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First Plenary Conference

Industrially Contaminated Sites and Health Network (ICSHNet, COST Action IS1408)

Istituto Superiore di Sanità
Rome, October 1-2, 2015

PROCEEDINGS

Edited by R. Pasetto and I. Iavarone

AMBIENTE E SALUTE

ISTITUTO SUPERIORE DI SANITÀ

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This volume reports the contributions to the First Plenary Conference of the COST Action IS1408 (*Industrially Contaminated Sites and Health Network,* ICSHNet), held in Rome at the Istituto Superiore di Sanità (the National Institute of Health in Italy) on 1-2 October, 2015. The first section focuses on the Action's framework, objectives, tasks and goals, the principal challenges for science and policy posed by Industrially Contaminated Sites (ICSs), and the progress in the management of ICSs in Europe. The second section concerns methodological issues related to the impact of ICSs, including exposure assessment, environmental burden of disease, integrated environmental health impact, ecological public health, residential cohorts and geographic epidemiological studies based on *a priori* evaluation of the scientific evidence. The third section includes 17 European case studies from participating countries, describing environmental health assessments, human biomonitoring surveys, risk management and remediation activities related to ICSs.

Key words: Industry; Contaminated sites; Health impact assessment; Human exposure; International cooperation

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Questo rapporto include i contributi alla Prima Conferenza Plenaria della COST Action IS1408 (*Industrially Contaminated Sites and Health Network,* ICSHNet), tenutasi a Roma, presso l'Istituto Superiore di Sanità, il 1-2 ottobre 2015. La prima sezione del rapporto fornisce il quadro di contesto della COST Action, descrivendone gli obiettivi, i compiti, le principali sfide per la scienza e la politica poste dai Siti Industriali Contaminati (SIC), e lo stato di avanzamento nella gestione di SIC in Europa. La seconda sezione affronta aspetti metodologici dell'impatto dei SIC, inclusi gli approcci emergenti per valutare l'esposizione, il carico di patologie dovuto all'ambiente, l'impatto integrato ambiente e salute, l'approccio ecologico in sanità pubblica, le coorti residenziali e gli studi epidemiologici geografici basati sulla valutazione *a priori* dell'evidenza scientifica. La terza sezione include 17 casi studio europei riguardanti valutazioni di impatto sulla salute, biomonitoraggio, gestione del rischio e attività di bonifica nei SIC.

Parole chiave: Industria; Siti contaminati; Valutazione di impatto sulla salute; Esposizione umana; Cooperazione internazionale

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FOREWORD

In Europe, earlier industrialization and poor environmental management practices have left a legacy of thousands of contaminated sites. Past and current industrial activities can cause local and diffuse contamination, to such an extent that it might threaten human health of resident populations. Moreover, health, environment, and social aspects are strongly interconnected, local communities are often alarmed, and both scientists and policy makers have expressed concern. Distinct research initiatives on the health impact of contaminated sites have provided considerable pieces of evidence, however data are sparse, and assessments are characterized by a fragmentation of objectives and methods. It is therefore urgent to promote coordination and collaboration between researchers and risk managers to identify common strategies at European level to deal with this issue more systematically.

A long lasting collaboration between the World Health Organization (WHO) and the Istituto Superiore di Sanità (ISS, the National Institute of Health in Italy) on the health impacts of contaminated areas lead in 2013 to the institution of a WHO collaborating Centre for environmental health in contaminated sites at the ISS (http://apps.who.int/whocc/Detail.aspx?cc_ref=ITA-97&cc_ref=ita-97&).

As a result of these activities, in 2015 the proposal for a COST (European Cooperation in Science and Technology) Action on Industrially Contaminated Sites and Health Network (ICSHNet: http://www.icshnet.eu/) was approved, and the first Plenary Conference of the 31 participating countries was held in Rome (1-2 October 2015) at the ISS, the scientific coordinator and grant manager of the Action (http://www.cost.eu/COST_Actions/isch/IS1408).

COST supports trans-national cooperation, contributing to reducing the gap between science, policy makers and society throughout Europe and beyond. As a precursor of advanced multidisciplinary research, COST plays a very important role in building a European Research Area (ERA). COST anticipates and complements the activities of the EU (European Union) Framework Programmes, constituting a "bridge" towards the scientific communities of COST Inclusiveness Target Countries. It also increases the mobility of researchers across Europe and fosters the establishment of scientific excellence (http://www.cost.eu/).

This ICSHNet Action aims at establishing and consolidating a European Network of experts and institutions, and developing a common framework for research and response in environmental health issues related to industrially contaminated sites, also accounting for local needs and feasibility. The benefits of the Action concern scientific, societal, environmental and public health aspects, and will result in the collection, formulation and dissemination of information and advice on contaminated areas, environment and human health. This information will include consideration of health and social inequalities, provision of guidance and resources on risk Governance and communication on environmental health risks in contaminated areas, including the transfer of scientific findings into the policy making process.

The participating countries are Albania, Belgium, Bulgaria, Bosnia and Herzegovina, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, fYR Macedonia, Greece, Hungary, Iceland, Ireland, Israel, Italy, Lithuania, Montenegro, The Netherlands, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Switzerland, Turkey, United Kingdom, with the official support of the WHO European Centre for Environment and Health, and of the Directorates Environment and JRC (Joint Research Centre) of the European Commission.

Ivano Iavarone
Chair of the COST Action IS1408

SECTION 1
Action’s framework

INDUSTRIALLY CONTAMINATED SITES AND HEALTH NETWORK

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In Europe the percentage of people living close to contaminated sites is large. The European Environment Agency (EEA) estimated that about 342,000 sites require clean-up, corresponding, on average, to 5.7 estimated CSs (Contaminated Sites) per 10,000 inhabitants. The principal sources of contamination in these contaminated sites are represented by industrial activities, including industrial waste disposal and treatment, causing about two thirds of overall soil contamination; these estimates have not greatly changed from 2006 to 2011. The key contaminants are similar in the liquid and the solid matrices. The main contaminants are heavy metals, mineral oils and aromatic hydrocarbons (1).

Among contaminated areas, Industrially Contaminated Sites (ICS) are of high concern from a public health perspective, mainly due to the toxicological profile of many contaminants, to the exposures experienced by local populations, and to the potential health effects and impacts in populations living in such areas.

Characterizing the overall impacts of industrialized areas is however a challenging task. This is linked to several factors often related each other, including: heterogeneous hazards and chemical mixtures affecting several environmental matrices (soil, air, water and food chain); multiple agents from multiple sources, mostly assumed not to interact; close contiguity of industrial settings to urban areas, often densely populated; difficulty in gathering quantitative exposure estimates; multiple aetiology of most potentially related diseases; complexity of the socioeconomic context, including occupational patterns and issues of inequalities and environmental justice.

Health, environment, ethical and social aspects related to contaminated sites are strongly interconnected: disadvantaged people often live in polluted areas, near industrial and waste dumping sites, with poor-quality housing, limited access to green space and higher prevalence of lifestyle and occupational risk factors. Sub-groups of people at high risk from dangerous exposures like children, pregnant women, elderly people, ethnic minorities, should be better identified and protected (2).

Promotion of public health in contaminated areas is a central theme of a long-standing collaborative work between the Istituto Superiore di Sanità (ISS, the National Institute of Health in Italy) and WHO (World Health Organization), carried out by sharing experiences in ad hoc workshops, conferences and publications (3-6).

Several research initiatives on the health impact of contaminated sites have provided important pieces of evidence, however data are still sparse, and assessments are characterised by a fragmentation of objectives and methods. An integrated approach is still largely missing, as many results come from studies related to single pollutants/environmental media (particularly air). Hence, notwithstanding the multiplicity of ICS, the considerable extent of their potential health impact, and the availability of sound methodology for studying their health implications, a picture of the overall health impact remains unclear, limited to localised studies, and difficult to compare. It is therefore urgent to promote international collaboration to identify appropriate strategies and methods to deal with this issue systematically.

Building on these considerations and on available experiences, the COST (European Cooperation in Science and Technology) Action "Industrially Contaminated Sites and Health Network" (ICSHNet) has been launched in 2015 in the domain ISCH (Individuals, Societies, Cultures and Health) (Action IS1408, http://www.cost.eu/COST_Actions/isch/Actions/IS1408).

COST is the longest-running European framework supporting trans-national cooperation among researchers across Europe. According to the COST's institutional mission, the COST Action primary goal is to establish and consolidate an international network of experts and institutions, and develop a common framework for research and response on environmental health issues related to industrially contaminated sites.

To reach the above goal the COST Action was structured and organised in 4 Working Groups (WGs) dealing with *Environmental and health data* (WG1), *Methods and tools for exposure assessment* (WG2), *Methods and tools for health risk and health impact assessment* (WG3), and *Risk management and communication* (WG4). The WGs activities are planned to perform the following overall tasks: 1) clarify needs and priorities among participating countries on the environmental health issues related to industrial contamination in Europe; 2) support collection of available information, methods and data; 3) promote shared initiatives and develop guidance and resources on exposure evaluation, risk assessment, management and communication across Europe; 4) address a comparative reading and interpretation of existing data on health of citizens who live in contaminated sites; 5) create the conditions for the undertaking of comparable HIAs (Health Impact Assessments) of contaminated sites in Europe; promote guidance on interventions to protect and promote public health in contaminated areas.

One of the major relevant features of the Action is the multidisciplinary composition of its participants, which is likely to allow the identification of integrated evaluating approaches. The Action can count on experts and institutions from many different relevant disciplines and with different mandates and institutional roles (primary etiologic research, risk assessment and management, health impact assessment, international coordination, as well as food safety, air pollution, chemical safety, waste management, risk prevention and reduction, European chemical legislations, inequity, environmental justice, occupational exposures and risks, among the others).

Capacity building in environment and health has been recognized as a critical issue by the WHO. This is particularly true in low income countries, where the legacy from the past and the rapid economic transition result in high environmental contamination with industrial origin. These countries, also corresponding to less intensive research regions, are often unprepared to face the challenge of adequately addressing the growing burden of disease arising from environmental exposures in industrially contaminated areas.

Training schools and short term scientific mission for early-stage researchers on environmental health in contaminated site are among the milestones of the Action. They will promote exchange of knowledge and experiences among participant countries. The Action training activities will be specifically aimed to strengthen in-country building capacity to deal with contaminated sites issues, by teaching early career investigators on how appropriately respond to current and emerging challenges in this area.

The COST Action is fully open to any cooperation worldwide. The COST Action dissemination plan is based on direct interactions with government organisations, EC (European Commission) and European Union's agencies and international organisations, like WHO, in order to facilitate expanding and consolidating networks and mechanisms for the collection and dissemination of information on environment and health in contaminated sites, through a mutual benefit in organisation of conferences, workshops, training and dissemination activities. These activities will ensure that the outcomes of the COST Action are made available to all relevant and potentially relevant stakeholders and interested parties, including the populations who live and/or work in or near industrial facilities, public authorities with an environmental or public health mandate and especially with responsibilities for the health surveillance, monitoring and management of industrial facilities established or suspected of environmental contamination, and responsible for remediation of contaminated sites.

The outcomes of the COST Action concern scientific, societal, environmental and public health aspects. The environmental health issues related to industrially contaminated areas must be addressed through an intersectoral approach if we are to protect health and maximise wellbeing and prosperity in such areas. Assessing the health dimension of contaminated sites has therefore to be seen as part of a social negotiation, where the legitimate needs and aspirations of vulnerable groups, children, residents, workers, investors and business are taken into account, in a non-discriminatory process.

The ICSHNet, currently involving WHO, EU and EC bodies and many public health institution of 30 countries, is expected to identify research needs and priorities across Europe and to produce guidelines on how characterizing and managing health issues in ICS, as well as a contribution on how to transfer scientific findings into the policy making process.

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INDUSTRIALLY CONTAMINATED SITES AND HEALTH: CHALLENGES FOR SCIENCE AND POLICY*

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Since the 1980s, Member States of the WHO (World Health Organization) European Region (currently 53) have been part of the so-called European Environment and Health Process (EHP), collaborating on concerted actions to identify priorities, address environmental risks and promote health-supportive environments. Since its inception, the process has involved the two sectors, health and environment, on equal footing – an early example of intersectoral work, or what has later become known as a Health in All Policies approach. The need for intersectoral action has been recently underlined by Health 2020, the WHO Regional Office for Europe's flagship public health policy framework, which advocates whole-of-government and whole-of-society approaches, thus acknowledging the importance of considering the broad spectrum of health determinants, including distal ones, often controlled by sectors other than health (1).

The EHP has been marked by a series of five ministerial conferences, beginning in 1989 with the Frankfurt conference. The fifth conference took place in Parma in 2010 and produced, among its many outcomes, the Parma Declaration on Environment and Health, where Member States and other stakeholders (United Nations agencies and other international organizations, the European Commission, non-governmental organizations) agreed on common priorities and committed to pursue time-bound targets on air quality, water access, chemical agents, asbestos-related disease and children's environments (2). The EHP is currently moving towards its sixth Conference, scheduled for 2017, for which a "roadmap" has been developed and agreed by Member States. The roadmap is based on eight themes, in part confirming existing priorities, and in part introducing broad domains – in line with the growing realization of the importance of addressing complex and multidimensional health determinants. The themes are: air, water, chemicals, waste, energy, food systems, disasters and climate change, cities. In 2016 and 2017, Member States will work to identify specific objectives and targets for implementation of policies for reducing risks and impacts, and promoting healthy environments for all European citizens, with special attention paid to vulnerable and disadvantaged groups.

Industrially contaminated sites, already recognized by several health agencies, including WHO, as an important public health issue in Europe (3), are of direct relevance for several themes of the roadmap. In fact, they cut across the majority of them, and represent a conspicuous case of the kind of complex, multidimensional health determinants that modern orientations in public health, like those inspiring Health 2020, focus on. It is in fact become apparent that persisting health impacts due to environmental factors require policy responses capable of influencing not only the direct causes of disease, but also the "causes of the causes" and take into consideration, in other words, the web of causation leading to adverse health effects.

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* The authors are staff members of the WHO Regional Office for Europe. The authors alone are responsible for the view expressed in this publication and they do not necessarily represent the decisions or the stated policy of the World Health Organization.

Industrially contaminated sites play a significant role in multiple locations of such a web. Knowledge of such complex patterns of health causes and effects is difficult to build, and evidence is often incomplete. Proper assessment of the health impact of living in an industrially contaminated area, or near a polluting site, is challenging, given the occurrence of multiple risk factors. Numerous different contaminants are invariably present, alone or in mixtures, involving multiple environmental matrices and pathways (air, water, soil, food); other agents are often of relevance as well, for example noise; and powerful, lifestyle-related risk factors such as tobacco consumption or poor diet are also involved because of socioeconomic gradients, in that disadvantaged communities tend to be overrepresented in contaminated sites. As has been documented extensively in the literature, this combination results in a situation whose complexity can hardly be addressed by epidemiology or toxicology, and risk assessments exercise can only be partial, focusing only on specific agents or health outcomes.

Even so, available evidence on the health impact of industrially contaminated sites, if somewhat sparse, is rich and provides strong indications of the significant role that these sites play on people living in their vicinity. Unsurprisingly, given the heterogeneous nature of the risk factors involved mentioned above, many different health effects have been documented, including mortality, morbidity, hospital admissions, reproductive outcomes (4).

Against this background, WHO has been working for a long time in the area of industrially contaminated sites, through leading assessments (5) and promoting expert consultations (3). Given the highly heterogeneous nature of its European Member States, this work has taken into consideration very different realities in terms of past and present contaminated sites. Regional commonalities exist, however. In many cases, legacy from past industrial activities plays a central role. For example large and strongly polluting industrial facilities built in the 1950s-60s in western Europe, and gradually improved to comply with increasingly stringent national and European Union legislation, in some cases still pose serious health threats (6); left-overs from past industrial, mining or military operations in areas of the former Soviet Union remain a reason of concern (7); dismissed waste landfills are ubiquitous and may affect health, especially in densely populated areas or countries (8).

Current industrial activities, undertaken more recently, can also result in environmental contamination causing measurable health impacts. Power generation, for example, produces particle emissions with well-established and quantifiable increases in mortality and morbidity, which can be accurately described thanks to dispersion modelling and to reliable concentration-response functions, available for several health endpoints. Although this kind of evidence is rather partial (because particulate matter is but one of the risk factors), it has proven very useful for advocating the use of cleaner fuels and technologies.

Another distinctive feature, shared by many contaminated sites, is that they often involve marked health inequalities. As mentioned above, these sites, being in general not attractive residential areas, tend to be inhabited by people of lower socioeconomic level and deprivation gradients are often seen around contaminated sites. Given the concurrence of multiple contaminants, the social disadvantage, and additional burden imposed at the individual level by unhealthy lifestyles, contaminated sites can sometimes be seen as “hotspots” of generally bad environment and health, where pressures on health from different sources can produce peaks of bad health, in otherwise healthy populations. In addition society at large obviously benefits from the output of industrial activities, thus introducing an additional dimension of environmental (in)justice.

For these reasons, the issue of human health in industrially contaminated areas is best addressed with a strong sustainability perspective, taking into account, on the one side, the evidence on health effects and impacts, but considering the broader context of environmental and ecosystem health, as well as the social environment – including the occupational opportunities that arise from industrial activities. As said above, all of this requires an intersectoral approach, and has to be seen as a part of a social negotiation, where the legitimate needs and aspirations of vulnerable groups, residents, workers, investors and business are taken into account, in a fair process.

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LINKING ENVIRONMENTAL AND HUMAN HEALTH DATA TO CONTAMINATED SITES IN EUROPE

"When soil becomes sicker, so too do the people who rely on it"
Nature 2015;517:411-2

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This paper informs about the indicator established to monitor the progress on the management of contaminated sites in Europe, which is based on the Joint Research Centre (JRC) reference report "Progress in the management of contaminated sites in Europe" and about the development of the Information Platform for Chemical Monitoring (IPCheM) aimed to ensure a more coordinated approach for collecting, storing, accessing and assessing of data related to the occurrence of chemicals and chemical mixtures in human populations, in the environment, consumer products, food and feed (1,2).

A set of indicators contributes to the Core Set Indicator "Progress in the Management of Contaminated Sites" (CSI 015) of the European Environment Agency (EEA) (3), which is used for reporting on the State of the Environment in Europe (4). The indicator identifies local soil contamination as an important threat to human health and ecosystems. It aims to inform policy makers, professional practitioners, researchers, citizens and the media on the various Directives and projects related to soil protection. Data are collected from the National Reference Centres for Soil in 39 countries belonging to the European Environment Information and Observation Network (EIONET) during campaigns organised by the JRC European Soil Data Centre (http://esdac.jrc.ec.europa.eu/).

Contaminated sites are sources of pollutants in the form of chemical mixtures. At present there is an increasing focus on the effects on human health arising from air, water, soil and food exposure to many different chemicals. People living in the neighbourhoods of contaminated sites can be exposed to chemicals via multiple routes. In year 2009 the European Council in particular, invited the Commission,

> "… to assess how and whether relevant existing Community legislation adequately addresses risks from exposure to multiple chemicals from different sources and pathways, and on this basis to consider appropriate modifications, guidelines and assessment methods, and report back to the Council by early 2012 at the latest" (1).

European Union's bodies, Member State authorities and research organisations make significant efforts to monitor numerous chemicals in various matrices, (water, soil, sediment, biota, indoor and outdoor air, feed, food, products, etc.) either stemming from requirements of EU legal acts, or national and international initiatives and scientific purposes. However, to access this information today policy makers and scientists are forced to search and retrieve data from many different sources, using different interfaces with different level of accessibility. As a consequence, they cannot easily compare data or promptly recognize missing information in term of spatial coverage and temporal trends. This results in a lack of organised information on the hazardous chemical exposure and burden on the human population and the environment, and represents a major gap in the European Commission knowledge base for chemical policies.

To fill the gap in knowledge base for the European chemical policies and to overcome the lack of information on the chemical exposure and burden on the humans and the environment the Commission developed IPCheM, the Information Platform for Chemical Monitoring (https://ipchem.jrc.ec.europa.eu) a single access point for discover, access and support the assessment of chemical monitoring data across Europe,

> "… support improved understanding of the chemical mixtures to which human populations and the natural environment are actually exposed by promoting a more coherent approach to the generation, collection, storage and use of chemical monitoring data in relation to humans and the environment, through the creation of a platform for chemical monitoring data. This would help identify links between exposure and epidemiological data in order to explore potential biological effects and lead to improved health outcomes" (1).

IPCheM has been designed as a decentralised system to provide remote access to existing chemical monitoring data and information systems: while providers maintain the structure of their databases, the provision of data therein is harmonised in order to be accessible, retrievable and comparable through a unique interface. This creates greater visibility and promotes a wider use of valuable chemical monitoring data, thus increasing the knowledge base for sound risk assessment, management and communication. Combining information and chemical data from different sources on a variety of environmental media, consumer products and food, and ultimately from human beings themselves, provides the basis for better understanding of the effects of exposure to chemical mixtures (5).

Contaminated sites policy context

In September 2006 the Commission adopted a Soil Thematic Strategy including a proposal for a Soil Framework Directive. This originated from the need to ensure a sustainable use of soils and protect their function in a comprehensive manner in a context of increasing pressure and degradation of soils across the EU. The commitment to sustainable soil use is in line with the Seventh Environment Action Programme (7^{th} EAP) (6) which provides that by 2020:

> "land is managed sustainably in the Union, soil is adequately protected and the remediation of contaminated sites is well underway",

and commits the EU and its Member States to

> "increasing efforts to reduce soil erosion and increase organic matter, to remediate contaminated sites and to enhance the integration of land use aspects into coordinated decision-making involving all relevant levels of government, supported by the adoption of targets on soil and on land as a resource, and land planning objectives".

It also states that:

> "The Union and its Member States should also reflect as soon as possible on how soil quality issues could be addressed using a targeted and proportionate risk-based approach within a binding legal framework".

In 2012 the European Commission reports on the implementation of the soil thematic strategy and ongoing activities and on the state of soil in Europe. It is highlighted the continuous degradation of soils in Europe. The 2015 Status of the Environment Report (SOER) (4) of the EEA underlines that:

> "soil stores, filters and transforms a range of substances including nutrients, contaminants, and water. In parallel, this function in itself implies potential trade-offs: a high capacity to store contaminants may prevent groundwater contamination, but this retention of contaminants may be harmful for biota".

The issue of contamination is crucial for this function as both diffuse and point source pollution can impact human health and ecosystem services, thus affecting a soil's capacity to 'regenerate'.

To date soil is not subject to a comprehensive and coherent set of rules in the Union. The protection and sustainable use of soil is scattered in different Community policies contributing in various degrees to mainly indirect protection of soil, for example through environmental policies on waste, water, chemicals, industrial pollution prevention, nature protection and biodiversity, nitrates and pesticides, sewage sludge, forestry strategy, climate change adaptation and mitigation, or biofuels.

For soil contamination 13 different pieces of EU legislation apply, for example:

- Directive 1999/31/EC on the landfill of waste addresses the presence of toxic substances resulting from a land-filling operation, on the condition that it had not been closed and covered before 16 July 1999.
- Directive 2004/35/EC on environmental liability requests liable operators to undertake the necessary preventive and remedial action for a range of polluting activities, provided that serious pollution has been caused after April 2007.
- Directive 2010/75/EU on Industrial Emissions aims to ensure that the operation of an industrial installation does not lead to the deterioration in the quality of soil (and groundwater), and requires establishing, through baseline reports, the state of soil and groundwater contamination. However, a large number of installations do not fall under the scope of the directive.

Within regional policy, investment priorities relating to the environment – art. 5(6) ERDF and art. 3(c) CF – include: a) protecting and restoring biodiversity, soil protection and restoration and promoting ecosystem services including NATURA 2000 and green infrastructures; b) improving the urban environment, revitalisation of cities, […] regeneration and decontamination of brownfield sites (including conversion areas), reduction of air pollution and promotion of noise-reduction measures; and c) limiting land take on greenfields and recycling of land, including remediation of contaminated sites. Complementary state aids for the remediation of soil contamination can be granted under the Environmental Aid Guidelines provided that the 'polluter pay principle' is respected.

At national level the situation varies a lot from one Member State to the other. Only a few Member States have specific and comprehensive legislation on soil protection, very often national soil legislation is limited to soil contamination and soil sealing. The others rely on provisions on soil protection in the environmental legal *acquis*. On the basis of non-harmonised national inventories, local soil contamination in the EEA-33 (European Economic Area - 33 countries) plus the 6 cooperating countries has recently been estimated at 2.5 million potentially contaminated sites. About one third of an estimated total of 342,000 contaminated sites in the EEA-33 plus the 6 cooperating countries have already been identified and about 15% of these have been remediated.

The EU cohesion policy plays a role for the rehabilitation of certain industrial sites and contaminated land, in the period 2007-2013 €3.1 billion have been allocated to eligible regions (mostly in Hungary, Czech Republic and Germany). The Cohesion Funds (CF) and the European Regional Development Fund (ERDF) continue to support the regeneration of brownfield sites under the current programming period 2014-2020.

Monitoring the management of contaminated sites

In the area of soil contamination, the Soil Thematic Strategy [COM(2006) 231] proposed that Member States draw up a list of sites polluted by dangerous substances with concentration levels posing a significant risk to human health and the environment, and of sites where potentially polluting activities have been carried out (landfills, airports, ports, military sites, petrol and filling stations, etc.). The proposal for a Soil Framework Directive [COM(2006) 232] lists such potentially polluting activities.

The indicator "Progress in management of contaminated sites" (Land and Soil Indicator number 003 - LSI003) (7), which is part of the thematic cluster of land and soil indicators (LSIs) (3) of the EEA, has been agreed by the EIONET-NRC (National Reference Centres) Soil more than a decade ago. It is used to track progress in the management of local soil contamination in Europe, and is also used for reporting on the state of the environment (SOER). The "Progress in the management of Contaminated Sites in Europe" report (7) produced by the JRC in collaboration with the EEA and its 39 member and cooperating countries, presents the current state of knowledge about such progress (based on data collected in 2011-2012).

In the 2011-12 data collection exercise, parameters on the number of sites were introduced, specifically the parameters "Potentially Contaminated Sites", "Contaminated Sites" and "Sites under Remediation". In previous data collection exercises, all parameters focused on the management steps (i.e. preliminary study, preliminary investigation, main site investigation, and implementation of risk reduction measures).

According to this report, the number of potentially contaminated sites is estimated at 2.5 million. About one third of an estimated total of 342 thousand contaminated sites have already been identified and about 15% of this estimated total have been remediated. Municipal and industrial wastes contribute most to soil contamination (38%), followed by the industrial/commercial sector (34%). Mineral oil and heavy metals are the main contaminants contributing for around 60% to soil contamination (Figure 1). In terms of budget, the management of contaminated sites is estimated to cost around 6 billion € annually to European countries.

However, it has been recognised that the comparability of the data across countries is limited. Although definitions of potentially contaminated sites, contaminated sites and sites under remediation have been introduced with the latest update of the indicator, it has emerged that countries and regions measure the progress in the management of contaminated sites in different ways, owing to the variability in legislative frameworks. This variability applies both to terminology (inventory *vs* register, contamination *vs* pollution) and methodology (e.g., prioritisation, liability, etc.). For the purpose of the next indicator (LSI003) update, a common understanding of the key terminology and operational procedure (management steps) is needed so that comparability across countries can be improved.

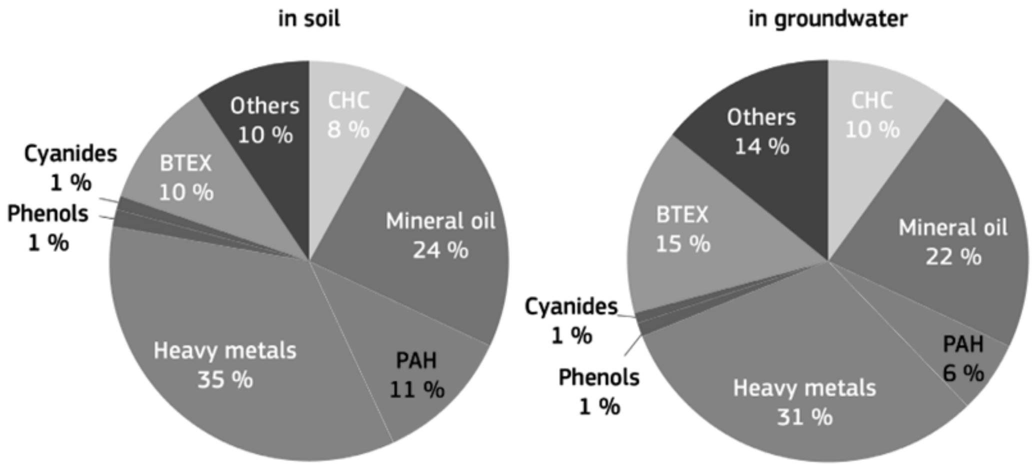

Figure 1. Most frequently occurring contaminants in soil and groundwater in Europe (BTEX: aromatic hydrocarbons; CHC: chlorinated hydrocarbons; PAH: polycyclic aromatic hydrocarbons). Source: Van Liedekerke et. al. (7)

Soil contamination research and development

The EU Research and innovation programmes, such as Horizon 2020 and LIFE+ projects, are contributing to improving the knowledge base on soils and soil protection measures, along with the JRC which hosts the European Soil Data Centre (ESDAC).

The publication 'LIFE and Soil protection' (2014) provides information on 23 LIFE projects on soil contamination (8). In these projects diverse pollution activities like landfills and waste treatment plants, industrial pollution – mainly heavy metals and mineral oil-mining, quarrying and military use are addressed.

The Research Framework Programme FP7 has financed 7 projects for a total budget of €28.460.484. More recently in 2014-2015, two calls for proposals have been launched under the Horizon 2020 "Societal challenges on climate action, environment, resource efficiency and raw materials" (9):

1. SC5-8-2014: Preparing and promoting innovation procurement for soil decontamination (2M€)
2. SC5-10-2014/2015: Coordinating and supporting research and innovation for the management of natural resources (9M€)
   a. [2014] Enhancing mapping ecosystems and their services
   b. [2014] Structuring research on soil, land-use and land management in Europe
   c. [2015] An EU support mechanism for evidence-based policy on biodiversity & ecosystems services.

Nowadays, public and private organizations are producing more evidence of the current and long-term impacts on human health and the environment from exposure to contaminants from soil and groundwater. This is very relevant at the local level, around contaminated sites, but has also implications at regional and national level. Following the initiative of the WHO meeting (8) in Syracuse (2011) and Catania (2012) a new COST (European Cooperation in Science and Technology) Action of Industrially Contaminated Sites and Health Network (ICSHNet) has been launched in May 2015 aiming to identify the knowledge gaps and research priorities, and propose harmonized methodologies and guidance on the environmental health issues related to industrially contaminated sites in Europe. In all areas (industrial contamination, landfilling, innovative restoration technologies, education, and others) there is a need to improve or update the knowledge base through a continuous dialogue with stakeholders using existing platforms (NICOLE, Network For Industrially Contaminated Land In Europe; Common Forum on contaminated land in Europe; CLAIRE, Contaminated Land: Applications in Real Environments; EUGRIS, European Groundwater and Contaminated Land Remediation Information System, EIONET-NRC Soil, etc.) and research institutions (agencies, research councils and universities) across Europe.

Information platform for chemical monitoring

There are key policy questions to support improved understanding of the chemical mixtures to which human populations and the natural environment are actually exposed, for example:

- What is the overall (via different routes) exposure of humans to a substance?
- Which is the spatial and temporal distribution of a substance within the environment, humans and food at EU level?
- Which mixture of chemicals is person living in a city exposed to?

The Information Platform for Chemical Monitoring (IPCheM) is developed to assist policy makers and scientists to respond at these key policy questions.

In the first phase of the project, the IPCheM objectives are:

- implementing searching facilities to discovery and access already-generated and future chemical monitoring data created for different purposes;
- setting up hosting facilities for data currently not easily accessible (e.g. outcomes of research projects) including data on new, emerging and less-investigated chemicals that will be searchable and accessible through IPCheM;
- providing chemical monitoring information of defined quality with regard to spatial, temporal, methodological and metrological traceability of data.

The ambition of the platform is also focused on the improvement of data quality as well as support for the risk assessment of chemical substances and mixtures.

The main scientific challenges for the project are how to handle in a transparent way the heterogeneity of sources, formats, data policies and work for the improvement of the comparability across multi-source data. Additionally IPCheM may support the evaluation of spatial and temporal trends of concentrations of chemicals and mixtures in the environment; evaluate the efficacy of risk management measures and serve as a tool to prioritise research. For these purposes it has been designed as a distributed infrastructure, avoiding data duplication and information systems replication, respecting any condition of data access and use defined by Data Providers, strengthening collaboration between different project partners and working on interoperability solutions with information systems of the same domain.

IPCheM, which is run under the responsibility of the European Commission Directorate General for the Environment as Chef-De-File and for which the JRC acts as technical coordinator, offers a unique interface to facilitate the access of Commission services. Agencies, Member State authorities and, where possible, the general public to already-generated and future monitoring data on chemicals. IPCheM will cover chemicals monitoring data for these thematic modules:

A. Food and feed monitoring;
B. Environmental monitoring;

C. Human bio-monitoring;
D. Products and indoor air monitoring.

The long term goal of IPCheM is to improve the information base for policy making to minimize the significant adverse effects of chemicals on human health and the environment, an objective agreed at the World Summit on Sustainable Development in 2002 and captured in the 7^{th} EAP (8). IPCheM is a tool for bridging the gap between national agencies, institutions and researchers that generate chemical monitoring data and policy makers who rely on a robust evidence base for decision making. The inclusion of additional data collections under IPCheM serves to enhance its coverage by pulling in data at a broader spatial and temporal range, as well as its scope in the chemical substances covered.

The vision of IPCheM for the future is the following:

- fit IPCheM into an international knowledge framework (e.g. eChemPortal of the Organisation for Economic Co-operation and Development already connected).
- collaborate, grant continuity, promote EU research projects.
- serve the needs of specific Communities as for the European Human Biomonitoring Initiative (EHBMI) be a 'two-way alert' system between environmental and food monitoring (to flag up contamination).
- become the support system for knowledge on exposure-dose-response relationships correlating health data with data on bio-monitoring, environment and food, to identify proper policy responses.

We invite all to visit IPCheM web site at: https://ipchem.jrc.ec.europa.eu and in particular the data providers to approach us and discuss modalities for the inclusion of their data in IPCheM Support: ipchem-support@jrc.ec.europa.eu

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SECTION 2

Industrially contaminated sites in Europe: methodological issues

EXPOSURE ASSESSMENT METHODS AROUND CONTAMINATED SITES

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Introduction

In this chapter we aim to give a short introduction to environmental exposure assessment and some applications to its use in the context of contaminant areas.

Exposure can be defined as "an event consisting of contact at a boundary between a human and the environment at a specific containment" (1). Before the environmental contaminants physically come into contact with the population, the contaminant needs to be *released* by the source (e.g., landfill, contaminated site, etc.). The emitted contaminant will then be *transported* through the environment across different media (e.g., air, soil, water). This will determine the exposure route or how the contaminant comes into contact with the population (e.g., inhalation, ingestion, or dermal). This exposure pathway is visualised in Figure 1 (2).

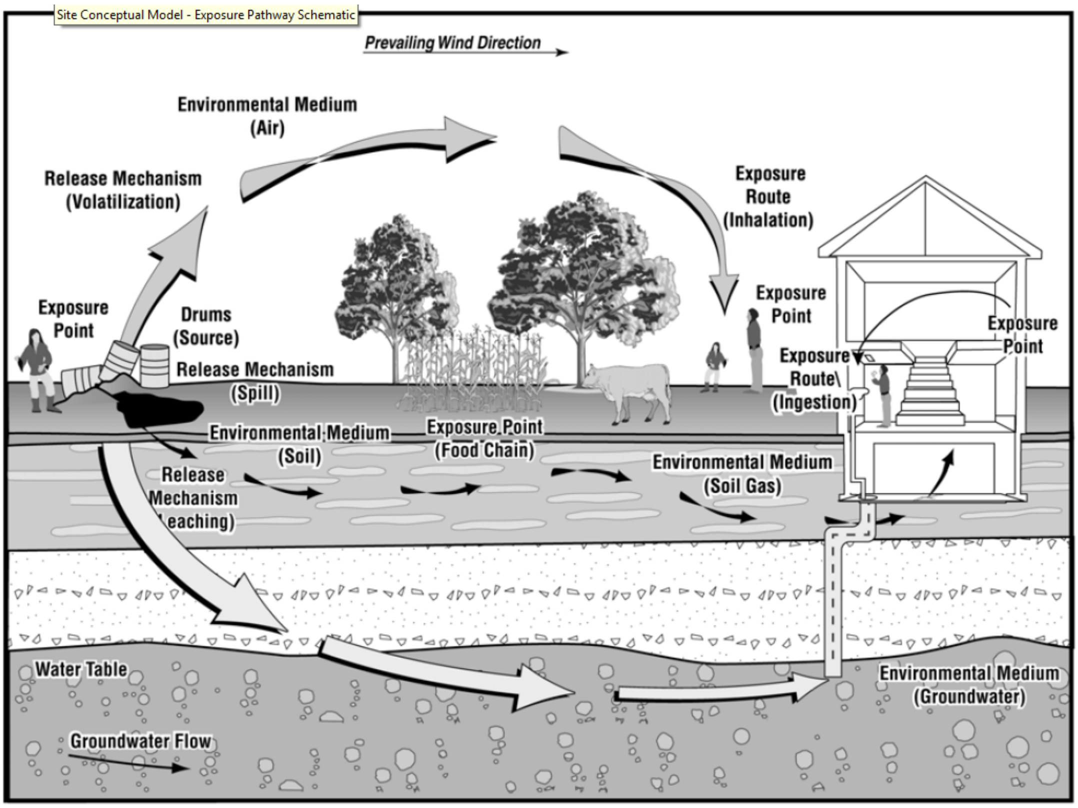

Figure 1. Schematic representation of exposure pathway (source ATSDR 2005) (2)

Exposure is important in a number of ways (3). In epidemiology, exposure forms the basis for establishing a link between a stressor and a health effect. By linking measured or modelled exposures to health data in large populations we can then also determine the magnitude of risk and establish an exposure-response relationship. In risk and impact assessment the same exposure-response functions form the basis to assign impact to the cause; e.g. an increase in x amount of pollution can lead to a y amount of extra cases of deaths. And in risk management the same information is used to run through different scenarios estimating the effect of prevention or intervention policies on the total burden of disease.

Methods

There are a number of methods available to conduct exposure assessments around contaminated areas. Often regarded as the gold standard of exposure assessment with the highest precision are methods measuring the contaminant at the individual level, either by taking blood, urine, hair samples and analyse them for levels of the pollutant of interest (biomonitoring) or by measuring contaminants with personal monitoring equipment (exposure monitoring). All other methods estimate exposures to populations, sub-populations or individuals by modelling the source to receptor pathway (source → emission → concentration → exposure). Methods, ranked in terms of precision, include:

1. Measurements: monitoring of pollutants at fixed or temporary site locations the measurements are used as direct exposures (or area averaged);
2. Indicators: such as proximity to source and/or source activity;
3. Regional modelling: modelling of concentrations using geostatistical (e.g. inverse distance weighting, kriging), dispersion or regression models;
4. Micro-environment modelling; probabilistic or time-activity modelling.

The choice of which method use in which situation is often driven by budget, availability of existing data, knowledge of exposure route, etc. Some methods are relying on specific input data (e.g., dispersion models need data on meteorology, emissions, stack characteristics, terrain, etc.) which might not always be available in certain situations. Some methods, like biomonitoring, can, due to the high costs, only be applied to small subsets of populations. When exposure routes are not well known, a simple proximity indicator might well be the best exposure measure. For example, a number of studies looking at health effects around landfill sites used the exposure metric distance to landfill site, with people living within 2 km exposed and outside 2 km unexposed. The reason for this was that exposure routes around landfill sites are extremely difficult to define, with some contaminates filtering through the soil into groundwater, ending up in drinking water or cattle or into vegetables. Landfill sites also emit fugitive emissions into the atmosphere, but, unlike controlled industrial processes (e.g. waste incinerators), records of emission rates rarely exit. In practise an exposure assessment will be a combination of methods described earlier. Geographical Information Systems (GIS) contain many of the tools needed in exposure assessment (proximity, inverse distance weighting, kriging) or can be used in combination with statistical software (regression) or specialist (dispersion) models. GIS can also help to link concentrations of contaminants to population and so establish the exposure.

Spatial and temporal variations

Exposures around contaminated sites can vary considerably, both spatially and temporally. For example, atmospheric emissions from a waste incinerator will disperse due to the local meteorological conditions, and, depending to the stack height, ground-level air pollution concentrations will peak some distance away from the location of the stack. The location of this so-called 'maximum ground level concentration' will change due to variations in meteorology (wind speed, wind direction, etc.) and emissions over time. Atmospheric dispersion models simulate these complex processes. Similar models also exist simulating transport in space and time through different media like water and soil.

Exposure misclassification

Exposure misclassification is an important issue in any exposure assessment as models are only a simplified representation of reality. Models are relying on assumptions and generalisation of the processes, interactions and feedbacks in the reality it describes. Also, exposure models make assumption about spatial patterns of environmental hazard concentrations and the individual or population under study. For example, exposures are often calculated at the home addresses of individuals, ignoring the fact that people spend more than 1/3 of their time outside the home (commuting, work, recreation). And lastly with each method of estimating exposure there are various aspects of uncertainty associated.

Confounding

Another important issue in epidemiology is confounding. Confounders are factors within the studied population which can lead to the same health end points which are being studied in relation to environmental exposures. One of the most important confounder is socio-economic position, where deprived populations are more prone to bad health, but, in many case, are more exposed to environmental pollution. It is good practise when importing population data into a GIS for calculating exposures, to also extract and obtain confounding data from for example health survey, census data.

Conclusions

Performing an exposure assessment around contaminated sites is not a trivial task. The many factors involved – in terms of establishing exposure routes, the complexity of processes involved, availability of data, budget constraints, etc. – can make it difficult to find the right method. Therefore, care needs to be taken when selecting the appropriate method in each exposure assessment.

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ENVIRONMENTAL BURDEN OF DISEASE, NEED FOR AN APPLICATION TO INDUSTRIALLY CONTAMINATED SITES

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Introduction

A risk assessment aims at characterizing the health risks and impacts associated with exposures of interest. The risk assessment paradigm developed by National Academy of Sciences in the United States in the 1980s does not propose specific risk parameters – these are chosen based on the material available. Nevertheless, it is clear that at industrially contaminated sites multiple exposures, exposure pathways and routes of intake coexist, and therefore it would be very useful to be able to characterize the risks in a comparable manner.

Comparable risk characterization allows for prioritization of risk management actions, setting research questions and evaluation of risk reduction potential, which is needed for cost-effectiveness and cost-benefit calculations. Therefore as part of the COST (European Cooperation in Science and Technology) Action on Industrially Contaminated Sites (IS1408) we propose supplementing the risk assessment paradigm with environmental burden of disease concepts that allow for comparison of health risks associated with large variety of different exposures and health endpoints.

Environmental exposures from industrially contaminated sites are associated with a large variety of human diseases ranging from lowering of cognitive performance, headaches and annoyance to cancer and premature deaths. Comparison of such risks based on incidence or prevalence rates is difficult at best. Environmental burden of disease methodology, developed by World Health Organization and World Bank in the 1990s, accounts for both years of life lost due to mortality as well as years lived with various disabilities (1). The latter are quantified using the duration of the condition together with a condition specific severity weight.

Such weights are inherently value-loaded and need to take into account differences in the patient treatment practices – e.g. the burden of disease from caries is very different when properly treated in comparison with no treatment. Nevertheless, the resulting environmental burden of disease estimates have been found useful in comparing various risks and setting policy priorities.

Improved population health registries and harmonization of disease codes together with statistical methods such as population attributable fraction that can be estimated from epidemiological data, allow for rapid and comparable international assessments.

Environmental burden of disease concepts have not been traditionally applied for industrially contaminated sites. One of the reasons is the limited spatial and population dimensions of the exposures. Environmental burden of disease is a metric that focuses on public health level issues. Therefore application to limited areas and populations requires special considerations. However, making health risks from wide range of exposures comparable for efficient risk management is attractive possibility. As part of the COST Action IS1408 activities we will attempt the application of Environmental Burden of Disease to industrially contaminated sites and will consider the strengths and weaknesses as well as give recommendations for future applications.

Methods

The Burden of Disease (BoD) is a measure of sickness and death in a population. The BoD methodology is based on making Years Lived with a Disability (YLD) comparable with Years of Life Lost (YLL) due to premature mortality. Summing these two components produces Disability Adjusted Life Years (DALY) (3):

$$BoD = YLL + YLD \qquad [1]$$

YLL in a case of premature mortality are calculated as the age-specific remaining life expectancy at the age of death. Mortality numbers, ages of death by causes, incidences of acute and chronic diseases and corresponding mean durations available in health registries are supplemented with disability weights.

Disabilities caused by various types of diseases are calculated by accounting for both the duration of the disease (L) and the disease severity expressed as a disease specific Disability Weight (DW):

$$YLD = DW \times L \qquad [2]$$

The value of the time lived in non-fatal health states, in comparison with life lost due to premature mortality, is estimated using health state weights reflecting social preferences for different states of health.

In practice, burden of disease estimates describe the overall burden in a population and generally only a small fraction of this is attributable to given environmental and other risk factors.

Burden of disease can be estimated using a bottom-up approach described in Equations 1-2. However, the mathematical properties of relative risks offer a lucratively easy way to estimate the fraction of disease burden associated with a given risk factor when epidemiological data are available. In 1953, Levin first proposed the concept of the population attributable fraction. Since then, the phrases “population attributable risk,” “population attributable risk proportion,” “excess fraction,” and “etiologic fraction” have been used interchangeably to refer to the proportion of disease risk in a population that can be attributed to the causal effects of a risk factor or set of factors (4).

$$EBD = PAF \times BoD \qquad [3]$$

As described in more detail in (1), the population attributable fraction (PAF) can be derived from relative risk (RR) as

$$PAF = \frac{f \times (RR - 1)}{f \times (RR - 1) + 1} \qquad [4]$$

where f is the fraction of population exposed to a given factor and RR is the relative risk of the exposed population.

Previous applications

Environmental BoD has been applied in several studies, including the World Health Organization Environmental Burden of Disease programme and the Institute of Health Metrics and Evaluation (IHME) Global Burden of Disease study (5).

A European example looking at national estimates for a selection of exposures was the EBoDE-study (6). It covered nine environmental risk factors selected based on their *(a)* presumed public health impact (e.g., particulate matter, second hand smoke, radon, traffic noise), *(b)* individual high risk (several carcinogens), *(c)* public concern (e.g., benzene, dioxins), and *(d)* economic values (e.g., formaldehyde). The overall annual environmental burden of disease was estimated to be 11 324 DALY/million, or 2.6 million DALY in total in the participating six countries. Fine particles were by far the dominating source of burden, followed by second hand smoke, traffic noise, and radon. Fine particles were the leading cause in all countries, but the order of the following factors varied between countries due to the national conditions.

The COST IS1408 participants have also applied the Environmental BoD methods to indoor air exposures on European level to estimate the associated burden of disease and to analyze the contribution of indoor and outdoor sources to the burden (7). In this application also a range of risk reduction options were evaluated to determine a framework for health based optimization of ventilation rates in European Union countries.

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INTEGRATED ENVIRONMENTAL HEALTH IMPACT ASSESSMENT METHODS AROUND CONTAMINATED AREAS

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Introduction

Assessment of health impacts of industrially contaminated sites poses significant scientific challenges related to the complexity of the exposure of populations living around these areas (1). Contaminated sites may or may not lead to population exposure through inhalation of polluted air, ingestion of polluted water or food and direct skin contact, depending on the pollutant and physico-chemical processes in the environment. For most pollutants, multiple media contribute to population exposure (2). Relatively few epidemiological studies have investigated health effects directly, further complicating the assessment of health impacts. Because of the complexity and variability of the exposure, results from different epidemiological studies can also not be easily compared.

In a specific setting of an industrially contaminated site, we have two approaches to characterize health impacts. First, we could set up an empirical epidemiological study in the local setting to investigate potential health effects. Second, we could assess the health impact by assessing population exposure and use existing information on exposure response relationships from the literature to calculate health impacts.

It is important to carefully distinguish these two approaches. Though the empirical approach may seem to be the optimal choice, this is not always the case. In case of small populations, an empirical study may not have enough power to detect health impacts, particularly if the effect is not frequent, such as leukaemia in children. Health effects with a long latency period may also be difficult to detect. If registry data are used, it may be difficult to disentangle health effects related to the exposure and those of potential confounders.

Finally, ideally we draw firmer conclusions about associations if multiple epidemiological studies are available, which is not the case in a specific local setting. Other contributions in this volume further discuss empirical approaches.

Here we discuss the contribution of Integrated Environmental Health Impact Assessment (IEHIA) implementing the second approach.

Integrated environmental health impact assessment

The IEHIA has been proposed as a method for health impact assessment in complex settings (3). It should be distinguished from risk assessment and health impact assessment, which have a narrower scope.

Risk assessment has been developed to assess risks related to chemical exposures and is viewed as a scientific process (http://www.epa.gov/risk).

Health Impact Assessment (HIA) has a broader scope than risk assessment. HIA deals with the health impacts of policies/actions and often compares the health impacts of at least two scenarios, such as the setting with and without the policy in place. HIA is a scientific process, but includes interaction with stakeholders. Guidelines for conducting a solid HIA have been developed by WHO and others. Impact pathways are part of the assessment. IEHIA is applied in complex settings with multiple health effects and interests. IEHIA goes beyond assessment of pollutants, but includes positive effects of the use of the environment as well. It is defined as (3):

> "A means of assessing health-related problems deriving from the environment, and health-related impacts of policies and other interventions that affect the environment, in ways that take account of the complexities, interdependencies and uncertainties of the real world".

Figure 1 explains the method of IEHIA.

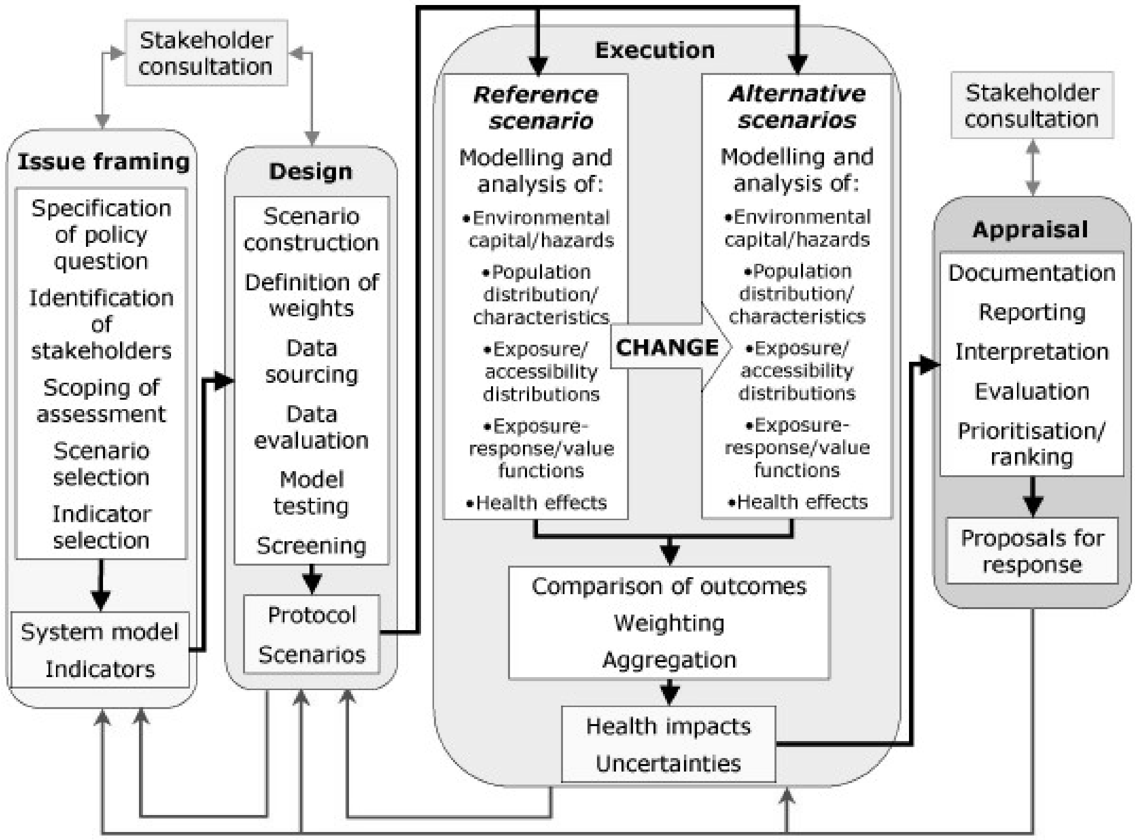

Figure 1 Framework for integrated environmental health impact assessment (source Briggs 2008) (3)

A full explanation of the rationale and methodology is included in the online Toolbox from the EU FP-6 project INTARESE. Important features of IEHIA include:

- Explicit issue framing as the framing determines the outcome of the assessment;
- Explicit involvement of stakeholders in framing and the final appraisal of the problem, to increase the acceptance of the outcome of the assessment;
- Aggregation of health outcomes, to compare the diverse health outcomes in easier to use outcomes (e.g., life years lost, disability adjust life years lost, health lost converted in economic costs);
- Transparent account of uncertainty at various levels. HIA is characterized by the necessity to make approximations in the assessment.

Application to industrially contaminated sites

IEHIA could be useful in the setting of industrially contaminated sites as these clearly represent a complex setting. Typically populations are concerned with the issue and therefore stakeholder involvement is important. Economic interests in use of the site may play an important role. A major issue in the execution of the assessment will be the limited number of previous studies that may apply to the specific location setting.

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ECOLOGICAL PUBLIC HEALTH: APPLICATION TO WASTE

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Ecological Public Health (EPH) is a new environmental conceptualisation of public health which represents a priority for the 21st century (1). EPH recognises that humans are now plundering resources and damaging planetary systems and processes in ways that will make it impossible to deliver health wellbeing and human survival in the medium to longer term. EPH demands a vast temporal and spatial extension of traditional public health activity allied to policies which respect the interconnection of social and ecological systems (2).

One practical implication of the EPH approach is the need think about the physical and mental effects of environmental exposures in a more inclusive way, going beyond toxic and infectious issues to consider both ecological and human social context in which pollution and human exposure take place. This is certainly true of waste management activities. More widely, if are to engender the necessary impetus as a society to act appropriately in the face of a growing environmental crisis public, professionals and policymakers alike must recognise the full extent of the threat to health and wellbeing from current and predicted environmental change. This is true in relation to their immediate or "proximal environment, but also of environmental changes which, for now, appear more remote or "distal". Often these distal threats remain unrecognised or are downplayed. This may be because the extent of their impacts on health, wellbeing and equity will only be felt over time or as problems only for those living in distant locations. Lastly threats may appear distal because they involve a particularly complex interplay of social and economic factors which multiply and modify risk (2).

In addition to demanding thinking on an increased temporal and spatial scale, EPH demands a rethink of many issues including evidence and its synthesis, ethics, aspects of infrastructure and governance arrangements. A precursor to such a fundamental rethink (and one which can be operationalised quickly and at limited cost) lies in the area of "issue framing". We urgently need better tools and approaches which will to frame issues in environmental public health on this new and extended scale and with overt reference to the factors (temporal and distal, social and economic, cultural etc.) which bear upon them (2).

In 2005, the Millennium Ecosystem Assessment (MEA) articulated four types of ecosystem services (the benefits humans gain from ecosystems): 1. Supporting services, 2. Provisioning services, 3. Regulating services, 4. Cultural services (3). The MEA analysis made a significant contribution to thinking around the environment and wellbeing by making explicit how disruption of ecosystem services can undermine human wellbeing, specifically, disruption of ecosystem services can deny the basic materials for good life, reduce freedom of choice, diminish the quality of social relations, undermine security and damage health itself (3).

In discussing issue framing in environmental science and public health, Reis *et al.* (4) highlighted the potential which might be unlocked by greater attention to conceptual models in environmental public health. By exploiting the concept of ecosystem services and their relationship to wellbeing, Reis *et al.* (4) developed a new tool to think about and communicate threats to health and wellbeing which are remote temporally and/or spatially as well as socially and economically complex.

The "ecosystems enriched Drivers, Pressures, State, Exposure Effects, Action" (eDPSEEA) is a development of the earlier mDPSEEA model (5). mDPSEEA was developed in Scotland as a tool to think about human social complexity in the relationship between the environment human health.

eDPSEEA takes things a step further by a integrating the Millennium Ecosystem Assessment's insights on ecosystems and human wellbeing alongside the more proximal physical, social, economic, etc. considerations embraced by the original (5). When populated for any issue by multiple stakeholders in discussion, eDPSEEA becomes a tool to identify gaps in knowledge and a way to capture both the proximal and distal health and wellbeing impacts of environmental change. The model can be used to link social and ecological systems and to integrate Health Impact Assessment with Environmental Impact Assessment (4).

Many waste related activities present both a proximal and distal threat to health through their impacts on the environment, society and the economy which demands to be understood communicated and regulated. There is significant potential to apply the tool to frame waste and human health issues in a policy-relevant way emphasising the need to regulate hazardous activity to prevent short, medium and longer term impacts on health and wellbeing. The commonplace activity of disposing of domestic waste to landfill provides a very simple illustration. Here, the proximal threat may be exposure to toxins through water supplies, air pollution or food contamination for those living in the vicinity but the distal threat to health may result from methane production which interferes with the climate regulation function of ecosystems. The resultant environmental damage and disruption of ecosystem services may occur in locations remote from the community in whose area the landfill site is situated. Use of the model also often reveals differing levels of exposure and vulnerability for different groups within society.

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THE ITALIAN EXPERIENCE ON CONTAMINATED SITES AND HEALTH: THE SENTIERI PROJECT

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Environmental health scientific literature mainly deals with the adverse health effects of (relatively) low-level but widely spread exposures, such as those associated with urban air pollution, drinking water contamination, electromagnetic fields generated by power lines and transmitters. These studies have produced over the years a remarkable amount of findings characterized by a high degree of replicability that have provided the rationale for important public health policies.

In the meanwhile, some authors have focused on the study of populations living in contaminated areas that have experienced, to different extents, elevated or even exceptionally high levels of exposure to particular agents or mixtures of agents (see for instance the epidemiological studies on "Superfund" sites performed in the US among else by Bullard and Wright (1), Sexton *et al.*, 1993 (2), Gensburg *et al.*, 2009 (3), Boberg *et al.*, 2011 (4). This sequence of studies started in the early Nineties and provided both scientific evidence on specific health impacts of environmental contamination, and, in broader terms, figures showing that communities living in contaminated sites also tend to be characterized by a fairly high prevalence of ethnic minorities and by an unfavourable socioeconomic status, the latter also being a determinant of poor health. These observations lead to the pursuit of "environmental justice", that means addressing the notion of heterogeneity in environmental risk distribution, concentrating the efforts on worst-off situation, contrasting both environmental risks and socioeconomic deprivation, pursuing environmental cleanup and support to the most vulnerable population subgroups.

The first systematic approach to the epidemiologic study of contaminated sites in Italy was coordinated by the WHO European Centre on Environment and Health that operated in Rome for about 20 years before moving to Bonn. In the subsequent years much work addressed at appropriately defining the rationale and methodology of epidemiologic studies on populations resident in contaminated sites (in Italian *Studio Epidemiologico Nazionale dei Territori e Insediamenti Esposti a Rischio di Inquinamento,* SENTIERI) was performed at Istituto Superiore di Sanità. Based on this background, the Authors of the abovementioned publications together with a number of colleagues from several Italian institutions designed a permanent epidemiological surveillance program focused on Italian populations resident in National Priority Contaminated Sites (NPCSs), the SENTIERI project.

As a first step, NPCSs to be studied were enumerated, and the criteria adopted to recognize them clearly indicated. NPCSs are selected, within a much larger number of contaminated sites managed by regional or local authorities, on the basis of the nature and extent of the contamination, the health risk and the public opinion alert.

Numerous and different environmental sources of contamination possibly leading to human exposures are usually present in NPCSs. All available NPCSs data have to be collected and described in a standardized, homogeneous way. Geographical characteristics, extension of the contaminated area and demographic information about residents potentially affected must be taken into account. Detailed description of contamination characteristics, presence of industries and other human activities that have contributed to the environmental deterioration of the NPCS have to be examined.

Populations at risk are identified as people living in the municipalities defined as contaminated. For the reference population the same data of the area units under study are needed: cases and populations stratified by gender and age categories. The reference population is selected balancing two different needs: 1) be comparable to the studied populations for factors that can affect the health profile with the exception of the contamination at study – the differences in the health profile between the compared populations should be ideally due only to the differences in environmental exposures, namely to the contamination; 2) be sufficiently numerous to obtain stable reference rates also for rare diseases. Following these criteria, the most suitable reference entity is represented by the population resident in the region where the contaminated site is located.

The aims of the study imply a sound outcome selection to include the ones for which environmental exposure/s is/are suspected or ascertained to play an etiologic role. The possible health impact from environmental exposures is measured in terms of mortality, morbidity and incidence of neoplastic diseases. General considerations about the quality of available information and data, as well as intrinsic limitations of the selected outcome have to be taken into account. An appropriate length of the period under study has to be considered in order to make research results and conclusions more informative for diseases with long latency times; precision of the epidemiological parameters will also improve with a longer study period.

In geographical studies of environment and health, confounding from social and economic factors may occur. To control such confounding effect, standardization techniques have been extensively used since the mid-1990s. To account for possible confounding from socioeconomic factors in SENTIERI project an *ad hoc* deprivation index was built and applied to the epidemiological indicators of standardized mortality, morbidity, incidence ratio.

When performing epidemiologic studies, there is a risk for researchers to become data-driven. This can be the case when commenting results for causes showing an increase, possibly on the sole basis of statistical significance. To control at least partially this problem, SENTIERI, for each NPCS focused on those diseases identified *a priori*, from the strength of their association with selected environmental exposures. This is the basic, key aspect of the SENTIERI approach. In SENTIERI possible relevant exposures were abstracted from legislative decrees, i.e. administrative sources defining NPCSs boundaries and coded on a productive sectors basis (i.e., petrochemicals and/or refineries, harbours areas, etc.). The choice was made because NPCSs had different level of environmental characterization (for some NPCSs information on specific chemical contaminants were available, for others only productive plants were listed). This is to point out that researchers should be able to adapt this approach to their specific situation. Once identified the environmental exposures of interest, researchers should examine the updated scientific literature to evaluate the associated health effects. This apparently easy task is in fact quite demanding, because by browsing the literature different kind of publications are collected: handbooks, meta-analyses, reviews, multi-centric studies, original articles, letters to scientific journals, editorials, and so on. Therefore, the first decision to be taken is about the "relevance" to give to the collected material. SENTIERI study group defined a hierarchy in the literature sources. Sources expressing the epidemiological community consensus, evaluating scientific evidence by means of standardized criteria, weighting the study design and the occurrence of biased results (i.e. monographs of the International Agency for Research on Cancer, IARC; publications of World Health Organization, WHO; European Environment Agency publications, handbooks of environmental and occupational medicine) were considered most important. They were followed in the hierarchy by quantitative meta-analyses. Multi-centric studies, systematic reviews and single investigations were also considered. Consistency among sources was a criterion used to classify the strength of the causal association. Literature sources were presented in the final report in a tabular form to let the reader follow the entire process of evaluation for each disease combined with different exposures. On the basis of explicit criteria the strength of the causal association for each disease-exposure combination was classified as Sufficient (S), Limited (L), and Inadequate (I).

A summary of the findings of SENTIERI project is provided by Pasetto *et al.* in the present report, and the reader is referred to that document in order to find the essential information. Detailed description of SENTIERI methodology and findings are available in a monographic issue of *Journal of Environmental and Public Health* (5) and in another recent publication (6). A fourth SENTIERI report specifically dealing with mesothelioma incidence in Italian NPCSs is currently in progress.

In the meanwhile, the researchers engaged in the SENTIERI project, developed a series of activities aimed at improving the adopted methodology, with special reference to the following aspects:

1. Updating of the evaluation of the available epidemiological evidence on population resident in contaminated sites, in order to generate specific hypotheses of etiological interest to be tested in data analysis, by use of a systematic review approach.
2. Improvement of environmental characterization of contaminated sites by defining in each site the Priority Index Contaminants (PICs) considering the following criteria: quality of information, presence in different environmental matrices, levels of detected concentrations, diffusion of the contamination in areas with risk for population exposure. Carcinogenicity data on PICs present in Contaminated Sites (CSs) are used to formulate specific *a priori* etiological hypotheses on cancer sites that might show excesses of incidence in the CSs at study (7). This approach has recently been applied to investigate in detail the contaminated site of Priolo in Sicily (8).
3. Application of novel statistical procedures for cancer risk profiling in the various areas at study, in order to identify priorities and tailor public health action.
4. Use of a meta-analytic approach aimed at evaluating the adverse health effects of specific sources of exposure that may be present in an adequate number of NPCSs, i.e. industrial waste landfill or illegal dumping sites (9).
5. Improvement of communications with the affected communities and specific stakeholders such as local authorities, general practitioners, teachers, non-governmental organizations, local environmentalist associations and the media. Within this activity, extensive reference is made to the recommendations of the Health Investigations Communications Work Group of the Agency for Toxic Substances and Disease Registries (ATSDR), namely to develop a relationship with the communities being investigated, to clarify the study objectives and to communicate research findings (10). An example of this approach within SENTIERI project is represented by a recent document dedicated to the community resident in Biancavilla (Sicily) and exposed to fluoro-edenite amphybolic fibres (11).

The latter point subsumes connections with two other major issues: participation and ethics.

First of all, the implementation of an appropriate communication plan has the potential to foster community involvement, which may in turn imply community-based participatory research (12). The latter, as extensively discussed in the above mentioned ATSDR paper (10), implies the assumption of responsibility for the results of community health studies in contaminated sites, including the communication process, and the identification of follow-up activities by other parties.

Secondly, involvement of communities in research (which implies verifying the community relevance of the research being proposed), protection of the most vulnerable subjects in society and pursuit of integrity in public health correspond, respectively, to the ethical principles of autonomy, justice and beneficence/non maleficence (13). The Author of this latter paper explicitly states that being mindful of the inequalities in health from contaminated sites, it will be more likely to see justice delivered to the most vulnerable population subgroups. Similar conclusions are reached by Pagliarani and Botti (14), who focus on the moral requirement of transparency both when the study findings show a clear-out evidence of the existence of a risk and when the adverse effects on health are not clearly defined. The uncertainty associated with the final results of a study does not preclude the possibility of preventive or precautionary action, and the people's right to be informed always must be respected.

These observations lead us to a concluding remark. Partnership between researchers and affected communities is essential in the epidemiological study of contaminated sites, as well as the commitment to strive for improvement of environmental quality and for health promotion. The impartial procedures adopted by investigators can coexist with an empathetic approach to the victims of environmentally caused diseases, in the frame of an "inescapable engagement" (15) aimed at preventing further suffering.

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RESIDENTIAL COHORT STUDIES TO ADDRESS ENVIRONMENT AND HEALTH IN INDUSTRIALLY CONTAMINATED SITES

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Introduction

Environmental epidemiology aims to investigate the relationship between pollution from various sources and *short-* and *long-term* health effects such as cancer, cardio-respiratory disease and reproductive effects.

Human health is influenced from the surrounding environment; this is particularly the case for people living in contaminated sites affected by the legacy of past industrialization and the current industrial activities, especially when environmental remediation is lacking.

The European Environmental Agency report on industrial emissions indicates that the cost of damage caused by emissions from the industrial facilities in Europe in 2009 is 102-169 billion of Euros, with a small number of industries causing the majority of the costs to health and the environment (1).

The health impact from industrial sites is a controversial issue with many scientific uncertainties but also with a very high media coverage and communities concern. Notwithstanding the growing of environmental epidemiological research, scanty data are available in the European countries on the effects of emissions from industrial and polluted sites.

We refer to emissions from sources such as power plants, steel plants, petrochemical plants and refineries, industries of various types.

More complex situations are also those of industrial sites with multiple production activities developed in close proximity to urban centres. A better knowledge of the effects of industrial emissions is mandatory in order to update and support European Commission’s legislation in this field, to plan mitigation actions, and to implement efficient practical measures.

We have applied an innovative approach to design cohort studies in specific areas which is based on the INTARESE (Integrated Assessment of health Risk of Environmental Stressors in Europe) model (Figure 1) (2, 3).

We integrate dispersion modelling development, full use of registry data, and epidemiology data analysis techniques to provide science-based information on health risks attributable to environmental and occupational exposures around industrial sites in Italy (3).

This approach has been applied to assess the health status of people living in Latium nearby waste disposal plants (4), nuclear plant (5) and industrial areas (6).

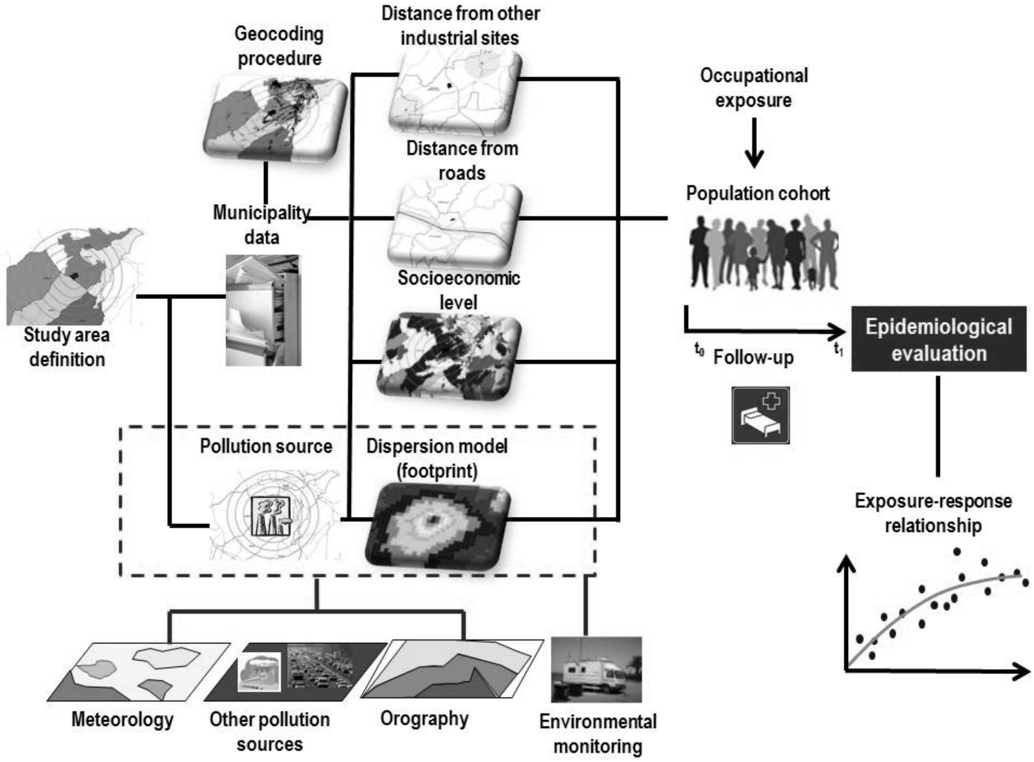

Figure 1. Integrated environment and health approach to design residential cohort studies (source Epidemiol Prev 2014) (3)

An innovative integrated approach in environmental epidemiology: a residential cohort study design

Most of available studies on the health status of people living nearby an industrial contaminated site have been conducted with an ecological approach: risk estimates reported were calculated using data from health information systems (regional archives of mortality and hospitalization) and using as denominator the national official statistics of the ISTAT (Istituto Nazionale di Statistica) (http://en.istat.it/ for Italy). The residential cohort study design is the most suitable approach for the analysis of the effects of a potential risk factor in an exposed population. It allows to evaluate the *long-term* effects of environmental exposure and to estimate the exact time when each subject is at risk of developing the event under study (person-time). The design of epidemiological cohort takes into account the individual residential history and allows assessing for each subject the individual level of environmental exposure, occupational history, and socioeconomic status. In order to conduct the study, a cohort of the population is recruited and followed-up, environmental exposure is assigned on the basis of residence, and the identification and control of a number of factors, potential confounders, is performed.

The residential cohort is defined on the basis of data from Municipal Registers. Data on the residing population are collected from Municipal Registry Offices: personal data of all people residing in the area during the study period, address information (residence changes within the same municipality included, if possible), data on the births and the deaths occurred during the period and dates corresponding to all the movements from and into the area (dates of immigration and emigration). All the residential addresses of the cohort are geocoded, assigning geographic coordinates (latitude and longitude) to each address.

Lagrangian dispersion models are used to reconstruct the spatial pattern of ground level concentrations of air pollutants. Dispersion models at high resolution are preferred in order to provide information concerning population exposure at residential level. The model simulates the transport, dispersion and deposition of pollutants emitted from the source using the characteristics of the plant, orography and meteorological data. The model follows the path of fictitious particles in the atmospheric turbulent flow, and it is able to take into account complex situations, such as the presence of obstacles, breeze cycles, strong meteorological non homogeneities and non-stationary, wind conditions. To each subject in the cohort, an exposure value of the industrial pollutant corresponding to the estimated map values at his/her address of residence at the time of inclusion in the cohort can be assigned.

We analyze natural and cause-specific mortality and hospital admissions. The underlying cause of death for deceased subjects is retrieved from the regional Registry of Causes of Death, while hospital admissions are obtained from the regional Hospital Information System. For each subject only the principal diagnoses reported in hospitalization record is used and the event is defined at the time of the first hospitalization for a specific cause during the study period.

For each subject age, gender, region of birth, civil status, and an area-based socio-economic position (SEP) index are considered. Socioeconomic status is of particular interest, since important differences in health depending on the social level have been found with a general trend towards worsening of mortality and morbidity for the most deprived populations. The indices of deprivation are multidimensional measures of disadvantage and are usually measured on aggregates defined on a geographical basis. Provided that the level of aggregation chosen is very small, for example the census block, the indices thus obtained can be related to individual subjects belonging to the units of aggregation.

Cohort members are usually linked to the National Social Insurance Agency (in Italian *Istituto Nazionale di Previdenza Sociale*, INPS) data-base, which includes information on the employing company, the industrial sector, duration of employment and worker position (blue or white collar worker) since 1974. In addition, as a surrogate of long-term exposure to traffic air pollution, the presence of a highway (in a 500 m buffer), major traffic roads (within a 150 m buffer) or industries (within 2 Km) could be taken into account.

Cox regression, Poisson regression statistical models are used to estimate the association between the exposure and mortality/morbidity risk of the residential cohort (Hazard ratios, Rate ratios and 95% Confidence Intervals).

Conclusions

Our residential cohort approach is an innovative methodology and represents a good strategy to evaluate the potential harm associated with residential environmental exposures. The use of dispersion models and the attribution of the individual exposure at residential address allow to overcome the limitations of the traditional ecological approach, while the registry-based cohort increases the statistical power of the study.

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SECTION 3

Industrially contaminated sites in Europe: national case studies

ENVIRONMENTAL CHANGE AND ENVIRONMENTAL POLLUTION IN ALBANIA

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Background

Economic, political and social system changes in Albania since post-World War II have affected industrial and environmental indicators with great potential effects on population health outcomes. From originally an agricultural country, heavy industrial complexes, along with other industries started being established from early 1950s, reaching a peak in 1970's.

The collapse of the socialist system and the introduction of neo-liberal economic policies in 1989-1990, affected abruptly the functioning and control of many of these industries, many of which were left in remnants, replaced by rapid development of smaller and less controlled enterprises across the country. Traffic density and emissions have rapidly increased in the past two decades, augmented by the use of old cars not meeting standards in other EU countries, or fuel banned in Europe. Some of the main cities in Albania are listed as the most polluted ones in Europe.

Other recent environmental contamination issues such as industrial and hazardous waste imports are also driven by the fact that Albania, as a non-European Union (EU) Member State, does not need comply with EU regulatory frameworks on environmental controls and regulations, and has no system in place for safe management of hazardous waste.

In addition to these issues, there is also lack of systematic environmental and health data collection, archiving and quality, in part driven by the rapid changes of the country's political and economic system.

As a result, it is difficult to measure the societal and population health impacts of historical environmental pollution, and specifically of industrial contamination and waste.

Examples of environmental pollution

Previous reports, international and national, have identified numerous issues in regard to environmental pollution in Albania. In 2001, the United Nations Environment Programme (UNEP) Environmental Report identified several environmental "hotspots" which required immediate attention, as posing high risk to human health and the environment[1]. Thousands of Albanians were reported of being poisoned on daily basis very high levels of fatal toxins in their environment; toxic levels thousands of times higher than those permitted in EU states were found on land where communities have built their homes, small private farming, and where animals graze. The UNEP assessment of the environmental change and pollution, recommended the Albanian authorities and international community to take urgent measures to deal with such catastrophic catalogue of environmental degradation (1). The report estimated 1500 tons of chemical and hazardous waste, 1000 tons of pesticides, wastes from copper and chromium mining, and from extraction and refining of oil, all stored on site, without adequate safeguard or monitoring systems. Some of the examples of the most hazardous sites include:

- Durres, central-Albania, on three different sites including an old chemical plant and storage for pesticides (i.e. lindane and thiram), and chemicals for leather tanning (sodium dichromate), new residents, mostly internal migrants from disadvantaged parts of Albania and refugees from Kosovo, used factory land and bricks for their homes. Drinking well water measurements on the site revealed levels of chlorobenzene to be over 4000 times the acceptable level of some EU countries. This is considered one of the worst environmental hotspots in the Balkans.
- Other examples listed are a former PVC factory in south of Albania, facing the Adriatic and Ionian sea, where soil samples showed mercury contamination 1000 times the level permitted by the EU; the continuous burning at the Sharra rubbish tip which serves the capital, Tirana, produces dense smoke, with potential toxic and harmful air pollutant spread; oil extraction and refineries in Patos and Ballsh, which have led to contaminated groundwater, soil and air pollution; one of the largest metallurgic complexes in Europe in the 1970s, closed in 1990s, is located in the valley facing one of the largest cities in Albania, Elbasan, the impact of which on soil, water and air pollution with heavy metals is still to be assessed (Figure 1).

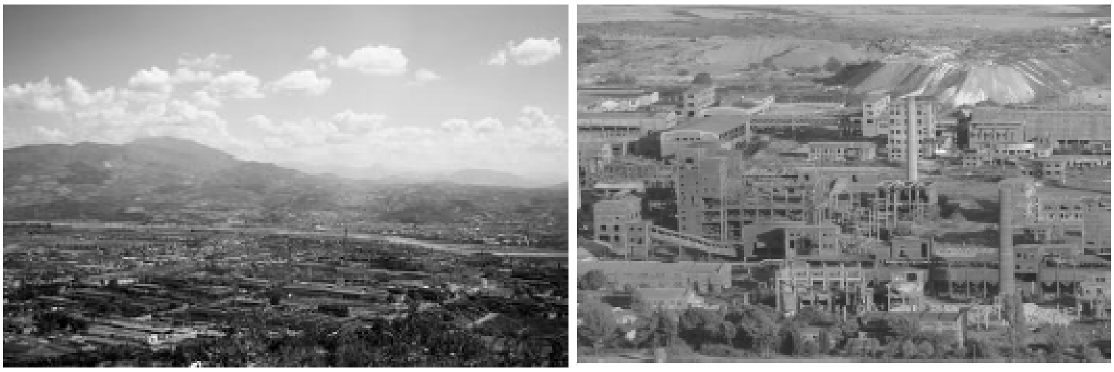

Figure 1. Metallurgic complex in Elbasan

In 2004, the Guardian published a news article titled: “Welcome to Tirana, Europe’s pollution capital” (2). At the time of this article in *The Guardian* (2004), Tirana had recorded levels of PM_{10} ten or more times greater than those recommended by the WHO, and several times higher than most other European cities. Tirana, as the rest of the country, was home to old cars that burned fuel banned in the EU (leaded fuel and diesel). Rapid urbanization and the resulting rapid increase in traffic density still contribute to very high levels of air pollutants (http://www.instat.gov.al/en/themes/environment.aspx).

The European Environmental Agency report of 2010 on the Western Balkans (3) indicates that issues of serious and hazardous environmental pollution in Albania are present and need to be addressed, requiring appropriate development and implementation of environmental legislation and policies.

Progress in environmental issues

A recent State of Environment Report by the Albanian National Environmental Agency (4, 5) highlights key points of progress (below). However, management of hazardous waste and industrially contaminated sites, and relevant policies are still to be considered.

- Albania intends emission reduction by abatement scenario to reach 48% by 2025, as mitigation measure for climate change. The measures proposed will include all the main economic sectors: industry, energy, services, transport, and agricultural.
- The completion of a national legal framework on the integrated management of waste in accordance with the EU Directive on waste.
- Improvement in the quality of coastal bathing waters during recent years, due to investments made in the waste water treatment infrastructure.
- A new law on environmental protection has been approved and entered into force in 2012, with the goal to raise the level of environment protection by establishing a consolidated network of environmental institutions at national and regional level linked with environmental policy implementation.
- One of the priorities of the Albanian government has been to complete the legislation on Air Quality (AQ) in fully accordance with the EU Directive 2008/ 50/EC. The relevant national law was duly amended.

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A COMMUNITY-BASED PARTICIPATORY APPROACH TO HOTSPOT BIOMONITORING IN BELGIUM

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Background

A Community-Based Participatory Research (CBPR) is a collaborative research approach that equitably involves community members, practitioners, and academic researchers in all aspects of the research process (1). The analytic-deliberative approach combines technical expertise with discussion of public values and preferences to achieve more acceptable decisions (2).

The participation of community members is important for the following main reasons:
- *functional argument*: broadens the knowledge base;
- *instrumental argument*: increases legitimacy and public support;
- *normative argument*: deepens democracy.

Underlying trends are:
- *Shift in knowledge production*: from positivism to constructivism (linking lay knowledge with scientific knowledge)
- *Shift in research finality*: from data-driven to action-driven
- *Shift in ethics*: from unilateral to two-way interaction (study participants are not just objects but partners)

Human biomonitoring in industrial hotspot in Flanders (Belgium)

The community-based participatory approach was applied to biomonitoring studies carried out in two Flemish hotspots: a non-ferrous industry in Genk and shredder industry in Menen (Figure 1).

The Human BioMonitoring (HBM) study was carried out to provide an answer to the following two main questions: 1) is living near the industry associated with increased internal chemical exposure and health effects?; 2) how to involve the local community in the HBM study? To respond to the first question the research strategy encompassed: i) the recruitment of 200 adolescents living nearby an industrial zone; ii) the collection of biological samples (blood, urine, hair) and submission of a questionnaire; iii) the analyses of biomarkers for heavy metals, Persistent Organic Pollutants (POPs) and Volatile Organic Compounds (VOCs).

GENK

non-ferrous industry

MENEN

shredder industry

Figure 1. Industrial hotspots in Flanders

The community involvement was required not only to obtain a high response rate among adolescents, but also to address the high concerns and trust deficit in a context of environmental injustice related to the presence of socio-economic disadvantaged neighbourhoods in the contaminated sites.

The strategy for community participation was based on four key points:

1. *Community advisory board*
   A community advisory committee was established, consisting of a flexible group of about 30 persons representing societal gatekeepers as well as local government and industry. Five meetings of the advisory board were organized during the study period in order to deal with the multi-ethnical and multi-cultural characteristics of the study population, and to define the timing of the study according to the fall back of industrial activities due to the economic crisis. Members could give voluntary advice during meetings; majority voting was organised for crucial issues.
   The research team provided feedback on the decisions made through reports.

2. *Community outreach and engagement*
   Community members helped in implementing a two-step strategy for study promotion and recruitment of participants. Two kinds of actions were carried out: 1. standard actions for the whole study area that comprised: production of promo material (i.e. brochure, poster, flyer, TV-spot), informative sessions in schools and for GPs, personal invitation letter for participants; 2. extra initiatives in disadvantaged neighbourhoods: inform key persons of the immigrant community (chairmen mosques), announcements in mosque by Turkish GP, production of flyers and posters with translated heading (in Arabic, Turkish, Italian), investment in personal contact with home visits together with trusted third party.

3. *Co-designed risk communication plan*
   The coesigned risk communication plan (Figure 2) followed golden rules of risk communication (3):
   - Scientific controversies and uncertainties are normal
   - Different actors perceive risk in different ways
   - Facilitate involvement and dialogue
   - Transparency of all results and of study design
   - Participants come first: individual and group results.

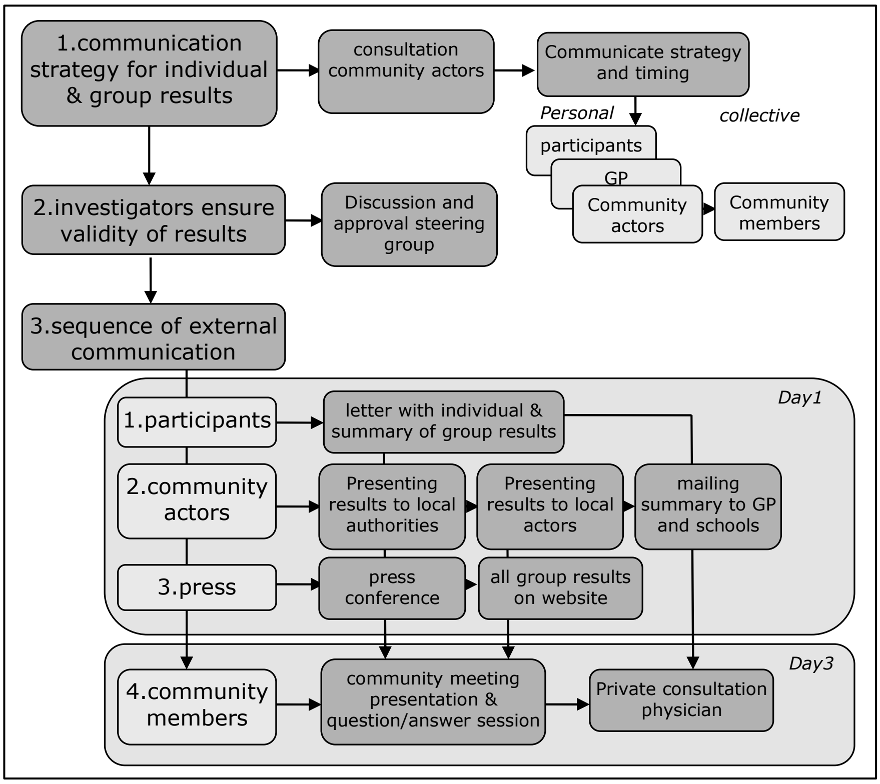

Figure 3. The communication plan for the human biomonitoring study in hotspots

4. *Participation in policy translation of the study results*
   The action plan to translate HBM results into policy actions combined analytic and deliberative steps (4) and was based on two phases: 1. selection of priorities, and 2. detailed interpretation and policy formulation (Figure 3).

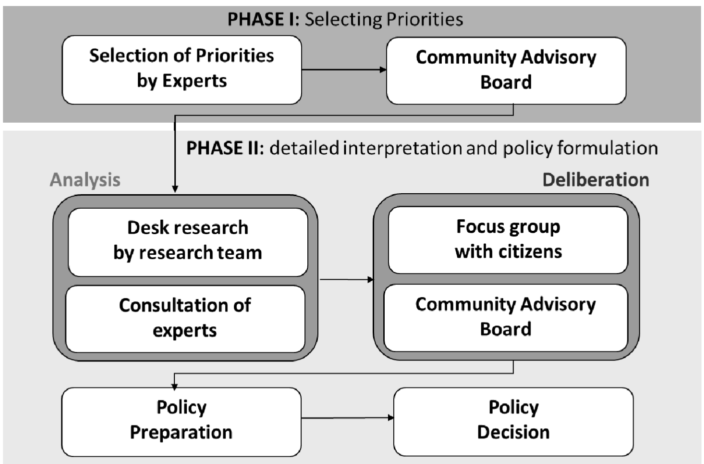

Figure 3. Phase I and II of the action plan

Community input was organised around the following key points: i) problem framing (mapping questions, concerns and expectations, and discussion on priorities preselected by experts); ii) expert consultation including non-scientific expertise and contextual evidence; iii) evaluation of the feasibility of the proposed options in specific contexts, and definition of priorities and support.

Conclusions

In a community-based participatory approach, research activities benefit from a broadened knowledge base and legitimacy. To promote an active engagement of community stakeholders, an early and sustained involvement in these activities needs to be facilitated with a transparent and two-way communication process.

Such transdisciplinary processes stimulate integration of perspectives and contextualization of research and policy recommendations. They should trigger discussion on available evidence and precaution and lead to preliminary conclusions for action.

The adoption of a community-based participatory approach is beneficial for policy uptake because it allows the implementation of more comprehensive action planning.

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RAISING PUBLIC AWARENESS CONCERNING CONSUMPTION OF LOCALLY GROWN FOOD INFLUENCES INTERNAL HUMAN EXPOSURE TO CHEMICALS IN BELGIUM

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Menen is a community in the South-West part of Flanders, close to the French border, containing a municipal waste incinerator that was active until 2005 and situated close to metal recycling plants on both sides of the border.

Elevated levels of PCBs (PolyChlorinated Biphenyls) and dioxins have been repeatedly measured in air samples and in locally grown food.

FLEHS I: 1st human biomonitoring survey (2002-2006)

A human biomonitoring survey (Flemish Human biomonitoring programme, FLEHS) was organised by the Flemish Centre of Expertise on Environment and Health between 2002 and 2006. It was financed by the Flemish authorities. Levels of environmental chemicals were measured in human blood or urine samples from representatives of the general population living in different parts of Flanders. The study participants provided information on life style, dietary habits, socio-economic status and health through questionnaires.

FLEHS I included 4460 participants of 3 age groups – newborn-mother pairs, adolescents (14-15 years old), adults between 50 and 65 years old –, recruited from 8 different areas in Flanders.

For each biomarker and each age group an overall mean was calculated. The biomarker results of Menen were compared to the mean values of the whole group using ANOVA (Analysis of Variance).

Age-specific biomarkers were compared with the corresponding overall means, by *post hoc* tests (Table 1), showing significantly higher internal exposure to PCBs and p,p'-DDE

(DichloroDiphenyldichloroEthylene, metabolite of DDT, DichloroDiphenylTrichloroethane) in Menen compared to the reference mean.

Table 1. Geometric mean concentrations of PCBs, p,p'-DDE in ng/g lipid weight, and dioxin-like compounds (Calux assay) in pg BEQ/g lipid weight for newborns, 14-15 years old adolescents, and 50-65 years old adults in Menen, Flanders (2002-2006)

Age group	n.	PCB (ng/g l.w.)	p,p'-DDE (ng/g l.w.)	Dioxin like compounds (pg BEQ/g l.w.)
Newborns	14	111*	181*	25
Adolescents	14	114*	117	
Adults	35	341.04	473.9	19.11

*Significantly higher than Flemish reference mean

Actions necessary: awareness raising

Analysis of the questionnaires answered by all 4460 participants of FLEHS I showed that consumption of locally grown food was related to higher body burden of POPs (Persistent Organic Pollutants) alike PCBs and p,p'-DDE (1). Measurements in eggs and soil from Menen confirmed high concentrations of these compounds in eggs of chickens and in gardens of local inhabitants.

To lower exposure of inhabitants of Menen to these POPs, the local and the Flemish authorities started sensibilisation actions towards consumption of food from people's own gardens. The following recommendations were given to inhabitants of Menen:

- avoid consumptions of eggs from chickens foraging in open air;
- avoid consumption of farm milk from local farms;
- remove outer leaves of leafy vegetables, wash and peel locally grown vegetables and fruit.

FLEHS II: 2nd human biomonitoring survey (2007-2011)

In FLEHS II, the results of 199 adolescents (14-15 years old) from the region of Menen (2010) were compared with the results of a Flemish reference group of 210 adolescents of the same age (2008).

In blood samples, 3 marker PCBs and p,p'-DDE were analysed. All participants completed a questionnaire on life style and nutritional habits (2).

Participants in the region of Menen significantly less indicated being breastfed as a baby, consuming locally grown vegetables and fruit and eggs from local chickens (Table 2).

In 2010, the adolescents in the region of Menen showed significantly lower serum concentrations of sum 3 marker PCBs and p,p'-DDE compared to the Flemish reference group (Table 3).

Consumption of local eggs still contributed to higher serum PCB levels (Table 4) and DDE levels (Table 5), consumption of locally grown vegetables was also associated with higher serum DDE levels.

Table 2. Characteristics (%) of the study population

Characteristics	Flemish reference group (n. 210)	Region of Menen (n. 199)	p-value
BMI boys			**0.24**
underweight	6.6	9.7	
normal weight	82.6	85.1	
overweight	10.7	5.3	
BMI girls			**0.74**
underweight	13.5	10.6	
normal weight	76.4	76.5	
overweight	10.1	12.9	
Smoking			**0.78**
non-smoker	91.3	92.5	
less than daily	4.3	3.0	
daily	4.3	4.5	
Breastfed as a baby			
yes	66.5	53.8	0.009
Locally grown vegetables			
yes	39.8	22.2	<0.001
Locally grown fruit			
yes	23.3	4.1	<0.001
Eggs local chickens			**<0.001**
yes	45.0	19.3	<0.001

BMI: Body Mass Index

Table 3. Geometric mean exposure to PCBs and DDE

Pollutant	Flemish Reference group (n. 210)	Region of Menen (n.199)	p-value
Sum 3 marker PCB (ng/L blood)	218	166	<0.001
(ng/g l.w.)	49.59	37.21	
p,p'-DDE (ng/L blood)	300	213	<0.001
(ng/g l.w.)	70.79	47.85	

lipid weight *(*l.w.*).*

Table 4. Explaining factors for PCBs (ng/L) in a multiple linear regression model

Confounder/covariate	p-value	Partial R^2
Blood lipids (mg/dL)	0.047	0.43
Gender	<0.0001	7.17
Age	0.39	0.57
BMI	<0.0001	8.53
Smoking	0.756	0.18
Education	0.0011	3.42
Breastfed as baby	<0.0001	10.14
Season	0.0035	3.65
Consumption local eggs	0.0032	3.01
Area (Flanders *vs*. Menen)	0.0004	2.17

Table 5. Explaining factors for DDE (ng/L) in a multiple linear regression model

Confounder/covariate	p-value	Partial R^2
Blood lipids (mg/dL)	0.365	0.89
Gender	0.156	0.65
Age	0.192	0.57
BMI	0.01	1.93
Smoking	0.376	0.02
Breastfed as baby	0.0003	4.19
Consumption local eggs	<0.0001	12.81
Consumption self captured fish	0.0062	3.24
Consumption locally grown vegetables	0.065	1.20
Area (Flanders *vs*. Menen)	0.023	1.09

Conclusions

Targeted awareness raising actions aiming to reduce the uptake of chemicals through food consumption in environmental polluted areas, have likely contributed to decreased exposure of inhabitants to halogenated persistent compounds.

Compared to the Flemish reference population, the participants in Menen consume less locally grown food and have significantly lower blood concentrations of PCBs and DDE. Consumption of local eggs explains 3.0% (PCBs) and 12.8% (DDE) of the variation in body burden, after correction for confounders (e.g., gender, age, smoking).

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HEALTH IMPACTS OF THE OIL SHALE SECTOR IN EASTERN ESTONIA

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Oil shale sector

Oil shale is a mineral resource that contains organic matter known as *kerogen*, when heated can produce a liquid oil very similar to crude oil. Oil shale is used for electricity generation plants and for producing shale oil, phenols, phenol products and other chemical products. The main excavation and extraction of oil shale is carried out in the Eastern-Estonia since 1916 (1).

The main pollution sources are thermal power and oil processing plants, mine and pitch waste deposit, ash fields of thermal power plants, old semi-coke deposits and also residual pollution, one of examples is phenol lakes which are the remnants of oil shale industry from Soviet times. Oil shale mining and processing affects the surrounding environment. Major possible impacts are air emissions of pollutants, groundwater contamination which in turn may affect the quality of drinking water.

During this analysis we concentrated our activity on the assessment of the impacts from ambient air and drinking water. This study aimed to identify oil shale mining and oil shale processing impact on the Ida and West-Viru counties resident's health in Eastern-Estonia.

Air and drinking water quality in Eastern-Estonia

There are two groups of air quality indicators. The first group contains general pollutants that include both those related to oil shale, and those unrelated to oil shale such as particulate matter $PM_{2.5}$, nitrogen oxides**,** sulphur dioxide**,** volatile organic compounds**.** The second one refers to specific pollutants which characterise oil shale industry impact such as benzene, formaldehyde, phenol, polycyclic aromatic hydrocarbons**.**

The analysis of the quality of ambient air has shown a clear problem in relation to industrial pollutants – formaldehyde, phenol, benzene, hydrogen sulphide, particulate matter and fine particles. The concentrations have often exceeded the limit values. However, due to introduction of new technologies and treatment facilities, the number of exceedances has been decreasing in recent years (2). As modelled concentrations from reported emissions of pollutants are lower than measured (real) concentrations, the emissions are probably higher than reported or there are problems in modelling methods (2). The modelled annual average concentrations of benzene and fine particles are shown in Figure 1.

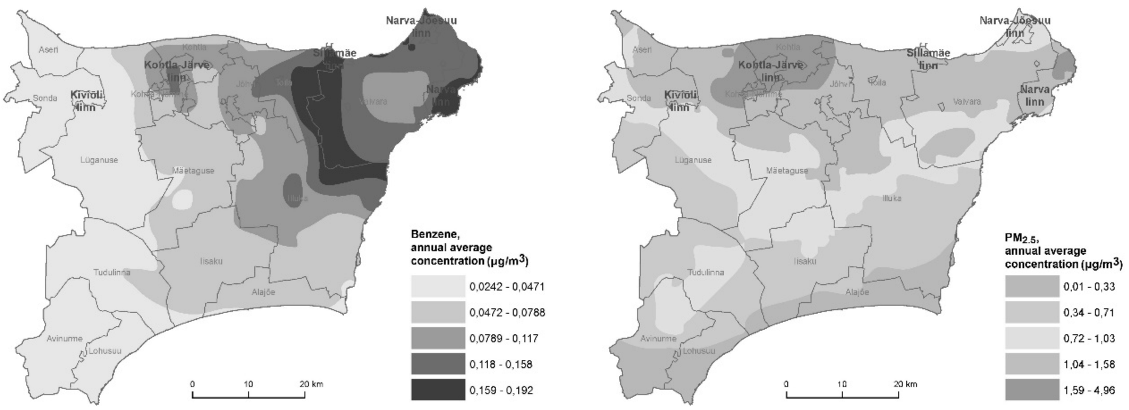

Figure 1. Annual average concentrations of benzene and $PM_{2.5}$ ($\mu g/m^3$) in Ida-Viru County

Assessment of monitoring of drinking water showed that water supplied through public water supply networks generally meets the quality requirements for drinking water (2). Qualitative risk assessment of drinking water regarding phenols, benzene, polycyclic aromatic hydrocarbons showed very low risk for health. However, the quality of drinking water obtained from private water wells (bore wells and pit wells), on the other hand, may be at risk due to pollutants originating from the oil shale industry, because the majority of the wells get water from water layers that are nearer to the surface and not protected from pollution. Nevertheless, microbiological pollution of private water wells is a greater threat, which is not related to the oil shale industry (3).

Health status of residents in Eastern-Estonia

Although the environmental situation has improved significantly in Ida-Viru County over the years, the health status of residents of Eastern-Viru County is worse in many aspects than elsewhere in Estonia. The data of Statistics in Estonia, for example, show that the life expectancy of a child born in Ida-Viru County is still nearly five years shorter compared to that of a child born in Tallinn or Tartu (cities with 400.000 and 100.000 residents).

Also, the rates of disorders of the respiratory system diagnosed in children living in Ida-Viru County and mortality from disorders of the circulatory system are higher than elsewhere in Estonia. On the other hand, mortality from accidents, poisonings and trauma is also significantly higher, which points to high risk behaviour among the residents of the region.

This region is characterised by a complex mix of problems (such as various forms of industrial pollution, legacy pollution, difficult socio-economic situation, risk behaviour, a large percentage of drug users, widespread HIV, ethnic peculiarities, etc.), which all have an impact on the health of the residents. In order to evaluate the role of the environmental pollution originating from the oil shale sector several studies have been carried out, as described in the following sections.

Epidemiological studies in oil shale sector areas

In 2014-2015 the epidemiological "Study of the health impact of oil shale sector – SOHOS" was conducted in Eastern-Estonia (2). The study consisted of *1)* questionnaire among adults, *2)* questionnaires, spirometry and exhaled NO data among 9-10-yrs-old school-children (n. 1000) and *3)* ecological analysis on cancer registry. The results in Eastern-Estonia were compared with Tartu as the control area with no industrial pollution and the connections with the air quality were also analysed.

The SOHOS study revealed that the residents of Ida-Viru County are concerned about the environment and their health. More than half of them were worried or very-worried about air quality. The analysis also showed that the residents of Ida-Viru County, compared with the reference region, complained statistically significantly ($p<0.05$) more frequently about tightness, long-term cough, phlegm in the lungs, wheezing and heart diseases, hypertension, stroke, diabetes and stenocardia. People living in regions where ambient air contained higher levels of benzene, phenol, formaldehyde or fine particles had significantly ($p<0.05$) higher odds for experiencing in the last year shortness of breath, asthma attacks, long-term cough, phlegm in the lungs, wheezing or chest tightness as well as heart attacks or angina.

Children living in East-Viru region had more frequently dry cough, mucous secretion and allergic rhinitis as compared to children living in Tartu County in the 12 months before the administration of questionnaire. The prevalence of asthma was higher in this area as well as in the other regions of Estonia as compared to a previous study (4). There was relatively high proportion of children with high values of exhaled NO among children with and without asthma diagnosis. Statistically significant ($p<0.05$) associations were observed between diagnosed asthma and ambient air formaldehyde concentration. No associations were observed with other pollutants.

The cancer registry analysis showed that men living in municipalities of oil shale mining in Ida-Viru County had higher lung cancer rates compared to the average incidence rate in rest of Estonia. One possible explanation of this result could be a higher occupational exposure to lung carcinogens among male workers in these municipalities. As environmental radon levels in mining municipalities are lower than in other municipalities in these areas, the reasons are probably either industrial pollutants or higher radon levels in mines (2). The smoking prevalence among men in Ida-Viru County has been only slightly higher than in rest of Estonia (in 2006 42.6% *vs* 39.1% at age 16+) (5).

Conclusions

It appeared that people living in East-Viru County have more health complaints and diseases whose incidence is related, among other things, to environmental pollution.

While no one doubts the necessity and importance of the oil shale sector in East-Viru County, on the other hand the results of this study show that we need to pay more attention to the state of the environment and the health of residents in the region.

The overall results suggest that some policy actions should be implemented, such as the remediation activities, interventions aimed at reducing population exposure levels, and the establishment of a surveillance system to periodically monitor the health status of the populations residing in East-Viru County. This is particularly important as the health impact is expected to concern particularly vulnerable subgroups like children.

Besides environmental, also occupational health risks are very important. The higher lung cancer incidence rates appeared among men in mining municipalities, where, besides other pollutants, high radon concentration appear in mines in Estonia.

Long-term improvement of the health of people living in East-Viru County depends on cooperation between decision-makers, scientists, local governments, businesses, health systems and local residents. Results of the study have been taken account on the preparation of the Estonian Oil Shale Strategy for 2016-2030 for planning mitigation measures and further researches.

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CONTAMINATED SITES IN FINLAND: STATE OF SRT IN 2014 AND NATIONAL RISK MANAGEMENT STRATEGY

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The number 24.600 of contaminated sites in Finland have been registered in the National Soil Statue Data System called MATTI. All sites that are suspected or confirmed cases of contamination or have already been remediated are included in the MATTI data base. The total amount of those sites continues to rise, mainly as a result of sector-specific surveys. Investigations are currently under way to study environmental contamination caused by fire drill areas and waste areas used by the extractive industry. Most of these sites were contaminated years ago. New contaminated areas are created when oil and chemical accidents occur and when waste management is neglected, but their number is limited and the area affected is usually small (1).

One third of MATTI sites are contaminated by fuel distribution. The next most common sectors are landfills and the servicing and repair of motor vehicles. Sector breakdowns describe the number of locations and, to a large extent, the focus areas of the survey, not the extent and nature of the soil contamination problem. Large-scale soil contamination occurs in industrial, storage and mining areas, as well as on shooting ranges. On the other hand, minor sites, such as dry cleaners, metal finishing facilities or salt impregnation and creosoting facilities, may have caused widespread contamination of the environment (1).

In the years 1986-2012, environmental authorities issued almost 4900 remediation decisions for contaminated land. Changes in land use or excavation and construction work have been the primary reasons for undertaking remediation. Remediation is usually related to mitigating health risks in future residential areas or classified groundwater areas. In approximately 3000 cases, remediation measures have been carried out in residential areas or in their immediate vicinity, and in around 1000 cases in classified groundwater areas. Since 2007, decisions made to remediate and the setting of remediation objectives (a risk assessment protocol) has been mandatory by the Government Decree on the Assessment of Soil Contamination and Remediation Needs (214/2007) (2) and the related guidelines (3). They emphasize the importance of site-specific assessment, especially in cases that include possible groundwater pollution.

Remediation of contaminated land is usually carried out by removing soil and depositing it off site (ex situ). In situ remediation is annually initiated on only 10–15 sites. Examples of remediation techniques used on site were containment, soil vapour extraction, biological methods and chemical oxidation. The annual amount of excavated contaminated soils sent for treatment in landfills and other facilities comes close to 1.5 million tons. Of this, approximately 10% is categorized as hazardous waste. Of the total soil volume, 70% is contaminated with organic compounds, 10-20% with metals and the rest with mixtures of contaminants. (1)

The reuse rate of contaminated soils has been high, 70–80%. Almost half of the soils transported to treatment facilities were used without treatment, as landfill cover material or in landfill structures. Most of the remaining treated soils were also taken to landfills, either for reuse or disposal as waste. So far, little use has been made of soils outside landfills and the original sites. (1)

Remediation has been supported through two national remediation programmes. By the end of 2012, a total of 370 remediation projects had been completed through the state waste management work system. Their cost was approximately €68 million, of which €30 million was funded from the state budget. The costs of investigating 715 and remediating 360 former points of distribution contaminated with oil were paid from the Finnish Oil Pollution Compensation Fund (SOILI). These costs amounted to €21 million. Funds are accumulated by collecting oil protection fees from companies that import oil to Finland.

If the surveys on soil contamination and remediation activities continue to progress at the current pace, assessment of the rate of contamination of around 20000 MATTI sites and remediation of the necessary areas will take one hundred years, i.e. be completed in the 2120s. According to a preliminary estimate, remediation is needed on some 11,000 sites. The total costs of investigations and remediation are expected to rise as high as €4 billion. Most of this will have to be paid by those responsible for contamination and the holders of the areas. Private parties have so far remediated around 60% of the sites, while local governments and the state have been responsible for the rest.

Policy framework of risk management for contaminated sites

In Finland, the risk management of contaminated land is governed by a rather consistent regulatory framework. The main legislative instrument is the Environmental Protection Act (EPA 527/2014) that integrates the regulation of environmental contamination under one law. The general purpose of the act is to promote sustainable development within the policy and practice. It also includes generic principles for sustainable environmental practice, such as the precautionary and ‘polluter pays’ principles, and the principle of using the best available technique (BAT).

However, a more comprehensive policy framework for promoting sustainable Contaminated Land Management (CLM) practice in Finland was deemed necessary. The Finnish Ministry of the Environment appointed, in October 2014, a working group to prepare a national strategy for Finland (4). The working group maintained a close interaction with multiple interest groups that included representatives from the environmental administration, regional authorities, major landowners, consultants, agents for industry, as well as researchers and experts in research institutes and universities. The working group recorded and evaluated the problems related to CLM, specified policy objectives and goals, and designed policy measures and instruments (4). The national strategy for risk management for contaminated land was completed in December 2015 (5).

The main policy goal of the strategy is to ensure that significant risks to human health and the environment due to land contamination will be managed in a sustainable way within the next 25 years. This principal goal of the strategy is further divided into six more specific objectives that are connected with required policy measures and instruments (Figure 1). The strategy serves as a policy framework that encompasses and promotes the development of several targeted policy measures and instruments for attaining the overall goal of the strategy.

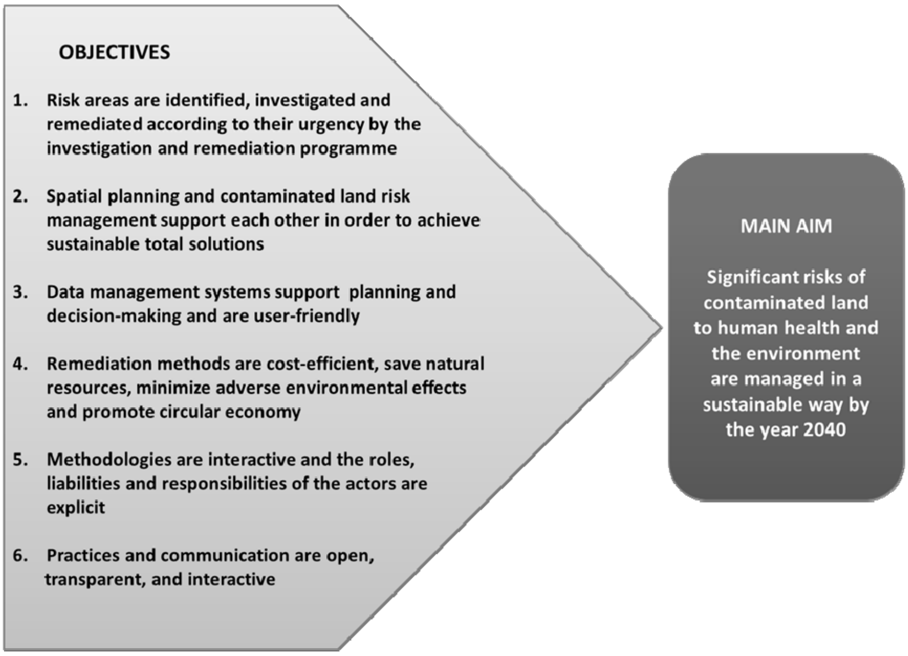

Figure 1. Main goal and specific policy objectives of the Finnish national risk management strategy for contaminated land

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INDUSTRIAL CONTAMINATION AND HEALTH IN GREECE

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Overview

The extent of industrial contamination and its impact on public health is difficult to assess fully in Greece. Key dimensions of environmental management principles such as the *polluter pays* principle are hardly ever applied, while there has traditionally been quite a significant number of industrial and municipal waste dumpsites and the informal sector of waste management is flourishing yet in an uncontrolled manner. This situation creates sever problems to the rational management of new investment and industrial activities, such as gold mining, waste recycling, or natural gas terminal stations operation. Even though both land use and emergency reaction (Seveso II) plans are mandated by law serious concerns persist regarding the public health impact of such investments. These concerns have a very negative impact on the societal acceptance of new industry or of the refurbishment of existing plants.

Currently there is a significant paucity in organised data collection with regard to industrial contamination on a regular basis. Regulatory compliance checks are made by the Environmental Inspectors of the Ministry of the Environment. Thus, collating the information made available through *ad hoc* scientific studies, the Ministry of the Environment and competent regional authority services is recognised as an urgent need in order to perform robust exposure and health impact assessment on the population level. This task becomes ever more difficult as the financial crisis unfolds and the necessary resources become more and more scarce. In the sections that follow three highlights of industrial contamination with significant ascertained and potential adverse impacts on the local and regional population are given in order to give a first experiential metric of the industrial, socio-economic and environmental settings that determine population risk from similar activities.

Asopos basin – Cr(VI)

A major local environmental issue in Greece is related to the presence of hexavalent chromium Cr(VI) in drinking water of the Oinofyta municipality (50 km North of Athens, Greece), within the wider area of Asopos basin and the related cancer mortality. In 1969, a ministerial decision gave permission for depositing processed industrial waste in the Asopos river, which runs through Oinofyta. This decision, furthered by a presidential decree in 1979, permitted free disposal of processed liquid industrial waste into the river. Initial concerns were raised after Oinofyta area citizens complained about the discoloration and turbidity of their drinking water. Regular protests ensued from the 1990s onward. In 2007, the Ministry of Environment, Regional Planning and Public Works of Greece imposed fines on 20 industries for disposing industrial waste with high levels of hexavalent chromium into the Asopos river. Since 2007, three independent sets of hexavalent chromium measurements are available for the Oinofyta area, indicating that public drinking water Cr(VI) concentrations were above 8 μg/L (1, 2). Moreover, groundwater samples from the Asopos aquifer (3, 4), showed a wide spatial variability, ranging from <2 to 180 ppb Cr total content [almost same to the Cr(VI)-values] despite their spatial association. According to official Oinofyta municipality authorities, in early 2009 the main drinking water supply of Oinofyta was diverted to receive water from Mornos lake (reservoir) which is part of the drinking water supply network of the city of Athens. Therefore, more recent measurements made by the Oinofyta municipality (June 2009 - July 2010) record relatively lower levels of Cr(VI) (<0.01-1.53 μg/L). A measurement made by the Oinofyta municipality in 1996, showed Cr(VI) levels of 54 μg/L in the public drinking water supply. Association to health effects was based upon existing epidemiological data already published by Linos *et al.* (5). The SMR (*Standardized Mortality Ratio*) for all cancer deaths over all the years was slightly increased but not statistically significantly (SMR = 114, 95%CI 94-136). For primary liver cancer, the observed deaths were eleven fold higher than the expected number of deaths (SMR 1104, 95% Confidence Interval-CI 405-2403, $p < 0.001$); statistically significant SMRs for primary liver cancer were observed among both males and females. Observed deaths associated with kidney and other genitourinary organ cancers (five deaths with ICD-9 (International Classification of Diseases, 9th revision) code 189, and one death with ICD-9 code 184) were more than threefold higher than expected in women (SMR 368, 95% CI 119-858, $p = 0.025$). The SMR for lung cancer was also statistically significantly elevated (SMR 145, 95% CI 101-203, $p = 0.047$).

Accidental Aspropyrgos recycling plant fire – dioxins release

Calculating the health burden due to increased exposure to dioxins and furans of the Aspropyrgos area (close to Athens) residents by an accidental fire in a plastics recycling plant in June 6, 2015 was the challenge of this case study. For this purpose, several type of data were combined mechanistically, including: a) dioxins and furans biomonitoring data of previous years to determine the background exposure of the population (equal to 7.3 pg/g_lipids) and b) exposure to environmental media as shaped the days of the fire. The equivalent potential toxic dioxins in the air was found to be 1.8 pg/m^3 TEQ (Toxic Equivalents) of the WHO (World Health Organization) (in accordance with measurements of the National Center for Scientific Research, EKEFE Demokritos), a value that is significantly greater than the 0.1 pg/m^3 TEQ WHO atmospheric background concentration of an industrial area (Figure 1).

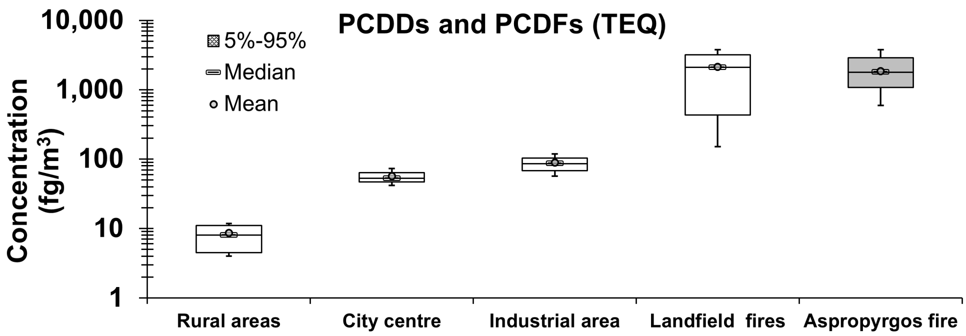

Figure 1. Levels of dioxines and furans at various Athens sub-areas, as well as during the fire in the recycling plant

In various parts of the food chain calculated values were less than 1 pg TEQ/g fat. The change of the internal exposure of the population as to the background is then calculated using a validated Physiology Based BioKinetic (PBBK) model for dioxins and furans. Considering bioaccumulation, for 6 days exposure to dioxins/furans smog, additional burden of internal exposure for the exposed population is about 13%. Cancer risk increases similarly, and is estimated equal to $3 \cdot 10^{-7}$ (Figure 2).

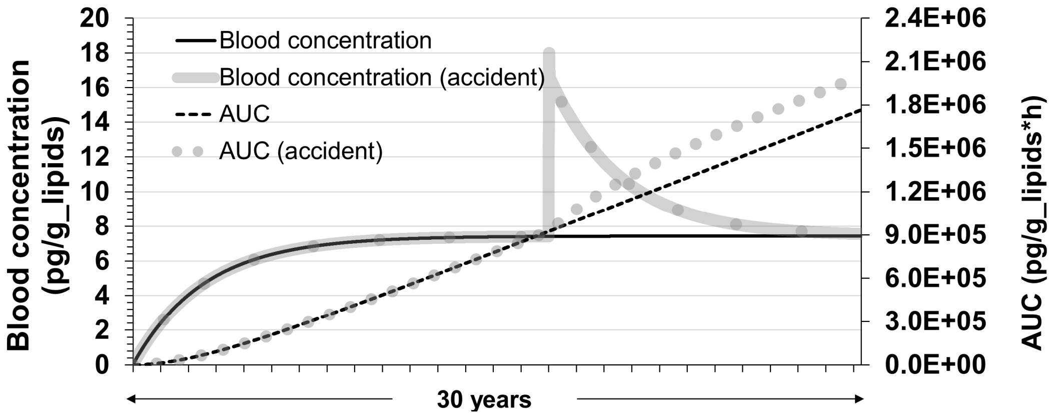

Figure 2. Internal exposure to dioxines under usual conditions (continous line) and under accidental release (doted line) (AUC: Area Under the Curve)

Goldmining in Skouries Halkidikis – heavy metals contamination

In Skouries of Halkidiki (Northern Greece), a mining company wants to establish an open-pit mine in the middle of the Skouries forest on the Kakavos mountain, which happens to be the main freshwater source for the entire region. By the company's own estimates, the open pit will generate 3,000 tons of toxic dust per hour. Galleries will be dug at 700 meters deep, taking the mine below sea level, so that even water that is not contaminated with heavy metals and other toxic materials from the mine will surely be contaminated by seawater. A 9 kilometres long tunnel aimed at connecting two mining sites will cut through a geological fault line that caused a devastating earthquake in the area in 1932. Finally, an ore processing factory will be built in the mountain where gold will be separated from other substances. The company claims this will be done without using cyanide, but this method has not been shown to be effective on Skouries ore. This raises additional concerns about the possible disposal of cyanide inside the forest. Major environmental compartments are expected to be contaminated, including:

– *Water*
  The Kakkavos mountain supplies water to the entire N.E. Halkidiki. The proposed mining activity will directly and irreversibly affect the region's water resources. The EIA does not meet any of the goals of the Framework Directive 60/2.000/EK - "Establishing a framework for Community action in water policy" which has been incorporated into Greek law.

- *Air*
  Only in Skouries the particulate emissions are estimated to 430 t/y PM_{10}, with high concentrations of heavy metals, particularly arsenic. The ore dust production sums up to 4.324 t/h with high concentrations of sulphur compounds such as heavy metals antimony, arsenic, barium, cadmium, chromium, lead, mercury, etc. The emission of carbon monoxide, nitrogen oxides, volatile organic compounds, sulphur dioxide and particulate matter PM_{10} and $PM_{2,5}$, is in total 715 t/y in the first two years of operation and over 950 t/y over the next years.
- *Soil*
  The decrease in soil pH due to acidic runoff and the high heavy metal concentration makes the soil unsuitable for organisms and plant growth. The mining activity will cause drying topsoil within kilometres of the open pit and severe soil erosion with subsequent catastrophic flood events.

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DEVELOPMENT OF RISK ASSESSMENT OF CONTAMINATED SITES IN HUNGARY AS PART OF THE NATIONAL CLEAN-UP PROGRAMME

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Soil- and groundwater contamination are special environmental-health problems, because the usually not-visible pollution is a typical example of the 'out of sight, out of mind' mind-set, that is: if we cannot see the problem, we will not deal with it. But contaminated sites represent a growing challenge due to the complex relations among environmental health, technical, methodological, socioeconomic, legal component of remediation.

The development of the environmental-health risk assessment in Hungary is described through the management of cases of significant environmental pollution that also affected the population.

Excerpts from case studies

At the beginning of the 1980s *experimental toxicological methods* were available for public health assessments of the adverse health effects of environmental pollution. An example is provided by the case study of Monorierdő, a small town in Pest county, where the soil- and groundwater pollution caused by illegally buried chemical waste led to a situation, which threatened the health of the residents. The elimination of the contamination was done by soil removal, the extend of which was determined by evaluating the toxicity of the extracts of soil samples through experiments on laboratory animals and *in-vitro* test systems. Investigating the polluted environmental samples in this way undeniably contributed to the evaluation of the health risks of multi-component chemical mixes, but it had limited usability as a basis of quick public health response due to the time- and cost intensive nature of these methods. In the meantime, the number of environmental pollution cases that threatened the environment and human health kept growing (1).

Hungary did not have to wait long for problems caused by *inadequately dumped chemical waste*. More and more hidden and uncontrolled abandoned pollution sources were revealed. In 1982, residents from several small cities situated along the Danube complained about the foul smell and taste of piped drinking water. As it turned out, the bank filtrated wells of the waterworks in the chief town of the district (Vác), which supplied these small cities, became polluted not from the Danube, but from the nearby improper disposal of 16 thousand barrels of chemical waste by Pharmaceutical Works and the seeping pollution reached the bank-filtered water abstraction site.

An abandoned tuff mine not far from Budapest was used for *open field burning of pharmaceutical waste* between 1964 and 1980 that resulted in the soil and groundwater of the site becoming heavily contaminated. The groundwater contamination endangered the nearby drinking water abstraction area of the regional waterworks. Remediation target-concentration for the soil and groundwater, calculated by reverse risk assessment procedure, was set up (2).

Factories with outdated technology caused typical contamination in industrialized areas.

A factory called Metallochemistry operated between 1910 and 1990 as a non-ferrous metallurgical plant in the Budafok district of Budapest. The plant processed tin, copper, zinc and mostly lead. Almost 1 million tons of metallurgic slag as byproduct of the production was spread out several meters thick on the factory territory. A large amount of metals got into the air as a result of production, which sedimented as a thick layer of dust on the homes, gardens, and farms in the vicinity of the factory. 1273 family houses were affected. The cost of remediation, including soil exchange, reached 40 million Euros.

Another remarkable case is the site of a former limestone mining operation in Budafok. People were living in 374 dwellings until the 1950s that were formed in the 19th century as limestone miner groove caves. The local government decided to fill up the caves with coal-gas slurry from the Budapest Gas Works where the slurry piled up since the beginning of the 20th century. The cave dwellings were filled in, then 40 years later 46 thousand tons of slurry with cyanides, and different hydrocarbons were removed from the site.

The cases could be listed with contamination caused by: filling stations, oil refineries, petroleum products storage; the repair yards of bus garages; military aerodromes and facilities; dumping of hazardous chemical wastes without soil and groundwater protection (3).

National Environmental Remediation Programme

It has become evident that the enormous volume of polluting materials accumulated almost since the beginning of the industrial revolution can only be eliminated with careful, different, purposeful research work, which would take a long time. The National Environmental Remediation Programme was adopted as a Governmental Decision in 1996. The implementation of the Programme has started and is now running without much publicity (4). The goals of the Programme are to identify the contamination of and damage to soil and groundwater, to reduce risks, and to promote the implementation of remediation projects in the fields of mining, self-government, military, transport, and other sectors. An essential task was the elaboration of technical regulations (standards & guidance) to ensure that the site investigations, surveys and analyses can be carried out with a uniform methodology, regardless of who or where would undertake them; accordingly, methodologies for risk assessments and cost/benefit calculations were developed. Modern technologies applicable in remediation were reviewed and disseminated. Publishing activity was intensified. Numerous remediation handbooks, guidelines, booklets and informative publications and brochures were published.

Concluding remarks

The scientific approach for assessing chemical risks to the environment and human health is fundamentally sound, but at the same time there is a need to amend nearly every step of the risk assessment process. Quality assurance could improve the reliability of the risk assessment process (5).

Risk assessment has been characterised on one hand as holistic-science and on the other hand as science providing solutions to local, site-specific problems. In essence, risk assessment requires that we help decision-makers in the application of the findings on the adverse effects of chemicals. As the models become more complicated and since the practical users come from different backgrounds other than the traditional modelling, it is necessary that the underlying assumptions regarding biological effects or the behaviour of chemicals in environment is taken into consideration completely. The level of knowledge in modelling and good modelling practice will greatly determine the quality of the prediction.

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HEALTH CONSEQUENCES OF RED SLUDGE CATASTROPHE IN HUNGARY

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Hungary's largest ecological disaster took place in 2010 when the dam of a red sludge reservoir ruptured.

In the first phase of the red mud disaster, health measures were primarily implemented to minimize the exposure to the extremely high alkalinity of the sludge (pH >12) and to protect the people taking part in the rescue and damage control work as well as the population.

In the damage mitigation phase the public health activity was aimed at the analysis of environmental health risks.

One of the most urgent tasks was to set up the monitoring of air pollution because the drying red sludge caused increased dusting. The concentration of iron, aluminium and sodium indicated that the airborne dust (PM_{10}) was originated or released mainly from the red sludge during the two weeks after the disaster and remained at a low level. The average concentration of PM_{10} frequently exceeded the 50 ug/m^3 daily guideline value.

The examination of the contaminated soil samples showed that among the elements of geochemical significance Al, Fe, Na, Mn and Ti occurred in high gr/kg concentrations. The concentration of toxic metals exceeded the respective limit values of soil quality but was lower than the criteria for the sewage sludge used for agricultural disposal.

Formal risk assessment based on the concentration of soil and airborne dust contaminants did not raise health concerns (1).

In the case of any large scale contamination with a direct impact on the population, the preliminary results of the model calculations give quick and useful information but cannot substitute environmental health surveillance. Therefore, the potential association between the weekly mean concentration of suspended particulate matter and the incidence of some respiratory diseases among the child and adult populations of the exposed and neighbouring settlements was examined.

PM_{10} concentration was measured in four areas, the weekly morbidity of upper respiratory catarrh, bronchitis, asthma and pneumonia was reported by general practitioners. The statistical analysis was carried out by regression methods, temperature and influenza epidemics were controlled for. A significant association was detected between the PM_{10} concentration and the incidence of upper respiratory catarrh. It is important to note, that during the heating period - from October to April - emission of pollutants originating from the communal heating of households significantly contributed to the overall PM concentration (2).

Concentrations of some toxic metals in the urine samples of children in the red sludge area were investigated to study the possible health risks due to the dust from the dried red sludge.

Each month 10 randomly chosen children were selected from both the exposed (Kolontár and Devecser) and the control (Ajka) settlements. Cadmium, nickel, arsenic, cobalt, chromium and vanadium concentrations of freshly collected urine samples of 135 children in total were analysed by ICP-MS (Inductively Coupled Plasma Mass Spectrometry). There were no significant differences in the concentrations of the various metals between the urine samples of the children from the exposed and the control sites. There was no increasing time trend observed, either. The measured concentrations were similar to those published in the international literature referring to non-exposed areas (3).

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EPIDEMIOLOGY OF INDUSTRIALLY CONTAMINATED SITES IN ITALY

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Characterizing the health impact of industrially contaminated sites involves a multidisciplinary approach, with a relevant role for epidemiology, both in the analysis of the evolving pattern of the health profiles of populations, and in the study of the associations between environmental exposures and health effects. In Italy SENTIERI Project (*Studio Epidemiologico Nazionale dei Territori e Insediamenti Esposti a Rischio di Inquinamento:* epidemiological study of residents in National Priority Contaminated Sites), funded by the Italian Ministry of Health, was planned to study the health profile of residents of 44 National Priority Contaminated Sites (NPCSs) included in the “National Environmental Remediation Programme” (Figure. 1) (1).

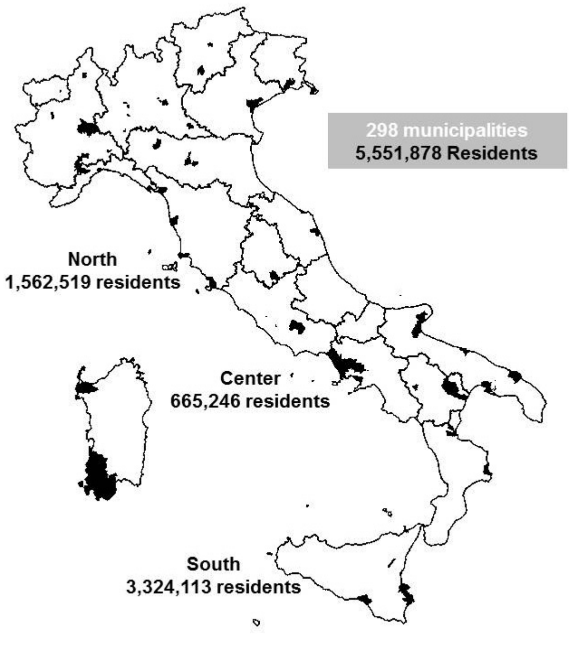

Figure 1. Location and number of residents in municipalities included in Italian NPCSs

The first SENTIERI Report was published in 2010; it describes methods and results of the *a prori* evaluation and classification of the epidemiological evidence on the associations between environmental sources of contamination in NPCSs and 63 causes of deaths with a possible environmental etiology. Environmental sources of contamination in NPCSs were classified as chemical industry, petrochemicals and refineries, steel plants, power plants, mines and/or quarries, harbour areas, asbestos or other mineral fibers, landfills and incinerators.

A second SENTIERI report was published in 2011; it describes the health profile of residents in 44 NPCSs carried out using mortality data (1995-2002).

The third Report was published in 2014; it integrates the study of mortality extended to 2010 with cancer incidence (1996-2005) and hospital discharges analysis (2003-2010) to provide a more comprehensive picture of the health profile of residents in NPCSs. These analyses are available only for 17 NPCSs covered by cancer registries. SENTIERI has become a permanent epidemiological surveillance system.

Recent developments of SENTIERI concern the description of the health status of vulnerable sub-populations such as children, (SENTIERI Kids project), the risk of adverse reproductive outcomes and Congenital Anomalies (RISCRIPRO-SENTIERI Project), and the distribution of socioeconomic inequalities and inequities in NPCSs.

In the overall 44 NPCSs analysis, the study of mortality (1995-2002) showed excesses of deaths for diseases with *a priori* Sufficient or Limited evidence of association with the environmental sources of contamination in NPCSs, with an estimated excess of 2,439 extra deaths in men and 1,069 extra deaths in women. These excesses were also observed when analysis was not restricted to the *a priori* causes of death: an excess of 9,969 deaths, an average of around 1,200 extra deaths per year for a total of 403,692 deaths (men and women combined).

In the 17 NPCSs combined the analysis of cancer incidence (2) showed an excess in both genders for overall cancer incidence (9% in men and 7% in women) as well as for specific cancer sites (colon and rectum, liver, gallbladder, pancreas, lung, skin melanoma, bladder and Non Hodgkin lymphoma). In the following sections, the contribution of epidemiological studies in two Italian NPCSs is presented.

A site contaminated by a petrochemical complex

Gela is a town of approximately 80,000 inhabitants located by the sea on the southwest coast of Sicily Region, in southern Italy. Crude oil was found in Gela underground in the late ‘50s; since the early ‘60s a vast area of the Gela municipality, nearby Gela town, has hosted a large oil refinery, together with a thermoelectric power plant and petrochemical plants for production of organic (ethylene, acrylonitrile) and inorganic (sulphuric acid, ammonia, chlorine, urea) chemicals. From 1998 a part of Gela municipal area – the entire petrochemical complex and an extended sea portion – was included among the Italian NPCSs.

Data collected in this site after 2000 documented groundwater, soil and air contamination. Maximum concentrations of arsenic, vinyl chloride, mercury and benzene were some orders of magnitude higher than concentration limits. It was documented that soil and shallow water in Gela were severely contaminated by metals and by organ halogenated compounds and area emissions of NOx, SOx, and benzene represented respectively 11%, 30%, and 31% of the total emissions occurring in Sicily.

Furthermore, two monitoring studies of pine needles and road dust samples showed that Gela town was heavily affected by metals and metalloids. Finally, a biomonitoring study in a group of Gela residents showed high levels of total arsenic in urine. Urinary arsenic levels higher than background levels, although indicative of recent exposures, are of interest because inorganic arsenic or its metabolites can have adverse health effects including lung cancer.

Results from studies on workers of the petrochemical plant and on the population of residents in Gela, the latter carried out using the SENTIERI approach, showed high risk for lung cancer, non malignant respiratory diseases and genitourinary diseases which are consistent with a causative role of the local contamination (3).

These results underline the urgent need of adequate monitoring programs of water, soil, air and food-chain, in order to look for active sources of exposure and to define adequate preventive strategies. In particular, an ad hoc air pollution program, as recommended since 1995, need to be implemented.

A site contaminated by a steel plant

The NPCS of Taranto, located in Apulia region (southern Italy), includes two municipalities and 216,618 inhabitants at 2001 Census. This site is of interest because of several polluting sources, such as a large steel plant, a refinery, the harbour, and both controlled and illegal waste dumps.

Environmental studies carried out in the area have provided evidence of environmental contamination. These studies have documented severe air pollution originating mainly from the steel industry, that is, particulate matter, heavy metals, polycyclic aromatic hydrocarbons, and organ-halogenated compounds.

The SENTIERI approach was applied to Taranto NPCS producing health indicators on mortality (2003-2009), mortality time trend (1980-2008), and cancer incidence (2006-2007) (4). In addition, the cohort of individuals living in the area was followed up to evaluate mortality (1998-2008) and morbidity (1998-2010) by district of residence (4).

The results from the SENTIERI approach consistently showed excess risks for a number of causes of death in both genders, among them: all causes, all cancers, lung cancer, and cardiovascular and respiratory diseases, both acute and chronic. An increased infant mortality was also observed from the time trends analysis. Mortality/morbidity excesses were detected in residents living in districts near the industrial area, for several disorders including cancer, cardiovascular, and respiratory diseases. These coherent findings from different epidemiological approaches corroborate the need to promptly proceed with environmental cleanup interventions. Most diseases showing an increase in Taranto NPCS have a multifactorial aetiology, and preventive measures of proven efficacy (e.g., smoking cessation and cardiovascular risk reduction programs, breast cancer screening) should be planned.

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CONTAMINATED SITES IN LITHUANIA

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This report is aimed to address the attention on the situation of contaminated sites, importance and need for their rehabilitation. The model for contaminated sites evaluation in Lithuania was developed and consists of two main stages – preliminary and detailed investigation. The first is used to collect preliminary information on the contaminated site and evaluate a need for detailed analysis.

Contamination of Lithuania's sites emerged from both previously and currently pursued industrial, commercial and intensive agricultural activity and various chemicals and toxic substances used in them. Dangerous chemical substances, found when examining the soil and the underground water of contaminated sites are petroleum products, heavy metals, miscellaneous pesticides and other less common dangerous chemical substances used in specific industry branches and others. The main part of contaminated territory consists of historically contaminated sites. Cleaning of the contaminated territories is a process of several stages for removing the negative impact of contaminants.

Management of potential source of contamination in many European states requires information on the status of object, their surrounding territories or geological structure, but also minimal results of pollution analysis. Principles used to evaluate contaminated territories are generally provided. Management of contaminated territories covers several stages.

Based on research work carried out in the period 1999-2014 12,089 potentially contaminated sites were identified in Lithuania (1).

Methods

There are several methods for prioritizing the potentially contaminated sites in Lithuania. These are: i) methodology for evaluating the danger of pesticide storages and division of priority sites (2), ii) methodology for preliminary evaluation of hearths of geological contamination of environment during inventory (3). Methodologies were prepared by partially considering the method of assessing the level of danger of contamination sources. The application of such methodologies enables to solve only the problems of inventory stage, i.e. perform the evaluation of danger of potentially contaminated sites and 'objects' as well as make the preliminary eco-geological research list of the most hazardous 'objects' (4).

Results

In 2009 in Lithuania more than 800 small old landfills were closed and started to operate 10 new engineering-designed sites. Landfilling is in the end of disposal hierarchy of municipal solid waste management, but it is the cheapest way of treating the waste. Poorly controlled water inflow into landfill can cause faster degradation, leachate formation, which can potentially cause clogging into drainage layers. All environmental problems make a big danger for the surrounding areas. This particularly concerns all closed landfills that require more investigations because they were built without any leachate and gas collection system and therefore they pollute the environment (5).

Contaminated sites were divided into 4 categories (Figure 2):
- *first category:* industrial, energy, transportation and service objects
- *second category:* objects accumulating and regenerating contaminated substances
- *third category:* stock husbandry objects
- *fourth category:* sites of accidental spills of contaminated substances

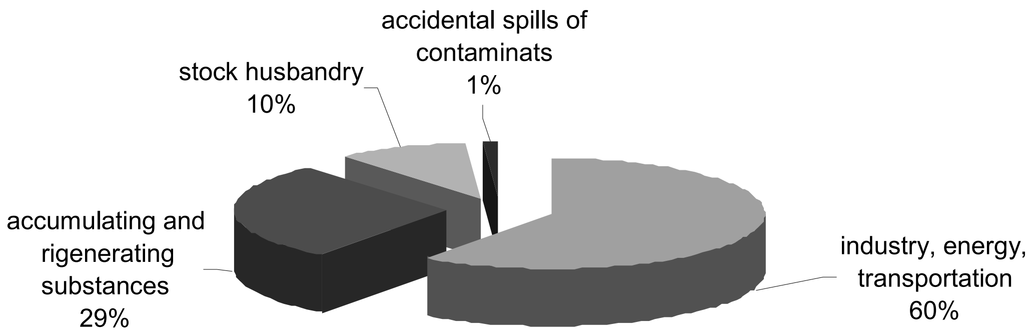

Figure. 2 Preliminary risk of potentially contaminated sites

In 2007-2014, most eco-geological investigations were carried out in petrol stations, landfills, storages of petrol products, and sites of previous pesticide warehouses. A considerable amount of research has also been undertaken in areas where no economic activity has been present. These areas can be remediated and reused for commercial activities or as residential areas. The numbers of such investigations have been rising since 2012. In most cases such sites are not contaminated, however 1–2 % of cases resulted in discovery of contaminated earth entrails not only in the examined area, but sometimes in the neighbouring areas as well. These areas are usually detected because of the contamination of underground waters, which is often brought with the flow from the contaminated sites nearby (1).

Out of potential 'objects' of contamination in Lithuania, 39% are 'objects' accumulating and regenerating the pollution materials, around 30% - cattle-breeding 'objects', and around 31% - industrial, energy, transport and service 'objects'. During the last 15 years all contaminated sites in Lithuania were registered, but no research was done about the impact of contaminated sites on human health.

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ASSESSING ENVIRONMENTAL AND HEALTH RISKS FROM CHEMICALS IN REPUBLIC OF MACEDONIA

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The paper presents the current status of the contaminated sites in Republic Macedonia including policy aspects. Special emphasize has been put on the most dangerous site of the ex chemical plant near the capital city of Skopje.

The Republic of Macedonia faces similar problems in the environmental sector to those of many other former command economies in Central and Eastern Europe. In particular, inadequate solid waste management and numerous industrial hotspots (including historical industrial pollution sites) have in some cases led to threatened public health with environmental implications (1). The lack of suitable infrastructure hampers adequate waste disposal in general and disposal of hazardous waste in particular. There is only one licensed (though not acquis-compliant) landfill in the country compared to around a thousand illegal dumps; there are no incineration (except for medical waste), no composting and few recycling facilities. Hazardous waste is exported in accordance with the Basel Convention. A register and maps for pollutants and polluting substances for solid and hazardous waste and waste waters were completed in September 2005.

Decades of industrialization and extensive exploitation of natural resources have left certain number of areas heavily polluted in the country. Since independence no significant concrete investments in this regard have taken place for the protection of the environment. As a result many uncontrolled municipal, as well as industrial landfills and wild dumps proliferated.

With regard to economic activities contributing to soil contamination expressed in percentage, the highest share belongs to mining and metallurgy with 31.25%, followed by organic chemical industry with 12.5% and oil refining and leather manufacturing industry with 6.25% (2).

There are many barriers in the management of the hot spots such are: no official National Strategy for remediation of contaminated sites; no specific law on soil protection; lack of technical guidelines for investigation of contamination, human health and/or environmental risk assessment and prioritizing the need of actions and management of contaminated sites; insufficient institutional capacity for contaminated site management; no permanent inter-governmental or inter-institutional coordination bodies established for the coordination of contaminated sites management, with the consequence of improper inspection on site.

Lack of sufficient financing sources in Macedonia is often seen as one of the main constraints for implementation of environmental improvements, especially lack of Strategy for investment, as well as staff to implement high cost infrastructure projects. Furthermore there is a lack in specialists experienced in contaminated land management and, moreover, there is no institutional body responsible for this issue. Other issues regard the insufficient analytical and research capacities; insufficient data from the HCH (Hexachlorocyclohexane) contaminated site investigations; low level of public participation and awareness on the Persistent Organic Pollutants (POPs) associated risks and dangers; no secure storage facility for POPs/HCH containing waste in place; no facilities for environmentally sound disposal of HCH waste;

The sites which require urgent attention in order to halt serious risks to public health and the natural environment are presented in Table 1.

Table 1. Contaminated sites in Republic of Macedonia - three top priorities

Hazardous site	Hazards	Possible health effects	Potential number of exposed	Measures to reduce exposure
SILMAK Jegunovce	groundwater contamination by chromium; air pollution; chromium slag	Cr (VI) is carcinogenic to humans; lung diseases	10.000 inhabitants 1000 workers	removal of chromium thoroughly monitor wells; mapping of Cr in groundwater; EKOMAK activities
OHIS Skopje	organic chemical plant; HCH isomers are stored; waste water into Vardar River, Hg residuals	Carcinogenic in humans (liver, kidney and immune system diseases	470.000 inhabitants 700 workers	land remediation due to Hg residuals; storage areas remediation; renewal of WWTP; monitoring wells
MAKSTIL Skopje	Iron and steel plant; groundwater contamination by dump; air pollution	Heavy metals contamination	470.000 inhabitants 800 workers	Dump remediation

Case study

OHIS site was ranked as number one priority for the remediation in the country. The chemical plant OHIS is located at the south-eastern edge of the city of Skopje near the Vardar River. The applied hazard and risk assessment method showed moderate to high potential health risk due to stored HCH isomers in enormous quantities for employees and population in Skopje as well as potential local mercury contamination of groundwater and soil. The manner those substances have been disposed and managed can be marked as inappropriate one compared to various well-known HCH disposal facilities in Europe. Secondary migration paths such as groundwater and soil cannot be excluded. A removal of the existing wastes will eliminate the present risk. The total Lindane production was around 2,800 tons resulting in a generation of around 25,000 tons of inactive isomers that were improperly dumped, causing secondary contamination of the soil and underground water, and emissions to air as well.

The factory's waste water was discharged directly into the river without any treatment. A closed chlorine alkali electrolysis plant used mercury, and its wastewater was drained to the Vardar River as well. The plant was also storing tens of thousands of square meters of industrial and hazardous waste in poorly constructed storage facilities (3).

The recent feasibility study proposes and assesses alternative remedial actions aiming at reducing and/or eliminating risks related to the existence of HCH waste dumps and HCH-contaminated superficial soil beneath and in the surroundings of the HCH dumps by:

- capping of both HCH dumps, including adjacent HCH contaminated soil;
- excavation of dumped HCH waste and HCH-contaminated soil with off-site disposal;
- excavation of dumped HCH waste and HCH-contaminated soil with on-site waste treatment using Gas Phase Chemical Reduction and treatment of soil by biodegradation;
- excavation of dumped HCH waste and HCH-contaminated soil with on-site waste treatment using Base Catalyzed Decomposition and treatment of soil by biodegradation (4).

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LEAD AND CADMIUM EXPOSURE IN CHILDREN INHABITED IN INDUSTRIALLY CONTAMINATED REGION OF SILESIAN VOIVODESHIP, POLAND

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It is well documented that place of residence is essential for proper development of children. Living in a polluted area could result to diminished intelligence, behavioural disorders, failure at school, delinquency and diminished achievement (1).

Lead (Pb) is a significant hazard for children; numerous epidemiological evidences confirmed that even the exposure to a small amount of lead can cause serious health consequences. In Poland consumption of lead has decreased sharply in the past two decades and published data shows clear significant decrease of average blood lead level in children during years 1991–2009 (2). However, higher value of Pb are observed in children living in some regions of Poland, especially in those who live in the proximity of sources of its emission or close to degraded sites. Piekary Slaskie is one of the most exploited by industry cities of Silesia region, about 1/4 of its area are brownfield sites polluted by lead, cadmium and zinc.

The aim of the study is to present the relationship between lead and cadmium concentration in blood of children and their place of residence in Piekary Śląskie, Silesian voivodeship, Poland.

Methods

The study area was Piekary Slaskie, the city located in Silesian voivodeship, south part of Poland. To assess the relationship between place of residence and measured level of lead or cadmium in blood we used data obtained from a cross-sectional study carried out among 3-6 years old preschool children in Piekary in 2013. Samples of blood were collected from spring to autumn (hot season). After obtaining parental consent to study children we took 1 ml of blood from each child, we used lead-free vacutainer tubes. Then, parents completed a questionnaire, which included questions about potential sources of exposure to heavy metals in the environment of the child, as well as socio-economic issues. Finally, complete data were obtained from 678 preschool children (341 female and 337 male). In the study group there were: 259 children (37.8%) living in the vicinity of a busy road; 41 children (6.0%) living close to a gas station; 53 children (7.7%) living close to an industrial plant; and 115 children (16.8%) living close to a metallurgical slag heap.

Measurement of biomarkers were based on standard procedures (3) (http://www.cdc.gov/biomonitoring/): Blood Lead Level (BLL) and Blood Cadmium Level (BCL) were detected by atomic absorption spectrophotometry (ICE 3000 Thermo Fisher).

Statistical analysis was performed using Statistica 9.0 software. Significance of between-group differences for continuous variables was evaluated by means of ANOVA Kruskall-Willis or U-Mann Whitney test, respectively. Statistical significance level was set to $\alpha = 0.05$.

Results

Table 1 shows concentrations of both pollutants (lead and cadmium) in the surface layer of the soil. The highest level of geometric mean is observed in gardens and also in waste lands. Obtained results confirmed, that exist relationship between PbB in children and place of their residence (Figure 1). Observed differences were statistically significant in ANOVA Kruskall-Wallis test ($p<0.0001$). The highest exposure was recognized in Brzeziny Slaskie where is located the Orzel Bialy smelter and its landfill.

The number of children who exceeded reference value of PbB (5 µg/dL) was 52 (8% of subjects): 29 girls and 23 boys. In the case of cadmium levels in blood, the number of children who exceeded reference value (0.5 µg/L) was 5 (0.8% of study group): 3 girls and 2 boys.

Table 1. Concentration of pollutants in the surface layer of the soil (mg/kg)

Pollutant	Gardens			Waste land			Playgrounds		
	min	max	ave	min	max	ave	min	max	ave
Lead	201	2159	569.7	92.7	9301	429.2	64.2	1546	293.1
Cadmium	5.52	58.6	16.9	2.5	507.3	15.1	1.3	48.5	8.8

ave – average value; min – minimum value; max – maximum value

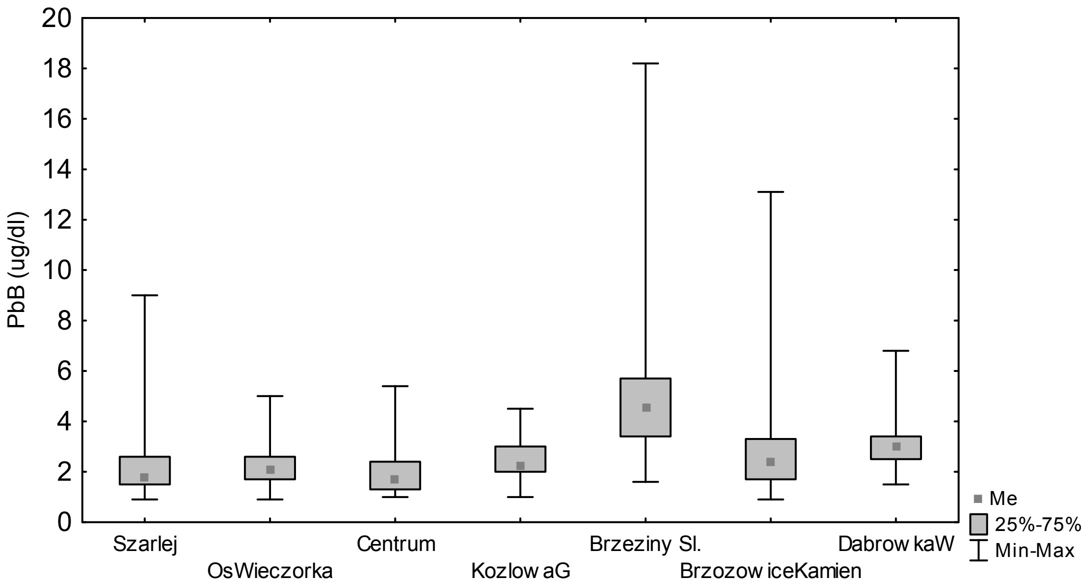

Figure 1. Blood lead level (median and the range of lead concentration in blood) in children inhabited in Piekary Slaskie by city district, 2013

Furthermore, results of the study revealed an association between place of residence close to a busy road and a metallurgical slag heap with higher concentration of lead in blood of children. Observed differences were statistically significant in U-Mann Whitney test. Similar effect was detected for cadmium and the proximity of gas station (Table 2). Age is essential for blood lead concentration, higher level was recognized in younger children (Figure 2). Gender have no statistically significant impact to value of geometric average of both biomarkers in the study group, however higher levels was detected in boys than in girls (PbB: 2.54 and 2.39 µg/dL and CdB: 0.25 and 0.24 µg/L, respectively).

Table 2. Lead and cadmium concentration in blood of children according to their place of residence in vicinity of hazardous sources

Pollutant	busy road		gas station		metallurgical heap	
	yes	no	yes	no	yes	no
Lead (µg/dL)	2.9±2.2	2.7±1.4	3.0±2.2	4.3±2.5	4.4±2.5	3.0±2.2
Cadmium (µg/L)	0.26±0.14	0.26±0.14	0.25±0.08	0.22±0.07	0.22±0.07	0.25±0.08

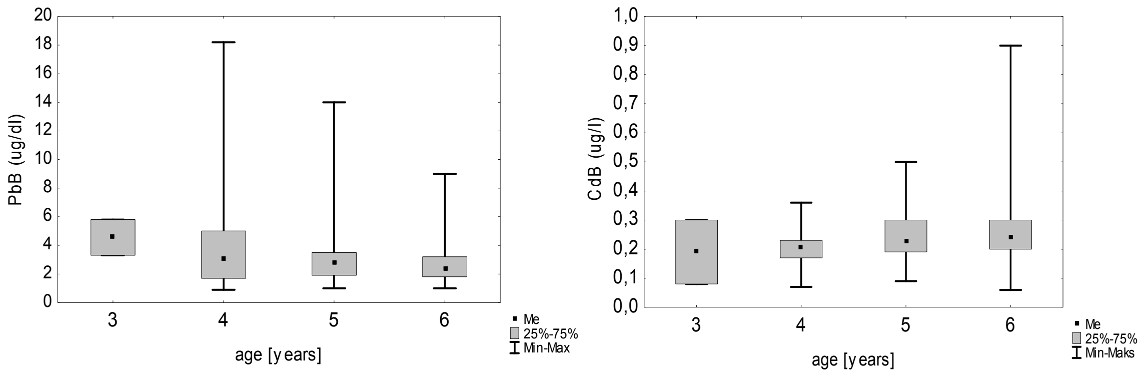

Figure 2. Blood lead and cadmium level (median and the range) in children inhabited in Piekary Slaskie by the age, 2013

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A VIEW ON THE ROMANIAN CONTAMINATED SITES: NATIONAL STRATEGY AND A CASE STUDY

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This paper gives a brief overview on the Romanian contaminated sites and an insight into the nature of the related issues, by means of a case study. Given that the *National Strategy and National Plan for Management of Contaminated Sites in Romania* (1) has been enforced only recently (August 31st, 2015) by the Ministry of Environment, Waters and Forests of Romania, there is much to be done in order to deal with the inventory, investigation, remediation and post-remediation monitoring of the contaminated sites. The goals of the strategy are: to define the principles of managing the contaminated sites by the end of 2015, to remediate the sites that require urgent action until 2020 and to conclude the action until 2050.

According to the National Plan (1), the number of contaminated/potentially contaminated sites, presently known in Romania, is 1393 (210 are reported as contaminated and 1183 as potentially contaminated). The first inventory (2) has been performed by the Romanian Ministry of Environment and Sustainable Development in 2007-2008. The main economic sectors that had (and still have, in several cases) an impact on the air, soil, underground and waters are: mining and metallurgical industry, chemical industry, oil industry, old pesticides warehouses, transportation activities, and other industrial activities at large or small scale (military sites, wood industry, electric power plants based on coil). The estimated costs for assessment and remediation are 1,264 billion euro for the contaminated sites and 7,145 billion euro for the potentially contaminated ones.

The highly controversial case of Roşia Montană gold mining project, that we present in what follows, is an example of “a vector of globalization penetrating the open society that characterized Romania after the fall of the communist regime” (3). Criticism of the project points, among numerous aspects, towards the health impact of the cyanide used in the gold recovery process.

Roşia Montană is a community of sixteen villages situated in the Metaliferi Mountains (“Ore Mountains”) of Transylvania, within the area called the *Golden Quadrilateral* - a territory rich in deposits of precious metals. The systematic mining started there almost 2000 years ago. The operations ceased in 2006 due to the lack of economic efficiency. A new mining project was proposed by Roşia Montană Gold Corporation (RMGC, a Canadian company) in 1995, at a much wider scale compared to the previous operations. At the moment, the restart of mining is being delayed, as not all the necessary permits have been released. No decision has been made yet whether the mining should continue, or it should be stopped for a significant period of time, and remediation works should be implemented over the mining impacted area (4).

The targets of Roşia Montană project consist in 225 tonnes of gold and 819 tonnes of silver over 17 years, the exploitation concession covering approximately 2,388 ha. The interests share between RMGC (80.69%) and Minvest Deva SA, a Romanian state-owned mining company (19.31%), while the Romanian state would collect 2% of the profits from the mining taxes, if the project were put into practice. The effects of the creation of four open-pit mines, covering 205 ha, would be up to 250 million tonnes of cyanide-laced tailings to be stored in a 363 ha pond in Corna Valley, behind a 185 m high dam. The project would destroy 958 households, 10 churches belonging to the Orthodox, Catholic, Greek-Catholic, Unitarian and Reformed rites, and unearth 12 cemeteries.

Roşia Montană is the oldest documented Romanian locality and has been considered for inclusion on the UNESCO World Heritage list for its cultural and natural richness. It hosts a multi-ethnical and religiously diverse community of about 3,800 inhabitants (Romanians, Hungarians, Germans, Czechs, Roma) and a wider diversity of vegetal and animal species. But its tremendous value comes from a dense layering of vestiges belonging to the pre-Roman, Roman, medieval, modern and present-day mining: dwellings, mining tunnels, still inhabited century-old houses.

Due to this situation, Roşia Montană turned into an international case. Resistance to RMGC's plans started in 2003, following the release of a Romanian Academy report (5), which recommended that all cyanide mining should be suspended in Roșia Montană. Besides the Romanian Academy, the academic community (professional bodies), international finance corporations (such as World Bank), the church, large NGOs such as *Greenpeace* and political organisations such as the *European Federation of Green Parties* involved in fighting for the preservation of Roşia Montană. In 2013, protests against the Roșia Montană project took place in major cities across Romania. In response, the Romanian Government decided to stop the project and review the legislation.

When referring to the matters implied by the *National Strategy and National Plan for Management of Contaminated Sites in Romania*, the needs and potential of improvement are high. With respect to human health issues, the public health authority faces important challenges. Numerous industrially contaminated sites are situated close to urban areas and, quite often, involve socially deprived communities. This leads to interactions with other health determinants. Human health assessment methodologies should be revised in order to be clearly defined, detailed and adapted to the ones used internationally.

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ENVIRONMENTAL REMEDIATION AND HEALTH PROTECTIVE ACTIVITIES IN A SLOVENIAN VALLEY POLLUTED BY TOXIC METALS

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Introduction

The Upper Meža Valley is situated in the north of Slovenia, near the Austrian border. This narrow valley has a population of almost 7,500 people. This part of Slovenia has been an important industrial area with a 500-year mining tradition. The health studies conducted in the area in the past 50 years revealed large toxic metals (Pb, Cd) concentrations in the environment and large lead burden in the inhabitants (1).

Studies conducted in 2002 and 2004 confirmed that the concentrations of toxic metals and especially lead are still high. The results showed high blood lead levels (≥ 10 µg/dL) in majority of the tested children (2).

Remediation program

Due to high levels of lead in the area, Upper Mežica Valley was proclaimed as a brownfield site in 2007 and a special remediation program was built up with the aim to protect human health, especially children. Ordinance on the areas of the highest environmental burden and on the program of measures for improving the quality of the environment in the Upper Meža Valley represents the legal basis for the implementation of the program.

The goal is to reduce blood lead levels in children under 10 µg/dL by 2022. The Program includes different activities: asphalting roads, grassing surfaces, soil exchange, safe gardens, complementary diet, wet cleaning of roads, attics and facades renewal, coordination, information and motivation and monitoring of lead concentration in soil, air and blood (3).

Blood lead levels

Regular lead biomonitoring of children's blood have been carried out since 2004. Every year blood samples of three-year old children are collected and analyzed for lead concentration. The results of the screening serve as the basis for progress evaluation. Since the beginning of screening, 849 blood lead samples have been analyzed.

The results show that in the period from 2004 to 2009 the levels of lead in the blood samples of children (445 samples) were reduced. In the period 2004-2007 approximately one half of the children had high values (≥ 10 µg/dL), in the period 2008-2009 approximately one fifth of children and in the period 2010-2013 approximately one tenth of children had high values of lead in their blood. The median value declined from over 10 µg/dL to less than 5 µg/dL in the same period. In the period from 2011 to 2015 results became stable. Median value varied from

4.5 to 5 µg/dL and proportion of children with high blood lead levels varied from 9 to 17% (4) (Figure 1).

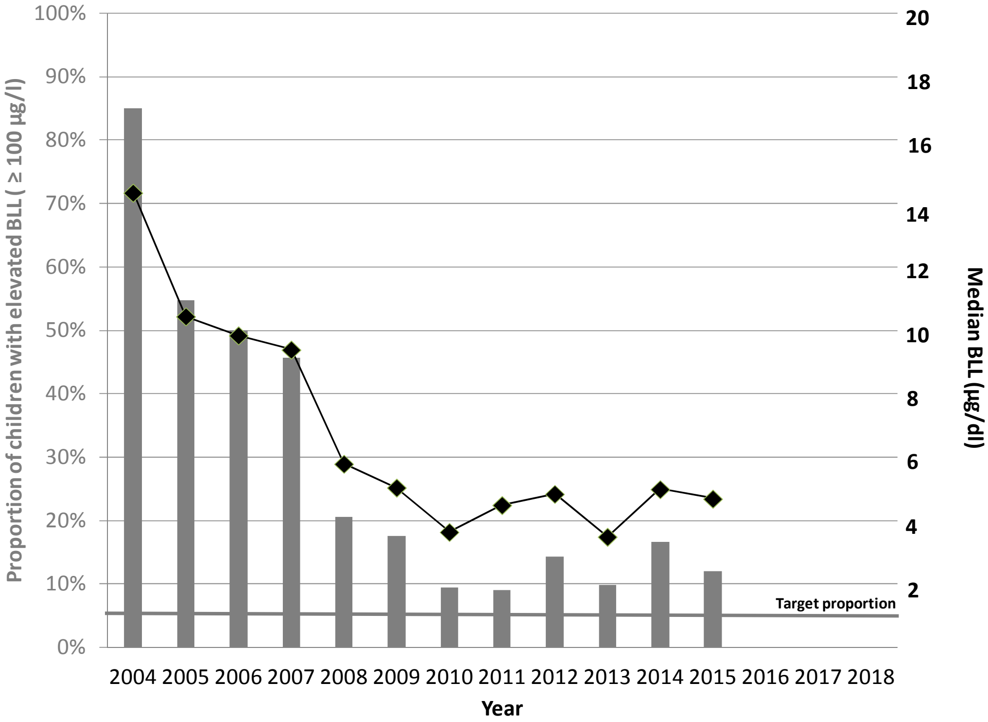

Figure 1. Proportion of children with high blood lead levels (>10 µg/L) and median blood lead value of three year old children from the Upper Meža Valley, sampling period 2004-2015

Conclusions

At the beginning of the program the implemented measures had a significant impact on exposure reduction and they also motivated the population to implement their own habits so helping in reduction of lead exposure. Therefore, blood lead levels declined.

For further improvement more targeted work would be required. That means working with smaller groups and individual children with an increased risk of exposure to lead and implementing additional measures for reducing lead exposure in their surrounding environment.

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HEALTH STUDIES CONDUCTED IN INDUSTRIALISED SITES OF SOUTHERN SPAIN

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Background: description of the industrialised sites

The Western part of Andalusia (Southern Spain), conformed by Huelva, Seville and Cadiz provinces, already showed a significant excess of mortality during mid-1950`s and early 1960's in relation to other areas of Andalusia or Spain. The very low socioeconomic status of the region in that time was tried to be improved by the establishment in late 1960s of two big petrochemical settings, one in the Algeciras Bay (Cadiz), and the other in the Ria of Huelva.

Other sources of pollutants common to both sites include a paper mill factory, chemical industries, and a power generation plant. In addition, the activity of a large fertilizer plant in Huelva has produced about 100 million tons of Phosphogypsum wastes which have been piled up along the shores of the estuary, less than 1 km far from the city of Huelva.

Special attention also requires the very intense activity for merchant transportation occurring in the Algeciras Bay, with a high volume of road traffic and shipping movement in the bay. The Port of Algeciras Bay is also Spain's number one port for marine fuel supplies, and together with the ports of Gibraltar and Ceuta, represents the second bunker market in Europe after Amsterdam-Rotterdam-Antwerp.

The discharge of large amounts of pollutants in both areas (mainly heavy metals but also radioactive materials, BTEX, poly-aromatic hydrocarbons, flame retardants, particulate matter, SO_2, NO_x, and Ozone), and chronic oil spills (low or moderated but continuous in time) from shipping and bunkering activity in the Bay has posed a huge environmental impact, affecting the aquatic biota, estuarine sediments, soils, and air quality.

Environmental diagnosis at the sites

Several accidents (i.e., the discharge of a radioactive cloud from the stainless steel manufacturing plant in the Algeciras Bay in May 1998) and serious sulphur incident as well as intermittent flaring episodes and oil spills provoked great outrage and public protests among citizens of both industrialised sites. As a result the Regional Government of Andalusia promoted an Environmental Diagnosis at the two contaminated areas.

The assessment of the ambient air quality showed a proved influence (~32%) of the industrial activity on chemical composition of particulate matter (PM_{10}, $PM_{2.5}$ and PM_1) in the two sites. The annual mean concentration of As in coarse PM_{10} in Huelva was close to the target value of 6 ng/m^3 established under EU regulation (Directive 2004/107/CE). Relatively higher concentrations, compared to other cities in Spain, were also reported for V, Ni, Zn, Cr and La measured in PM_{10} in the Algeciras Bay, with a very relevant contribution from shipping emissions especially in the case of vanadium. However, episodes of high peaks of PM_{10} (daily concentrations exceeding 50 µg/m^3) due to anthropogenic origin were usually below the EU limit of 35 days/year. A general steady decreased in annual mean concentrations of main pollutant related to industrial activity (SO_2, NO_x, other organic compounds) was registered in both sites due to new regulatory and control measurements. Even so special attention still requires the sporadic high peaks of fine and ultrafine particles recorded in both sites.

Main health studies conducted at the sites

Following or in parallel to the Environmental Diagnosis, several health studies were conducted, some funded directly by the Regional Government of Andalusia, some others through national and international research calls.

The Interactive Mortality Atlas for Andalusia (AIMA) developed at EASP allows analysing the geographical distribution and time-related evolution of mortality in all Andalusian municipalities since 1981. This GIS system gives results for the main causes of death, by age groups and gender. Using this approach Ocaña-Riola and Mayoral-Cortes (1) showed that mortality trends for the majority of Andalusian municipalities seem to converge with Spanish rates, and significant male and female mortality excess for the period 1981-2006 in Western Andalusia (include the two industrialised sites under study) were only recorded in the age groups over 65 years. In a more recent study focused on the evaluation of the age-period-cohort effects on overall mortality in Andalusia, Ocaña-Riola et al. (2) showed that for cohorts born between 1945 and 1965, the mortality risk for men climbed steadily, overtaking that for the base year of 1932. After 1965, the mortality risk turned downwards, reaching values below the reference year for individuals born after 1975 and continuing to fall up to 1990. The male mortality rate largely held steady for subsequent generations, with a slight rise in more recent years. The malnutrition, deprivation and poor living conditions that were a feature of life, most particularly from 1940 to the end of the 1950s, may explain the increased risk of death from all causes for the generations born between 1940 and 1965.

One of the key elements for a better understanding on the impact that industrial activities might pose on human health is linked to a better characterization of human exposure assessment. In this sense a biomonitoring study of urinary levels of arsenic and other heavy metals (Cd, Cr, Cu and Ni) in adults (n=857) and children (n=227) living in the industrialised area of Ria of Huelva was conducted between 2003-2004 (3,4). Arsenic levels were significantly higher in adult population from Huelva as compared to other Andalusian cities, whereas Cd and Ni levels were significantly lower. Among children from Huelva, no significant differences were found with the reference population for all metals with the exception of Cd levels which were significantly higher in the reference group. Despite these differences, levels of the five metal ions in both groups were generally within the range of values reported by other biomonitoring European studies. A more recent study conducted in the area (5), tried to estimate the association between neuropsychological development and cadmium exposure measured in urine samples of children aged 6 to 9. The geometric means of urine cadmium level recorded in this population were 0.75 µg/g creatinine, 10 times higher than those observed in a similar population from the US, or in German children but still below the threshold limit value of 2 µg/L, above which it is considered that there is an increased risk of adverse health effects in children. The observed levels of cadmium in urine in this study were associated with a reduction of two points (95% CI: 3.8 to 0.4) in the Full-Scale intelligence quotient (IQ) in boys. Thus, the effect on neuropsychological development observed in this study occurs at exposure levels below those considered to be a risk.

In spite of the efforts invested so far, more comprehensive epidemiological studies on individual basis that include a better monitoring of environmental exposure but also other factors linked to social position, occupational activity, diet and style of life are needed.

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HOW TO REMEDIATE? TWO SWISS EXPERIENCES

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Two exemplary cases of landfills in Switzerland are presented in this chapter to illustrate the complexity of the decision-making process that is often needed for determining an environmentally sound, socially acceptable and financially feasible remediation strategy.

The first example is the Feldreben Landfill located in northern Switzerland (Muttenz District in the Canton of Basel-Land).

The landfill was historically a quarry with a surface of approximately 350 x 150 m and a depth of ≤20 m. During its operation from 1930 until 1967, the quarry also served as a disposal facility, accepting primarily construction waste material. Between 1940-1957 the chemical and pharmaceutical industry also deposited waste in the landfill. These now account for about 1-2% of the total landfill contents. The terrain was open and undeveloped until the 1960s. It was during this time that the site was also open to wild deposits and erosion by rainwater. Approximately 80 percent of all pollutants are therefore no longer in the landfill itself, but the underlying rock.

In a first phase (2001-2011) a through appraisal of the landfill was conducted, placing emphasis on its potential to contaminate the drinking water system (1). It was concluded that there is a need to remediate the landfill, though no urgency was given. In a second phase (2012-2104) the remediation project was designed, taking into account various health-related factors: (i) potential for air and noise pollution, locally and along waste transport routes; (ii) CO_2 emissions; (iii) potential for traffic accidents; and (iv) potential for destabilization of the landfill, which may ultimately increase groundwater contaminant concentrations.

In July 2014, the optimised remediation project was submitted to the local authorities, proposing two main strategies: (i) a groundwater treatment, which aims at purifying the underlying rock of the landfill; and (ii) partial excavation (highly contaminated material in the centre of the landfill) by using sealed buildings (negative pressure and cleaning of air before release) and subsequent transportation by train and ship.

The cost of the initial appraisals and planning of the remediation project was CHF (Swiss Franc) 5 million. The implementation cost of the remediation project are estimated at CHF 176 million. The decision about the start of the remediation project is still pending (2).

The second example is the Kölliken Hazardous Waste Landfill Site, which is also located in northern Switzerland, approximat 50km south-east of Feldreben Landfill. Between 1986 and 2004, extensive investigative and safety work was carried out, the cost of which was in the order of CHF 150 million. From 1978 to 1985, 300,000 m^3 or 475 000 tons of hazardous waste was deposited in drums, big bags or as loose material in a former quarry. In 1985, after complaints from residents of Kölliken, the local council ordered the closure of the landfill site. In 2003, the cantonal supervisory authority ordered a thorough decontamination of the site, meaning the complete dismantling of the landfill.

For this purpose, three sealed buildings with internal negative pressure were built in 2006-2007. The waste air from the buildings is constantly exhausted and cleaned. All in all, some 628000 tons of material (waste, rock and surface covering) has to be removed, sampled and disposed of. The remediation work began in autumn 2007 and is anticipated to be completed by the mid-2016. Once evidence of decontamination has been provided, the empty pit will be filled with clean material, the buildings dismantled and the land re-cultivated. Based on the planning and the current progress of the remediation work, the total cost is envisaged to be around CHF 660 million (as at July 2014).

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THE POTENTIAL FOR ACUTE HUMAN HEALTH RISKS DURING REMEDIATION (UK)

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Introduction

The remediation of land affected by contamination can occur as a result of sites being legally determined as “Contaminated Land” under Part 2A of the Environmental Protection Act 19901, voluntary remediation or through the redevelopment of sites for new uses, usually controlled through the planning regime (1). Methods of remediation are varied, and may involve treatment or removal of contaminated soils from a site. During remediation there is the potential for contaminants to migrate off-site, as vapours or in dust (Figure 1).

Figure 1. Example of remediation activities

All remediation activities carry potential risk, and sometimes significant risk to public health, particularly as communities are often very close to works. Whilst general controls are established for such works, in the form of planning conditions and environmental permits, there is often a need to develop more detailed health based triggers and action plans for potentially hazardous emissions.

Public Health England (PHE) (formerly the Health Protection Agency, HPA) provides expert support and advice in developing such controls, including toxicological advice.

Toxicological considerations

One of the main toxicological considerations is the selection of suitable trigger/action levels for contaminant vapours, particulates, odour and other emissions to protect the public in the surrounding areas of the remediation works. If trigger/action levels are exceeded, then necessary actions are taken to reduce the emissions (e.g. stop the remediation works until levels have returned to below the trigger values, use of equipment to suppress emissions) (Figure 2).

Figure 2. Atomisers suppressing off site emissions

Health Criteria Values (HCVs) are intake values that are considered to be protective of human health. They are guidelines on the level of long-term human exposure to individual chemicals in soil that are tolerable or pose a minimal risk. HCVs are a critical component in the derivation of Soil Guideline Values (SGV) which are used in human health risk assessments of potentially contaminated sites (2). HCVs could be used as trigger/action levels however, not all commonly encountered volatile Organic Compounds (VOCs) have HCVs. Therefore, other health-based guideline values may need to be considered e.g. World Health Organization (WHO) Air Quality Guidelines (3).

The following factors should be taken into account when selecting appropriate trigger/action levels to protect off-site receptors during remediation work:

- The expected duration of the remediation works
  Is it likely to be an acute, intermediate or chronic exposure issue?
- Short-term peak exposure
  How will acute peak exposures be assessed?
  It is necessary to have separate action values for peak exposure?
- The contaminants present
  What are the critical effects of the chemicals present?
  Which chemicals are of most concern in terms of human health?
- Chemicals mixtures
  If there are multiple chemicals present, it may be necessary to assess the health impacts of exposure to a mixture of chemicals
- Susceptibility of receptors
  Sensitive subgroups (e.g. children, elderly) should be considered

Case studies

Case study 1: former dry cleaning site

The site had planning permission granted for residential housing and was located in a residential area. There were a number of volatile organic compounds present at the site including trichloroethylene, benzene and vinyl chloride. The HPA reviewed the remediation strategy.

Proposed strategy

A "total solvent" HCV was calculated using a formula used in occupational settings for mixed solvent exposure. This assumed a constant solvent mixture in air with fixed relative fractions (FR) of key solvents:

Reciprocal calculation procedure (RCP)

$$1/HCV\ total = FRa/HCVa + FRb/HCVb + FRn/HCVn$$

Three different "total solvent" HCVs were derived for different areas as the contaminant mixture varied across the site. The environmental consultant proposed the use of site boundary PhotoIonization Detector (PID) monitoring to confirm that mixed solvent emissions would be below the HCV. A PID reading less than the "total solvent" HCV indicates that all the individual HCVs are met. However, if the PID reading exceeds the "total solvent" HCV, intervention would be required.

PHE input

As the solvent profile across the site varied the use of a mixed solvent approach (as discussed above) was not considered appropriate in this instance:

- recommended the use of a surrogate chemical marker approach;
- concerns about short term peak exposures and how these would be picked up and evaluated.

Case study 2: former industrial landfill

An illegal waste site in operation between the 1960s-1970s, containing hazardous waste had planning permission granted to build residential properties; the site was bordered on three sides by residential properties. Excavation and removal of the waste occurred between November 2010 and September 2011.

The HPA reviewed the monthly air quality monitoring reports. There was discussion at monthly multi agency (Primary Care Trust, Local Authority, Environmental Consultant) meetings about the potential for off-site public health impacts.

PHE input

The annual running mean of total chromium slightly exceeded the agreed target value. However most of the chromium present in the samples was the less toxic chromium (III), and chromium (VI) was below the chromium (VI) long term target value

The long term Environmental Assessment Level for aniline was marginally exceeded. However over a life-time a slight elevation in one year's exposure to aniline, is unlikely to lead to any health effects.

Overall, there was unlikely to have been a significant risk to public health resulting from the remediation. Public health messages were communicated to local residents via monthly public meetings, the environmental consultants' web pages, newsletters and the phone number for the environmental consultant.

Conclusions

Remediation of contaminated land can result in the release of vapours and dust which can migrate off-site and pose a significant risk to the health of the population in the surrounding area.

It is therefore important to ensure that necessary actions are taken to protect the health of off-site receptors.

A toxicological assessment may be required to select appropriate existing, or to derive new, levels for screening, reassurance or intervention.

Various factors need to be considered when selecting the appropriate levels to protect the public during remediation works.

Public Health England provides expert support and opinion in developing controls, data interpretation and toxicological advice in order to protect public health.

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