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Medical Geology: An Emerging Field of Interdisciplinary Research on Geology and Human Health

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Abstract: Medical Geology is an emerging scientific discipline that examines the impacts of geologic materials and processes on human health and ecosystem. It is the science dealing with relationship between natural geological factors and health in man and animals and understanding the influence of ordinary environmental factors on the geographical distribution of such health problems.

Every day human beings interact directly with nature by way of eating, drinking and breathing, and in the process ingests minerals and trace elements. The material consumed is mostly harmless and even beneficial, supplying essential nutrients to the body. However, the interaction with minerals and trace elements can sometimes have devastating, even fatal effects. All these interactions are covered under the realm of medical geology. It is therefore a fast-growing field that not only involves geoscientists but also medical, public health, veterinary, agricultural, environmental and biological scientists. In the broader perspective, medical geology includes the study of the effects of geologic materials and processes on human, animal and plant health, with both good and bad, even hazardous results. Precisely, medical geology studies exposure to or deficiency of trace elements and minerals; inhalation of ambient and anthropogenic mineral dusts and volcanic emissions; transportation, modification and concentration of organic compounds; and exposure to radio-nuclides, microbes and pathogens.

Medical Geology thus relates to the natural sciences such as botany, zoology, ecology, environment and allied sciences. It is therefore high time that the researches in these branches should come forward for the inter-disciplinary research on this subject of prime importance.

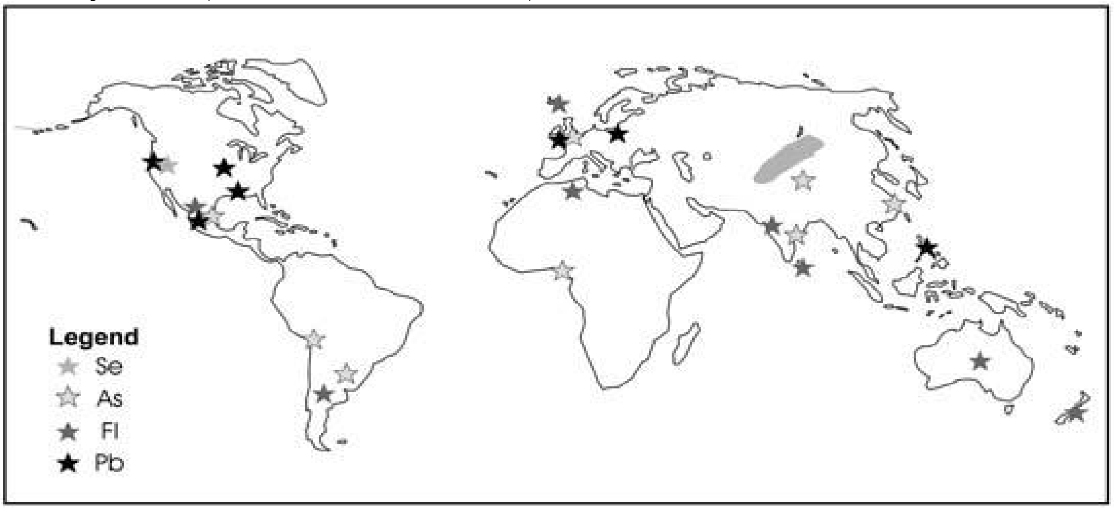
Keywords: Medical Geology, Heavy metals, Natural hazards.

Introduction

The Greek philosopher Hippocrates (400 B.C.) is considered by most scientists to be the founder of medical geology. He recognized that environmental factors affected the distribution of disease[1-3]. Later in the first century AD, the Greek physician Galen reaffirmed the potential danger of mining activities when he noted acid mists are often associated with the extraction of Cu from the ground[4]. In the past, geoscientists and biomedical scientists have collaborated on a range of environmental health issues[5].

Recently the relation between adverse health effects and heavy metals in our environment in the world (Fig.1). Heavy metals or potential pollutants have been termed 'geo-genic contaminants' and include such elements as Se, As, Fl, Pb, Cd and Hg. Elevated levels of these and other potential pollutants have been recorded in many areas of the world including Canada, USA, India, China and

Figure 1. A map of the world indicating some areas that have experienced adverse health effects due to heavy metals (after Bowman *et al,* 2004)



Bangladesh. The recognition that an intimate relationship exists between geology, as measured by geochemistry, and human/animal health, has led to the development of a new field of science called Medical Geology[6].

Effects of Geological Materials:

Researchers of medical geology realization that tiny amounts of many inorganic elements are necessary for good health in humans and other mammals yet may be injurious in excess. The geology of an area has a direct impact on the regional input of elements into the soil, air and water. Health issues related to a region's geology are visible in both humans and animals on almost every continent.[7]

Our planet Earth is the ultimate source of all metals and they are in homogenously distributed and occur in different chemical forms. Metals which occur in common rocks, sediments and soils are of greater significance to the total metal loading in the environment. All known elements are present at some level of concentration throughout the natural environment, in humans, animals, vegetables and minerals, and their beneficial and harmful effects have been present since evolution began.[8]

Rocks are the fundamental building blocks of the planet surface and different rock mineral assemblages contain the 92 naturally occurring chemical elements found on Earth. Many elements are essential to plant, animal and human health in small doses. Most of these elements are taken into the human body via food and water in the diet and in the air we breathe. Through physical and chemical weathering processes, rocks break down to form the soils on which the crops and animals that constitute the food supply are raised[9].

Drinking water travels through rocks and soils as part of the hydrological cycle and much of the dust and some of the gases contained in the atmosphere are of geological origin. Hence, through the food chain and through the inhalation of atmospheric dusts and gases, there are direct links between geochemistry and health[10]. Table 1 shows the significant differences between different rock types and their content of heavy metals.

Table 1 . Average abundance of selected elements in bedrock (all values in ppm)[8].

Element	Earths Crust	Ultrabasic	Basalt	Granite	Shale	Limestone
As	1.8	1	2	1.5	15	2.5
Cd	0.2	-	0.2	0.2	0.2	0.1
Co	25	150	50	1	20	4
Cr	100	2,000	200	4	100	10
Cu	55	10	100	10	50	15
Pb	12.5	0.1	15	20	20	8
Se	0.05	-	0.05	0.05	0.6	0.08
U	2.7	0.001	0.6	4.8	4	2
W	1.5	0.5	1	2	2	0.5
Zn	70	50	100	40	100	25

A few examples will illustrate the effects of geology on the geochemical environment:

Silica

Silicosis is a common occupational lung disease in the mining and aggregate industry, but it also occurs in non-industrial settings due to its abundance in the soil, resulting in major respiratory problems and, in extreme cases, death[11].

Vanadium and Cobalt

Vanadium is essential for photosynthesis by blue green algae, and yet this element is highly toxic to humans. Similarly, Co is required for fixing N_2 in blue green algae and other microorganisms, however, it is unknown if it is needed in higher plants[12].

Arsenic

Areas which contain high levels of As in the groundwater are found all over the world, however, the Bengal Basin in India represents one of the largest problems, with an estimated 40 million individuals drinking water with elevated and potentially dangerous levels of As. The dominant resulting health problems in the region are skin disorders (e.g., changes in skin pigmentation and keratosis)[13].

Fluoride

Fluoride is a minor element in groundwater, but very important for the development of teeth and bones. Fluoride has dual adverse effect on human health, if not present in prescribed limit. Low fluoride content (less than 0.6 mg/1) in drinking water causes dental caries, while high content (greater than 1.5 mg/1) leads to fluorosis[14].

Molybdenum

Elevated natural levels of molybdenum in the soil pose a serious health concern for grazing livestock in several areas around the world if it leads to Molybdenosis. Livestock that ingest elevated levels of Mo are unable to absorb Cu; and the resulting Cu deficiency may lead to growth or reproductive problems. Molybdenosis has been documented in impala of Lake Nakura National Park, Kenya and in cattle of Fort Fraser, British Columbia, Canada[5].

Radon

Radon exposure provides an example of the relationship between geology and negative human health implications. Radon gas, a decay product of uranium, easily migrates through soil and in turn may leak into houses through cracks and drains making it a significant potential health threat of natural radiation[15]. Although radon concentrations in the air tend to be very low due to a quick dilution, concentrations can become dangerously high in poorly ventilated buildings. The most common risk associated with radon exposure is lung cancer[16].

Table 2. Shows the Diseases at state of deficiency respectively toxicity caused by the some element[8].

Element	Deficiency	Toxicity
Iron	Anaemia	Haemochromatosis
Copper	Anaemia 'Sway back'	Chronic copper poisoning Wilson- Bedlington-disease
Zinc	Dwart growth Retarded development of gonads Akrodermatitis entero-pathica	Metallic fever Diarrhoea
Cobalt	Anaemia White Liver disease	Heart failure Polycythaemia
Magnesium	Dysfunction of gonads Convulsions Malformations of the skeleton Urolithiasis	Ataxia
Chromium	Disturbances in the Glucose metabolism	Kidney damage (Nephritis)
Selenium	Liver nechrosis Muscular dystrophy (White muscle disease)	Alkali disease Blind staggers

Selenium toxicity in horses was described in the USA and Ireland and, subsequently, the link between low environmental selenium and cardiomyopathy in sheep has stimulated work on the protective action of Se in human health. In the mid 20th century Itai-itai disease in Japan was linked to Cd pollution of food and water while methyl mercury poisoning in Japan became notorious as Minamata disease. In the 1960s lead was recognized as more than an industrial poison and Pb in air, water and dust was shown to injure young children, especially their nervous systems.

Results and discussion

Medical Geology is therefore an emerging discipline and a science which will grow rapidly. Several geological surveys are integrating Medical Geology in their work and Medical Geology is now taught in some university courses for medical students. In the future it will be important to improve communication amongst the various disciplines concerned with diseases caused by geological factors which influence the well being of humans and animals. It will also be important to develop information material for the use of schools, public and private organizations interested in Medical Geology problems to show the impact of geologic factors on the well being of humans and animals, as well as arranging joint technical meetings to address issues of mutual concern amongst geoscientists and other disciplines concerned with Medical Geology. Geological surveys, universities and geological and medical societies should take a more active role in providing useful information on geologic conditions in medical geology and encourage the development of local working groups of multi-disciplinary Medical Geology experts. It would also be useful to encourage research in the area of producing more effective methodologies for the study of geological factors in environmental medicine and formulate recommendations for mitigation of effects of natural and man-induced hazardous geochemical conditions. Medical Geology is thus an interdisciplinary science which will be heard of increasingly in the future[8]. Today there are 30 elements considered essential for the health and survival of living organisms[17].

Table 3. A list of essential elements for living organisms.

Essentials to all organisms	Essential to most organisms
C, Co, Cu, Fe, H, K, Li, Mg, Mn, Mo, N, P, S, and Zn	Al, As, B, Br, Ca, Cd, Cl, Cr, F, I, Na, Ni, O, Se and V

Conclusions

An important task is to foster acceptance of the sub discipline medical geology. This may facilitate support for research by raising awareness among funding agencies and decision-makers.The general public must be educated on the value of this field, not only for its promise of finding practical, effective solutions to serious public health problems, but because people can encourage their elected leaders to champion this important cause.

This is study of the relationship between natural geological factors and health in man and animals, and the influence of ordinary environmental factors on the geographical distribution of such health problems. The wide ranging research portfolio including

- Identifying and characterizing natural and anthropogenic sources of harmful materials in the environment[18].
- Measurement and spatial distribution of the bioaccessibility of potentially toxic elements (e.g. As, Pb, Cd) and organic substances (e.g. PAH and PCB) in soils[3].
- Studies relating to the impacts of climate change on human and ecological health, particularly the effects of contaminant mobility resulting from extreme weather events such as flooding or increased temperatures
- To identify geochemical anomalies in soils, sediments, and water that may adversely impact human and animal health.
- To forge links between developed and developing countries to find solutions for environmental health problems.
- Method development and associated studies related to the bio-monitoring of potentially toxic elements such as As in toenails, hair and urine
- These complementary communities together can forge a strong, selfsustaining inter disciplinary scientific discipline—Medical Geology.

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