1.1. INTRODUCTION

Geomedical study of essential trace elements and human health involves analysis of cause and effect relationship of human health and geographic environment by analyzing the geo-chemical status of soil, water, food items and air, assessing the dependence of people on local food items and their nutrient content, the prevalence of food preparation and cooking methodologies, incidence and prevalence of related disorders in the community, and mapping and modeling the spatial distribution and correlation of the human health with the physico-chemical and socio-economic factors. Both the physico-chemical (as nutrients in soil, water or food) and socio-economic (as income levels, type of diet, cooking styles, and the like) determinants have a close relationship with the human health.

The essential trace elements primarily occur in rocks and are transferred to the soil and water systems through a complex network of processes wherefrom their exposure to humans is increased. It is from here that these elements enter into the food chain and reach the human body leading to their imprints in terms of different states of health. Trace elements reach into the human body through drinking water, food intake, or air. The concentration of trace elements in soil, water or food items is mainly determined by the geological conditions of the area. Both natural processes such as weathering, erosion, pedogenesis and volcanism and human activities such as mining and smelting are responsible for the redistribution of the trace elements in the soil, and water and organic environments through a network of pathways called as biogeochemical cycles. Food chains play an important role in the transfer of trace elements from soils and waters to plants and animals/humans and then to human beings and finally back to the geo-physical environment.

The amount of a particular element that reaches a human body from the food chain depends upon a series of intervening human activities or factors such as dependence on local/non-local foods, amount of food taken, type of food taken, use of boiled or non-boiled water, methods of cooking, type of salt used, income level of the people and the like. These socio-economic factors directly and indirectly limit the quantity of trace elements in the food intake. These factors act as links between the human body

and the food chains and determine the deficiency or toxicity of a particular element in the human body.

The essential trace elements have a crucial and important role in the survival of life and maintenance of good health. Human health is determined and conditioned to a great extent by the essential trace elements. So, whenever there is deficiency or toxicity of these elements in the human body, there occurs a series of health ailments. But, the deficiency of these elements in human body occurs only when there is deficiency of them in their diet because diet is the main source of these elements for humans. Diets become nutrient deficient when there is deficiency of the nutrients in the soil and water. Also, they are rendered deficient due to the socio-economic factors like food preparation and cooking methods and others.

It was in the first part of the 20^{th} century that scientists could detect small amounts of mineral elements in living organisms which are now called as trace elements. The trace elements found in living organisms may be essential, i.e., important for performing function necessary for life, or they may be non-essential in their original specific state but can be beneficial to health through pharmacological action. All trace elements even essential ones are poisonous for health in their imbalanced state i.e., in concentrations more or less than required quantity.

In the 1960s and 1970s, the standard to define a nutrient as essential was liberalized for mineral elements that could not be fed in amounts low enough to cause death or interrupt the life cycle (interfere with growth, development or maturation). Thus, an essential element was defined as one whose dietary deficiency consistently and adversely changed a biological function from optimal, and this change was preventable or reversible by physiological amounts of the element. Later on, this definition of essentiality became less acceptable when a large number of elements were suggested to be essential based on small changes in physiological or biochemical variables. Many of these changes were questioned as to whether they were necessarily the result of a suboptimal function, and sometimes were suggested to be the consequence of a pharmacological or toxic action in the body, including an effect on intestinal microorganisms. As a result, majority of scientists now define an element an

essential only if it performs a defined biochemical function. However, some scientists still rely on the older definition. So, it is clear there is no universally accepted list of trace elements, though WHO has listed six elements as essential i.e., Cu, Zn, I, Mo, Se and Cr (WHO, 1996).

Cu, Zn, I, Mo, Se and Cr are uncontroversial essential trace elements. Specific biochemical functions have been defined for all of them. Below are given some important bases through which one can identify that an element is essential.

1. A dietary deficiency consistently results in modified biological function, body structure, or tissue composition that is preventable or reversible by an intake of an apparent physiological amount of the element in question.

2. The element fills the need at physiological concentrations for a known in vivo biochemical action to proceed in vitro.

3. The element is component of known biologically important molecules in some life forms.

4. The element has an essential function in lower forms of life.

When an essential trace element is absent or too low for adequate activity of an essential body function for long time, death takes place. As the intake of the essential trace element increases, the following events/phenomena take place: i) the organism/human being survives but with suboptimal health and well-being, ii) as intake reaches to normal content in which optimal health and well-being are maintained. This normal range is quite large because of powerful homeostatic mechanisms and iii) a decline in health and well-being, and finally death, as regulatory mechanisms are overcome by increasing intakes that become toxic.

The homeostatic regulatory mechanisms involve the processes of absorption, storage and excretion. The relative importance of these processes varies among the trace elements. The absorption of cationic trace elements such as copper, zinc, etc. is controlled by the gastrointestinal tract (GIT). If the amount of the element is low in the body, amount of absorption from GIT is increased and vice versa. But, the anionic

trace elements such as selenium and iodine are usually freely absorbed from the GIT. Excretion through the urine, bile, sweat and breath is, therefore, the major mechanism for controlling the amount of these trace elements in the organism. Some of these elements are prevented from causing adverse reactions when present in high quantities by being stored at inactive sites (e.g., copper as metallothionein; iron as ferritin). Release of a trace element from storage forms also can be important in preventing deficiency.

Generally, simple essential trace element deficiencies are uncommon due to powerful homeostatic mechanisms. However, there are certain situations which reflect the nutritional significance of these elements. These are i) inborn metabolic abnormality which led to abnormal absorption, retention and excretion, ii) alteration in metabolism and/or biochemistry as a secondary result of malnutrition, disease, injury, or stress, iii) marginal deficiencies (slight deviation from an optimal intake of an essential nutrient) induced by various dietary manipulations or by direct or indirect interaction with another nutrient or drug, and iv) the enhanced requirement for a trace element caused by sudden or severe change in the system requiring that element. It can be summed up that the insufficient intake of a specific trace element would become obvious only when the body is stressed in some way that enhances the need or interferes with the utilization of that element. It can be presented through formula as:

Pathological Effects = Stress × Organic Vulnerability (Tapp and Natelson, 1988 cited in Nielsen, 2008).

The above mentioned formula seems quite valid for trace element nutrition. It can be said that pathological effects are not likely to be seen if a trace element deficiency (organic vulnerability) is not coupled by some significant stress. Likewise, the pathological effects are not large if stress is not accompanied by an organic vulnerability.

1.2. SIGNIFICANCE OF THE STUDY

The essential trace elements are very important for the human health. Since, they primarily occur in rocks and are transferred to the soil and water systems through a

complex web of processes wherefrom their exposure to humans is increased. It is from here that these elements enter into the food chain and reach the human body leading to their imprints in terms of different states of health. These elements are increasingly been recognized as vital to human health. They are components of haemoglobin, DNA, RNA, and various enzymes (Warren, 1991). These elements play an important role in the synthesis of both proteins and nucleic acids. Each trace element has a standard requirement adequate for human health recommended by W. H.O (Fishbein, 1986). Since they are very essential for human beings, they may cause different health problems when their intake is less or more than required amounts. All essential trace elements either in excess states or in deficit states are known to create serious health problems particularly in the areas where these are regionally deficit (Hunter & Akhtar, 1991) or surplus. Diseases due to imbalance of trace elements for iodine, copper, zinc, selenium, molybdenum, manganese, iron, calcium, arsenic, and cadmium and radon are well established.

Trace elements play a number of functions in the living organisms/human beings. Their importance and role is given under five major categories of functions which are as (Nielsen, 2008):

1. Some elements occur in close association with enzymes forming metallo-enzymes and are so integral parts of catalytic centers at which the biochemical reactions necessary for life occur.

2. Some elements donate or accept electrons in reactions of reduction or oxidation. In addition to the generation and utilization of metabolic energy, redox reactions frequently involve the chemical transformation of molecules.

3. Some elements particularly iron, bind, transport and release oxygen within living organisms.

4. Some elements have structural roles, imparting stability and three-dimensional structure to important biological molecules.

5. Some elements have regulatory roles. They control important biological processes through such actions as inhibiting enzymatic reactions, facilitating the

binding of molecules to receptor sites on cell membranes, altering the structure or ionic nature of membranes to prevent or allow specific molecules or ions to enter a cell, and inducting genes to express themselves, resulting in the formation of proteins involved in life processes.

In developing countries, the deficiency of essential trace elements in the soils, waters and diet is widespread resulting in diverse health and social problems, such as mental retardations, impairments of the immune system, degenerative disorders, thyroid disorders and overall poor health. According to UNICEF (2002), 'IDDs remain a major public health problem….Globally an estimated 740 million people are affected by goiter and nearly more than 2 billion are estimated to be at risk of IDDs'. Zinc deficiency is recognized as a major problem of human nutrition world-wide. It has been estimated to affect up to one-third of the world's population and inadequate dietary intake of bioavailable forms of Zn is considered the most frequent cause of Zn deficiency (Roohani, 2012). Zinc deficiency, for example, represents a major cause of child death in the world and is a widespread global issue (Cakmak, 2009).

Endemicity of many chronic or mild disorders such as goiter, dental fluorisis, cancers, skin disorders, etc. is quite prevalent across the spatial extent of India spanning from Kerala in South to Kashmir valley in North and Rajasthan in West to West Bengal in East because of the variable concentrations of certain trace elements such as arsenic, fluoride, iodine, cerium, etc. (Mukhopadhyay, 2005). Mayer while working out the goiter incidence in Kashmir Valley during 2004-2005 found that Anantnag district has the highest incidence of goiter and he suggested that nature of bedrock and soils is responsible for the variable goiter incidence in the valley.

Therefore, the present research work was focused to investigate, 'Trace elements and human health in the foot hill settlements of Pir Panjal Range in Kashmir'. It was, first, carried out to analyze the essential trace element status in the soil and water systems of foot hill settlements of Pir Panjal range in Kashmir and dependence of people on local food items and relationship of the two and second, their cumulative effect on human health that would serve a base for the subsequent developments in the field and to the concerned management bodies.

1.3. OBJECTIVES

1) To determine the concentration of essential trace elements in the soils. From the soils, these elements enter into the food chain and reach to the human body.

2) To determine the concentration of essential trace elements in the drinking water sources. The content of these elements in the drinking waters directly reaches to the human body by using the water in drinking and cooking purposes.

3) To assess the dependence of people on the local food products. It is because the local food products constitute the main diet of the people and it is the main source of essential trace elements for human body.

4) To analyze the impact of essential trace element deficiencies and toxicities in the soils and dinking waters (and hence local foods) on the health of the people. The prevalence of essential trace element deficiency diseases is to be appreciated in relation to the concentration of essential trace elements in the soil and drinking waters and socio-economic character of the people of the area.

5) To suggest a suitable planning strategy. A suitable planning strategy is to be suggested to reduce the magnitude of the prevalence of essential trace element deficiency and toxicity diseases in the area.

1.4. REVIEW OF LITERATURE

Though analysis of trace element-human health relationship is a recent geochemical approach in medical geography, it was probably since mid-1950s that medical geographers, medical scientists, geochemists, and medical geologists paid a good attention to this aspect and a good amount of literature, though scattered, is available in the form of books and research articles published across the world and on internet. Some notable contributions are as follows:

Warren and Delavault (1949-1960) while working on the concentration of heavy metals (Cu, Pb, Zn) in certain plants of Montreal, Canada, concluded that metal uptake by the plants is related to underlying bedrocks and the soils developed from them. This means that the soil chemical composition is mostly the reflection of the bedrock and the same is reflected in plant tissues.

Cannon (1964) pointed out that heavy metal concentration above normal values in human body is known to disturb the rate of body growth, mental development and degree of sensitivities in the sufferers.

The investigation of copper concentration in different parts of human body led Blanke (1971, cited in Nergus, 2002) to conclude that about 50% of it concentrates in muscular tissues such as liver and brain thereafter increasing its urinary excretion.

Akhtar (1978) carried out goiter zonation in Kumaon region. He dealt in detail with the causes of goiter in the Kumaon region in special and Himalayan belt in general. The main cause of goiter is iodine deficiency in human body developed due to ingestion of iodine deficient food. Calcareous bed rock areas and glaciated areas have been identified more prone to goiter incidence for these areas are robbed of iodine through the translocation and leaching processes. Cropping patterns also contribute their part in removing the iodine from the soil.

Pyle (1979) highlighted that three kinds of environmental elements may place human tissues in jeopardy: inorganic, organic and socio-cultural. May intended inorganic stimuli to include such natural environmental aspects as heat, humidity, wind, luminosity, and mineral trace elements in soils and water. Pyle has also focused on that there exists a good relationship among such natural features as bedrock type, water pollution, animal food, soil properties, (human health), plants and man's ingestion of food and water. He pointed out that more meaningful associations can be drawn in rural areas. Moreover, he mentions that recently Warren examined the same metals and compared British and Canadian examples (diseases) to common garden vegetables such as lettuce, cabbage, potatoes, beans, carrots and beets.

The concentration of trace elements decreases progressively in leaves, twigs, cones, wood, roots and bark. He also highlighted that different species of plants take up different amounts of inorganic materials from the soil. The inorganic minerals are absorbed through leaves also.The concentration of trace elements in the soils varies from one to the other type e.g., the chernozems, some saline soils, and vertisols are richest in copper content (average value is 20 ppm) for it depends on parent rock, humus content, pH, etc. (Pinta and Aubert, 1980). The clay crystals and organic matter bind up the metal ions in the soils. pH increases the mobility of the metals in the soils.

Lag (1983, cited in Nergus, 2002) discussed the scope of Geo-Medicine in Norway and established a relationship in the transfer of elements from soil to plants and animals and finally to human beings living under varying geographical controls which further complicates the mobility of the elements. He worked on Zn, Cd and Pb concentrations in soil and plants of Roros and King-berga area of Norway and found that sheep eating grasses grown on high copper content soil died due to copper poisoning.

Paleozoic sedimentaries, Triassic Limestone, Karewas and alluvium are the predominant geological formations of the Pir Panjal with lime stones, volcanics, shales, sandstones, and unconsolidated sediments as the dominant lithologies (Wadia, 1981). The higher altitude regions (>3000 m AMSL) are mostly occupied by the Panjal Traps and the Triassic Limestone. The valley is filled up with a great thickness (>2000 m) of fluvio-lacustrine sediments of Quarternary age belonging to the Karewa Group and river deposited alluvium of recent age. The bedrock is either Triassic Limestone or Panjal Traps.

The deficiency of copper in humans may result in many diseases such as: retarded growth, hair and weight loss, disorders of nervous system, osteoporosis and Menke's syndrome. While as an excess of Cu causes Wilson's disease, mostly ending in death (Aaseth and Norseth, 1986).

GIT cancers such as of esophagus, stomach, particularly in women and the subsequent mortality may be related to the local geology or soil composition as found in Britain,

North Wales, and other parts of the world (Learmonth, 1988). Again, he proposes that a range of factors such as the trace elements in soil and water and hereditary predisposition are associated with the diseases such as cancers, cardiovascular disorders, diabetes, goiter, etc. in different parts of the world.

Misra and Mani (1990) found that lead contamination of foods leads to chronic illness characterized by severe anaemia and changes in kidneys arteries. Lead enters into human body by inhalation and ingestion. Lead poisoning can cause severe mental retardation or death and persons who consume fresh garden salads are more affected than others because leafy vegetables absorb more lead (Misra and Srivastava, 1990).

The North-eastern India especially West Bengal is notorious for arsenic toxicity or contamination. Misra and Shukla (1990) found that arsenic poisoning causes a number of health disorders in humans in almost all amounts if taken over a longer duration of time.

The deficiencies of micronutrients in soils are commonly related to low contents of these elements in the parent rocks or transported parent material and toxic quantities are commonly related to abnormally large amounts in the soil forming rocks and minerals (Brady, 1990).

While analyzing the concentration of trace elements in the different spheres of earth, Warren (1991) pointed out that trace elements are more likely to be more concentrated and much more unevenly distributed in the earth's crust than they are in the oceans. Anomalous concentrations of trace elements are much commoner in the earth's crust than they are in the oceans and atmosphere.

Hunter and Akhtar (1991) worked out that while naturally occurring contaminants may be harmful to man, health may be adversely affected where there is absence or deficiency of essential trace elements such as iodine, copper or zinc. So, the human health is conditioned by the dietary intake of essential trace elements as well.

Lag (1992, cited in Nergus, 2002) investigated that mankind is affected in many ways by fertilizers, lime discharges and chemicals. The term anthropogenic soil is used

when the original characteristics of the soil have nearly changed. He suggested that air, water and soil often cause serious problems of geo-medical character.

Shukla and Srivastava (1992) made analysis of rice, roots and soil and found that plants selectively absorbed the heavy metals from the polluted soil and ingestion of the contaminated heavy metal rich rice caused osteomalacia.

Man's physical and mental health depends on the genetic and environmental factors (Agnihotri, 1995). The components of natural environment such as the land, the water, the flora and the fauna make certain places more suitable for human habitation and healthy living than others. Again, the group of inorganic factors influencing human health consists of geology, relief, climate, hydrology, and edaphic resources. Quality and quantity of available water for drinking purpose determines the health status of the people.

Alloway (1995) has put forth that trace elements occur as trace constituents in the minerals of the rocks among them sedimentary rocks have monopoly on the surface of earth. It has been found that black (bituminous) shales contain high concentrations of several metals and metalloids, including As, Ag, Cu, Cd, Pb, Mo, U, V, and Zn.

Needleman, *et al.* (1996) have pointed out that more recently, it has been suggested that lead in urban areas can cause social problems such as attention deficit, delinquency and aggressive behavior. Newsome *et al.* (1997) analyzed the lead contamination in soils and found that imbalances in its concentration in soils, air, water or food have adverse health effects on humans. Although adults are at risk from high lead levels, fetuses, infants, children, under the age of seven, and expectant mothers are most at risk.

Iodine deficiency has been identified all over the world. It is a significant health problem in 130 countries and affects 740 million people. Jammu and Kashmir is a state particularly affected by iodine deficiency. An extensive survey on school children spanning three years (1993-1995) revealed that 45.2% of children were having thyroid enlargement and quantification of urinary iodine excretion

demonstrated iodine deficiency. In some highland areas of the Valley, goitre prevalence was as high as 70% to 77% (Zargar, *et al.*, 1997).

Akhtar (1997) related high prevalence and incidence of cancers such as cancers of colon, leukemia, stomach, larynx, thyroid, etc. in Kerala to trace elements (radioactive) such as ilmenite, cerium, uranium, zircon, goitrogen etc. occurring in soils and locally produced and consumed food products. He also studied geographical distribution of Cancer in India. He concluded that each region has typical type of cancer, related to the region's physical and cultural characteristics. The occurrence and distribution of cancer in India is deep rooted cultural practices, socio-economic standards and the diet intake. Physical environment plays its role in altering the trace elements in the soil and water.

Haque (1998, cited in Nergus, 2002) reported that cardiovascular mortality rates are much higher in those countries where the rocks are geologically very old. This may be due to high heavy metal content in the rocks.

Keller (1999) has mentioned that lead poisoning is an example of geologic, cultural, political and economic influences on patterns of disease. He points out that lead poisoning causes anemia, mental retardation and palsy. It occurs in human bodies in a number of ways and sources. Mining and smelting are the primary activities responsible for it.

Keller (1999) while making study in American cities highlighted that observations over many years have suggested that some regional and local variations in human chronic diseases such as cancer and heart disease are related to the local geo-environmental conditions. Further he proposed that radioactive Radon-222 present in the soils and ground water is the probable cause of the lung cancer.

Investigations in the area of silicon toxicity are almost invariably associated with the silicosis problem (Nath, 2000). This disease occurs in certain classes of miners as a result of continued inhalation of silica particles into the lungs. He also points out that epidemiological studies in the USA have shown negative correlations between lithium in drinking water and mortality, especially from heart disease, and admission rates to

mental hospitals. Nath (2000) further points out that ingestion of large amounts of fluoride (5-40 mg d^{-1}) in drinking water produces severe forms of skeletal deformity. These include kyphosis, fixed spine, and other joint deformities, and the dramatic skeletal manifestations of the disease genu valgum.

A varied number of factors can greatly influence the micronutrients nutriture and their identification and recognition can enhance our understanding of effects of trace elements on health (Bogden, 2000). Moreover, he mentions that these factors include interactions between micronutrients, dose-response effects, oxidation state, binding to enzymes, and other macromolecules, chelation, immutability and bioavailability (also absorption and excretion behavior).

While analyzing the dose-effect relationships, Markert *et al.* (2000) have pointed out that a positive relationship exists between dose of a pollutant and the harmful effect it causes on the organism i.e., more of substance X is taken in, the greater is effect Y. When the concentration is increased further, a stage reaches when the system becomes saturated. Copper, manganese, selenium, cobalt and zinc, e.g., are essential trace elements whose absence inevitably causes several deficiency diseases or loss of proper functioning. On the other hand, large doses are cytotoxic or cause cancer.

Ursinyova and Hladikova (2000) analyzed the concentration of lead in many countries of Central Europe. They pointed out that lead found in the earth's crust enters into physical (soil, water, atmosphere) and organic systems through physic-anthropogenic processes and adversely affects many organ systems in the human body (also plants), especially central nervous system of children, manifesting itself as an impairment of cognitive functions.

Nergus (2002) has highlighted in her research work "Problems of health and environmental geochemistry" that in addition to development of various diseases, imbalance in concentration of heavy metals in the human body affects the general health, growth and social behavior of human beings. She also pointed out that imbalance in trace metals in human body may affect daily life activities to a great extent. Such conditions may lead to various types of tumors, heart diseases and

psychic conditions that damage/retard memory and intellectual abilities of human beings.

Jeelani (2004) studied chemical characteristics of natural springs of Anantnag. He pointed out that subsurface lithology is responsible for the different concentrations of heavy metals in water. The high concentrations of iron and chromium are because of lithology. But the high and variable concentration of zinc (Zn=2-38^{-6} mol/kg), although within the drinking water quality standards is related to the fertilizer application in the area, as zinc sulphide is common component of the fertilizers used for rice cultivation.

Hazra (2004) while analyzing the arsenic problems in West Bengal found that arsenic poisoning is endemic to West Bengal and its sporadic distribution is perhaps related to the geology and geomorphology of the area.

Zinc is an essential microelement for biological systems of plants, animals, and humans, taking part in many physiological reactions. It behaves like a traffic policeman, directing and controlling the flow of processes in the organism and regulating enzyme systems and cells (Komatina, 2004).

Jain (2005) while analyzing the ground water quality of District Dehradun found that the trace elements in ground water except iron and nickel, which are present in appreciable concentration, are below the prescribed maximum permissible limits. The concentration of manganese, copper, chromium, lead, cadmium, and zinc have been found within the permissible limits.

Iodine was first element recognized to be essential to human beings. The deprivation of the element in the body causes a series of iodine deficiency disorders, the most common of which is endemic goiter (Fuge, 2005). Highlighting the concentration of iodine in different rocks, sedimentaries contain greater concentration with clay-rich or argillaceous rocks more enriched than others. The iodine moves like other elements in a cyclic manner in the earth system.

Selenium, a naturally occurring metalloid is essential for human and animal health in trace amounts but is harmful in excess (Fordyce, 2005). Since diet is the most

important source of selenium in humans, understanding the mobility and behavior of environmental selenium is the key to the assessment of selenium related health risks.

Mayer (2007) highlights that where the bedrock structures are made up of limestone, the areas are prone to be goitrous. Water flowing through rocks contains large quantities of lime and makes thyroid gland to function more than its normal activity and thus contribute to the goiter incidence. The disease can also be associated with granites and quartzite. Mayer while working out the goiter incidence in Kashmir Valley during 2004-2005 found that Anantnag district has the highest incidence of goiter. He suggested that nature of bedrock and soils is responsible for the variable goiter incidence in the valley.

Kabata-Pendias and Mukherjee (2007) described that soil is the main source of trace elements for the plants both as micronutrients and as pollutants. It is also a direct source of these to humans due to soil ingestion affected by 'pica-soil', geophagia, dust inhalation, and absorption through skin. They, moreover, mention that soils contain trace elements of various origins: a) lithogenic, b) pedogenic and c) anthropogenic.

Galan, *et al*. (2008) uses the term "geochemical baseline" to contextualize the trace element concentrations in different geologic and geographic environments, officially introduced in 1993 in the context of the International Geological Correlation Program (IGCP Project 360), Global Geochemical Baselines. It includes the geogenic natural concentrations (natural background) and the diffuse anthropogenic contribution in the soils. Geochemical baseline concentrations depend not only on the dominant soil forming factors (parent rock, climate, topography, biota and time) but also on sample material, grain size and extraction method. The soils developed on crystalline rocks of the southern Iberian Massif are characterized by geochemical baselines with high concentrations of potentially toxic trace elements. Parent rock lithology and mineralisation seem to be the main factors influencing the abundance and distribution of trace elements. Significant enrichments of Co, Cr and Ni are observed in soils derived from basic and ultrabasic rock throughout the survey area. The highest concentrations of the remaining elements are found in soils derived from acid igneous rocks of the South Portuguese Zone, SPZ (median values: 34 mg kg^{-1} of As, 56 mg

kg^{-1} of Pb and 57 mg kg^{-1} of Cu) and those developed on carbonate rocks of the Ossa-Morena Zone, OMZ (median values: 28 mg kg^{-1} of As, 44 mg kg^{-1} of Pb and 83 mg kg^{-1} of Zn).

Marmiroli and Maestri (2008) have pointed out that there is correlation between endemic diseases and geological features and so the concentration of trace metals/elements in the soil and water affects the local population through availability in diet. Selenium, cadmium, zinc, fluoride, etc. are many trace metals for which geological correlates are stronger.

Environmental exposure to arsenic has serious consequences for human health with common chronic effects including skin disorders and internal cancers (West and Coombs, 2009). Highlighting that both aquatic and terrestrial invertebrate can be used as biomarker species, they, pointed out that there was a good correlation between the effects on the worms and concentrations of arsenic in soil.

Appleton (2009) has worked out that mercury is a potent toxin that can have adverse effects on physiological and neurological processes of which the degeneration of the central nervous system is the most pronounced. While working on mercury menace, he, found that mercury and cyanide pollution caused by Diwalwal mines in Philippines has produced 50 percent decline in rice yields from 1980s to 1990s, together with unexplained skin disease in the local population and the death of a significant number of oxen.

Geology can affect plant, animal and human health in the physical sense such as volcanoes, etc. whereas elements such as arsenic and mercury are toxic at high doses (Fordyce, 2009). Geological factors such as rock types determine the chemical composition of essential nutrients and toxic elements in the soils and waters that form the basis of plant-animal-human food chain.

Fortey, *et al*. (2009) by applying scanning electron microscopic (SEM) technique found that lead, cadmium and other toxic heavy metals have a potential to cause health hazards in humans such as occurred in the American cities near Brownfield sites especially those in proximity to housing or earmarked for land reclamation.

The soils of India suffer deficiencies in micronutrients such as Zn, Fe, Cu, Mn, B, Mo and S by 48%, 12%, 4%, 5%, 33%, 13% and 41% respectively (Singh, 2009). About half of the Indian soils are categorized as zinc deficient. Zn deficiency is further expected to increase from 49% to 63% by the year 2025 as most of the marginal soils are being brought under cultivation. Since rice is the staple crop of the country and is highly sensitive to Zn deficiency, it contains low Zn content which in turn may lead to the impairment in growth and immune functions leading to infectious illness and the risk of mortality especially in young children. Most of the Indian soils are adequate in Mo but its deficiency was found more in acidic, sandy and leached soils. Its deficiency is reported more in eastern high rainfall zone. Mo is found in high concentration in grain legumes. Mo toxicity is reported in animals and humans in some parts of Punjab which affects the copper utilization in the body due to Mo-Cu interaction.

Trace elements or heavy metals which are present in the rocks of the earth's crust are scavenged from them by leaching (Jeelani, 2010). Jeelani while working on the water quality of the Anantnag springs has found the concentration of certain trace elements such as iron and chromium higher than permissible limits that may had been scavenged and leached from the hosted carbonate rocks, basalts and sediments.

Jeelani (2010) while conducting the chemical analysis of Anantnag spring waters found that all the major ions such as magnesium, calcium, sodium, potassium, chloride, etc. and heavy metals such as Pb, Zn, Cd, Cu, and Mn are below the WHO permissible limits of drinking water quality standards with the exception of Fe, and Cr. The respective concentrations of Pb, Zn, Cu, Cd, Mn, Fe and Cr are 0.002-0.02 ppm, 0.1-2.5 ppm, 0.01-0.1 ppm, nd-0.002 ppm, 0-0.1ppm, 0.08-0.51 ppm and 0.04-0.06 ppm.

The trace elements occur naturally in soils, some are essential micronutrients for plants and animals, and are thus important for human health and food production (Hooda, 2010). At elevated levels, however, they become potentially toxic. Their introduction into food chains through human activities poses a range of ecological and health problems.

Khan *et al*. (2010) highlighted that use of trace element ions in modern day industries and agricultural sector has increased tremendously and has deteriorated groundwater quality. They found that some groundwater samples had marginally high concentration of Mn, Fe, Pb, and Cr, whereas, concentration of Al and Sr in water samples is very high as per W.H.O. standard for potable water. These high concentrations of metal ions in groundwater was probably due to unsafe discharge of effluent from sugar mill, pulp and paper, cooperative distilleries, municipal wastewater, fertilizers and other industries.

According to a recent research conducted in 2013 on school children of Kulgam district of Kashmir valley, it was found that 18.9% of school children suffer from Total Goiter Rate (TGR). The percentage prevalence was found relatively greater in male students than in female students. Out of total, 21.2% were boys and 16.7% were girls (Khan, *et al*., 2014).

Hajam *et al.* (2015) while conducting a study on the Zinc-Copper deficiency diseases in the foot hill settlements of Pir Panjal range in Anantnag district of Kashmir valley revealed that the deficiency of zinc and copper in the soils and drinking waters (and hence food) is responsible for the prevalence of these diseases in the area. It has also been pointed out that the socio-economic character of the people played an important role in the determination of the prevalence of these diseases.