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A cross-disciplinary approach to global environmental health: the case of contaminated sites

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Abstract

Cross-disciplinary approaches to Global Environmental Health are essential to address environmental health threats within and beyond national boundaries, taking into account the links among health, environment and socio-economic development. The aim of this study is to present a cross-disciplinary approach where knowledge and findings from environmental epidemiology and social research are integrated in studying environmental health issues, focusing on environmental health inequities, public and environmental health literacy, and international scientific cooperation. In the case of contaminated sites, environmental epidemiology can contribute investigating the multidimensionality of equity for sustainable development practices. These practices entail a better understanding of environmental contamination, health effects pathways and improved capacities of different stakeholders to identify policy options for environmental risk prevention, remediation and management that will foster informed participation in decisions influencing communities. International scientific cooperation frameworks adopting equity principles shared by scientific community, populations and decision-makers may be of valuable support to this task.

Key words

- global environmental health
- contaminated sites
- health inequities
- environmental health literacy
- international cooperation

INTRODUCTION

The global dimension of the environmental burden of disease represents a worldwide concern associated with the increasing awareness of the extent and severity of environmental risks and health impacts caused by different contamination sources [1-3]. The results of epidemiological research demonstrate that air, water and soil pollution are affecting populations health in both the most industrialized and industrializing countries in the world, thus corroborating the intrinsic relationships among development, environment and health [4-6].

The available scientific evidence is very strong with respect to urban air pollution and to a number of specific chemical agents, while the adverse health effects of many contaminants present in soil, groundwater and food chain are still object of major research projects. In this frame, development of Global Environmental Health (GEH) relies on an increasing number of studies on health impact of environmental risks and hazardous exposures within and outside national boundaries. The scale and the complexity of environmental health challenges require increasing efforts for assessing the interactions among population, health and the environment, and cannot be tackled by a single stakeholder category. This observation clearly illustrates the need to foster collaborations in order to respond these challenges starting from the strengthening of multidisciplinary research [7, 8].

Referring to the global dimension of environmental health, the 2030 Agenda for Sustainable Development adopted in September 2015, implements a trans-disciplinary approach to include a set of seventeen Sustainable Developments Goals (SDGs), many of which focus on the quality of the environment for population well-being [9]. In 2010 criticisms of the Millennium Development Goals (MDGs) were raised concerning the lack of interactions among individual objectives [10] while the present formalization of SDGs allows the identification of potential interactions among different areas through interdisciplinary approaches [11]. In this view, the SDGs are mutually integrated to balance the economic, social and environmental dimensions of sustainable development: the most important aspect of this new agenda is indeed the recognition of the necessity of not accumulating further delays to reducing inequalities (the SDG number 10) as a core action on the sustainability of development [9, 12]. For the specific interest of this paper, this means to take action towards the goal of reducing environmental health inequalities acknowledging the interdependence among

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health, environment and socio-economic components of development. This aspect of inequalities can be regarded as one of key cross-cutting issues of GEH, as it will be discussed later.

The Word Health Organization Program "Public health, environmental and social determinants of health" (www.who.int/phe/health_topics/en/) as well as the National Institute of Environmental Health Sciences (www.niehs.nih.gov/research/programs/geh/) represent authoritative scientific sources corroborating the relationship between the social determinants of health and the environment and, consequently, disseminating information to different stakeholders. The NIEHS defined GEH *"research, education, training, and research translation directed at health problems that are related to environmental exposures and transcend national boundaries, with a goal of improving health for all people by reducing the environmental exposures that lead to avoidable disease, disabilities and deaths"*.

The aim of this study is to present a cross-disciplinary approach to GEH through key cross-cutting issues that characterize the global dimension of environmental health, namely: i) environmental health inequalities, ii) public health and environmental health literacy, and iii) international scientific cooperation, by integrating knowledge and findings from environmental epidemiology and social research. This approach is applied to an environmental public health issue, namely the health impact of industrially contaminated sites.

CROSS-DISCIPLINARY ANALYSIS OF GEH

A cross-disciplinary approach to study the relationship between population health and environmental risk factors has to take into account geographical, social and economic implications at global, regional and local scale. In this perspective, collaboration between socio-economic and environmental health sciences contributes to a better understanding of environmental contamination risks and impacts [13], focussing on the causal chain associated with structural and interconnected environmental and health inequities within a world-system [14].

Starting from the integration between the Environment and Health domains, environmental health assumes a global dimension through two major and strictly connected components: the health impact on populations associated with worldwide contamination and pollution of different sources, and the industrial development policies and practices as a critical factor of socio-economic development. These two components contribute to the modification of everyday life of communities in a single country and worldwide. Along the past and present century, in both first and currently industrializing countries, low quality industrial development including externalization of costs on population health and the environment has often been characterizing the economic growth (as measured by Gross Domestic Product) of countries. Dislocation of industrial settings and practices producing contamination and pollution in disadvantaged areas within a single country as well as towards new industrializing countries worldwide has been affecting communities involuntary and unknowingly exposed to hazardous substances.

In this perspective, this study discusses GEH through a three-pronged approach including key cross-cutting topics of environmental health, namely i) environmental health inequities, ii) public health and environmental health literacy, and iii) international scientific cooperation. These can mutually support and influence the role of environmental epidemiological research on health impact of environmental contamination. As shown in *Figure 1*, these three cross-cutting topics can be seen within the GEH representation as horizontal layers intersecting the two major components of GEH, which represent the bottom-up implementation towards the global dimension of environmental health as a clue to human development.

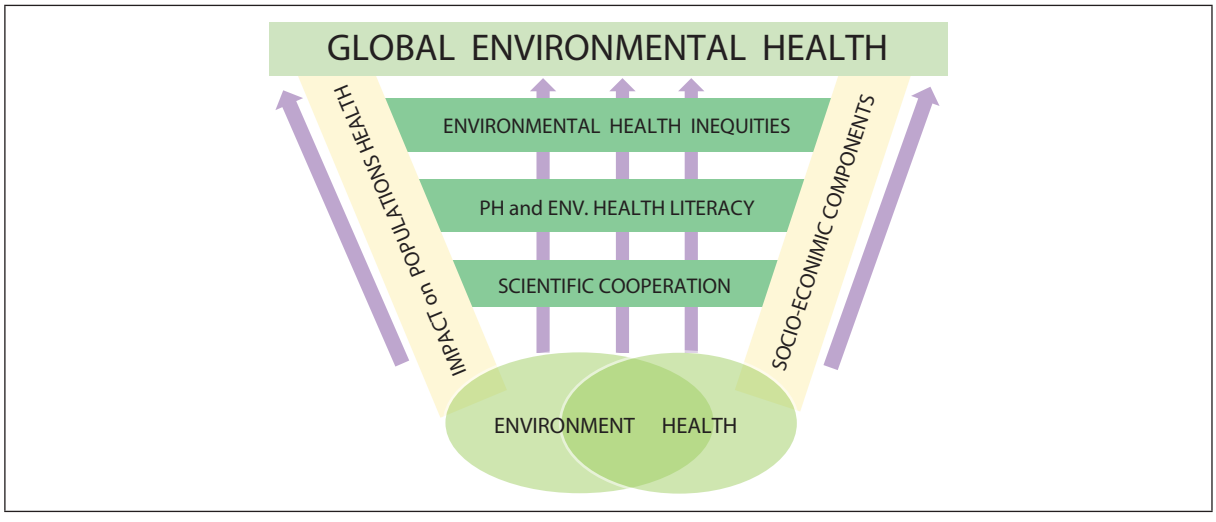

Figure 1
Schematic representation of GHE pointing out two major components of GEH and three key cross-cutting topics of its global dimension.

Environmental health inequities

During the last 25 years, social and health scientists defined health inequities as unfair, unnecessary, and preventable differences in health within and between countries [15-19]. Whitehead (1990, [15]) specified that exposure to unhealthy living and working conditions would be considered to be avoidable and the resultant health differences to be unjust. More recently, the definition of environmental health inequalities focuses on unequal distribution of environmental hazardous exposures often associated with socio-economic deprivation and vulnerability [20, 21].

In this frame, in order to analyse the diverse magnitude and impact of environmental health inequities within and among countries, the socio-economic determinants of health, that are the conditions in which people are born, grow, live, work and age, should be taken into account. These conditions are shaped by the distribution of money, power and resources at global, national and local scales [17]. The adoption of quantitative and qualitative research approaches may be suitable to identify the root factors of inequities, the socio-economic impacts of environmental health inequities, and therefore the most appropriate actions to improve socio-economic determinants of population health [22], in particular of the most deprived and marginalized subgroups of population and countries. In this perspective, effective examples may be represented by:

- studying socio-economic causes and implications of local contexts within and beyond national boundaries may strengthen knowledge of root factors concerning interconnected structural inequities within a world-system [14]. A socio-economic analysis of the market drivers associated with the dislocation of industrial productions and settlements at local and international scale, as well as on low quality industrial processes and practices [23-25], can foster stakeholders commitment to improving industrial and occupational policies and to reclaiming industrially contaminated areas in order to contrast economic decline and social vulnerability (including health impacts);
- a socio-environmental and anthropological research can identify the social effects of environmental degradation and community health-related impact focusing on disarticulation of affected communities associated with the weakening of local institutions and social interactions, and on raising socio-environmental conflicts [26, 27]. This research can better focus communication strategies for enabling communities and in particular actions for increasing environmental health literacy of communities as one of the critical social determinant of health (this specific point will be discussed in detail later);
- multi-disciplinary studies for prevention interventions aimed at improving socio-economic determinants of health may focus on the domain and indicators of environmental quality [28], including working conditions and industrial practices relying on externalization of costs on population health and the environment. This has the potential to indentify and tackle the causal chain of environmental health inequities in specific contexts. The engagement of multi-stakeholders within and outside the health domain is critical in order to develop tools to support informed decision-making processes and inter-sectorial interventions, within a public health approach, supported by a cross-disciplinary research.

Public and environmental health literacy

Public and environmental health literacy is based on scientific evidence and includes review of research findings, dissemination of validated information, individual and collective decision-making and critical thinking [29-32]. GEH relies on public and environmental health literacy to improve ability of stakeholders to understand environmental health information, to increase their awareness on hazardous substances and exposures, to engage and empower communities in the evaluation and use of environmental health information both at local and global level [33, 34]. Public and environmental health literacy may support communities to make informed choices to reduce hazardous exposures and improve their health and quality of life [35]. In particular, this is relevant when it is addressed to a wide range of stakeholders within and outside the health domain, because of exposure reduction strategies require policy changes [36].

Moreover, if health implications of hazardous exposures are uncertain, it is critical that communities acquire knowledge on what is and is not known, including why the epidemiological studies are focused on those hazardous agents. Effective communication and the engagement of stakeholders should jointly rely on both the oral exchanges and written dissemination of health information, and not relying on a single literacy skill, to meet moderate reading ability with high oral skills and conversely [37]. This implies *incorporating, where appropriate, traditional pedagogies into the education process with a view to preserving and making full use of culturally appropriate methods of communication and transmission of knowledge* [38].

It is well-known that the lack of literacy is often associated with low socio-economic status of communities, low-institutional organization and low-income countries. The improvement of public and environmental health literacy on hazardous substances and exposures in living and working environments contributes to increasing awareness as a starting point to a better preparedness of communities and countries to prevent and manage environmental health risks and related socio-environmental conflicts. Gaps in health inequities may be addressed by initiatives aimed at strengthening health literacy among vulnerable population sub-groups [39]. All this may play a crucial role in reducing environmental burden of disease at country level and in tackling environmental health inequities among countries

International scientific cooperation

Within GEH, a suitable scientific cooperation approach requires equitable relationships among cooperation partners from different countries adopting a bi-directional exchange of scientific knowledge, skills and practices on environmental health issues. This cooperation network has the potential to address both well-

known and emerging environmental health research issues, and to favour the raising of local knowledge, socio-environmental, ecological and epidemiological studies within international scientific community and literature [40, 6]. The role of local knowledge on socio-environmental priorities and epidemiological studies consistent with specific contexts are fundamental to identify causal chain of inequities. This framework may contribute to adopt the most appropriate prevention actions at local level as well as to mitigate the global dimension of the environmental burden of disease. In other words, a multidisciplinary international cooperation networks may be effective frameworks to support social research on local priorities and needs to contrast environmental health inequities, to be complementary to epidemiological studies using internationally validated research methodology and evidence.

Environmental epidemiology can contribute to identify and contrast environmental health inequities, developing tools to empower stakeholders both at local and global scale, and on this ground developing scientific cooperation networks.

Furthermore, an international scientific cooperation framework adopting a public health approach focused on prevention can implement collaborative efforts in production and dissemination of evaluation of available evidence as well as through training and capacity building to increase awareness and literacy of whole communities in critical contaminated areas in support of informed practices and policies [41]. This specific task may contribute in contrasting environmental health inequities within and among countries.

THE CASE OF CONTAMINATED SITES

The cross-disciplinary analysis here presented is used to address a global environmental health issue: health impact of industrially contaminated sites, taking into account the links among health, environment and socio-economic development and the associated environmental health inequities. Preventable and involuntary hazardous exposures of the most vulnerable communities living in contaminated areas highlight persisting environmental health inequities associated with a higher burden of disease affecting these populations and countries.

The health impact of industrially contaminated sites is addressed as an important global public health threat [42-44]. A high number of polluted areas worldwide are industrially contaminated sites, often characterized by the presence of petrochemical, chemical and steel industries, as well as by asbestos mining and industrial activities, and toxic waste dump sites. Evaluating the health impact of contaminated areas is very complex due to the concurrent presence of multiple pollutants, different pathways of exposure (all environmental matrices can be potentially involved), and a variety of possible health consequences for the exposed populations [45]. Industrially contaminated sites are often located close to urban areas and/or socially deprived neighbourhoods. This increases the possible impacts, makes exposure patterns more complex, and involves interactions with other health determinants [46].

In this work two case-studies of contaminated sites have been investigated, which represent distinct cases of environmental contamination and related health effects associated with industrial activities in two countries of different Continents: environmental contamination and childhood leukaemia incidence associated with oil exploitation/production in Amazon basin in Ecuador [47] and lead poisoning epidemic affecting population and in particular childhood due to artisanal gold mining in Zamfara State, northern Nigeria [48].

The first selected case study concerns the burden of disease affecting indigenous communities living in proximity to oil fields in the Amazon basin in the provinces of Sucumbios, Orellana, Napo, and Pastaza in Ecuador where foreign and national oil companies operated for decades realising toxic waste, gas and oil (benzene, xylene, toluene) into the environment [47, 49, 50]. In particular, Hurtig and San Sebastian (2004, [47]) focused on the incidence of leukaemia in the population 0-14 age-group, and suggested a relationship between leukemia incidence in children and living in proximity of oil fields. Although the authors recognized several limitations in available data and methods adopted in their ecological study (the study cannot indentify a causal inference, but the possibility of a causal relationship on the basis of plausible criteria), they pointed out the need for building an environmental monitoring system and a surveillance system on cancer incidence in these affected Ecuadorian areas. Results of these studies point out persisting environmental health inequities affecting the indigenous communities as a vulnerable and marginalized sub-group of population in terms of socio-economic deprivation (impediments to access to adequate health care, lack of diagnostic skills and transport facilities that can result in under-reporting cancer cases from those study areas in the Quito Cancer Registry) and of their dependency from the Amazon basin integrity ecosystem and its irreversible environmental degradation. In the same years of these ecological studies, sociological research in Ecuador elaborated methodologies and practices for local management of socio-environmental conflicts associated with oil extractive exploitation affecting indigenous communities living in the Amazon basin, in particular in the province of Pastaza [51]. Even if environmental justice concerns were raised at national and international level, a structured multidisciplinary international cooperation framework did not support the adoption of an inter-sectorial programme joining environmental and health interventions to successfully address the environmental health threats in the Amazon basin of Ecuador.

The second selected study presents the adoption of a health response programme, including environmental remediation activities, in the Zamfara state in Nigeria to address a childhood lead poisoning epidemic associated with local artisanal gold mining. The successful results of this programme reported in the study of Tirima *et al.* (2016, [48]) point out how a cross-disciplinary approach can successfully address an "environmental health crisis". In particular, environmental health inequities represented by the higher burden of disease (irre-

versible neuropsychological effects) affecting the most vulnerable population subgroups, have been contrasted through medical treatment for children 1-5 years old. The social determinant of health of environmental- and public health literacy was improved through training medical, technical and institutional local stakeholders and adapting protocols successfully developed in another country (at the Bunker Hill Superfund Site in Idaho, US), as well as considering socio-cultural patterns (religious and cultural practices) of the affected communities. Involvement of local stakeholders concerned both trained workers employed in cleanup activities and management of environmental remediation of the polluted areas, and governmental authorities responsible to fund the implementation of the remedial protocols and to regulate safer mining practices. The international scientific cooperation framework, which involved local and foreign actors (including Nigerian environmental and health authorities, foreign health research Institutes, international medical ONGs, United National UNEP and WHO), succeeded in developing the health response programme by integrating scientific research and environmental and health interventions in Zamfara state.

The case studies here discussed, although not exhaustively representing the complex typologies worldwide, are representative of the implications (causal mechanisms and factors) of industrially contaminated sites for GEH because they go beyond the specificity of the local context.

As far as environmental health inequities are concerned, the geographical location of these contaminated sites demonstrate that deprived areas and vulnerable population subgroups are affected by contamination produced by transnational and national companies, which often adopt low standards in industrial processes through externalizing contamination costs on health and environment. Environmental health inequities and environmental justice topics demand for the adoption of strong multi-sectorial prevention interventions in order to contrast environmental degradation and human health impacts. In fact, the improvement of daily living conditions of the most vulnerable and affected communities in their working and living environments requires shared efforts by different stakeholders at local, national and global level. In this view, a cross-disciplinary approach can design and adopt multi-level governance (local, national, global) and multi-sectors policies (economic, social, environmental) producing health co-benefits [52], and therefore play an important role in contrasting environmental health inequities. In fact, the use of the "umbrella" co-benefits concept is particularly useful to support multidimensionality and the integration needs of economic, social, ecological and institutional aspects of a sustainable development [52].

Often in contaminated sites, lack of knowledge and awareness of local stakeholders on ascertained and potential contamination caused by industrial hazardous practices, (resulting in community exposure to chemical agents such as oil, heavy metals, chlorinated compounds, asbestos, industrial wastes), are frequently accompanied by institutional weakness in terms of regulation and control. Environmental and public health literacy assumes a fundamental role in contaminated areas: interactions and collaboration among scientific community and multi-stakeholders are critical in promoting awareness, participation, engagement, and capacity-building to address health impact of contamination and adopt prevention actions. Social research may play an important role for identifying the different stakeholders and understanding how each stakeholder understands and perceives environmental health risks [33]. This is essential to identity and adopt the most appropriate and effective approaches to increase public and environmental health literacy of affected communities, thus contributing to adapt global challenges to local priorities.

An effective communication strategy, jointly designed by cooperating partners (local and/or national and international) and including training, dissemination of scientific evidence and engagement of local stakeholders in literacy plans, may contribute not only to increase public awareness but to foster informed policies within and outside the health domain [53]. Health, environmental and social co-benefits of sustainable industrial production and consumption patterns can represent a balancing factor to economic development contributing to manage the improper "choice" between health and occupation.

International and multi-disciplinary cooperation frameworks can be potentially effective to highlight the strong interconnection between the socio-economic components and environmental and health impacts of contaminated sites at local and global scale. Sharing scientific knowledge, experience and best practices adopted in different countries [54-56] can contribute to contrast environmental health inequities.

CONCLUSIVE REMARKS

The cross-disciplinary approach to GEH presented in this paper and its application to contaminated sites suggest several additional considerations for emphasizing the implications for environmental health and, in particular, for environmental epidemiology.

Environmental epidemiology research is aimed at promoting prevention actions to mitigate environmental risks and health impact of industrially contaminated sites, which need a cross-disciplinary approach relying on social research on environmental health inequities, public and environmental health literacy, as a social determinant of health, and international scientific cooperation. Taking into account the interactions between environment and health domains, the origins, the causes and the socio-economic impact of environmental health threats have to be considered to tackle environmental health inequities as a key contribution to sustainable development practices.

Environmental epidemiology and public health are also committed to foster environmental remediation initiatives and socio-economic interventions in contaminated sites to reduce the major environmental burden of disease affecting the most vulnerable communities living in contaminated areas. This represents an effective contribution for contrasting environmental health

inequities. These endeavors require a participative approaches at local scale, which involve the diversity of cultural processes and the socio-economic needs and concerns of affected communities and population subgroups, and that will benefit from a coordinated approach at global scale to share best practices and successful policies. The cross-disciplinary approach here presented, relying on the analysis of health co-benefits, may add effectiveness to local-national-global actions in supporting public policies for improving the working and living conditions of affected communities.

In the case of contaminated sites, discussed here as an increasing global environmental health concern, environmental epidemiology can contribute to investigating the multidimensionality of equity through cross-disciplinary approaches for sustainable development practices. These practices entail a better understanding of environmental contaminations and health effects pathways as well as improved capacities of different stakeholders to identify and propose policy options for environmental risk prevention, remediation and management that will foster informed participation in decisions influencing communities.

Multidisciplinary approaches within international scientific cooperation frameworks have the potential to engage stakeholders at different scale (local, national, international) to promote multi-sectorial efforts for improving the socio-economic determinants of health and population subgroups and communities health. This might represent a practical and effective way to adopt and implement sustainable development strategies requiring a new inclusive cooperation perspective and equity principles shared by scientific community, populations and decision-makers.

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Conflict of interest statement

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