A CLOSER LOOK AT THE HISTORICAL PROGRESS AND VARIOUS APPLICATIONS OF MEDICAL GEOLOGY IN ITALY

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ABSTRACT

Medical geology is defined as the science that deals with the relationship between geology and health in humans, animals, and plants (Skinner and Berger, 2003; Selinus et al., 2005,‑2010; Florinsky 2010; Centeno et al., 2016). While medical geology can be recognized as having distinct links to geomedicine, an emerging field that focuses on geographic location and environment into account when studying individual and public health, it should be distinguished from medical geography, which has slightly different meaning and application. Medical geography is concerned solely with the geographic distribution of disease without focusing on the underlying geological basis of health factors; it examines the causal associations between specific diseases and physical and social environments (Foster, 2002). Medical geology, a complex and emerging field, requires a multidisciplinary approach using a wide variety of specialists ranging from geologists, health specialists, physicians, veterinarians, and biologists.

■ INTRODUCTION

From a cursory glance, geology and medicine may seem like distinct fields of study. Today, however, it is estimated that the health of at least 5 billion people worldwide is directly related to geological factors and contexts. The importance of geological contexts for health is created by the ongoing interactions between living organisms and their environments. Medical geology, as an emerging scientific endeavor, studies the relationships between health, geological materials, and environmental and processes. The overall goal is to identify the factors that influence certain disease onsets and the related protective factors. This can only be achieved through careful integration of different disciplines including those of geology, biology, and medicine. Medical geology is, therefore, a frontier approach that is distinctly interdisciplinary and very new, hence lacks a broad foundation of prior studies. We anticipate that this will change significantly as the number of databases related to the importance of the environment on health is increasing in local, national, and international levels.

In common perception, the natural environment is considered "healthy" while an anthropogenically altered environment, especially if industrial, is perceived as "unhealthy". An entirely "natural" water spring, however, can intercept sulfide mineralization in its underground path and be rich in mercury, an element known to be neurotoxic (Aschner et al., 1990). Similarly, radioactive contamination can occur by geomorphological and lithological processes if there is a concentration of radon gas due to rocks rich in thorium and uranium; in these contexts, thorium tends to concentrate in soils while uranium is leached by

water. Air, water, and soil – all deeply impacted by geological contexts - are essential for life and their quality directly influence health conditions. Relatively few research projects have analyzed the characteristics of these elements and their influence on health. It is not easy to carry out such research due to disciplinary boundaries. Fortunately, these conceptual walls are becoming more porous and the number of inter- or multidisciplinary collaborations are increasing. Much remains to be done, however, and adequate resources, analytical tools, fieldwork skills, and evaluators capable of providing peer review for multidisciplinary projects of a distinctly nature will be indispensable. Additionally, a combination of political will and scientific willingness is requisite.

■ DISCUSSION

The International Medical Geology Association (IMGA) sponsors conferences every two years in a different country; the most recent of these, the 8th International Medical Geology (MEDGEO) Conference, was held in Guiyang, China, in August 2019. [Due to the pandemic, the 2021 MEDGEO conference will be entirely virtual]. A special volume of the journal *Ecotoxicology and Environmental Safety* was dedicated to 2019 MEDGEO conference. Topics included the relationship of human health to environmental geochemistry, water, soil pollution and remediation, and air pollution. These studies embody medical geology through their combinations of analytical methodologies, toxicology, epidemiology, public health, and regulatory science with contextual geological data.

Another association that is very active in Italy, the

Italian Association of Medical Geology (AGMItalia), aims to support and promote this new multidisciplinary approach through an informal group of over 250 researchers and specialists. Following suggestions and discussions over multiple meetings, AGMItalia was founded at the end of the 1st advanced course of Medical Geology held in Urbino in October 2009. Thematic meetings, short congresses, and scientific sessions have been organized by AGMItalia in collaboration with the International Society of Doctors for the Environment (ISDE Italia, www.isde.it), the National Institute for Insurance against Accidents at Work (INAIL), and as part of the National Festival of Geosciences "Settimana del Pianeta Terrra" (www.settimanaterra.org). Publications and documents related to these events are available at the internet site of AGMItalia (http://www.agmitalia.org).

In broad stroke, natural materials such as water, mud, gas, etc. are used to improve human health. The use of geo-materials for healing purposes is based on documented results and is also fostered by the public's frequent trust in the natural world over industrial pharmacological solutions. The use of curative geo-materials can improve patient compliance with the physician's proposed therapy. As mentioned already, these geo-materials must be evaluated for both favorable effects and possible contraindications. Multivariate analyses can help analyze these.

The measurements and analyses can be complex, as is the case with solar radiation exposure of an entire territory and its significant effects on health risks and benefits. These include the risk of developing melanoma versus the benefits of UBV rays for the reduction of the spread of the Sars-Cov19 pandemic (De Natale et al. 2020), vitamin D production, or protective effect for multiple sclerosis. In this context, Sardinia appears to be an ideal territory for the study of models of correlation between environmental factors and some diseases for their high incidence in the regional territory due to the genetic characteristics of the population and unique environmental context. This is the case for autoimmune diseases such as Type 1 Diabetes and Multiple Sclerosis, which are increasingly frequent in the Sardinian territory (Pugliatti et al. 2006, Bruno et al 2013) and for which geo-environmental factors seem to influence their onset (Valera et., 2014, 2015; Monti et al., 2016; Sanna et al., 2018). In another example, a soil sampling campaign has recently been initiated throughout the Italian country with the aim of assessing the concentration of compounds harmful to human health such as polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and organochlorine pesticides (OCPs).

Another important aspect on human health is the evaluation of atmospheric dispersion of hydrogen sulfide (H_2S) from 32 geothermal power plants (out of 35 active ones) belonging to the geothermal districts of Larderello, Travale-Radicondoli and Monte Amiata, in Tuscany (Italy). An updated geographic database, to be used in a GIS, was constructed to process the input data required by the code and to manage the outputs. The results suggest that H_2S plumes emitted from geothermal power plants are mainly concentrated around the emission stacks (H_2S concentration up to 1100 μg/m3) and rapidly dilute along the dominant local wind direction. Although the estimated values of airborne H2S concentrations are orders of magnitude higher than in unpolluted areas, they do not indicate an immediate health risk to nearby communities under the more frequent local atmospheric conditions. Starting from the estimated values, validated by field measurements, it is possible to formulate some considerations on the environmental impact of H_2S emission in all geothermal areas in the Tuscany region (Somma et al., 2017). The production of thematic maps at different scales, such as the Atlante Geochimico d'Italia, responds to the need for large-scale geochemical mapping based on FOREGS procedures. The aim of the Atlante Geochimico d'Italia is to define the base values of chemical elements on a national scale and to help governmental decision makers to define the limits of activation and action on a local scale, keeping in mind the complex spatial variability of Italian geology (De Vivo et al., 2009; Cannas et al., 2020; Zuzolo et al., 2020).

Numerous studies carried out on marine sediments in coastal areas and ports affected by former industrial sites are of national interest. Disused industrial activities are responsible for persistent environmental degradation, mainly due to the long-term accumulation of xenobiotic contaminants in the environment. This chronic form of pollution poses a great threat to human health, biodiversity, and ecosystem functioning. Environmental remediation practices should be coupled with restoration plans that aim to reverse the trend of degradation and return areas to environmental health so that they can provide valuable ecosystem goods and services. A striking case is offered by the industrial site of Bagnoli-Coroglio and the characterization of the contamination of marine sediments by arsenic and other potentially toxic elements or PAHs (Giglioli et al., 2020). Pioneering research suggests to us that CoDA represents a powerful tool for answering long-term questions about sediment geochemistry in polluted areas. This work suggests that anomalous arsenic concentrations are mainly due to pyroclastic deposits in the Phlegraean Fields and from seeps with hydrothermal component, supported by a low contribution of variables in a robust PCA of sediments from the distal zone (Buccino et al., 2021; Somma et al., 2021).

Recent medical geology studies have the great merit of identifying the complex factors that may be involved and thus the way to appropriately address subsequent investigations. The potential for the identification of predisposing factors and of protective factors and treatments related to multifactorial pathologies with important social and economic implications is truly remarkable. Considering the large number of geo-environmental topics potentially related to health, it is not surprising that several issues are still underdeveloped: for example, contributions from geophysics on natural electromagnetic fields and their variations are very rare. However, what really seems to be missing in a systematic way is the significant "descent into the field" of medical sciences. Epidemiological data, at least in Italy, are often inaccessible. At the moment, though, the major difficulties seem to be represented by disciplinary barriers and by the scarce attention of public administrations towards the important role that medical geology can play in the health field.

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