Environmental Health Surveillance Systems

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ABSTRACT

An integrated environmental health surveillance system is the systematic, ongoing collection and analysis of information related to disease and environment, and its dissemination to individuals and institutions. This type of system provides scientific evidence and tools for implementing and evaluating policies aimed at preventing, controlling and protecting health and the environment. An integrated environmental health surveillance system can be realized by setting up environmental and health indicators. Indicators are useful for understanding the spatial and temporal trends of environmental parameters and related health effects, both acute and chronic.

In recent years, much attention has been focused on surveillance systems, and, in particular, on developing methods for combining and integrating information in order to better understand these phenomena. Several analytical approaches have been proposed for classifying environmental and health indicators: Thacker's model; the DPSEEA framework (WHO) which represents an evolution of the PSR model (OECD) and the DPSIR framework (European Environmental Agency).

As part of the Environment and Health Inter-departmental Project (PIAS-CNR), the Working Group on Environmental Health Surveillance Systems has been tasked with the development of a protocol to be tested in areas with different environmental risks, in order to monitor environment and health indicators and to provide useful tools for primary prevention programs and communication. The goal is to select a set of environmental and health indicators to be assessed against their utility and availability in time and space.

1. Introduction

Environmental effects on health are associated with many different factors: environmental degradation, such as air, water and soil pollution, and food contamination; global environmental problems, such as the reduction of biodiversity, the degradation of the ecosystem through deforestation, global warming, ozone layer depletion and contamination by persistent organic chemicals, waste cycle mismanagement and industrial disasters.

As part of the Environment and Health Inter-departmental Project (PIAS-CNR), the Working Group on Environmental Health Surveillance Systems has been charged with developing a protocol to be tested in areas with different environmental risks, in order to monitor environment and health indicators and to provide useful tools for primary prevention programs and communication. The analysis of the scientific literature on this subject, and the study of the most advanced international experiences are the basis on which a protocol can be defined and tested in areas with different degrees of environmental degradation. In Italy, the Apulia region, a territory with three areas at high risk of environmental crisis (Brindisi, Taranto and Manfredonia), is an interesting experimental site.

The areas chosen to test the surveillance system require epidemiological and environmental characterization, that can be performed using available statistical information or conducting specific surveys.

These elements, based on a conceptual model (Thacker, DPSEEA or DPSIR) integrated with established international experience and shared with local and national stakeholders, are the platform on which to build an information system that can provide information on environment-health interaction and lead to preventive and communication actions.

This chapter aims at providing a summary of our knowledge on this subject, with particular regard to several international experiences that are generally considered as more advanced.

Major conceptual models in the field of environment and health indicators will be discussed.

2. Environmental and health surveillance: state of the art

2.1 Definitions and purpose

Public health surveillance is "the ongoing systematic collection, analysis, and interpretation of outcome-specific data, closely integrated with the timely dissemination of these data to those responsible for preventing and controlling disease or injury" (1). The modern definition of surveillance, which at the beginning included only transmittable diseases (2), currently refers to chronic and acute diseases, reproductive health, work, domestic and road accidents, environmental and occupational risk, and behavior (3).

In 1988, the Centers for Disease Control and Prevention (CDC) of the United States defined environmental health surveillance as "the ongoing, systematic collection, analysis, and interpretation of health data essential to the planning, implementation, and evaluation of public health practice, closely integrated with the timely dissemination of these data to those who need to know. The final link of the surveillance chain is the application of these data to prevention and control. A surveillance system includes a functional capacity for data collection, analysis, and dissemination linked to public health programs." (4).

Most surveillance systems are usually implemented in order to:

- Provide estimates on the size of a health problem;
- Investigate emerging health problems and epidemics;
- Document the distribution and diffusion of health events on a given territory and in specific populations;
- Provide the basis for epidemiological research and clinical trials;
- Describe the natural history of a disease;
- Monitor trends in risk factors related to specific diseases;
- Identify changes in health practices;
- Monitor the spatial and temporal variation of the occurrence of diseases and risk groups;
- Evaluate programs for prevention and disease control (1).

In recent years, attention has been increasingly focused on the need to improve environment and health monitoring systems by developing methods designed to combine information from different information-systems and to support an integrated knowledge of phenomena.

An environmental health surveillance system must be able to assess, analyze and disseminate the information necessary to properly plan policy-makers' actions in

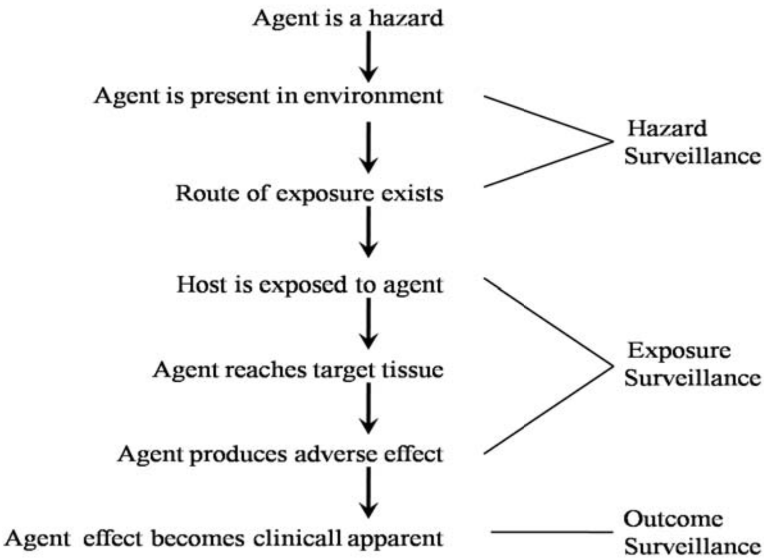

Figure 1. the process by which an environmental agent produces an adverse effect and the corresponding types of public health surveillance.

health care.
Environmental indicators (quality of the environment, environmental contamination and results of specific monitoring) and health indicators (e.g, indicators of morbidity, mortality and reproductive health) which can be obtained by current health information flows, from a pathology registry or from specific surveys, are the bases of an integrated environmental health surveillance system.
Environmental and health indicators provide a quantitative summary of the phenomenon under study and are useful to understand the spatial and temporal patterns of health-impacting environmental parameters , acute and chronic health effects and social and demographic factors.

2.2 Conceptual models

Several models have been proposed to provide a conceptual synthesis of the monitoring of environmental and health problems. These include
- The Thacker model (5);
- DPSIR and DPSEEA model (6, 7).

They emphasize the role of social and environmental macro-determinants and consider exposure to be a central event in environmental causes and in the occurrence of disease. Therefore, exposure is the key element in environmental and health surveillance. In fact, epidemiological surveillance systems have developed, from disease surveillance to surveillance of collective risk factors (8).

2.3 The Thacker model

The Thacker model (5) proposes three different kinds of surveillance (Fig. 1):
- Hazard surveillance;
- Exposure surveillance;
- Outcome surveillance.

Thacker defines hazard surveillance as the "assessment of the occurrence of, distribution of, and the secular trends in levels of hazards (toxic chemical agents, physical agents, biomechanical stressors, as well as biological agents) responsible for disease and injury" (9).

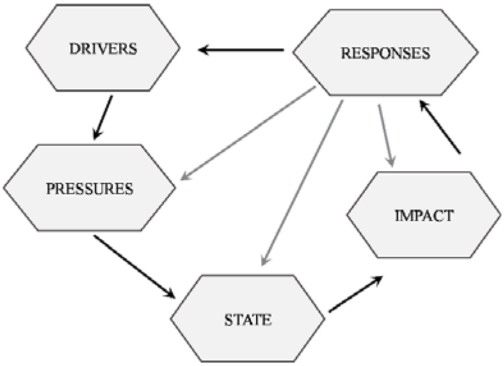

Figure 2. The DPSIR model

Data on risk factors can be derived from the amount of hazardous agents produced, sold, used or released, or from the concentrations of these agents in various environmental matrices (air, food, soil and dust, water) (10).

Exposure surveillance is the monitoring of individual members of the population to assess the presence of an environmental agent or its clinically unapparent (e.g, subclinical or preclinical) effects. (5, 11).

The definition of target groups for surveillance in areas with documented or presumed environmental pressure is one of the most critical points in the researcher's decision-making chain, since it depends on many factors and considerations.

Actually, exposure is defined as the relationship between the environment (external factors) and the individual (internal factors) as a result of inhalation, ingestion, dermal contact, or via fetus or placenta.

The need to establish a relationship between environmental monitoring and health-related policies and actions led to the addition of a fourth monitoring category regarding the assessment of policy options (10).

2.4 The DPSIR and DPSEEA

The methodology of the DPSIR (Determinant, Pressures, State, Impacts, Responses) allows us to organize environment-health indicators implemented in an environmental health surveillance system (12) (Fig. 2).

The DPSIR framework is a system to analyze the Driving forces responsible for change, the resulting environmental Pressures on the State of the environment, the Impact of changes on environmental quality, and Society's Response to these changes.

In this model the determinants (or sources, e.g. Agriculture, industry, transport, settlements, animal husbandry, mining) identify the factors influencing the environmental conditions as sources on which to act. They are useful to identify relationships between the factors responsible for pressure and the pressure itself.

Pressures (e.g. emissions of pollutants, waste, noise emission , vibration and radiation) identify the direct effects of increased human activities (i.e. the variables responsible for the degradation) and are useful to quantify the causes of environmental change.

States (e.g. quality of air, water, soil, vegetation, fauna, ecosystems, landscape, physical agents, public health) represent environmental quality and the environmental resources that should be protected. They are useful to evaluate environmental conditions in terms of degree of impairment.

Impact refers to the effects of a pressure: they are major changes in the environment compared to a state-based condition, taken as a reference.

Responses (laws, plans, rules) are actions taken to address the impact, and take different forms depending on the level of the model on which to act (e.g. demands of structural determinants, interventions prescriptive or technology, etc.) (13).

Each of the areas identified above can be summarised by using specific indicators, as resulting from current environmental and health data, environmental bio-monitoring and biomarkers of human exposure.

The model comes from the general concept when applied to specific environmental areas such as environmental matrices that define the real component within which chemical, physical and biological agents act. Matrices are generally identified as air, water, soil, waste, physical agents, and foods. To better address the effect of the human exposure to environmental factors, the World Health Organization (WHO) extended DPSIR to the DPSEEA model (Determinant, Pressures, State, Exposure, Effect, Action).

The introduction of health effects evaluation involves a refinement of the DPSIR conceptual model, translating the concept of impact into ”exposure“ and ”effect“ and the Responses into ”actions”.

In the DPSEEA model, according to the classical epidemiological model, Determinants and Pressures are recognized as determinants of disease, distinguished in individual and contextual determinants.

State, Exposure and Effect represent the extent of the problem (respectively, in terms of emissions, exposure and health effects) (13).

The number of indicators relating to the areas outlined above is very high. There is abundant literature on the selection of indicators useful to describe the state of the environment and health (7, 14).

The indicators include both environmental and health indicators for which the relationship between exposure to environmental hazards and health effects is already established.

Wills and Briggs (15) define two categories of indicators:

- Health-related environmental indicators (HREIs);
- Environment-related health indicators (ERHIs).

The first relates to environmental conditions that suggest potential harmful health effects; the latter relates to health outcomes that suggest an environmental cause or a contribution from environmental factors.

In environmental impact assessment studies, an indirect measure of the level of exposure (e.g. concentrations of pollutants or emissions) is used as an environmental indicator (16).

In studies of health impact assessment of environmental pollution, indicators that describe health outcomes caused by exposure to polluted matrices are used. To determine which diseases are related to the environment (e.g. infant mortality, mortality from respiratory causes), it is necessary to carry out studies on risk assessment from exposure (16).

In general, indicators should have specific requirements:

- Validity, reliability and representativeness of data;
- Availability of data, their systematic measurement in time and space (not separated from their representation);
- Usefulness, i.e. the indicator has to be oriented to the action.

3. Environmental and health surveillance experiences

Integrated environment and health surveillance systems have recently been developed at international level.

The CDCs, the Californian Policy Research Centre (CPRC), WHO-Europe, and the Institut National de Santé Publique du Québec have produced comprehensive reports on the strategy to implement an for environment and health monitoring

system.
The strengths and weaknesses of these systems are summarized in Table 1 (10). These three systems differ as for their state of the art and completeness, but may represent a good basis to initiate a program of environmental and health surveillance in Italy or in specific areas of the country.

3.1 USA

In the United States, the CDC ”Pew Environmental Health Commission“ report first defined the purpose of a surveillance system (17). This document underlined the gaps in our knowledge of environmental medicine and recommended implementing a national environmental health surveillance system.
In 2002, CDC in collaboration with the Environmental Protection Agency (US-EPA) and the National Aeronautics and Space Administration and Member Partners the development of this system was started (18).
The goal of the system is to ”monitor and distribute information about environmental hazards and disease trends, advance research on possible linkages between environmental hazards and disease, develop, implement, and evaluate regulatory and public health actions to prevent or control environment-related diseases“ (19).
In 2002, the State of California initiated the first environmental health surveillance system (20). The ”Strategies for Establishing an Environmental Health Surveillance System“ report led the early development of this system.
It defined the objectives and usefulness of developing and planning an environmental health surveillance system, estimating its costs, defining diseases, environmental hazards and exposures to be monitored and describing the related political, ethical and legal issues (10).
In summary, the program of the CDC has three objectives:

- to develop the technological infrastructure, such as the use of GIS for mapping the use of pesticides and the concentrations of pollutants in urban areas;
- to improve data availability and use;
- to promote the translation of knowledge into policy actions.

In this surveillance system, environmental and health indicators (Environmental Public Health Indicator, EPHI) are divided into the following four categories (21):

- Hazard indicators: Conditions or activities that identify the potential for exposure to a contaminant or hazardous condition.
- Exposure indicators: Biological markers in tissue or fluid that identify the presence of a substance or combination of substances that could harm an individual.
- Health effect indicators: diseases or conditions that identify an adverse effect from exposure to a known or suspected environmental hazard.
- Intervention indicator: Programs or official policies that minimize or prevent an environmental hazard, exposure, or health effect.

Indicators are also divided into three topics:

a) pathways or sources (e.g, air, water);
b) agents (e.g. lead, pesticides);
c) events (e.g. sentinel events, environmental disasters).

Topics may also overlap due to the complexity of environmental and public health laws and programs. However, an indicator is generally included under only one topic, although it may be relevant to several.

Table 1. CDC, EU and Quebec environmental health tracking systems: strengths and weaknesses.

Initiative	Strengths	Weaknesses	Indicators
Centers for Disease Prevention and Control (CDC 2006b)	1. Partnership with federal, state and local government agencies, academic and community groups, healthcare organizations 2. Strong stakeholder input 3. Pilot projects well coordinated	1. Varying levels of state readiness 2. Early in development: • First national report, 2008 • Network launch 2008	Topics Air, ambient (outdoor) Air, indoor Disasters Lead (Pb) Noise Pesticides Sentinel events Sun and ultraviolet Toxics and waste Water, ambient Water, drinking Indicator Types Hazard Exposure Health effect Intervention
European Union (WHO Europe 2004)	1. Includes upstream driving forces 2. Includes home, work and ambient exposures 3. Includes population exposure and health impact assessment (air quality, noise) 4. Linked to health-based policy action programs (NEHAPs) 5. Developing a children's environment and health indicator set	1. Diverse data systems across EU 2. Gaps in survey and biomonitoring data 3. Still to define outputs (printed reports and Web-based data)	160 indicators proposed in: Air quality Housing Noise Traffic accidents Water and sanitation Food safety Chemical emergencies Radiation Workplace
Quebec (Institut national de santé publique du Québec 2006)	1. Common surveillance with occupational and infectious diseases within Ministry of Health and Social Services 2. Annual reporting 3. Research in environmental health surveillance since 1997 with Geomatics for Informed Decisions National Centre of Excellence (GEOIDE NCE) 4. Strong public health surveillance mandate in 2001 Public Health Law 5. Stable funding 6. Strong Quebec Public Health Institute [Institut national de santé publique du Québec (INSPQ)]	1. Not all indicators completed 2. Gaps in data for some proposed indicators	Twenty-six of 41 indicators reported. Environmental Indicators: Recreational water quality (beaches) Drinking water quality Boil-water advisories Waste water treatment Air pollution Environmental tobacco smoke exposure Health-Based Indicators: Carbon monoxide and other poisonings notification rates Allergic rhinitis prevalence Cancers of interest for environmental health Hospitalization/mortality rates for diagnoses linked to environmental hazards Proposed Indicators: Noise Indoor air Pesticides Climate change (mortality for heat waves, morbidity and mortality linked to extreme weather events)

3.2 Canada

In the state of Quebec, the Ministry of Health and Social Services has established a surveillance system regarding environmental hazards, occupational health and infectious diseases. The system is based on 26 of the 41 indicators proposed by a panel of experts (17 refer to environmental data, 9 to health data) (Table 1).

3.3 European Union

The ECOEHIS project (European Community Health and Environment Information System), conducted under the leadership of the WHO-European Centre for Environment and Health (22), has developed environmental health (EH) indicators as part of the European Community Health Indicators (ECHI), which would serve as tools to aid in the following:

- To measure the health impact of selected environmental risk factors, their determinants and trends therein, throughout the Community;
- To facilitate planning, monitoring and evaluation of Community programs and actions;
- To provide Member States and international organizations with information to make comparisons and evaluate their policies (22).

The core set of environmental health indicators has been developed within the DPSEEA framework and focuses on the population's exposure to environmental hazards, their health effects, and policy actions to prevent illnesses, injuries and deaths.

Based on feasibility and usefulness testing and after approval by the EU Member States, the indicators were to be delivered according to the evidence, data and methodological limitations, in one of three categories:

- ready and recommended for implementation (these indicators are recommended as 'core' European Community Health Indicators)
- ready, but not feasible for immediate implementation (these indicators are recommended for WHO projects such as ENHIS)
- desirable but requiring further developmental work (these indicators are recommended for further elaboration).

The Institute for Environmental Protection and Research (ISPRA) acting as National Focal Point (NFP) for Italy, has coordinated the national feasibility studies of these indicators. Indicators refer to the following areas:

- Air;
- Housing and health;
- Noise and health;
- Traffic accidents;
- Water and sanitation;
- Chemical Emergencies ;
- Radiation.

Based on the pilot project conducted in Italy, ISPRA-APAT has classified the indicators according to availability, data quality and feasibility of their implementation for three environmental sources (air, water, soil) and for each of the five categories of the DPSEEA framework.

Some indicators are not calculated due to the unavailability of data or the gaps in the informative flows.

The selected indicators are considered of national importance, both in terms of comparability and of data quality. They need to be implemented and adapted at local scale for surveillance in areas with different environmental risks.

3.4 Italy

In 2001, as part of the Italian Association of Epidemiology, the Environmental Epidemiology Group (GEA) was established (23) in order to coordinate, organize and take over environmental epidemiology and risk assessment activities throughout the country (24).

The environmental protection agencies that have joined the group are: ISPRA, Regional Environmental Protection Agency (ARPA) Marche, ARPA Piemonte, ARPA Emilia Romagna, ARPA Tuscany, ARPA Veneto, ARPA Campania, ARPA Friuli Venezia Giulia, ARPA Umbria, ARPA Lombardia, APPA Bolzano , ARPA Basilicata, ARTA Abruzzo, ARPA Liguria, ARPA Puglia, ARPA Sicily, ARPA Sardegna.

As part of the GEA, the following four subgroups have been formed:

- Group 1. Definition of guidelines for environmental epidemiology studies in small areas, in order to collect information and experiences reported in the literature for epidemiology studies in small areas.
- Group 2. Integration between essential health care levels (LEA) and the Essential Levels of Environmental Protection (LETA), in order to send proposals to the Ministry of Health and the Environment on LEA/ LETA related issues.
- Group 3. Realization of a reference network for environmental epidemiology studies, in order to promote organizational proposals to create a network of experts on environment and health.
- Group 4. Environmental and health indicators at the local level (IAS). It is based on the formulation of a proposal for the definition and testing of environment and health indicators at local level (25).

These groups have produced ideas and documents contained in the acts of the second national workshop Portonovo (Ancona) (26).

4. Epidemiological and environmental characterization of Brindisi (experimental site)

In the province of Brindisi, an area at "high risk of environmental crisis" has been identified by the Italian Ministry of the Environment (Law n. 305 of 1989), due to the presence of numerous industrial sites. They produce a remarkable environmental impact and cause serious alterations of every type to the equilibrium of the environment, as well as adverse effects on the health of the population.

In fact, in the province of Brindisi and particularly in the southern area of the main town, on the Adriatic sea, many sources of air pollutants with high environmental impact are located near the urban area.

Next to the petrochemical area (built in 1959), various industries have grown up over the years: three fossil-fuel power plants, among them one of the largest in Europe (Federico II Enel); several chemical, pharmaceutical, metallurgical and manufacturing industries; an airport; an harbour, mainly for passenger traffic to Greece.

In 2002, in seven municipalities including Brindisi, the State Forestry Service has discovered 15 illegal dumps (covering an area of 127,278 m^2).

The Federico II Enel plant has the highest record of CO_2 emissions in Italy, and in the area designed as Reclamation Sites of National Interest (RSNI) there is a significant concentration of particulate matter as underlined by emissions and concentrations recorded by the Region of Puglia (CORINE-AIR).

Southwest of Brindisi there is the province of Taranto, whose industrial area includes steel factories, a refinery and a cement factory and proximity to this border could be a further source of exposure to environmental pollutants.
The town of Brindisi can be selected as a site to test the surveillance system. This requires epidemiological and environmental characterization

4.1 Epidemiological characterization

Between 1990 and 1994, the World Health Organization has conducted an epidemiological study in four municipalities (Carovigno, Torchiarolo, S. Pietro V. and Brindisi) located in the RSNI of Brindisi. Significant excesses of mortality from all causes, all cancers, lung cancers, respiratory and ischemic diseases were observed both for males and females. In particular, an elevated value of mortality from melanoma was reported (27).
In Brindisi, in the male population, excesses of mortality from all causes and from all cancers were detected, while in the female population excesses were found for digestive system and for psychiatric causes. Different mortality patterns by gender are likely to be caused by professional exposure.
A recent descriptive geographical study of the province of Brindisi estimates the mortality among residents in the twenty municipalities of the province aggregated in four geographic areas: the one at "high risk" including the main town, and the areas located north, west and south of the Brindisi RSNI area (28).
The analysis was run by gender, specific causes of death, and by two 10-year-periods between 1981 and 2001. Results for RSNI area confirmed the previous WHO analysis, while ither excesses for specific causes were observed in the remaining areas.
In the province of Brindisi, excess mortality due to cardiovascular disease and cancers is higher than regional levels.
The analysis restructed to working age groups (34-64 years), showed higher rates of mortality than those reported for cardiovascular mortality, among men as well as women; excess mortality for cancer of the prostate and for trauma was higher in men, wheras women show a higher mortality rate for the cancer of the central nervous system. In addition, for Brindisi Municipality, excess mortality for pleural mesothelioma was reported also among women.
Table 2 shows the results of death incidence analyses from all cancers and from specific causes during the period 1999-2001, also compared with the data of the whole province. (the data source is the Jonico-

Table 2. Standardized rates of cancer incidence (x 100,000 inhabitants) and IC 95%.

Site	Brindisi		Risk area of Brindisi		Province of Brindisi	
	Rate	CI 95%	Rate	CI 95%	Rate	CI 95%
All cancer sites	424,5	391.3-459.9	382,3	356.0-410.2	368,1	353.8-382.8
Lung	88,9	74.1-105.9	83,6	71.5-97.1	77,6	71.2-84.6
Pleural	0,6	0.0-3.8	0,4	0.0-2.7	0,5	0.2-1.4
Urinary Bladder	38,1	28.6-49.8	32,7	25.3-41.6	32,1	28.0-36.6
NH-lymphoma	14,8	9.1-22.7	12,8	8.3-18.8	11,1	8.7-14.0
Soft Tissue	4,2	1.5-9.3	2,95	1.1-6.5	2,4	1.3-4.0

Source:RTJS 1999-2001

Table 3: emissions in atmosphere in Puglia and in each of the five provinces – 2006.

Province/Pollutant	Emissions	Measure Unite
	CO_2	
Foggia	926.714	Mg / y
Bari	925.379	Mg / y
Taranto	23.492.769	Mg / y
Brindisi	19.799.096	Mg / y
Lecce	1.018.493	Mg / y
Puglia	46.162.451	Mg / y
	C_6H_6	
Taranto	237.308	Mg / y
Brindisi	11.000	Mg / y
Puglia	248.308	Mg / y
	PAH	
Taranto/Puglia	32.240	Mg / y
	NO_X	
Foggia	1.243	Mg / y
Bari	3.370	Mg / y
Taranto	35.846	Mg / y
Brindisi	11.961	Mg / y
Lecce	2.444	Mg / y
Puglia	54.864	Mg / y
	SO_X	
Foggia	252	Mg / y
Bari	1.452	Mg / y
Taranto	53.077	Mg / y
Brindisi	12.697	Mg / y
Puglia	67.479	Mg / y
	CO	
Bari	1.555	Mg / y
Taranto	541.434	Mg / y
Brindisi	2.900	Mg / y
Lecce	1.860	Mg / y
Puglia	547.749	Mg / y
	Particulate	
Bari	57	Mg / y
Taranto	11.805	Mg / y
Brindisi	730	Mg / y
Puglia	12.591	Mg / y
	PCDD, PCDF	
Taranto/Puglia	92	g / y

Source: INES registry

Salentino Tumor Register- RTJS).

In 2004 a case-control study was published to investigate mortality from cancer in the areas near Brindisi petrochemical industry.

In period 1996-1997, a moderate excess of mortality, from lung and bladder cancer and lymphohematopoietic system was observed in the population residing in an area within 2 km from the centroide of the petrochemical site, compared to the population residing outside 5 km (29).

A case-crossover study has recently been conducted to investigate the association between daily mortality and hospital admissions data, on the one side, and the daily concentration of atmospheric (PM_{10} and NO_2) pollutants, on the other. The study population included residents in Brindisi city who died or hospitalized for several diseases during the period 2003-2006 (30).

This study found strong and consistent associations between outdoor air pollution (coming from both industrial emissions and urban traffic) and short-term increases in both mortality and morbidity.

In particular, PM_{10} was associated with mortality from all natural causes. The risk was more pronounced for cardiovascular mortality. The association with hospitalization for cerebrovascular diseases was statistically significant for PM_{10} among females and elderly over 75 years old. In specific population groups, increased mortality and hospital admissions have been associated with NO_2 (31).

4.2 Environmental characterization

AIR characterization

The Italian Pollutant Emissions Register (INES) registry can be used to gather information about emission in water and air coming from the facilities under

Table 4: emissions in atmosphere in Brindisi by industrial complex – 2006

Industries	**Emissions**	**Meysure Unite**	**%**	**Thresold value** **Kg / year**
CO_2				
POLIMERI EUROPA SPA - Brindisi	481.738	Mg / y	2,4	100
ENIPOWER S.P.A. - Brindisi	2.132.833	Mg / y	10,8	100
ENIPOWER S.P.A. - Brindisi	130.172	Mg / y	0,7	100
POWER PLANT Federico II (BR South)	14.372.364	Mg / y	72,6	100
Power plant Brindisi	2.681.989	Mg / y	13,5	100
Total	19.799.096	Mg / y	42,9	100
C_6H_6				
POLIMERI EUROPA SPA - Brindisi / Brindisi	11.000	Kg / y	4,4	1
NO_X				
POLIMERI EUROPA SPA - Brindisi	262	Mg / y	2,2	100
ENIPOWER S.P.A. - Brindisi	826	Mg / y	6,9	100
ENIPOWER S.P.A. - Brindisi	310	Mg / y	2,6	100
POWER PLANT Federico II (BR South)	9.282	Mg / y	77,6	100
Power Plant Brindisi	1.282	Mg / y	10,7	100
Total	11.961	Mg / y	21,8	100
SO_X				
ENIPOWER S.P.A.	430	Mg / y	3,4	150
ENEL PRODUZIONE SPA	10176	Mg / y	80,1	150
EDIPOWER	2.091	Mg / y	16,5	150
Total	12.697	Mg / y	18,8	150
CO				
POWER PLANT Federico II/Brindisi	2.900	Mg / y	0,5	500
	Particulate			
POWER PLANT Federico II/Brindisi	730	Mg / y	5,8	50

Source: INES registry

The Integrated Pollution Prevention and Control (IPPC) Directive (2008/1/CE). The emission concentrations are available on the site: www.eper.sinanet.apat.it

In 2006, the Apulia region had the highest emissions of all the pollutants considered, against national data. The emissions could be attributed mostly to the provinces of Taranto and Brindisi (table 3).

CO_2, NO_x and SO_x emissions - typical of energy production - and benzene (C_6H_6) emissions from the chemical sector mostly originate from the province of Brindisi (Tab. 3-4) .

WATER characterization

Table 5 shows the list of pollutants with threshold values for each specific issue and polluting industrial complex.

Table 5: emissions in water in Brindisi from industry – 2006

Industries	Emissions Kg / year	%	Thresold value Kg / year
Phenols			
POLIMERI EUROPA SPA - Brindisi	77,5	0,6	20
Zn and compounds			
ENIPOWER S.P.A. - Brindisi/Brindisi	269,0	0,4	100
As and compounds			
POWER PLANT Federico II/Brindisi	108,4	28,5	5
Cd and compounds			
POWER PLANT Federico II/Brindisi	12,1	0,1	5
Cu and compounds			
POWER PLANT Federico II/Brindisi	73,3	0,6	50
Hg and compounds			
POWER PLANT Federico II/Brindisi	2,1	0,5	1
Ni and compounds			
POWER PLANT Federico II/Brindisi	72,2	2,4	20
Pb and compounds			
POWER PLANT Federico II/Brindisi	36,4	4,4	20
Fluorides			
POWER PLANT Federico II/Brindisi	7.391	100,0	2.000

Source: INES registry

SOIL characterization

In April 2008, ARPA-Puglia has published a study on pollutants' concentration in soil near the industrial area of Brindisi.(31)

Soil samples were collected at five depth strata (0-1, 1-2, 2-3, 3-4, 4-5) in 23 samplig areas near the Federico II ENEL power plant.

Concentrations of arsenic, beryl, tin, cobalt, Chlordane, Vanadium, DDE, DDD and DDT were measured.

The results show excesses of arsenic, beryl, cobalt, tin, DDD in the sampling points between 0 and 1 meter; excess of beryllium and DDE in the top soil (layer between 0-15 cm).

The arsenic concentrations in the five sampling points (0 and 1 m) is between 24 mg/m^3 e 53 mg/m^3 (the threshold value in residential area is 20 mg/m^3). The arsenic concentrations in 11 samples range from a minimum of 2.2 mg/m^3 to a maximum of 3.8 mg/m^3. In a top soil point the concentration is 2.1 mg/m^3 compared to a limit value of 2 mg/m^3 for residential areas.

Cobalt values are always higher than the threshold value with concentrations ranging from 30 to 39 mg/m^3 (the threshold value in residential areas is 20 mg/m^3).

Tin concentrations in four sampling points (0 and 1 m) range from 1.2 mg/m^3 to 5 mg/m^3 (compared to a threshold value of 1 in residential area).

DDD values in the only one sample point (0 and 1 m) are between 1.2 mg/m^3 and 5 mg/m^3 (the threshold is 0.1 mg/m^3). The concentration (0.63 mg/m^3) exceeded the threshold (0.1 mg/m^3) in one on the two samples (0-1 meter).

5. Proposal for an enviromental health surveillance system

A systematic proposal for sentinel events regarding the environment and health (ESAS) was drawn up by a consensus conference organized by the Agency for Toxic Substances and Disease Registry (ATSDR) in early 1990s (32).
There are two types of events:
Type 1) Acute conditions as sentinel indicators of environmental pollution, as defined by Rutstein (33):

– Intoxication by pesticides, metals or other substances present in refuse sites, such as lead and carbon monoxide, with particular attention to the most vulnerable groups, such as children;
– Some tumors, such as pleural mesothelioma, clear-cell vaginal cancer and hepatic angiosarcoma, which although characterized by long periods of induction-latency have been associated with a high degree of specificity for exposure to chemical or physical agents;
– Precocious puberty as an indicator of exposure to endocrine disruptors, such as many pesticides, industrial products, and food additives;
– Hemoglobinemia as a classic indicator of intoxication;
– Neuropathy from exposure to toxic chemical agents (such as methylmercury causing Minamata disease).

Type II) Unusual models of disease incidence or conditions identified by means of surveillance:

– Bladder cancer, especially in non-smokers and in the absence of occupational hazards;
– Lung cancer in non-smokers;
– Liver cancer in non-drinkers;
– Rare tumors having a proven association with environmental exposure, such as rhabdosarcoma, myeloblastic leukemia, acute leukemia in children and granulocytic leukemia in adults;
– Asthma in children, especially shortness of breath in children in absence of allergies and passive smoke exposure;
– New environmentally-correlated rare diseases such as eosinophilia-myalgia syndrome, toxic oil syndrome, and Kawasaki disease;
– Measures of biological markers, such as the concentration in biological fluids of persistent organic pollutants (POPs);
- DNA or hemoglobin adducts.

6. Conclusions

In environmental health surveillance, especially in the case of small areas, unusual events, low exposures, there is a high statistical probability that many warnings will be revealed by chance (due to the effect of multiple testing). On the other side, in case of alarm signals coming from outside the surveillance system there is a typical risk of an *a posteriori* selection.
No signals should ever be considered conclusive, since investigation should always be focused on statistical-probabilistic confirmation and search for the cause. No sign should be neglected since it must be considered anomalous until proven otherwise.
The adoption of a health surveillance protocol for a polluted site is a suitable tool to provide an answer to the legitimate concerns of citizens regarding their environment and the consequent health impacts. The other crucial aspect of such a surveillance system is the ability to transfer reliable information and suitable recommendation to decision-makers in order to allow them to carry out and evaluate political choices and programs on the basis of scientific evidences.

The environmental and epidemiological characterization of Brindisi represents the first step to set up environment-health indicators, which represent the core of a site-specific surveillance system.

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