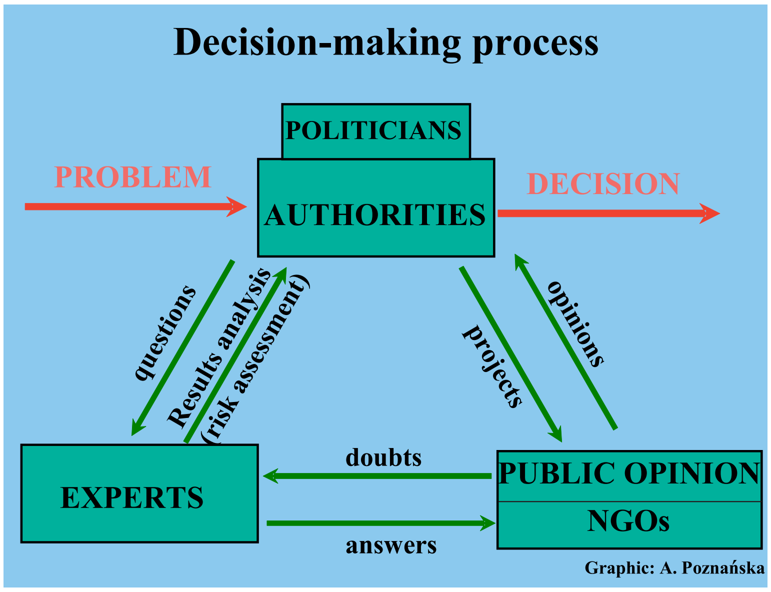
Communication is critical if we wish to increase confidence and foster public involvement, in order to address the lack of information, answer outstanding questions and promote educational processes.
The aim of this section is to give an overview of the communication role within decision-making and risk management processes on environmental issues and of the methods, times and people who should provide information to *target* groups. Namely:

- **politicians** who are confronted with citizens' requests and economic interests
- **public services** which are confronted with political indications and citizens' requests
- **industrial managers, farmers or any other owners or planners** of plants who wish to construct or enlarge an industrial site, seeking for the acceptance by the people living nearby, without loosing the trust of the population in their companies and products
- **members of interest groups** who have to represent citizens' interests
- **citizens** who wish to live in a healthy environment and can provide useful ideas to improve the surrounding environment.

These guidelines have been drafted on the basis of documents available in literature and the experiences and information emerged from the studies carried out in the **3 pilot areas in Italy (Coriano- Forlì), Hungary (Dorog) and Poland (Warsaw).**
The following notes summarize the English document "Environmental Communication Guidelines" drawn up by the project working group.
Public involvement's objective is to take into account the interests and needs of every involved group. The basic steps of public involvement are regulated by international conventions (UNCED, Rio de Janeiro 1992), national conventions and mainly environmental rules and regulations (Environmental impact assessment, Strategic Environmental Assessment, Integrated Environmental Authorisation…).
Examples of good practices of information communication to citizens by plant managers do actually exist.[43]

RISK COMMUNICATION

Risk assessment and management is a complex process requiring the intervention of many subjects with their varied competences.
The scheme below shows how potential subjects interact. The result of such a process should be a decision satisfying either party.



To make it simpler, we could say that risk communication shall:

- increase the knowledge of problems by taking on the challenge of facing scientific uncertainties
- bridge the gap between different risk perceptions.

Risk perception is also affected by other factors such as people's trust in authorities and experts, the attention paid by media to these issues, which information are provided to the population and how often. Once again communication is involved: if properly used, it can bring consensus; but it may also increase distrust and misunderstanding, if improperly used.
Risk communication is defined by ONR 49000 (1.1.04) as the exchange or sharing of information on risk between risk managers and stakeholders[45-46].

Based on what has been previously said, some of the activities to be carried out (but not limited to them) in order to ensure an effective risk communication are the following: talk with other people, exchange information, provide objective answers, enter into agreements, give tips, coordinate, accept other people's opinions.

A FEW RULES FOR EFFECTIVE COMMUNICATION

Over the last few years risk communication has been the key element for various innovative experiences.
The following basic notions are always referred to:
- Communication is a complex and intentional activity which requires thorough planning.
- The communication process between people and social groups does not only involve information but also feelings, values and emotions.

Among the most valuable contributions to the debate, we should mention the Seven Cardinal Rules of Risk Communication by Sandman and Covello, published by the EPA in 1988.[47]

Legal and political rules envisaging public involvement:
Some European and national rules set the reference framework of processes where citizens should be involved in.

- The Brundtland report (1987) "Sustainable development is the development that meets the needs of the present without compromising the ability of future generations to meet their own needs"; one of the principles is political participation.
- The Rio Declaration (1992) "One of the fundamental prerequisites for the achievement of sustainable development is broad public participation in decision-making" - definition provided in the Agenda 21.
- The Aarhus Convention (1998). Access to environmental information, public participation in decision-making in Environmental Matters.
- The White paper on European Governance (2001) sets guidelines for political and governance good practices, public participation.
- Directive 2003/4/EC on public access to environmental information (dated February 14 2005) *confirms the right of access both for individuals and organisations to information on emissions into the environment and their impact on population's health. It entitles (local) authorities of member states to refuse a request for environmental information only if the public interest served by disclosure is weighed against the interest served by the refusal.*
- EIA Regulation (Environmental Impact Assessment) with public participation
- IPPC Regulation (Integrated Pollution Prevention and Control)
- IEA Regulation (Integrated Environmental Authorisation) with public participation
- Regulation on public access to Public Administration's documents
- Regulation on decentralization in Public Administration
- Addressing the judicial authority

Different types of public involvement can be mentioned:

- To inform the people involved or interested in programmes and their effects (informative public participation).
- To give the opportunity to provide suggestions and *feedback* (consultative public participation)
- To give the opportunity to take part in planning stage (i.e. round tables) (co-decision-making)
- Involvement in planning and programming stage (EIA, IEA).

FIRST STEPS AND CONSIDERATIONS

Before any planning, it is necessary to gather:

- information on real risk perception within the given area and on the factors described in literature which really play a major role
- data on knowledge, levels of perception and attitudes of various subjects – including institutional ones -, as a basis for their participation in communication development
- information on socio-cultural and demographic features of the area in question, which could affect intervention strategies planning
- contextual elements and relationships between subjects, which may affect communication processes.

Experts have different roles, responsibilities and interests. They can be divided into three categories:

- Technicians, physicians and members of local authorities and public services participating in the decision-making process
- Technicians from the companies managing the plants
- Scientific advisors from protest committees.

Owing to either their professional skills or simply the institutional roles they play, they are considered as opinion leaders and can influence, even unintentionally, public opinion. The said subjects rarely interact with each other, except when carrying out the Integrated Environmental Assessment to which they all work together, excluding protest committees.

To define communication topics: communication programmes, messages, specific roles, implementation methods and times should be agreed upon by institutional subjects and shared with all stakeholders, following their roles, responsibilities and skills.
To foresee costs and examine the financial plan
To draft documents on programme, work and outcomes.

SOME USEFUL TIPS

The following chapter provides a set of practical tips found in literature, which proved to be useful to effective risk communication.

THE SEVEN CARDINAL RULES OF RISK COMMUNICATION BY ALLEN AND COVELLO

1. Accept and involve the public as a Legitimate partner
2. Plan carefully and evaluate your efforts
3. Listen to the public's specific concerns
4. Be honest, frank and open
5. Coordinate and collaborate with other credible sources
6. Meet the needs of the media
7. Speak clearly and with compassion

OBSTACLES TO RISK COMMUNICATION EFFECTIVENESS

Please refer to the guidelines set in the publications indicated below:

- Vincent Covello and Peter M. Sandman, "Risk communication: Evolution and Revolution" in *Solutions to an Environment in Peril*, Anthony Wolbarst (ed.) John Hopkins University Press (2001)
- Peter S. Adler, Ph.D. and Jeremy L. Kranowitz, M.P.A., M.S., *"A Primer on Perceptions of Risk, Risk Communication and Building Trust"*, The Keystone Center, February 2005.

Checklist for public participation processes:

- To find **information**: within the community, on the Net, on newspapers, from environmentalists
- Which **activities** have been already carried out under the project?
- To identify ***stakeholders***
- Is public participation to be implemented **by law**?
- If not, what **level of intensity** should the process have: Information, Consultation or Co-decision?
- Or could an informal process back a formal one?
- Are all involved people **invited**?
- Does any official **calendar** to refer to exist?
- What are the potential **advantages** for you and each target group?
- Are you aware of the process **possibilities** and **risks**?
- Are the process **roles** clearly defined?
- Are all participants aware of the process goals and tasks?
- Have you tried to involve also the most difficult groups to be contacted?
- Have you checked who's **competent in decision-making**?
- Have you defined **times and costs** and informed all people involved?
- Can the project **be financed**?
- Does everybody know **communication rules**?
- Is the process well **documented**?
- Are decisions **confirmed by surveys**?
- Are there any possibilities for ***feedback***?
- Have you decided how information will be published?

PROPOSAL FOR AN ACTIVITY PLAN:

A few instruments and activities are indicated below. According to literature and our experience they proved to be effective when adopted, whereas they caused problems if not. Not all of them are always suitable for the aim we wish to achieve or easy to be organized.

- **Preliminary information on the project**
- **Visit to a plant or similar project**
- **Information events**

Keep them simple. These events are not intended to provide technical details, but to let everybody have an overview of the situation and planning. Professionalism is crucial to the event's success. Additionally, you should present both advantages and disadvantages.

- **To involve resident people (public participation)**
- **Information about all official steps**
- ***Open days***
- **Public relations**
- **Leaflet/*Newsletters***
- **Web site**
- **Opening event**
- **Regular round tables, meetings with citizens**

Timetable for the proposed activity plan:

	ACTIVITY	BEFORE PLANNING	DURING PLANNING	AT THE BEGINNING OF WORK	PERMANENT
1	Preliminary information on the project (officers)	✓			
2	Invitation to visit a plant or similar project	✓			
3	Information on the event's name	✓	✓		✓
4	Involvement of neighbours (public participation)	✓			
5	Information about all official steps	✓			
6	Open day		✓	✓	
7	Public relations		✓	✓	✓
8	Leaflet/newsletter		✓	✓	✓
9	Homepage		✓	✓	✓
10	Opening event			✓	
11	Regular round tables, meetings with citizens				✓

COMMUNICATING WITH MEDIA

The people interested in the project but not involved in the same, and the ones who cannot provide regular contributions, may wish to be informed by media or through a communication tool of the working group (*newsletter*).
Before holding a press conference, you should answer the following questions:

- What message do I want do convey? Can I present it to journalists? Will they accept it?
- Who are the *target* groups?
- What shall I prepare for the press conference (photos)?
- What is the best date to hold the press conference?
- Whom shall I invite? (local press, TV, radio, national press,…)?
- Do we need a buffet?

When drafting a press release, bear in mind the following:

- The most important information shall be given on top of the list!
- Be clear and simple!
- Try to think like your *target* group does!

CONCLUSION

This document provides a set of recommendations that are the final outcome of the European project 'ENHance health', under which environmental and health investigation methods were defined, shared and experimented. It contains the guidelines for all the necessary procedures to develop environmental and health surveillance systems in areas where incineration plants are located.

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