Nigerian Journal of Engineering Science Research (NIJESR).
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ISSN: 2636-7114
Journal Homepage: https://nijesr.iuokada.edu.ng/

Geosciences and Public Health Medicine: The Nexus of an Evolving Society in a Highly Dynamic Environment

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Manuscript History
Received:24/12/2024
Revised: 19/04/2025
Accepted: 22/06/2025
Published: 30/06/2025
https://doi.org/10.5281/zenodo.15829278

Abstract: There has been a tremendous development of Medical Geosciences globally with several branches of Geosciences revolutionizing public health Medicine. Given the importance of Geo-environmental materials, factors and processes, including both geogenic and anthropogenic activities as well as reported cases of diseases associated with such activities in our evolving society, medical geosciences are thus crucial to human existence. This review delves deeply into comprehensive studies on the impact of geosciences factor on human health. Diagnostic imaging technology traced to earth imaging tools have transformed the health sciences by enabling earlier and more precise disease identification, robust therapy and improved patient care. Geophysics, a branch of Geosciences is commonly and currently been used to explore Earth's subsurface providing innovative insight to crucial medical problems. The geologic sources of contamination by toxic elements in the environment which has led to human exposure through food, air, gases, soil, rocks and water intake are examined closely. Furthermore, discussion extends to raising awareness about the harmful effects of water contamination caused by toxic and highly hazardous metals that find their way from the Geosciences habitat into the body system. Human exposure to toxic minerals and metals in the current evolving society deserve a common collaboration by various specialists to make this dynamic Environment safe and secured for generations. Environmental health challenges can no longer be treated in isolation but by the combined efforts of diverse background. This synergy is crucial and inevitable among stakeholders to understand and eradicate various diseases in this highly dynamic and modern Environment.

Keywords: *Geoscience, Environment, Public Health Medicine, Geogenic, Contamination*

INTRODUCTION

Rocks and soil are the fundamental building blocks of the Earth's surface, containing a multitude of minerals and chemical elements that form the earth treasures. These rocks are broken down by weathering processes which restructure the minerals to form the soils on which crops and animals are raised (Selinus *et al.,* 2001). Through the consumption of plants and animals i.e., the food-chain man comes in contact with those elements originally in the rocks. Should the rock/soil be deficient in a particular element such as iodine, the effect would manifest as adverse health effects on the consumers. On the other hand, if there is excess concentration of a particular element such as arsenic in the rock/soil, the health of the consumer is equally at risk (Selinus *et al.,* 2011). The intake of contaminated groundwater exposes the consumer to the risk of injecting harmful elements into the body system. Groundwater is made available to man as springs, rivers, lakes and through man-made wells. Volcanism is another geologic process that poses potential harm to human health, ejecting tons of different poisonous gases and volcanic ash. These travel kilometers round the planet to be inhaled by people at different radii from the vent thereby causing diverse toxicity problems on the victims (Skinner 2007). Medical geology is an emerging discipline in this evolving society and highly dynamic environment (Fig. 1) as it explores the broader relationships between the Geo-environmental elements and the health or occurrence of disease in humans, animals and plants living in the environment. It reveals the impact of geological materials and geological processes on public health and provides scientific support for the prevention and treatment of endemic diseases. In addition to the geographical distribution, characteristics of geochemical elements and diseases. It is an interdisciplinary (Fig. 1) field involving disciplines such as hydrogeology, geochemistry, geography, biomedicine, and public health and evolving at a faster pace. The most vital objective of it is to recognize, solve and improve health and disease problems related to the geological environment using multidisciplinary knowledge and tools.

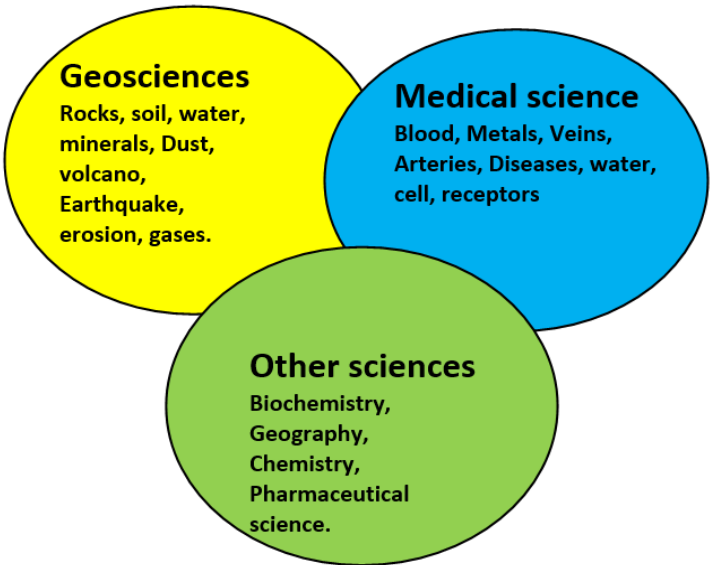

Fig. 1. Venn Diagram of relationship between Geosciences, Public Health Medicine and other sciences (Ibrahim *et al.*, 2025)

Medical geochemistry is a sub-branch of medical geology, which focuses on the relationship of geochemical processes of elements with human and animal health. Medical imaging has traditionally relied on technologies like X-rays, CT scans and MRI, each offering unique advantages but also facing limitations. X-rays and CT scans are excellent Geomedical tools for visualizing dense structures like bones, expose patients to ionizing radiation, posing potential health risks. Magnetic Resonance Imaging developed from principles of Nuclear Magnetic Resonance (NMR) of Geoscience, provides detailed images of soft tissues but often requires lengthy scan times and significant infrastructure (Table-1).

Table-1 Geoscience tools for human body imaging technique (Ibrahim *et al.*, 2025)

S/N	Diagnostic Technique	Description
1	Magnetic Resonance Imaging (MRI)	MRI has completely changed medical imaging. Its foundations traced to the concepts of strong magnetic fields employed in geophysics. It produces fine-grained pictures of soft tissues using strong magnets, enabling non-invasive visualization of anatomical features and pathologies inside the human body.
2	Electrical Impedance Tomography (EIT)	EIT has been modified to track alterations in electrical conductivity within the body EIT is a technique traditionally used in geophysics to map subsurface electrical

		conductivity. It might be used for tissue property monitoring and lung imaging..
3	Magnetoencephalography (MEG)	MEG measures the magnetic fields produced by neural activity in the brain and is derived from techniques for detecting electromagnetic signals of Earth's magnetic field. It is employed in neuroscience research and offers useful insights into how the brain functions.
4	Ultrasound Imaging	High-frequency sound waves are used in ultrasound procedures to produce images of soft tissues and organs. These techniques were inspired by seismic approaches. For real-time visualization, it is commonly utilized in obstetrics, cardiology, and other medical disciplines.
5	Elastography	Elastography techniques which were adopted from seismic technologies, measure the movement of mechanical waves across the body to determine the stiffness of the tissue. These data are useful for identifying anomalies and evaluating tissue health.
6	Computerized Tomography (CT)	CT scans, which employ X-rays to create cross-sectional images of the body, are not directly geophysical methods. There are similarities between the reconstruction algorithms used in CT imaging and the tomographic methods used in geophysics.
7	Positron Emission Tomography (PET)	PET imaging picks up injected positron-emitting radionuclides. Although not explicitly a geophysics technique, the concepts of gamma-ray detection are comparable to those of the gamma-ray spectrometry used in geophysics.
8	Functional MRI (fMRI)	fMRI is an advancement above conventional MRI in that it maps brain activity by monitoring changes in blood flow and oxygenation. This method sheds light on the cognitive functions and functional connectivity of the brain.
9	Diffusion Tensor Imaging (DTI)	DTI, which is based on the diffusion of water molecules, is a technique used in neuroimaging to show the neuronal connections and pathways in the brain. Diffusion-based geophysical techniques serve as the basis for this strategy.
10	NMR Spectroscopy	NMR spectroscopy, which is derived from NMR methods used to study molecular structures and is utilized in medical settings to examine biological molecules, is an area of study in molecular biology and medicine.
11	Near-Infrared Spectroscopy (NIRS)	The NIRS technique evaluates the tissues' near-infrared light absorption, which was first applied in geophysics to examine mineral composition. It is used in the health sciences to measure brain activity, monitor vital signs in neonatal care, and evaluate tissue oxygenation.
12	Photoacoustic Imaging	Photoacoustic imaging combines optical and ultrasonic approaches and is inspired by seismic methods. By sensing the acoustic waves that tissues emit when they absorb laser-generated light, it creates images. High-resolution imaging of tumors, blood arteries, and other structures is made possible by this method.
13	Fluorescence Imaging	Despite not being a direct geophysics tool, fluorescence imaging is analogous to how fluorescence is used in geology. Fluorescent molecules are employed to mark certain cells in medical settings, facilitating cellular imaging, cancer diagnosis, and therapeutic development.

In essence, geophysical techniques, initially designed for exploring Earth's subsurface are now being adopted to medicine with more accuracy and precision. Techniques such as electromagnetic wave analysis and acoustic wave propagation are central to geophysical studies offer innovative solutions to enhance imaging accuracy and provide deeper insights into human anatomy and its physiology.

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2. **Geosciences Tool for Public Health Diagnosis**

Fundamentally, geophysics, a branch of Geosciences provides essential insights into the structure, composition and resources of the earth. Geophysicists have revealed the stratified nature of Earth's interior, from the molten core to the solid crust, by painstakingly analyzing seismic waves from earthquakes. Maps of subsurface features have been produced using gravity and magnetic surveys, assisting resource exploration and providing a better knowledge of tectonic plate movements. Additionally, geophysical techniques allow us to explore the exteriors and interior of other celestial bodies in addition to our planet. Geophysics has a significant role in many parts of contemporary life. Natural resource exploration is one of its major contributions. Geophysical technologies support sustainable resource management and economic growth by locating mineral deposits, groundwater aquifers and hydrocarbon reserves as earth resources (Nordberg *et al.*, 2010). Additionally, geophysics is essential for hazard reduction. Geoscientists can better forecast earthquakes, tsunamis and volcanic eruptions by keeping an eye on seismic activity, ground deformations and volcanic processes. Climate change has made the weather variability to lead to low amount of precipitation with attendant flooding of coastal cities during the very short period of rainfall and low availability of potable water for man to use (Ibrahim *et al.*, 2004a). This global pandemic has led to varieties of diseases in our communities.

3. Geophysical Technique as Human Body Imaging Tool

However, in recent evolving time, geophysical tools used in the field of geophysics have been redesigned to reveal the internal anatomy and physiological functioning of the human body in unparallel detail. The use of methods like magnetic resonance imaging (MRI) is an illustration of the growing collaboration between geophysics and the health sciences (Table-1). Strong magnetic fields are used in MRI to provide precise images of soft tissues and organs. MRI was first designed to map geological features beneath the surface of Earth. Through non-invasive visualization of interior anatomy, physiology, early illness identification and surgical intervention guidance, this interdisciplinary synergy among all (Fig. 1) has revolutionized diagnostic medicine in modern societies (Wang *et al.*, 2023). Additionally, the similarities in characteristics between biological tissues and geological formations have inspired creative uses globally in recent years (Jimenez *et al.*, 2023). For instance, the geophysical technique known as electrical impedance tomography (EIT) which is used to map differences in subsurface electrical conductivity has been re-tooled to capture changes in electrical conductivity inside the human body. Due to the complexity of health problems arising from the geology, medical geology and other sciences need a multidisciplinary approach in its operations as it integrates experts from geology, geography, biochemistry and medical sciences etc., who work as a team to tackle health problems (Fig. 1).

3.1 Electromagnetic Technique

Electromagnetic methods in geophysics use electromagnetic waves to collect data on the characteristics of Earth's subsurface. These techniques use electromagnetic field interactions with materials to infer information on the underlying composition, conductivity and structures of the Earth. The foundation of electromagnetic techniques is the idea that various materials respond differently to electromagnetic waves with different frequencies. Geophysicists can generate representations or models of the subsurface by monitoring these responses and assisting in geological exploration, resource discovery and environmental studies. Faraday's law of electromagnetic induction and Ampère's law which states that electric currents produce magnetic fields, serve as the foundations of electromagnetic survey methodologies (Rashed, 2015). Faraday's law, which can be expressed in its most basic form as "a changing magnetic field will induce an EMF," asserts that the electromotive force (EMF) in a closed circuit is proportional to the rate of change of magnetic flux through the circuit. It has been a revolutionary convergence of disciplines when electromagnetic techniques of geophysics are been utilized in the health sciences.

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These techniques which were first created to investigate Earth's subsurface have been imaginatively re-aligned to reveal complex bodily landscapes. The field of health sciences has been explored through these geophysical techniques which have historically been used to reveal the contents of Earth's subsurface composition. They were originally developed to decipher geological and geophysical features and uncover earth resources. A transformational synergy has developed by fusing this seemingly unrelated fields of geophysics and health, providing non-invasive methods for imaging medical problems, tracking physiological processes and solving medical problems. Several techniques currently used in health sciences have their principles derived from geophysics (Table-1 and Fig. 1).

3.2 Seismic Imaging in Medical Applications

Seismic waves, which are produced by controlled sources like explosions or vibrators and recorded by sensors called hydrophones, geophones or seismometers, are used in seismic imaging in the context of geophysics. These waves interact with diverse geological features and formations as they move through Earth's subsurface. The created images of the subsurface, which reveal important details about its composition, structure and the presence of resources like oil, gas, water and minerals which are created from the recorded seismic data. The principles of wave reflection, refraction and transmission underlie seismic imaging. Seismic waves experience variations in speed and direction when they encounter subsurface boundaries that have different qualities (such as density, elasticity and rock type). Some of the waves are reflected back to the surface as a result of these modifications and the sensors capture these reflections. Geophysicists can determine the features of subsurface layers and formations by examining the arrival times and amplitudes of these reflected waves. Seismic profiles or sections are produced by combining data from various geophones or seismometers in seismic imaging. With the help of these profiles, one can study the strata, faults, folds, and other geological characteristics in two dimensions. Data are collected from different angles using more sophisticated techniques, such as 3D seismic imaging, petrel, geoframe, rockdog, geomatrix, kingdom suites software applications to provide three-dimensional images that offer even give more insight into subsurface structures.

4. Heavy Metal Toxicity

Some heavy metals are essential to the human biological process but depending upon their dosage intake leads to some unexpected hazardous effects on health and the physiological system disorder. According to (Kim *et al.,* 2019), studies show that despite its beneficiary in improving good health, heavy metals are acting as carcinogenic agents. Dissolved forms of these metals through different forms as soil pollutants, water pollutant and air pollutants entering into food chain and finally ending in human body system. These are leading to severe damage to the cellular system as such various diseases including cancer springing up. According to the reports of the international agency for research on cancer, non-essential heavy metals (Pb, As, Cd, Cr) are major cancer- causing agents (Kim *et al.,* 2019).

4.1 Sources, Exposure and Environmental Impacts of Lead

The sources of lead vary with different countries based on old and new usage of lead products. It is not limited to the processing of gold ore and recycling of used lead products. It is found that the decrease in blood lead levels in the population of the countries in which unleaded gasoline is in usage. A recent study has reported elevated blood levels in pregnant women in a rural village in Bangladesh. In this study, they found more than 30% of women they sampled were having lead levels in the blood to the range of above 5 µg/d (Proshad *et al.,* 2018). They found the major source of lead exposure to these women were identified as food storage cans. Nearly 18% of food storage cans were having lead soldering inside of the cans and are responsible for lead contamination in these women.

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Another study in China determined the blood lead levels (BLL's) in children who are taking treatment in lead specialty clinics. In this study, they found the BLL's ranging from 5 to 126 µg/dL. The major reasons they found for the higher lead levels in their blood was traced to industrial sources and folk medicine which is popular in China. Another important thing was determined as it is difficult to find lead poisoning in children due to non-specific symptoms. A very recent study from Australia (Dong *et al.,* 2020) determined the higher lead levels in children due to the high concentration of lead in soil and pretty dish dust at their premises. This study found that the population who are living in old houses built before 1940 are diagnosed with higher lead levels due to pretty dish dust. In Nigeria, lead poisoning in the population was observed in the area of Zamfara state, N/M Nigeria, which was associated to gold mining activities. It was (Mahuta, 2020) reported that in Nigeria, the sources of the lead were largely traced to mining of gold, lead pipes used for drinking water and cultural usage of lead. Based on these studies from different parts of the world, it is assumed that the sources of lead are historical usage of lead, mining activities, industrial activities and leaded gasoline i.e., petrol utilization which is highly ubiquitous among fossil engines. Major studies reported that children are the most common victims of lead poisoning as the most vulnerable in the societies with low immune system. The common way of exposure includes the inhalation and ingestion through drinking water and soil. There are several ways to minimize the lead levels in the environment such as remediation techniques (in soil), using adsorbents (in water) and using unleaded gasoline. After the identification of leaded gasoline as a source of lead poisoning by United State Environmental Protection Agency, a major decline in the level has been recorded by replacing leaded fossil fuel with unleaded gasoline. This is currently available in most fossil fuel retail outlets in developed world including United State of America, but yet to be seen in Nigeria and most African countries to reduce the lead content in the environmental space. It has been (Dongre, 2020) reported that the toxicological profile, remedial solutions for lead levels in water by using polymeric materials, such as, chitin and chitosan (Zaltauskaite *et al.,* 2020) resulted in the impact of lead concentration in soil on Eisenia fetida (earthworm). They found that lead in soil inhibits the growth of earthworms. Lead in soil can enter into human food by the vegetation in the contaminated soil. The types of carcinogenic effects of lead toxicity were explained in (Fig. 8). The lead toxicity in humans causes intestinal cancer, lung cancer and central nervous system problem (Fig. 2).

Fig. 2. Toxicity of lead and associated diseases

4.2 Sources, Exposure and Environmental Impacts of Cadmium

The major exposure of cadmium by human beings is through contaminated food and water. Cigarette smoke is another way of exposure through the inhalation route. The toxicity of cadmium is due to accumulation in plants and animals for nearly 25–30 years. Microbial fermentation is one of the effective methods to remove cadmium from food. Another major source of cadmium in the environment is phosphate fertilizers and the waste incineration process. Blood cadmium levels are having a huge difference between smokers and non-smokers of cigarettes. The presence of lead and cadmium in the human body can reach the brain and can cause Alzheimer's disease. After the exposure to the cadmium in human, it can accumulate in the kidney, due to this reason urinary cadmium levels have been considered as biomarkers for cadmium levels in humans (Suzzi *et al.,* 2016). In case of occupational

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exposure to cadmium which include the workers at battery production companies, pigment industries and electroplating. Because of long time accumulation in the human body at the work places, even small quantities are toxic and carcinogenic to the human body system. Another important source of cadmium in the soil is sewage sludge which can make the cadmium almost the same amount as fertilizers consumption. The types of carcinogenic effects of cadmium toxicity were explained in (Fig. 3). Cadmium shows its toxic effects on the gastric system and leads to gastric cancer, breast cancer, lung cancer, and it also affects the excretory system and leads to renal cancer (Fig. 3).

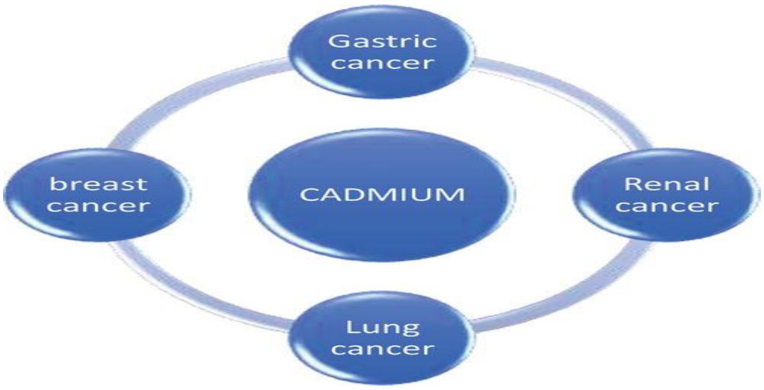

Fig. 3. Toxicity of cadmium and associated diseases

4.3 Sources, Exposure, and Environmental Impacts of Mercury

Mercury is the metal widely studied all over the world due to its toxic nature and easily entering into the food chain. An extensive review report was published (Jyothi *et al.,* 2020) regarding the sources, exposure, and toxicity of mercury. The toxicity of mercury depends on its chemical composition. Methyl mercury is more toxic than inorganic mercury. Due to its toxic nature and historical incidents like Minamata so many authors have published various facts regarding the sources, transport and fate of mercury in the environment. Both volcanoes and forest fires are natural sources of mercury in the atmosphere. The burning of fossil fuels in power plants is one of the major anthropogenic sources of mercury. Because of easy transportation, it is considered a global pollutant (Driscoll *et al.,* 2013). Even exposure to small quantities, shows toxic effects on various physiological systems, such as nervous and digestive systems and organs like lungs and kidneys. Due to this reason WHO declares mercury as one of the top most priority toxic metals. When it enters into water it largely affects the aquatic animal's life and through them, it can enter into the food chain to reach human beings. Yokoyama (2018) reported in his article the methylmercury poisoning control measures and the current situation of its effects on fetuses and infants particularly. In this study, they addressed the global cycle of methyl mercury also. Strode et al. studied the emission of mercury into the North American atmosphere due to gold and silver mining in the 19th century. The types of carcinogenic effects of mercury toxicity were explained (Fig. 4). Mercury toxicity effects on the rectal system and leads to colorectal cancer. It shows vast effects on the central nervous system leads to brain cancer and lung cancer (Fig. 4).

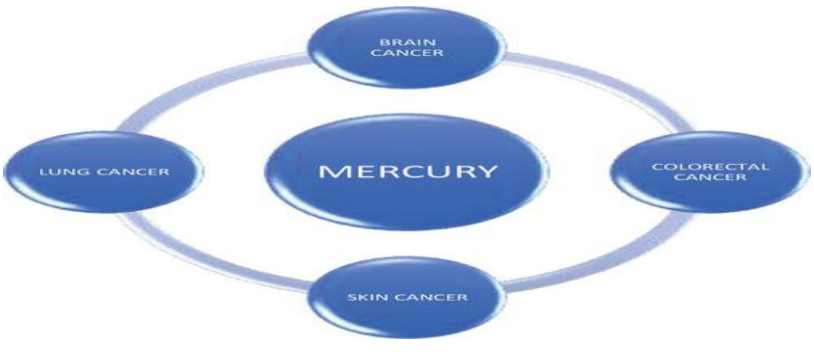

Fig. 4. Toxicity of mercury and associated diseases

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4.4 Sources, Exposure, and Environmental Impacts of Arsenic

Arsenic is a metalloid but due to its toxic and carcinogenic nature, it is commonly discussed under the heading of heavy metal toxicity. Researchers (Abdul *et al.,* 2015) reviewed the health effects of arsenic exposure to human beings. According to this study, the majority of the population expose to this toxic metal through atmospheric air, groundwater and certain kind of food intake. The health effects are not limited to damage to cardiovascular, endocrine, renal and reproductive systems. In various parts of the world such as India, Pakistan, and Bangladesh it was observed that major exposure to the arsenic is through groundwater. They also reported about the sources and health effects of arsenic through the contamination of groundwater in Pakistan. This study predicts nearly 47 million people of Pakistan are at risk due to arsenic contamination in groundwater (Fig. 5).

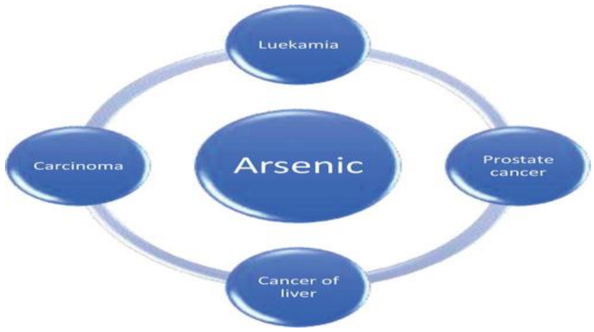

Fig. 5. Toxicity of Arsenic and associated diseases

They found that over 50% of the wells (shallow and deep boreholes) they studied are having higher arsenic levels than WHO recommended levels in drinking water. A recent study (Huq *et al.,* 2020) described the occurrence and mobilization of arsenic in the groundwater of Bangladesh. In this study, they found that intensive usage of land for agricultural activities and extensive application of agrochemicals are the major reasons for arsenic contamination in groundwater of Bangladesh. It was (Ahmed *et al.,* 2020) reported that the situation of arsenic contamination in groundwater in a village in Bangladesh to support this claim. For this purpose, they discussed 20 years situation of its exposure. Based on their results they found that the cancer risk is high among the population who are exposed to arsenic with about 40% of the population affected. The Types of carcinogenic effects of arsenic toxicity was explained (Fig. 5). Arsenic has its toxic carcinogenic effect on prostate glands and cause prostate cancer, leukemia and serious issues in hepatic regions that leads to main cause of cancer of the liver (Fig. 5).

5. Notable Diagnostic Ailments

Notable diagnostic breakthrough with various imaging tools that emanated from Geophysical principles include among others brain disorder, cardiovascular and cancer detection imaging tools.

5.1 Brain Disorder Imaging Tool

Magnetoencephalography (MEG) measures the magnetic fields produced by neuronal activity in the brain. This technique, akin to the magnetometers used in geophysics has become vital for mapping brain function and diagnosing neurological disorders (Fig. 6). MEG's ability to detect brain activity with millisecond precision is invaluable in understanding conditions such as epilepsy. MEG in epilepsy diagnosis demonstrated its effectiveness in locating epileptic foci with high precision, leading to successful surgical interventions and improved patient diagnosis and care.

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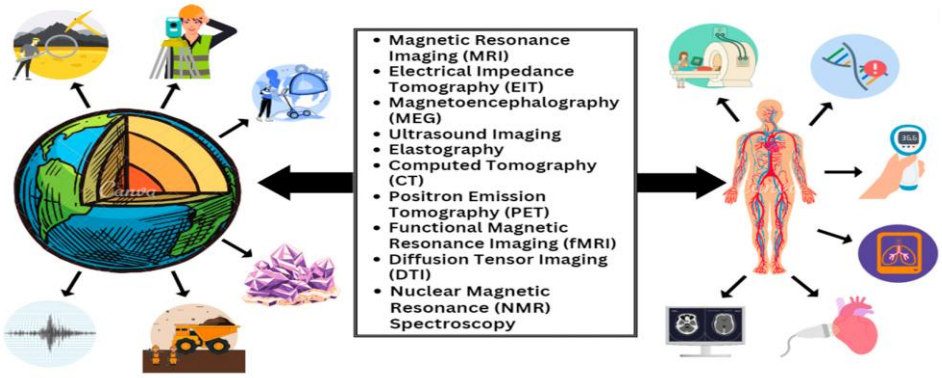

Fig. 6. Techniques that are used currently for diagnostic and imaging purposes in health sciences work on the same principles as those applicable to geophysics

5.2 Cardiovascular Imaging

Ultrasound combined with elastography assesses tissue stiffness, which is crucial for evaluating cardiovascular health. This technique has proven effective in detecting arterial stiffness and early signs of cardiovascular disease. A study on arterial blockages showed that elastography could identify changes in arterial elasticity with an 85% sensitivity and 90% specificity, surpassing traditional diagnostic methods.

5.3 Cancer Detection

Photoacoustic imaging tool measures high contrast and resolution capabilities of patients that makes it particularly effective and efficient in cancer detection. In breast cancer screening, photoacoustic imaging identified tumors with a 92% accuracy rate, significantly outperforming traditional mammography methods. This enhancement in early detection is crucial for improving treatment outcomes and patient prognosis.

5.4 Neurological Disorders

Transcranial Magnetic Stimulation (TMS) uses magnetic fields to stimulate brain neurons which is a principle derived from geophysical electromagnetism. TMS has applications in diagnosing and treating neurological disorders, including depression and stroke recovery. A study on TMS on patients for depression treatment found that 50% of such patients experienced significant symptom improvement following a series of sessions, demonstrating TMS's potential as a therapeutic tool.

5.5 Cardiopulmonary Issues

Impedance cardiography measures changes in thoracic electrical impedance of patients to assess heart function. This geophysical technique has proven valuable in monitoring patients with heart failure, correlating with invasive measurements with a coefficient of 0.92. This approach enables accurate tracking of cardiac function and disease progression.

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6. Origin of Toxic Metals in the Society

Chemical elements and compounds derived from geological materials and processes influence the quality of water we drink, air we breathe, food we eat and availability of major and minor chemical elements (nutrients) in soil to support plant life and sustain agriculture which finally find their way into the body system to nourish different parts of human body. There are many more ways heavy metals can enter the environment and agriculture. Heavy metal contamination of food originates by weathering of the bedrock, air pollution directly, as well as soil irrigation with polluted water and polluted groundwater (Ying *et al.,* 2018). Environmental contamination, primarily by industrial and human activity refers to soil or groundwater that are the most common access routes of heavy metals such as lead, mercury, chromium, arsenic and cadmium into the human body. Reports have shown that increased amounts of heavy metals in the human daily diet are related to region, available food products and industry. Occasionally, a metal is not released into the environment, but human industrial activities result in exposure to those which are naturally occurring. For example, in the vicinity of a mine, soil contamination can be observed, which can result in the presence of heavy metals in local crops (Ying *et al.,* 2018). Certain regions and related industries are known to be specific for the emergence of these heavy metals in high concentrations e.g., in China, areas surrounding coal-fired power plants are polluted by mercury up to 10 times more than the average soil sample 55 km away from pollution sites.

Hazardous geological processes, such as floods, landslides, earthquakes and volcanic activities mobilize chemical elements and compounds into the environment that can produce both beneficial and harmful impacts on all life forms. Geosciences in other words, play a key role in health and wellbeing of humans, plants, and animals. Notable toxic metals in our evolving society that will shape modern environment include lead, mercury, arsenic etc. Geologic materials, especially minerals, have been used for therapeutic purposes for several millennia in various cultures. Among the metals, arsenic, copper, gold, mercury and sliver were commonly used for treatment of various ailments. Despite their toxic nature, arsenic, copper and mercury in the right combination with herbs and other substances found many applications in ancient medicinal practices useful in curing ailments. Gold particularly was widely used in Arabic medicine and Avicenna used gold filings for treatment of bad breath, hair loss, depression, heart health and as a cauterizing agent for wounds.

7 Environment and our Health

Over the years, it has been observed that the environment man lives in affects his health. For instance, the people of Maputaland, South Africa, are plagued by nutrient-poor soil. Maize grown in this region has very low content of elements such as calcium, potassium and phosphorous. This is as a result of low concentration of these elements in the rocks of that region. Countries in southern Africa also suffer from selenium deficiency in their soil. This accounts for the spread of HIV-1 virus in this zone as selenium which inhibits the replication of HIV-1 is lacking in their soil. Still in Africa, Kerala Province in Uganda is another region under the "hammer" of geology. Children in this province suffer from a 'grave' coronary heart condition called endomyocardial fibrosis (EMF). This epidemic is attributed to the deliberate eating of soil containing the element cerium. China is not left aside in these problems. The country suffers from deficiencies and excessiveness of selenium in many parts of the country resulting in life-threatening health problems. China also suffers from the influx of arsenic into coal deposits whose domestic use has resulted to untold chronic health effects over the years. The use of water from the Colorado Springs at the Pikes Peak in the Rocky Mountain region of the United State had led to dental fluorosis amongst children. This condition arose as a result of meteoric waters that flowed over faulted granitic batholiths. The meteoric waters 'picked up' fluoride from easily dissolved minerals at the fault and incorporated it into the flow. Fluoride was also injected into the Colorado Springs by fluoride-enriched fractured and faulted Cretaceous Pierre Shale that underlies the spring.

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Table-2 Elemental composition in different rock types (Ibrahim *et al.*, 2024d)

S/N	Elements	Ultrabasic rock	Basalt	Granite	Shale	Limestone
1	As	1	2	1.5	15	2.5
2	Cd	-	0.2	0.2	0.2	0.1
3	Co	150	40	1	20	4
4	Cr	2000	200	4	100	10
5	Co	150	50	1	20	4
6	Cu	10	100	10	50	15
7	Pb	0.1	15	20	20	8
8	Se	-	0.05	0.05	0.6	0.08
9	U	0.001	0.6	4.8	4	2

Deficiency of these elements in the soil results in their low abundance in plants. Sequel to this, plants, as primary producers would decline in supplying them to animals and humans, the final consumers. Deficiency of these nutrients brings negative health effects to humans and animals. A typical example is iodine deficiency which leads to goiter which is caused by 'shortage' of iodine in the rocks. On the other hand, over-abundance of any of these elements causes toxicity problems (Table-2). For instance, excess arsenic is known to cause lesion of the skin in some Asian countries such as Bangladesh and China.

8. Geo-Chemobiological Pathway

This is the rock-soil-plant-animal/human pathway, and it is of major importance in the study of medical geology. It describes the various ways through which people can come in contact with elements originally in the rocks (Fig. 7). Elements are released from rocks through weathering, the process by which rocks are broken down into smaller components.

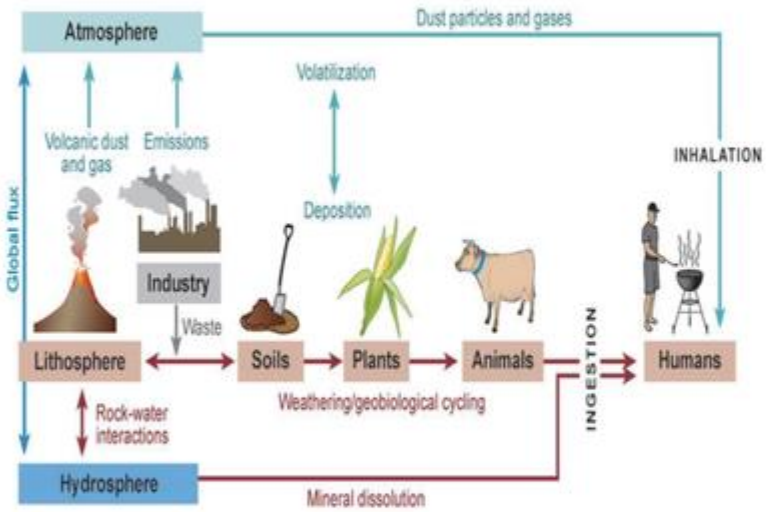

Fig. 7. Earth materials between the atmosphere, hydrosphere and lithosphere and the pathways for uptake of particles, gases and elements into plants, animals and humans

Physical weathering is the process by which rocks are broken down into smaller chunks without altering its mineral content. It occurs through temperature and pressure changes and by the action of the wind, water, glacier and frost.

Temperature variation leads to the development of flakes on the rocks whose removal exposes subsequent layers to further heating and cooling then, to chemical weathering. Physical disintegration of rocks is also caused by the action of burrowing animals and plant roots. Freezing of water in crevices of rocks is another force that disintegrates rocks making them prone to chemical weathering. Chemical weathering describes the process that alters the chemistry of minerals. It can proceed through hydration, hydrolysis, oxidation, reduction and dissolution processes. Chemical weathering is fuelled by water and weak soil acids. In addition to these, there are processes that make the various elements available to plants: sorption and desorption. According to a study (Selinus, 2004), sorption is the retention of metal ions on the surfaces of soil particles through mutual attraction between oppositely charged particles. Desorption refers to the release of these metal ions for plant use as a result of alterations in pH and redox conditions. By consuming plants and animals raised on such soils, man comes in contact with the elements originally in the rocks. Another pathway through which humans come in contact with the earth's elements is by water intake whether from man-made wells, rivers, streams or lakes. These emanate from groundwater which might have leached both toxic and non-toxic elements from rocks through which it flowed. Inhalation of volcanic gases and dust from deserts, un-tarred roads, mines and volcanic emanations form another important pathway of exposure to dangerous elements. Volcanism is the principal process that brings elements to the surface from deep within the earth. The volcanic eruption of Mount Pinatubo is a splendid example of the dramatic effects of geosciences. During just two days in June 1991, Mount Pinatubo, Philippines, ejected 10 billion metric tonnes of magma and 20 million tonnes of SO_2 for over 15,000 meters high into the atmosphere; polluting the air people breath and resulting aerosols influenced global climate for three years. This single event introduced an estimated 800,000 tonnes of zinc, 600,000 tonnes of copper, 550,000 tonnes of chromium, 100,000 tonnes of lead, 1000 tonnes of cadmium, 10,000 tonnes of arsenic, 800 tonnes of mercury and 30,000 tonnes of nickel to the surface environment.

9 Impacts of Toxic Metals on Enzymatic Pathways

The competition between metal ions for protein-binding sites can cause problems in the transport of some molecules and catalysis of chemical reactions in human organisms. The composition of the immediate environment of the metal-binding site is related to metal selectivity. However, the selectivity is different for each protein, so it should be studied at the single-protein level (Smith, 2015). The important aspect of metal ions impacts on the human body are metal-mediated protein–protein interactions. Understanding these interactions is central to understanding the molecular details of heavy-metal impact on human health. Mechanisms to maintain metal homeostasis in the cells involve mainly cysteine (Cys-)-rich metal-binding peptides such as glutathione (GSH) and proteins such as metallothioneins (MTs), as well as phytochelatins (PCs) in plants and microorganisms. Metallothioneins, discovered in 1957 as cadmium-binding proteins, can bind and sequester heavy metals due to their high cysteine contenty. They also exhibit high potential for other heavy metals, (Fig. 8) which makes them good candidates for protein-based metal biosensors. In addition, other proteins and several lysosome-like organelles participate in homeostasis, acting as storage sites and buffering cytosolic metal levels in eukaryotes. Metallothioneins seems to be protective proteins produced in response to different kinds of stresses.

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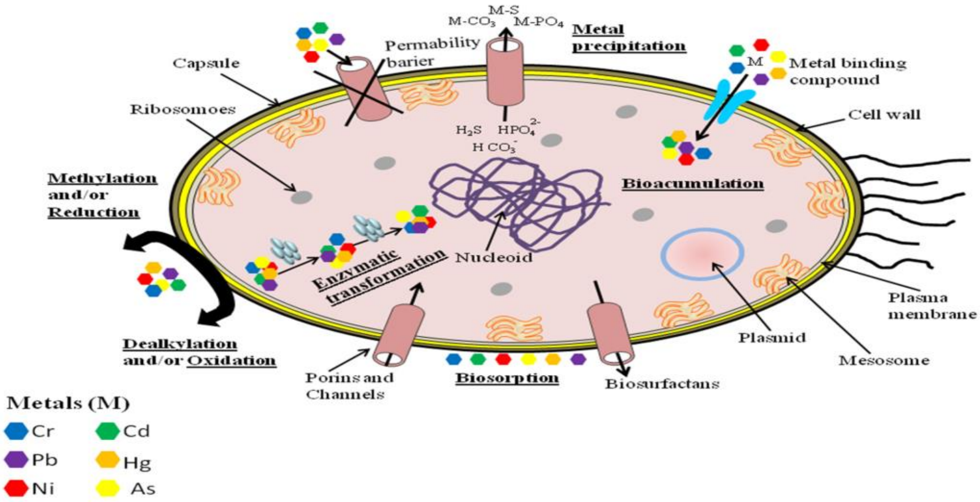

Fig. 8. Mechanisms utilized by bacteria, and plant cells for metal resistance and detoxification, which can be adapted in bioremediation techniques

10. Challenges on Collaboration

Medical geosciences, therefore, is a developing multidisciplinary collaboration that curtails the health effects arising from a changing climate, various geologic materials and processes of our evolving and highly dynamic environment in which man lives. Climate change with approximate 1°C temperature rise over the last half century globally has directly impacted public health with new diseases coming up that is posing new challenges to human existence on earth. Exposures to metals cause significant mortality and illness (Fig. 9).

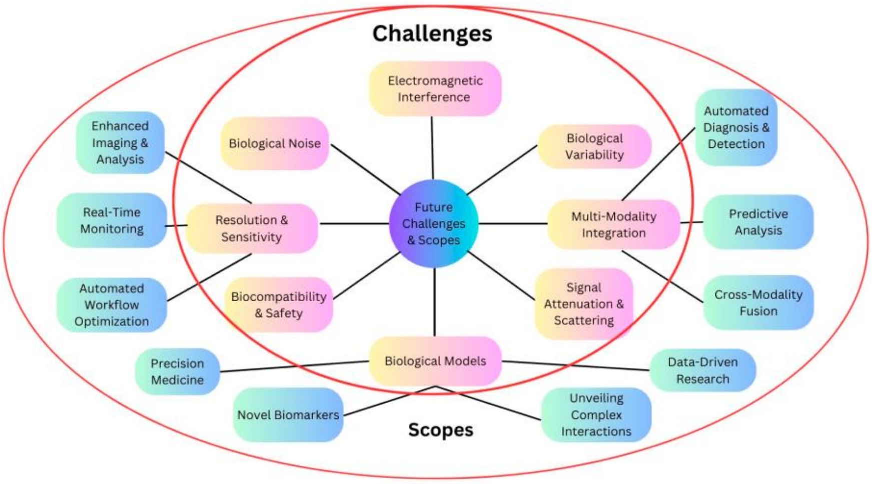

Fig. 9. Electromagnetic methods such as electromagnetic induction, GPR, and MT and their utilization for electromagnetic imaging (EIT-EIT, FES-FES, cardiac electrophysiology and MEG) in health sciences

Failure to recognize occupational and environmental health problems in health care settings remains a challenge. Inadequate training of primary care practitioners and health care students in the occupational and environmental health disciplines is of concern. The priority given to these subjects in the medical and nursing schools curricula is currently low.

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The causal co-factors of disease occurrence and progression are more in the society and include genetics, microbes/fungi, environmental factors such as exposure to geogenic contaminants (geochemicals, xenobiotics), geographical factors, seasonality, climate change, geopathic stress, heat waves, heat stress and spacio-temporal associations are enormous. In any discussion on the determinants of heath, the effect of socio-economic factors such as education income and wealth, should never be overlooked, for they shape our health in more important ways in providing clues on likely pathways and mechanisms that may explain their effects. Recently, (Ibrahim *et al.,* 2024a,b,c,d) a study noted that there is a tremendous environmental impact with serious health implications of anthropogenic complication sources on groundwater production and dam infrastructure traced to climate change variability in Akerebiata and Offa areas, Kwara state, North central Nigeria. This is bound to induce unwanted diseases in these areas if unchecked. Renewable energy and compressed natural gas need be used as the energy mix especially for transportation, cooking etc to reduce the impact on mankind.

Suggestions that the geo-environmental factors (geographical and climatic patterns, seasonal variations, geological and geochemical variables) can have significant influence on the occurrence and development of diseases that have captivated scholarly attention across a number of disciplinary and policy makers domains globally (Fig. 9). Study on geoenvironmental conditions was conducted in concert with infectious agents that activate innate and adaptive immune system in genetically susceptible patients. Geochemicals such as metals, metalloids and radionuclides, as well as transuraniums, referred to as geogenic contaminants (GCs) were found to occur naturally as geogenic sources in minerals, rocks, ground, surface underground water and volcanic emanations. Their accelerated release globally has been attributed to rapid population rise and economic growth and the associated increase in demand for water, energy, food and mineral resources. The release of GCs occurring in near surface environments can be triggered into the soil, water, air and biota compartments and subsequently enter the food chain (Fig. 8) with often severe health consequences.

CONCLUSION

The connection of medical sciences with Geosciences is the tool to understand and eradicate various diseases threatening humanity. Rocks are the fundamental building blocks of the earth's surface containing various minerals and chemical elements. These minerals and chemical elements are released from these rocks through the process of weathering to form soil upon which plants and animals are raised. Such elements of importance to medical scientist include: arsenic, iodine, selenium, fluorine, lead, mercury, cadmium and many more are trace elements. An overabundance of any of these chemical elements in the soil would lead to adverse health effects should plants or animals are raised on such soil. Conversely, deficiency of any of the aforementioned trace elements has been proven to cause adverse health effects. In addition, consumption of water from boreholes, springs, lakes or rivers is a possible route through which people ingest trace elements into the body system. The inhalation of geogenic dust, volcanic dust and gas is another proven route through which these trace elements can be contacted. Evidently, the right balance is just needed; unfortunately, this is not obtainable in most parts of the world. This has led to the outbreak of various diseases in the unfortunate regions. Collaboration is thus highly needed among various specialists and policy makers to further research the best approach to eradicate most diseases in our modern and highly evolving environment

ACKNOWLEDGEMENT

Appreciation goes to friends for providing the financial and material support to get the manuscript completed despite challenges during review stages. The authors specially acknowledge the invaluable and unquantifiable support received from the publisher, thanks so much. The authors specially thank Mrs. Ibrahim Bilqees for the assistance on typesetting and amending the manuscript despite tight teaching schedules.

CONFLICT OF INTEREST

No conflict of interest has been declared in this manuscript as the content of the work has been put together to contribute to novel knowledge dissemination.

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