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Sources and Deficiency Diseases of Mineral Nutrients in Human Health and Nutrition: A Review

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ABSTRACT

Mineral nutrients are fundamentally metals and other inorganic compounds. The life cycle of these mineral nutrients begins in soil, their primary source. Soil provides minerals to plants and through the plants the minerals go to animals and humans; animal products are also the source of mineral nutrients for humans. Plant foods contain almost all of the mineral nutrients established as essential for human nutrition. They provide much of our skeletal structure, *e.g.*, bones and teeth. They are critical to countless body processes by serving as essential co-factors for a number of enzymes. Humans can not utilize most foods without critical minerals and enzymes responsible for digestion and absorption. Though mineral nutrients are essential nutrients, the body requires them in small, precise amounts. We require them in the form found in crops and they can be classified into three different categories: major, secondary, and micro or trace minerals. This classification is based upon their requirement rather than on their relative importance. Major minerals such as potassium (K) and phosphorus (P) are required in amounts of up to 10 g d^{-1}. The daily requirement of secondary and micro minerals ranges from 400 to 1 500 mg d^{-1} and 45 μg d^{-1} to 11 mg d^{-1}, respectively. To protect humans from mineral nutrient deficiencies, the key is to consume a variety of foods in modest quantities, such as different whole grains, low fat dairy, and different meats, vegetables and fruits. For insurance purposes, a supplement containing various mineral nutrients can be taken daily.

Key Words: deficiency diseases, deficiency symptoms, origin, recommended daily dose, toxicity

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INTRODUCTION

Like water, carbohydrates, proteins, fats, vitamins and the enzymes required to digest them, mineral nutrients are also essential to life. Minerals are inorganic substances, present in all body tissues and fluids and their presence is necessary for the maintenance of certain physicochemical processes which are essential to life (Soetan *et al.*, 2010). Over 99% of the adult body's 1 000–1 200 g calcium (Ca) is in the bones and teeth, yet the remainder, less than 1%, plays an essential part in the functioning of many diverse vital activities, such as maintenance and functioning of cell membranes and activation of enzymes and hormone secretion (Wiseman, 2002). Humans require a number of mineral nutrients known to play key role in maintaining human health. This investigation will include mineral nutrients which have been shown to be essential and of utmost importance to human health. Silica (Si), tin (Sn) and cobalt (Co) are excluded from discussion as these are in plentiful supply in nature and their deficiency is seldom encountered. Furthermore, the understanding of their roles is less exact. Carbon (C), oxygen (O) and hydrogen (H) are primarily derived from air and water and are not discussed; nitrogen (N), a major mineral, has also been excluded as it is a component of proteins and that is not a part of the objective of this study.

Mineral nutrients are the key to the engines we know of as vitamins. No vitamin can be absorbed or can carry out its intended function without the specific minerals in very particular amounts. Minerals are fundamentally metals and other inorganic compounds that provide much of our skeletal structure, *e.g.*, bones and teeth. In addition, they are critical to countless body processes (Wikipedia Foundation Inc., 2002).

Mineral nutrients can be separated into major, secondary and micro or trace minerals. This classification is based on their requirement by humans rather than their relative importance. The mineral nutrients included in this study are categorized as follows. Major: P and K; secondary: calcium (Ca), magnesium (Mg) and sulfur (S); and micro, trace or rare: boron

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(B), chlorine (Cl), chromium (Cr), fluoride(Fl), iodine (I), iron (Fe), manganese (Mn), molybdenum (Mo), nickel (Ni), selenium (Se), sodium (Na), vanadium (V) and zinc (Zn). With ongoing and future research, this list is expected to grow longer.

The objective of this review was to report up-to-date information on mineral nutrients, their origin and natural occurrence, sources, daily requirement, functions, symptoms associated with their deficiency diseases, and their role in human nutrition.

NATURAL OCCURRENCE OF MINERALS

Plant foods contain almost the entire nutrient minerals and organic nutrients established as essential for human nutrition. Every form of living matter requires these inorganic elements or mineral nutrients for their normal life processes (Soetan, 2010). Minerals are inorganic (non-carbon) containing nutrients and are either positively charged (cation) or negatively charged (anion). Mineral nutrients are elements remaining after foods are burned completely to ash (Greene, 2000). The primary and the only source of mineral nutrients found in plants, animals and humans is soil. The kinds of nutrients found vary depending upon the origin of the soil. For example, B occurs in high concentrations in sedimentary rocks and in clay-rich marine sediment due to the relatively high concentration of B in seawater (Samir *et al.*, 2011). Deposits of B are found in association with volcanic activity and where marshes or lakes have evaporated under arid conditions (Samir *et al.*, 2011).

The abundance and diversity of nutrient minerals are controlled directly by their chemistry, in turn dependent upon elemental abundance in the earth. The majority of minerals are derived from the earth's crust (Stipanuk and Caudill, 2012). Eight elements in order of decreasing abundance are: O, Si, aluminum (Al), Fe, Mg, Ca, Na and K, which comprise 98% of the earth's crust by weight (Stipanuk and Caudill, 2012). Inorganic minerals include matter other than plant or animal and do not include C, H and O as in living things.

RELATIONSHIP OF MINERAL NUTRIENTS TO HUMAN NUTRITION

Mineral nutrients are absolutely essential for good health. Scientists have established that at least 28 mineral elements are indispensable for normal nutrition (Health Lifestyles Inc., 1993). Furthermore, they are even more important than vitamins. Lacking vitamins, the body can make some use of minerals, but lacking minerals, vitamins are useless (Health Lifestyles Inc., 1993). The shocking fact is that even if one prides themselves on eating a well-balanced diet, they are probably among the 95% of Americans who are lacking in at least one major mineral nutrient. The root of this problem lies in a mineral-poor earth. As far back as 1936, Senate Document No. 264 warned Americans that the soils used to grow fruits and vegetables were seriously deficient in needed minerals. Continuous cropping and the ravages of pollution were even then robbing the soil of the minerals needed to sustain life (Health Lifestyles Inc., 1993).

Unlike the body's complex organic compounds (carbohydrates, lipids, proteins, vitamins) that are used metabolically in the generation of energy, minerals are often found in the form of salts in the body that are inorganic and not metabolized (Carpenter *et al.*, 2013). Minerals constitute about 4 to 6 percent of body weight—about one-half as Ca, one-quarter P as phosphates, and the remainder being made up of the other essential minerals that must be derived from the diet (Carpenter *et al.*, 2013). Minerals not only impart hardness to bones and teeth but also function broadly in metabolism, *e.g.*, as electrolytes in controlling the movement of water in and out of cells, as components of enzyme systems, and as the constituents of many organic molecules (Carpenter *et al.*, 2013).

Mineral nutrition in humans is defined as the process by which substances in foods are transformed into body tissues and provide energy for the full range of physical and mental activities that make up human life (Carpenter *et al.*, 2013). The ultimate goal of nutritional science is to promote optimal health and reduce the risk of chronic diseases, such as cardiovascular disease and cancer, as well as to prevent classic nutritional deficiency diseases, such as kwashiorkor and pellagra (Carpenter *et al.*, 2013)

MAJOR CROP AND ANIMAL SOURCES AND THEIR RECOMMENDED DAILY DOSES

Recommended daily doses of all mineral nutrients studied

All foods contain several mineral nutrients; however, some are higher in certain minerals than other minerals. The recommended doses vary considerably as established by various agencies related to regulation of mineral nutrients in various foods.

A dietary requirement is defined as the lowest continuing intake of a nutrient that, for a specified indicator of adequacy, will maintain a defined level of nutriture in an individual (Sutherland *et al.*, 1998). An essential dietary component is one that the body can not synthesize in sufficient quantities to maintain health.