9

Environmental justice in industrially contaminated sites: From the development of a national surveillance system to the birth of an international network

Roberto Pasetto and Ivano Iavarone

Sites highly contaminated by a variety of hazardous agents are found in almost all countries as contaminants are routinely or accidentally released into the environment either by active industrial sources or as toxic waste from current or past industrial activities. From a public health point of view, contaminated sites can be defined as, "Areas hosting or having hosted human activities which have produced or might produce environmental contamination of soil, surface or groundwater, air, food-chain, resulting or being able to result in human health impacts" (Martuzzi et al. 2014). Industrial activities – especially those related to large petrochemical plants, power generation, heavy industry such as steel mills, and mining – lead to environmental pressure, with potential adverse social and health effects on local communities through both occupational and residential influences (World Health Organization 2009).

In recent years, networking, research initiatives, and literature on industrial contamination and health have increased, following the need to acquire evidence for risk management and policy actions (World Health Organization 2013a). One of the public health priorities identified in the European Ministerial Conference on Environment and Health promoted by the World Health Organization in 2017 was to prevent and eliminate the adverse environmental and health effects, costs, and inequalities related to waste management and contaminated sites in the context of a transition toward a circular economy (World Health Organization 2017a). Moreover, the resulting "Ostrava Declaration" states that environmental degradation and pollution, climate change, exposure to harmful chemicals, and the destabilization of ecosystems threaten the right to health, and disproportionately affect socially disadvantaged and vulnerable population groups, thereby increasing and compounding inequalities. In this perspective, and in order to provide evidence for actions, in many contaminated sites scientists and decision makers need to adequately address issues such as contamination-related health risks, the prioritization of efforts for remediation, the cost-effectiveness of actions directly or indirectly promoting public health. Another aim is to explore the sphere of environmental justice (EJ).

Environmental justice emerged as a theme in the United States in the 1980s as result of grassroots activism of some African American communities fighting against the unfair association between race and poverty and the uneven spatial distribution of waste and industrial sites producing pollution (Bullard and Johnson 2000). The applications of environmental justice have been broadened over the years to a wide variety of environmental themes including their relationship with public health. At the time of writing, the EPA, the US Environmental Protection Agency, defines environmental justice in terms of

> the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies … It will be achieved when everyone enjoys the same degree of protection from environmental and health hazards and equal access to the decision-making process to have a healthy environment in which to live, learn, and work. (www.epa.gov/environmentaljustice)

The debate on the meaning of environmental justice in academia has been intense, with different formulations around the concept of equal distribution for everyone of environmental risks and benefits. Among the different definitions and meanings, Schlosberg has stressed the need to focus on recognition, distribution, and participation as three interlinking, overlapping circles of concern: "Inequitable distribution, a lack of recognition, and limited participation all work to produce injustice, and claims for justice are integrated into a comprehensive political project in the global Environmental Justice movement" (Schlosberg 2004: 528–529). The subject of recognition is underlined by Schlosberg as a prerequisite for promoting environmental justice, since the different distribution of benefits and risks by ethnic and socioeconomic determinants among population groups and communities, together with the expression of their identities and cultural practices, are usually neglected in decision-making processes (Schlosberg 2004).

In this chapter, we refer to environmental justice, as summarized by Walker, in the intertwining between environment and social difference and how the justice of their interrelationship matters (Walker 2012), applying it to the topic of industrially contaminated sites. We describe the birth and evolution of a national epidemiological monitoring system, developed in Italy, to assess whether communities affected by environmental hazardous exposures from contaminated sites are also prone to be fragile in socioeconomic conditions (i.e., whether potential or actual risks from contaminated sites are unfairly distributed because of the concurrence in the same communities of environmental risks and socioeconomic fragilities). Then, we discuss how the above system can contribute to promoting awareness of risks to people and communities and empowering their involvement in decision-making processes linked to risk management. We also discuss strengths and limits connected to the national perspective on which the monitoring system has been developed: on one hand, it gives the opportunity of monitoring the health profiles and socioeconomic conditions of all communities at the national level, with the potential of identifying the areas with the greatest level of unfairness; on the other hand, it cannot describe the complexity of interconnection between different factors affecting health, and in each area, that are related to the peculiar history of each community. Notwithstanding the limits of a top-down perspective, we discuss how results from a national epidemiological monitoring system can contribute to identifying areas and priorities of interventions for improving public health in communities living close to industrially contaminated sites, thus promoting environmental justice in that context.

Finally, we describe how the experience developed at a national level can contribute to identifying approaches, methods, and tools to assess health risks and to implement primary interventions, accounting for local needs across a wide heterogeneous scenario of contaminated areas and communities across Europe and beyond.

Postwar industrialization and contamination from industrial areas in Italy

Italy's industrialization process can be described in three main phases in terms of its impact on the environment and health. The first phase, after World War II, witnessed the construction of major industrial complexes, in particular during the 1960s, the golden age of Italian manufacturing. In the second phase (1970s and 1980s), major efforts were directed at improving production efficiency, often accompanied by an increase in pollutant emissions into the environment. That was also when environmental legislation was first introduced. However, the implementation of laws was not monitored and relevant laws were sparsely applied, with the consequence of a growing contamination of the environment, mainly close to plants. The Seveso disaster occurred in 1976 in a small chemical manufacturing plant – leading to the exposure to 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) in the surrounding residential communities – and became an emblematic event of the time. The case led to numerous scientific studies and to standardized industrial safety regulations, including the first EU industrial safety regulation, known as the Seveso Directive (http://ec.europa.eu/environment/seveso/). In the third phase, beginning in the early 1990s, relevant authorities began documenting the effects of contamination on the health profile of populations residing close to industrial plants. Over the past decades, the impact of contamination on health has steadily grown and is still growing in areas without effective reclamation activities, and is now a major environmental health issue on the political agenda.

This was the context when, in the late 1990s and early 2000s, most of the main Italian industrial areas were listed as Sites of National Concern for Remediation (henceforth Sites). In the same period, the need for a better understanding of the impact of contamination on health grew, with requests coming from local and health authorities in the communities living close to contaminated areas.

The following case study has been chosen to illustrate the impact of socio-economic factors and the sphere of environmental justice in Italian industrially contaminated areas.

The Gela case

Gela is a town in southeast Sicily, in the province of Caltanissetta, on the shores of the Mediterranean. Until the 1950s, Gela was the center of a thriving farming community; the sea was crystal clear and fishing plentiful, as it had been for generations. Local tourism was also on the rise in the area. In other words, Gela was a large farming and maritime community mainly producing cotton, wine, and sulphur from the inland area, as depicted by the local non-profit environmental association LegaAmbiente.[1]

In 1963 an industrial complex for the refining, processing, and storage of hydrocarbons was built in Gela. In addition, its purpose was to exploit the crude oil discovered in the nearby area, on the initiative of Enrico Mattei, President from 1953 to 1962 of the newly formed oil and gas public company (ENI – Ente Nazionale Idrocarburi). On its opening, Enrico Mattei declared the Gela complex the "largest petrochemical plant in Europe."

The idyllic description given by LegaAmbiente differs from the portrait of Gela in the 1960s provided by a sociological study:

> Life in the city of Gela is partly determined by the overall underdevelopment of national agriculture and by the presence of a large petrochemical plant … although it is on the sea, Gela turns its back to it and unlike most comparable towns, the sea does not appear to play an important part in its life … alongside the new development following urbanisation and new arrivals, and the resulting construction of the village for the petrochemical workers of the plant, agriculture is still very poor: bare, empty housing, crumbling walls and even the public housing speak of the extremely basic living conditions of the community. (Hytten and Marchioni 1970, 18, 29–30)

Local literature and documents indicate that the town of Gela and its surroundings underwent major changes – in fact were completely transformed – in a matter of a few years following the discovery of oil fields in the district in 1956. The year of the plant start-up, 1962, was a watershed year, marking the beginning of a new era for the town, its surroundings, and its residents, separating the agricultural past from the industrial present. Within two decades, the population increased by more than 50%.

The petrochemical industrial complex in Gela hosted a large oil refinery, as well as thermoelectric power and petrochemical plants for production of organic and inorganic chemicals (Figure 9.1). In 1998, a part of Gela's municipal

9.1 The Gela petrochemical complex. View from the ancient acropolis of the town, now included in the archaeological museum district.

district – the entire petrochemical complex and an extended sea portion – was included among the Italian National Priority Contaminated Sites (Pasetto et al. 2012). Data gathered after 2000 by the Istituto Superiore di Sanità (ISS – the Italian National Institute of Health) documented heavy groundwater, soil, and air contamination (Zona et al. 2019). Healthwise, the residents of Gela suffered a number of critical problems highlighted in the mid-1990s and still present at the time of writing: they have a high risk for various diseases whose aetiological factors include the pollutants due to local contamination of industrial origin (Pasetto et al. 2012; Zona et al. 2019). Both the general population and the young age sub-groups suffer higher risks, and specific situations of congenital malformations have been documented (Zona et al. 2019).

The case of Gela was described as an example of “industrialization without development: a southern history,” the title of Hytten and Marchioni’s book (1970). The situation in Gela to a certain extent recalls industrialization processes promoted by transnational companies in recently industrialized low-income countries where processes promoted from the outside, rather than being the result of a progressive socioeconomic evolution of the local society, failed to induce local territorial and population development (LaDou 1992; Castleman 1995). For the purposes of the present chapter, we intend “development” as a sustainable process with the appreciation and not the deterioration of available resources in line with the principles of the sustainable development goals promoted by the United Nations (www.un.org/sustainabledevelopment/sustainable-development-goals/). Under this perspective, individuals and communities should develop capabilities to satisfy primary needs and to pursue their ambitions without undermining chances and conditions for future generations. The concept of development is thus strictly linked to the concept of “sustainability” as proposed by Agyeman, Bullard, and Evans: to “ensure a better of quality of life for all, now, and into the future, in a just and equitable manner, while living within the limits of supporting ecosystems” (Agyeman et al. 2003, 5).

In Gela, just like in many other cases, the industrialization process triggered mechanisms of societal acceptance of risky industries, mainly because it appeared to be the only viable option for people who feared unemployment and lacked better opportunities (Saitta 2012). Social contexts such as the ones mentioned may hamper the implementation of environmental monitoring and reclamation activities, leading to a deterioration of contamination with its resulting impact on the health of the population. Gela’s case is an example of a community where the origin and the development of industrialization made it impossible for the population to become resilient and cope with the damage to the environment and the impact on the community’s health resulting from industrial contamination. Furthermore, in Gela, as elsewhere, as time goes by, industrial processes become more automated, thus reducing the number of manual jobs and increasing unemployment. This has led to a higher level of individual and social conflicts affecting many parts of residents' lives: the economy, the environment, and the health services. As a result, the local situation has become increasingly chaotic and difficult to manage.

The epidemiological monitoring system of sites of national interest for remediation

In Italy, the situation of contaminated sites is not unique to Gela: throughout the past few years the Istituto Superiore di Sanità has received a growing number of requests by local authorities for help in understanding whether and to what extent the health of their residents was at risk in areas contaminated by the industries; they also requested advice on what could be done to eliminate or limit risks, as well as how to carry out decontamination and remediation work. In some cases, it was the epidemiological research implemented by ISS that enabled researchers to identify health risks from environmental pollution in areas that were eventually recognized as national priority contaminated sites (Bruno et al. 2015).

Starting in the 1990s, Italian epidemiologists began researching possible health risks due to contaminated sites more systematically, also thanks to specific contributions from WHO pointing to contaminated sites as an emerging environmental health priority (Cislaghi et al. 1997; Martuzzi et al. 2002). The ISS developed a system of epidemiological monitoring of the population thanks to a strict collaboration with WHO (Mudu et al. 2014) and to the experience gained in studying contaminated sites in several Italian regions. Data on resident communities living close to 44 contaminated sites of national interest earmarked for decontamination and remediation actions were used. The Sites included areas within the main Italian industrial complexes. The system is known as SENTIERI.[2] It was initially conceived as a study to describe the state of health of the communities residing close to the Sites, but subsequently it became a permanent epidemiological monitoring system. The system is essentially based on a descriptive approach and it has been progressively implemented, thus becoming methodologically more complex. Changes have been consistent with requirements for an area-based epidemiological monitoring of contaminated sites (Pasetto et al. 2016). In Italy, municipalities (*comuni*) are the administrative local authority and community basic unit, which is the main reason why SENTIERI used the population under municipal remit as its unit of observation. SENTIERI's approach has been described in detail by Pirastu and colleagues and by Comba (Pirastu et al. 2013a; Comba 2017). SENTIERI is based on an a priori definition of diseases to focus on when describing a health profile.

When performing epidemiological studies, especially descriptive studies, there is a risk that researchers become data driven. This can be the case when commenting on results for causes showing an increase, possibly on the sole basis of statistical significance. To control this problem at least partially, SENTIERI, for each monitored Site, focused on those diseases identified a priori, from the strength of their association with the sources of contamination in every contaminated site (Pirastu et al. 2013a) and, in the Sites where it was possible, also on the basis of the toxicological profiles of the main contaminants (Zona et al. 2015). In SENTIERI, possible relevant exposures were abstracted from legislative decrees – that is, administrative sources defining Sites' boundaries and coded on a productive sectors basis (e.g., petrochemicals and/or refineries, harbor areas, etc.). The choice was made because contaminated sites had different levels of environmental characterization (for some Sites, information on specific chemical contaminants were available, for others only productive plants were listed). Having once identified the environmental exposures of interest, researchers should examine the updated scientific literature to evaluate the associated health effects. To assess the strength of association between industrial sources of contamination and diseases, the SENTIERI study group defined a hierarchy in 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). They were followed 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 between sources of contamination and diseases. The final classification is used to select the list of diseases of a priori interest for each source of contamination.

SENTIERI's list of possible sources found in Italian Sites includes the following: chemical industry, petrochemical plants and refineries, steel mills, energy power stations, quarries, mines, ports, waste dumps/landfills, and incinerators. Epidemiological indicators are based on current statistics (mortality and hospitalization) or on data from Registries of Diseases (the cancer registries and the registries of congenital malformations) (Pirastu et al. 2014). SENTIERI uses a multidisciplinary, multi-phase approach to the contaminated areas, contributing to an epidemiological characterization of each Site. The system is also tailored to perform overall risk analysis in contaminated sites and comparative studies among various Sites with the same sources of contamination. In this regard, the first overall estimates of health impact resulting from SENTIERI monitoring showed an overburden for communities living close to the Sites. An excess of mortality was found in 44 Sites, with around 10,000 deaths more than expected among the 404,000 deaths observed (men and women combined) in a period of 10 years (Pirastu et al. 2011). Interestingly, about 3,600 among them were caused by diseases for which there was sufficient or limited a priori evidence of association with the sources of pollution present in the Sites. A subsequent overall analysis of cancer incidence data in 10 years, limited to the 23 Sites served by cancer registries, showed an overall excess of 9% in men and 7% in women (Comba et al. 2014).

SENTIERI reports started, in 2011, offering periodical updates of health profiles of the communities living close to Sites of national interest earmarked for decontamination and remediation (Pirastu et al. 2011, 2014; Zona et al. 2016, 2019). An integrated approach to available information makes it possible to suggest the best course of action to defend public health on a case-by-case approach. Specific investigations to gain a better understanding of unresolved issues are also suggested or carried out if so required. Given that it is a permanent monitoring system, SENTIERI can also track health profile trends and developments over time. It has the potential to assess the effectiveness of the actions undertaken in terms of the impact they have on public health.

Where possible, the relevant regional Departments of Public Health are involved in sharing the SENTIERI results. Results are then passed on to the national agencies (*Enti centrali*), first and foremost to the Ministry of Health and also to the relevant local authorities and local technical departments. Working Group Members take part in the projects to communicate results involving all stakeholders.

SENTIERI is an epidemiological monitoring system which can promote environmental justice for communities living close to industrially contaminated areas since it offers the same information nationally, supplying evidence and stimuli to carry out more in-depth studies and actions focusing on areas that have had fewer opportunities to be evaluated from a technical standpoint. In fact, the ability to carry out technical investigations on the environment and health differs greatly according to which of the twenty regions it is, because of their history and how the authorities and technical facilities able to identify the association between contamination and health were established. Hence, SENTIERI is able to supply the same information base in all contexts. The dissemination of epidemiological information collected by SENTIERI also has the potential to enhance awareness among local populations of the risks associated with contamination. Local and national decision makers are mostly aware of the SENTIERI program, and some resident associations and citizens have demanded that it should be applied in areas that are not yet under epidemiological monitoring.

The involvement of central and local administrative and technical agencies in producing the final reports, the efforts in spreading reports and results involving the national and local media, and the initiatives of communication to the local associations and residents are the hallmarks of the monitoring system and promote the fairness of the decision-making processes in contaminated sites (Marsili et al. 2017).

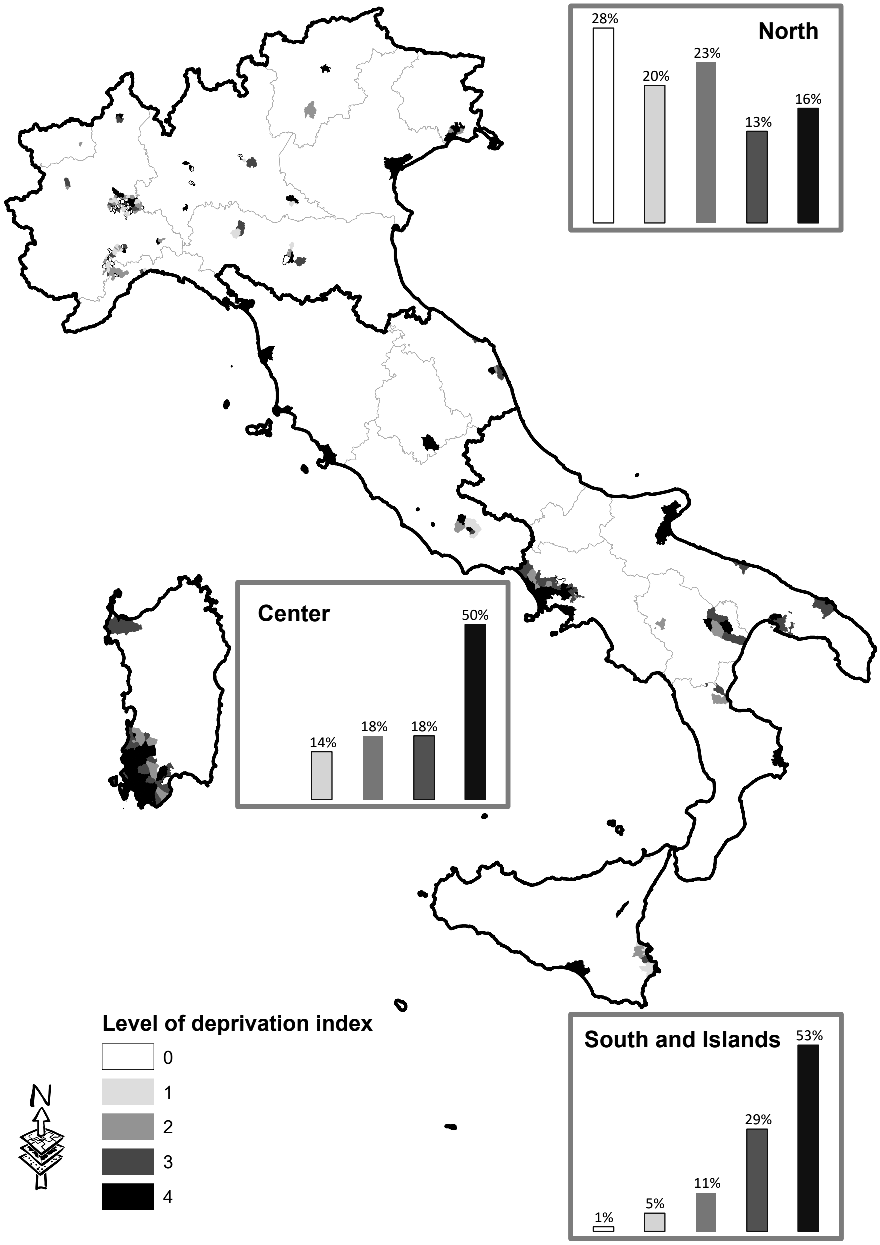
Socioeconomic Deprivation in Industrial Areas

SENTIERI has enabled us to gain a better understanding of the impact of socioeconomic differences in contaminated sites. Over the years, analyses have identified a range of approaches: in a first phase, socioeconomic deprivation indices were generated at a municipal level – that is, for the community. During that phase, socioeconomic indicators were used to correct health risk estimates as suggested by international literature on small-area epidemiological studies (Pasetto et al. 2010). In a second phase, the use of available socioeconomic indicators was tested considering a number of factors, such as the size of the population being studied, gender, and the differential association with dissimilar outcomes – such as mortality, hospitalization, incidence of cancer, and prevalence of congenital anomalies (Minichilli et al. 2017).

Such assessments made it possible to identify the limitations of the indicators being used, and specifically the following: which were only suited for small or medium sized populations; which were best suited for some areas of the country; and which displayed the associations between deprivation and health conditions more accurately in men than women.

In a third phase, socioeconomic conditions were analyzed in contaminated sites using area deprivation indicators as an additional description of risk indicators (Pasetto et al. 2017). Currently, we believe the most informative approach is not the generalized production of risk estimates corrected by socioeconomic indicators, but rather seeing how environmental exposure, and social, economic, and working conditions interact in determining risk profiles for populations living in the contaminated sites. The description of the socioeconomic characteristics of such communities is one of the preliminary steps for the analysis of the interactions among factors.

As previously mentioned, Gela is an exemplary case of "industrialization without development": the presence of an industrial complex did not become an opportunity to improve the socioeconomic conditions for the overall population living close by. Similar situations were observed in other sites contaminated by industrial plants. When implementing the SENTIERI system, we wondered whether all communities living close to the Italian Sites shared a similar situation. As a result, we tried to examine whether, as well as experiencing the disadvantages of living in a contaminated area, they were also socioeconomically vulnerable. Furthermore, we considered if, and if so to what extent, such unfavourable conditions impacted on their health profiles. Socioeconomic conditions were assessed using a multifactorial/multidimensional deprivation index based on census data: education (percentage of over 16-year-olds with primary school or lower education); employment (percentage of unemployed active residents); living conditions (percentage of rented accommodation and number of people per dwelling). A socioeconomic indicator was then developed using information on individuals. There are 298 communities living in the 44 contaminated sites monitored by the SENTIERI system. The distribution of the municipalities/communities being monitored by deprivation level was asymmetrical (i.e., the higher the deprivation level, the larger the number): 12% of the municipalities fell into the least deprived quintile, 38% in the most deprived. All in all, 60% of the monitored municipalities (i.e., 179) fell into the two most deprived quintiles. Such a disadvantage highlights a distributive injustice, with a marked north/south divide evidencing worse conditions in the south and on the islands where nearly all the communities living close to the contaminated sites fell into the most deprived groups (Figure 9.2). In addition, when health risks were compared among residents of the various Sites, the more deprived ones appeared at greater risk for mortality for all causes and for all cancers (Pasetto et al. 2017). Analyses were influenced by the limitations of the indicator and did not enable us to identify which had been the conditions of deprivation at the time the industrial complexes had been established and opened. Existing knowledge makes it impossible for us to establish whether conditions deteriorated following industrialization and subsequent contamination. What is clear is that most communities close to contaminated sites belong to the most deprived groups in their region, and that this is especially true in southern Italy. In the south, iron and steel plants, oil refineries, and petrochemical plants were established, and accounted for most industrial jobs. However, the industrialization process failed to stimulate the growth of related networks in the surrounding areas that ended up as isolated enclaves, to the point they were nicknamed “cathedrals in the desert.” In contrast, traditional manufacturing and tourism were neglected (Cento Bull 2016). Post World War II industrialization seems to have had a positive impact on socioeconomic conditions only where it started – that is, in the north of the country – and failed to do so in the south which had had a predominantly agricultural social organization and economy, prior to the postwar “industrial colonization.”



9.2 Italy. Percentage of communities living close to Sites of National Interest for decontamination and remediation by level of deprivation in macro-areas (North, Center, South and the Islands) (from Pasetto et al. 2017).

The above points contextualize the overall trend but are unable to fully explain the complexity of the relationship between the development or evolution of each industrial complex and their surrounding communities, in terms of their social profiles and health. Every Site and every community has its own history, which cannot be described by a national monitoring system. However, with such a system it is possible to improve the capability of monitoring socioeconomic conditions that have an impact on health profiles and identify the areas with the greatest level of unfairness where one can implement action plans (Pasetto et al. 2017).

From local, national experience to the development of an international network

The Italian long-standing experience in evaluating the impact of contaminated areas using SENTIERI was one of the first steps in bringing environmental health issues related to contaminated sites to a wider international attention. The process was facilitated by the international networking consultations promoted by WHO with two expert meetings aimed at reviewing priorities, needs, data, and resources to address the question of contaminated sites and their health impact. A WHO publication on these meetings focuses on a number of European case studies, including the SENTIERI system, and summarizes the findings of the consultation, indicating opportunities, challenges, and a suggested way forward (World Health Organization 2013a). Another relevant improvement was the production of a specific training module, “Methods for risk assessment related to contaminated sites,” which included a cross-sector training package developed by WHO for environment and health experts in Capacity Building in Environment and Health (World Health Organization 2013b). For the first time, the training course introduced concepts and guidance on how to deal with environmental health in contaminated sites using simple and frequently available vital statistics as proposed by the SENTIERI approach.

This experience led to the establishment of the key WHO Collaborating Centre on Environmental Health in Contaminated Sites in 2013 (WHO CC ITA97) at the ISS, in acknowledgment of its comprehensive activities in the field.

Since its creation, the WHO CC ITA97 has been operating in strict cooperation with WHO on:

- expanding and consolidating networks and mechanisms for the collection and dissemination of information on environment and health in contaminated

sites, through providing support in organizing WHO conferences, workshops, training and dissemination activities, and other events; and
- contributing to WHO's efforts in identifying priorities on how to assess environmental health risks and to promote primary prevention interventions to protect public health in contaminated areas and environmental hotspots.

Activities coordinated by the WHO CC ITA97 importantly include the launch of a COST (European Cooperation in Science and Technology) Action on "Industrially Contaminated Sites and Health Network" (ICSHNet) in 2015 (http://www.icshnet.eu). The COST Action ICSHNet is supported by WHO, European Union, European Commission bodies, and the European Environment and Health Youth Coalition (EEHYC), and involves about 130 researchers and experts from public health institutions, universities, and environmental agencies of 33 countries.

Based on the experiences shared at international meetings with exchanges among experts from relevant institutions, and on some documents specifically devoted to the issue of environmental health in industrially contaminated sites (Martuzzi et al. 2014; Iavarone and Pasetto 2018), we currently have a more comprehensive picture of the issue.

In many circumstances, industrially contaminated sites can be attributed to the impact of development models rarely committed to sustainability, and of high concern at local, regional, and global scale. Moreover, industrial development and urbanization are proceeding rapidly in parallel.

Especially – but not exclusively – in low-income countries, environmental threats to health include traditional hazards as well as newer hazards such as urban air pollution, toxic chemicals such as lead, asbestos, mercury, arsenic, pesticides, and hazardous and electronic waste. The mix of traditional and modern hazards varies greatly across and within countries reflecting industrialization, urbanization, and socioeconomic forces, and affecting vulnerable population subgroups such, as children, more than others (Laborde et al. 2015; World Health Organization 2017a, 2017b).

In Europe, the percentage of people living close to contaminated sites is estimated to be quite substantial: about 342,000 sites require clean-up, corresponding, on average, to 5.7 estimated sites per 10,000 inhabitants. The pattern of key contaminants (heavy metals, aromatic hydrocarbons, and mineral oils) is similar in the liquid and the solid environmental matrices (Panagos et al. 2013). The main sources of contamination in these sites are directly or indirectly due to industrial activities, including industrial waste disposal and treatment; these estimates did not change greatly between 2006 and 2011 (van Liedekerke et al. 2014). Moreover, a recent Technical Report of the European Environment

Agency recognized that the environmental performance of European industry has improved in recent decades, but the sector is still responsible for significant amounts of pollution to air, water, and soil, as well as generation of waste (European Environment Agency 2015).

Several aspects may contribute to an industrially contaminated site (ICS) becoming a major public health issue. As ably described by Martuzzi and Matic (Martuzzi and Matic 2016), one distinctive feature shared by many contaminated sites is that they often involve marked health inequalities: since they are generally not located in pleasant residential areas, they tend to interest residents of a lower socioeconomic level and deprivation gradients can be observed in the surrounding areas. These authors also underline that due the concurrence of multiple contaminants, social disadvantage, and additional individual burden due to unhealthy lifestyles (alcohol consumption and smoking habits), 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. Furthermore, society at large obviously benefits from the output of industrial activities, thus introducing an additional dimension of environmental injustice (World Health Organization 2010). For the above reasons, the issue of human health in ICS is best addressed with a strong sustainability perspective, by considering the evidence on health effects and impacts, as well as the broader context of environmental and ecosystem health, and the social environment – including the occupational opportunities that arise from industrial activities. The situation calls for a multi-pronged approach, and has to be seen as a part of social negotiation, where the legitimate needs and aspirations of vulnerable groups, residents, workers, investors, and business are taken into account, in a non-discriminatory process (Martuzzi and Matic 2016).

Economic development, social cohesion, poverty and social inequalities, environment and health management, gender, and human well-being are among the key aspects covered by the COST Action ICSHNet, as strongly related to industrially contaminated sites. Environmental justice is an issue of particular concern and is addressed with a focus on vulnerable social groups such as children, women, and disadvantaged communities: these people are thought to be among the priority target groups who will have major benefit from the ICSHNet. Disadvantaged groups are often disproportionally affected by the cumulative impacts of overall degraded environments and lack financial, educational, and cultural capacities to avoid such exposure, and poor environmental conditions tend to be spatially correlated with social stressors, though little is known about the combined and potentially synergistic health effects of stress and pollution (European Environment Agency 2013). While environment-related inequalities contribute to health inequalities, more work is needed to clarify the relationships and implications for policy (World Health Organization 2012).

The number and mix of ICSs, and the range of exposure scenarios and environmental social occupational settings, mean that an overall picture of the health impacts remains uncertain. Moreover, despite the expected considerable extent of the ICSs' potential health impact, and the availability of sound methodology for studying the health implications of living close to an ICS, a fragmentation of aims, methodologies, and assessment tools makes it difficult to identify common and standardized approaches. It is therefore urgent to promote international cooperation to identify appropriate strategies and methods to deal with this issue more systematically.

However, there are a number of commonalities across Europe such as the many legacies from past industrial activities that play a central role, large and strongly polluting industrial facilities built in the 1950s–1960s in western Europe that gradually improved to comply with increasingly stringent national and European Union legislation. In some cases, they can still pose serious health threats, like the Italian contaminated site of Taranto, one of the largest European steel factories (Pirastu et al. 2013b). In addition, plants from past industrial, mining, or military activities in areas of the former Soviet Union remain a reason of concern (Standring et al. 2009); waste landfills, especially hazardous and industrial waste, are ubiquitous and may affect human health – there preventive actions should support regulation and eliminate outdated and illegal practices of waste disposal (World Health Organization 2016; Fazzo et al. 2017). Several examples of local contexts were examined in a publication (Pasetto and Iavarone 2016) promoted by the ICSHNet reporting 17 case studies from the participating countries, especially eastern European countries, covering a wide range of issues from environmental health assessments related to industrial contamination: human bio-monitoring, risk management, remediation activities, as well as dealing with inequalities.

Conclusion

Contaminated industrial sites are a major environmental and health concern both in Italy and internationally. Both affect land and territorial management in the surrounding community. The communities in question are often overburdened by the accumulation of weaknesses ensuing from environmental risks in socially deprived contexts. The overall picture has to take into account complex interactions among the various pressure factors and their evolution. This requires adequate resourcing and a range of information, a combination which is unfortunately not very frequent. Some members of the communities living near contaminated sites are generally employed by the said industries, leading to social and individual conflicts. Furthermore, in several contaminated sites, inequality of environmental exposures and social differences and their impact on health can be greater in ethnic minority groups who are in jobs with a high level of exposure, or in vulnerable groups such as women and children. The picture may differ according to the geographical area and depending on whether it is an industrialized or a low-income country, thus expanding the notion of environmental justice to a range of contexts. If appropriately fine-tuned, national epidemiological monitoring programs can contribute to the promotion of environmental justice, offering the same opportunities to further develop and document the picture, especially in less favored areas. Such monitoring programs have a top-down environmental justice approach which enhances community awareness of the conditions of their area/territory by comparing their situation to the national picture, a process which will empower local communities in the decision-making process aimed at eliminating or reducing risks for the environment and health (De Castro et al. 2016).

Thanks to the establishment of an international network, experience accrued in specific Sites or in a given country can be shared and compared with others. As a result, this will favor local projects in countries that lack a background on the matter but have the need to deal with it. Both in Europe and elsewhere, industrial contaminations are long term, and are often found in socially and naturally deteriorated environments. Communities living in industrially contaminated sites lack the resources to plan a better future. Is there a way out? Remediation and decontamination may be an opportunity in such deteriorated environments. Remediation plans are a space to renew the social environment and its related symbols on top of reducing future health risks (Saitta 2012).

Finally, we would like to stress that a monitoring system like the one described can promote interconnection between top-down science-founded evidence coming from central institutions and bottom-up demands for environmental justice from local communities. This way of producing evidence is key to the development of trust of citizens in central public institutions.

Acknowledgments

Thanks to all colleagues of the Unit of Environmental and Social Epidemiology at ISS with whom we share daily discussions and research on industrially contaminated sites. Special thanks to Pietro Comba and Roberta Pirastu for their initial efforts in promoting SENTIERI and for their invaluable support over the years.

Notes

1 The Environmental League, an Italian national not-for-profit association with the aim of promoting environmental culture, new development, and widespread well-being (https://www.legambiente.it/english-page/).

2 In Italian, SENTIERI stands for "Studio Epidemiologico Nazionale dei Territori e degli Insediamenti Esposti a Rischio da Inquinamento" (National Epidemiological Study for Territories and Industrial Complexes at Risk of Contamination/Pollution). The acronym also means "paths" in Italian.

References

Agyeman, J., Bullard, R. D., and Evans, B. (eds) 2003. *Just Sustainabilities. Development in Unequal World*. London: Earthscan.

Bruno, C., Bruni, B., Scondotto, S., and Comba, P. 2015. Prevention of disease caused by fluoro-edenite fibrous amphibole: the way forward. *Annali Istituto Superiore di Sanità*, 51(2), 90–92.

Bullard, R. D. and Johnson, G. S. 2000. "Environmental justice: Grassroots activism and its impact on public policy decision making. *Journal of Social Issues*, 56(3), 555–578.

Castleman, B. 1995. The migration of industrial hazards. *International Journal of Occupational and Environmental Health*, 1(2), 85–96.

Cento Bull, A. 2016. *Modern Italy. A Very Short Introduction*. Oxford: Oxford University Press.

Cislaghi, C., Comba, P., Iavarone, I., Pirastu, R., Settimi, L., Di Paola, M., Mastrantonio, M., Forastiere, F., Michelozzi, P., and Nesti, M. 1997. Aree ad elevato rischio di crisi ambientale. In R. Bertollini, M. Faberi, and N. Di Tanno (eds), *Ambiente e Salute in Italia*. Rome: Il Pensiero Scientifico Editore, pp. 401–544.

Comba, P. 2017. The Italian experience on contaminated sites and health. In R. Pasetto and I. Iavarone (eds), *First Plenary Conference. Industrially Contaminated Sites and Health Network (ICSHNet, COST Action IS1408). Istituto Superiore di Sanità. Rome, October 1–2, 2015*. Rome: Istituto Superiore di Sanità. Rapporti ISTISAN 16/27, pp. 31–35.

Comba, P., Ricci, P., Iavarone, I., Pirastu, R., Buzzoni, C., Fusco, M., Ferretti, S., Fazzo, L., Pasetto, R., Zona, A., Crocetti, E. 2014. ISS-AIRTUM Working Group for the study ofcancer incidence in contaminated sites. Cancer incidence in Italian contaminated sites. *Annali Istituto Superiore di Sanità*, 50(2), 186–191.

De Castro, P., Pasetto, R., Marsili, D., and Comba, P. 2016. Fostering public health awareness on risks in contaminated sites. Capacity building and dissemination of scientific evidence. *Annali Istituto Superiore di Sanità*, 52(4), 511–515.

European Environment Agency 2013. *Environment and Human Health. Joint EEA-JRC Report*. Luxembourg: Publication Office of the European Union.

European Environment Agency 2015. *The European Environment – State and Outlook 2015: Synthesis Report*. Copenhagen: European Environment Agency.

Fazzo, L., Minichilli, F., Santoro, M., Ceccarini, A., Della Seta, M., Bianchi, F., Comba, P., and Martuzzi, M. 2017. Hazardous waste and health impact: A systematic review of the scientific literature. *Environmental Health*, 16(1), 107.

Hytten, E. and Marchioni, M. 1970. *Industrializzazione Senza Sviluppo. Gela: Una Storia Meridionale*. Milan: Franco Angeli.

Iavarone, I. and R. Pasetto, R. (eds) 2018. Environmental health challenges in contaminated sites. *Epidemiologia e Prevenzione*, 42(5–6), suppl. 1.

Laborde, A., Tomasina, F., Bianchi, F., Bruné, M. N., Buka, I., Comba, P. … Landrigan, P. J. 2015. Children's health in Latin America: The influence of environmental exposures. *Environmental Health Perspectives*, 123(3), 201–209.

La Dou, J. 1992. First World exports to the third world-capital, technology, hazardous waste, and working conditions – Who wins? *Western Journal of Medicine*, 156(5), 553–554.

Marsili, D., Fazzo, L., Iavarone, I., and Comba, P. 2017. Communication plans and in contaminated areas as prevention tools for informed policy. *Public Health Panorama*, 3(2), 261–267.

Martuzzi, M. and Matic, S. 2016. Industrially contaminated sites and health: Challenges for science and policy. In R. Pasetto and I. Iavarone (eds), *First Plenary Conference. Industrially Contaminated Sites and Health Network (ICSHNet, COST Action IS1408). Istituto Superiore di Sanità. Rome, October 1–2, 2015*. Rome: Istituto Superiore di Sanità. Rapporti ISTISAN 16/27, pp. 6–8.

Martuzzi, M., Mitis, F., Biggeri, A., Terracini, B., Bertollini, R., & Working Group Environment and Health in Italy 2002. Environment and health status in the population of the areas at high risk of environmental crisis in Italy. *Epidemiologia e Prevenzione*, 26(6) suppl.

Martuzzi, M., Pasetto, R., and Martin-Olmedo, P. 2014. Industrially contaminated sites and health. *Journal of Environment and Public Health*, 198574.

Minichilli, F., Santoro, M., Bianchi, F., Caranci, N., De Santis, M., and Pasetto, R. 2017. Evaluation of the use of the socioeconomic deprivation index at area level in ecological studies on environment and health. *Epidemiologia e Prevenzione*, 41(3–4), 187–196.

Mudu, P., Terracini, B., and Martuzzi, M. (eds) 2014. *Human Health in Areas with Industrial Contamination* (Copenhagen, World Health Organization Regional Office for Europe,).

Panagos, P., Van Liedekerke, M., Yigini, Y., and Montanarella, L. 2013. Contaminated sites in Europe: Review of the current situation based on data collected through a European network. *Journal of Environment and Public Health*, 158764.

Pasetto, R. and Iavarone, I. (eds) 2016. *First Plenary Conference. Industrially Contaminated Sites and Health Network (ICSHNet, COST Action IS1408). Istituto Superiore di Sanità. Rome, October 1–2, 2015*. Romae: Istituto Superiore di Sanità. Rapporti ISTISAN 16/27.

Pasetto, R., Martin-Olmedo, P., Martuzzi, M., and Iavarone, I. 2016. Exploring available options in characterising the health impact of industrially contaminated sites. *Annali Istituto Superiore di Sanità*; 52(4), 476–482.

Pasetto, R., Sampaolo, L., and Pirastu, R. 2010. Measures of material and social circumstances to adjust for deprivation in small-area studies of environment and health: Review and perspectives. *Annali Istituto Superiore di Sanità*, 46(2), 185–197.

Pasetto, R., Zengarini, N., Caranci, N., De Santis, M., Minichilli, F., Santoro, M., Pirastu, R., and Comba, P. 2017. Environmental justice in the epidemiological surveillance system of residents in Italian National Priority Contaminated Sites (SENTIERI Project). *Epidemiologia e Prevenzione*, 41(2), 134–139.

Pasetto, R., Zona, A., Pirastu, R., Cernigliaro, A., Dardanoni, G., Addario, S. P., Scondotto, S., and Comba, P. 2012. Mortality and morbidity study of petrochemical employees in a polluted site. *Environmental Health*, 18(11), 34.

Pirastu, R, Comba, P., Conti, S., Iavarone, I., Fazzo, L., Pasetto, R., Zona, A., Crocetti, E, and Ricci, P. (eds) 2014. SENTIERI - Epidemiological study of residents in National Priority Contaminated Sites: Mortality, cancer incidence and hospital discharges. *Epidemiologia e Prevenzione*, 38(2), suppl. 1.

Pirastu, R, Pasetto, R., Zona, A., Ancona, C., Iavarone, I., Martuzzi, M., and Comba, P. 2013a. The health profile of populations living in contaminated sites: SENTIERI approach. *Journal of Environmental and Public Health*, 939267.

Pirastu, R, Comba, P., Iavarone, I., Zona, A., Conti, S., Minelli, G., Manno, V., Mincuzzi, A., Minerba, S., Forastiere, F., Mataloni, F., and Biggeri, A. 2013b. Environment and health in contaminated sites: The case of Taranto, Italy. *Journal of Environmental and Public Health*, 753719.

Pirastu, R., Iavarone, I., Pasetto, R., Zona, A., Comba, P., and SENTIERI Working Group 2011. SENTIERI Project. Mortality study of residents in Italian polluted sites: Results. *Epidemiologia e Prevenzione*, 35(5–6), suppl. 4.

Saitta, P. 2012. History, space, and power. Theoretical and methodological problems in the research on areas at (industrial) risk. *Journal of Risk Research*, 15(10), 1299–1317.

Schlosberg, D. 2004. Reconceving environmental justice: Global movements and political theories. *Environmental Politics*, 13(3), 517–540.

Standring, W. J. F., Dowdall, M., and Strand, P. 2009. Overview of dose assessment developments and the health of Riverside residents close to the “Mayak” PA facilities, Russia. *International Journal of Environmental Research and Public Health*, 6(1), 174–199.

van Liedekerke, M., Prokop, G., Rabl-Berger, S., Kibblewhite, M., and Louwagie, G. 2014. *Progress in the Management of Contaminated Sites in Europe*. Luxembourg: Joint Research Centre, Report EUR 26376.

Walker, G. 2012. *Environmental Justice: Concepts, Evidence and Politics*. New York: Routledge.

World Health Organization 2009. *Manual for the Public Health Management of Chemical Incidents*. Geneva: World Health Organization.

World Health Organization 2010. *Environment and Health Risks: A Review of the Influence and Effects of Social Inequalities*. Copenhagen: World Health Organization, Regional Office for Europe.

World Health Organization 2012. *Environmental Health Inequalities in Europe, Assessment Report*. Copenhagen: World Health Organization, Regional Office for Europe.

World Health Organization 2013a. *Contaminated Sites and Health. Report of Two WHO Workshop:*

Syracuse, Italy, 18 November 2011 and Catania, Italy, 21–22 June 2012. Copenhagen: World Health Organization Regional Office for Europe.

World Health Organization 2013b. *Capacity Building in Environment and Health (CBEH) Project. Report of the International Training Workshop on CBEH. 19–23 March 2012 Riga, Latvia*. Copenhagen, World Health Organization Regional Office for Europe.

World Health Organization 2016. *Waste and Human Health: Evidence and Needs. WHO Meeting Report. 5–6 November 2015. Bonn, Germany*. Copenhagen: World Health Organization Regional Office for Europe.

World Health Organization 2017a. *Declaration of the Sixth Ministerial Conference on Environment and Health* 2017a. Available at http://www.euro.who.int/__data/assets/pdf_file/0007/341944/OstravaDeclaration_SIGNED.pdf?ua=1 (last accessed February 5, 2020).

World Health Organization 2017b. *Inheriting a Sustainable World? Atlas on Children's Health and the Environment*. Geneva: World Health Organization.

Zona, A, Fazzo, L., Binazzi, A., Bruno, C., Corfiati, M., and Marinaccio, A. 2016. SENTIERI- Epidemiological study of residents in National Priority Contaminated Sites: Mesothelioma incidence. *Epidemiologia e Prevenzione*, 40(5), suppl. 1.

Zona, A, I. Marcello, M. Carere, E. Beccaloni, F. Falleni, M.E. Soggiu. In press. "Priority index contaminants, target organs and human exposure in contaminated sites" in D. Marsili, R. Pasetto (eds) *Italy-Latin America Cooperation. Health Impact of Contaminated Sites: Methods and Applications*, (Rome, Rapporti ISTISAN 15/32, 2015).

Zona, A, Pasetto, R., Fazzo, L., Iavarone, I., Bruno, C., Pirastu, R., and Comba, P. (eds) 2019. SENTIERI epidemiological study of residents in National Priority Contaminated Sites: Fifth report. *Epidemiologia e Prevenzione*, 43(2–3), suppl. 1.