Chapter-9
Minerals

Minerals: Functions, Deficiency diseases, recommended dietary requirements of calcium, phosphorus, iron, sodium and chloride

Minerals

Introduction.

- Minerals are essential for the normal growth and maintenance of the body. Many of the essential minerals are widely distributed in foods, and most people eating a mixed diet are likely to receive adequate intakes. daily requirement of mineral is more than 100 mg, they are called major elements or macro minerals. If the requirement of minerals is less than 100 mg/day, they are known as minor elements or microminerals or trace elements.
- Mineral availability depends on the region/soil or environmental condition because of mineral percentage vary region to region.

General functions of minerals.

- It is very essential components for day-to-day life in organism. These include calcification of bone, blood coagulation, neuromuscular transmission, homeostasis, acid-base equilibrium, fluid balance and osmotic regulation etc.
- Certain minerals are integral components of biologically important compounds such as haemoglobin (Fe), thyroxine (I), insulin (Zn) and vitamin B12 (Co). Sulphur is present in thiamine, biotin, lipoic acid and coenzyme A.
- Several minerals participate as cofactors for enzymes in metabolism (e.g., Mg, Mn, Cu, Zn, K). Some elements are essential constituents of certain enzymes (e.g., Co, Mo, Se).

Classification of minerals.

A. Classification based on the requirement.

1. **Macrominerals.** The seven principal elements constitute 60-80% of the body's inorganic material. These are **calcium, phosphorus, magnesium, sodium, potassium, chloride and sulphur.**
2. **Microminerals.**
   - Essential trace elements. Iron, copper, iodine, manganese, zinc, molybdenum, cobalt, fluorine, selenium and chromium.
   - Possibly essential trace elements. Nickel, vanadium, cadmium and barium
   - Non-essential trace elements. Aluminium, lead, mercury, boron, silver, bismuth etc

B. Classification of minerals on the basis of the functions as.

1. Structural function— calcium, magnesium, phosphate.
2. Membrane functions— sodium, potassium.
3. Act as prosthetic groups in enzymes— cobalt, copper, iron, molybdenum, selenium, zinc.
4. Regulatory action in hormone— calcium, chromium, iodine, magnesium, manganese, sodium, potassium.
5. Essential, but function unknown— silicon, vanadium, bromine, nickel, tin, lithium.
6. Present in normal diet but may cause the toxic in excess— aluminium, arsenic, antimony, cadmium, caesium, germanium, lead, mercury.

Calcium.

- Calcium is the most abundant among the minerals in the body. The total content of calcium in an adult man is about 1 to 1.5 kg. As much as 99% of it is present in the bones and teeth. A small fraction (1%) of the calcium, found outside the skeletal tissue.
- Absorption is taking place from the first and second part of duodenum. Calcium is absorbed against a concentration gradient and requires energy. Absorption requires a carrier protein, helped by calcium-dependent ATPase.

Sources.

- Milk and milk products are the good source of calcium (cow's milk, yogurt, cheese).
- Egg, fish and green vegetables, fruits (Papaya, orange, kiwifruit) are also medium sources for calcium.
- Other than these, cereals (wheat, rice), dry fruits (almond), beans and some pulses also contain the calcium.

Recommended dietary requirements.

Daily requirement of calcium by age	
1-3 years of age	700 mg/day
4-8 years of age	1000 mg/day
9-18 years of age	1300 mg/day
19-50 years of age	1000 mg/day
50 years of age	1200 mg/day

Note- After the menopause condition calcium level in women decrease gradually so extra supplemental calcium require for women other than normal condition (1500 mg/day).

Functions of calcium.

- **Development of bones and teeth—** Calcium, along with phosphate, is required for the formation (of hydroxyapatite) and physical strength of skeletal tissue. Bone is regarded as a mineralized connective tissue. Bones which are in a dynamic state serve as reservoir of Ca. Osteoblasts are responsible for bone formation while osteoclasts result in demineralization.
- **Muscle contraction—** Ca^{2+} interacts with troponin C to trigger muscle contraction. Calcium also activates ATPase, increases the interaction between actin and myosin.
- **Nerve transmission—**It is necessary for the nerve transmission by activating the axonal vesicle in the neuron.

- **Membrane integrity and permeability—** Ca^{2+} influences the membrane structure and transport of water and several ions across it.
- **Activation of enzymes—** Ca^{2+} is needed for the direct activation of enzymes such as lipase (pancreatic), ATPase and succinate dehydrogenase.
- **Release of hormone and Secretory processes—** Ca^{2+} regulates microfilament and microtubule mediated processes such as endocytosis, exocytosis and cell motility and also helps in the release of certain hormone like insulin, PTH, calcitonin.

Deficiency diseases of calcium.

- **Hypercalcaemia—** Elevation in serum Ca^{2+} level (normal 9–11 mg/dl) is hypercalcemia. Hypercalcemia is associated with hyperparathyroidism caused by increased activity of parathyroid glands.
- **Hypocalcaemia—** Hypocalcaemia is a more serious and life-threatening condition. It is characterized by a fall in the serum Ca^{2+} to below 7 mg/dl, causing tetany. The symptoms of tetany include neuromuscular irritability, and convulsions.
- **Rickets—** Rickets is a disorder of defective calcification of bones. This may be due to a low levels of vitamin D in the body or due to a dietary deficiency of Ca^{2+}.
- **Osteoporosis—** Osteoporosis is characterized by demineralization of bone resulting in the progressive loss of bone mass.

Phosphorus

- An adult body contains about 1 kg phosphate and it is an intracellular component of cells. Most of it (about 80%) occurs in combination with Ca^{2+} in the bones and teeth. About 10% of body phosphorous is found in muscles and blood in association with proteins, carbohydrates and lipids.
- Calcitriol promotes phosphate uptake along with calcium and acidity favours while phytate decrease phosphate uptake by intestinal cells.

Sources.

- Best sources—milk and milk products, eggs, chicken meat, fish oil, seeds (sunflower, pumpkin), beans.
- Other sources— banana, vegetables oils, almond, nuts, cereals etc.

Recommended dietary requirements.

- It is based on the calcium intake. The ratio of calcium and phosphorus is required in 1:1 ratio means (generally 800 mg/day). But in infants it ratio about 2:1. Calcium and phosphate are distributed in the majority of natural foods in 1: 1 ratio. Therefore, adequate intake of Ca generally takes care of the P requirement also.

Functions of phosphorus.

- Phosphorus is essential for the development of bones and teeth.
- It plays a central role for the formation and utilization of high-energy phosphate compounds e.g., ATP, GTP, creatine phosphate etc.
- Phosphorus is required for the formation of phospholipids, phosphoproteins and nucleic acids (DNA and RNA).
- It is an essential component of several nucleotide coenzymes e.g., NAD+, NADP+, pyridoxal phosphate, ADP, AMP.
- Phosphate buffer system is important for the maintenance of pH in the blood (around 7.4) as well as in the cells.

Deficiency diseases of phosphorus.

- Serum phosphate level is increased in hypoparathyroidism and decreased in hyperparathyroidism.
- In severe renal diseases, serum phosphate content is elevated causing acidosis.
- Vitamin D deficient rickets is characterized by decreased serum phosphate.
- In diabetes mellitus, serum content of organic phosphate is lower while that of inorganic phosphate is higher.

Iron

- The total content of iron in an adult body is 3-5 g. About 70% of this occurs in the erythrocytes of blood as a constituent of haemoglobin. At least 5% of body iron is present in myoglobin of muscle. Haem is the most predominant iron-containing substance.
- Iron is mostly found in the foods in ferric form (Fe^{3+}), bound to proteins or organic acids. In the acid medium provided by gastric HCl, the Fe3+ is released from foods. Reducing substances such as ascorbic acid (vitamin C) and cysteine convert ferric iron (Fe^{3+}) to ferrous form (Fe^{2+}). Iron in

the ferrous form is soluble and readily absorbed. It is stored in body in the form of ferritin.

Sources.

- Rich sources— Leafy vegetables (spinach, silver beet, broccoli), pulses, apples, organ meats (liver, heart, kidney), fish, molasses, dry fruits, nuts, tofu.
- Other sources— Milk, wheat, polished rice, oats, egg etc.
- Cooking in iron utensils will improve the iron content of the diet.

Recommended dietary requirements.

- Adult man — 10 mg/day
- Menstruating woman — 18 mg/day
- Pregnant and lactating woman — 40 mg/day

Functions of iron.

- Iron mainly exerts its functions through the compounds in which it is present. Haemoglobin and myoglobin are required for the transport of O2 and CO2.
- Cytochromes and certain non-haem proteins are necessary for electron transport chain and oxidative phosphorylation.
- Peroxidase, the lysosomal enzyme, is required for phagocytosis and killing of bacteria by neutrophils
- Iron is associated with effective immune competence of the body

Deficiency diseases of iron.

- **Iron deficiency anaemia—**It is an important problem worldwide, because if iron losses from the body are relatively high (during heavy menstrual blood loss or intestinal parasites), it is difficult to achieve an adequate intake to replace losses. Iron deficiency anaemia mostly occurs in growing children, adolescent girls, pregnant and lactating women. It is characterized by microcytic hypochromic anaemia with reduced blood haemoglobin levels.
- **Nephrosis—** When kidney glomerular mechanism is damaged, proteinuria results. Then haptoglobin, hemopexin and transferrin are lost in urine, with consequent loss of iron.
- **Hemosiderosis—** This is a less common disorder and is due to excessive iron in the body. It is commonly observed in subjects receiving repeated blood transfusions over the years.

- **Hemochromatosis—** This is a rare disease in which iron is directly deposited in the tissues (liver, spleen, pancreas and skin).

Sodium

Sodium is the chief cation of the extracellular fluid. About 50% of body sodium is present in the bones, 40% in the extracellular fluid and the remaining (10%) in the soft tissues. Sodium is readily absorbed in the gastro intestinal tract.

Sources.

- common salt (NaCl) used in the cooking medium is the major source of sodium.
- Best sources— bread, whole grains, leafy vegetables, nuts, eggs and milk, sea fish, green vegetables.
- Other sources— fruits (Apple, mango, banana), tomato, cucumber.

Recommended dietary requirements.

- For normal individuals, the requirement of sodium is about 5-10 g/day.
- For patients of hypertension, around 1 g/day is recommended.

Functions of sodium.

- In association with chloride and bicarbonate, sodium regulates the body's acid base balance or homeostatic.
- It is necessary for the normal muscle irritability and cell permeability.
- Sodium is involved in the intestinal absorption of glucose, galactose and amino acids.
- It is necessary for initiating and maintaining heartbeat.

Deficiency diseases of sodium.

- **Hyponatremia—** This is a condition in which the serum sodium level falls below the normal. Hyponatremia may occur due to diarrhoea, vomiting, chronic renal diseases, adrenocortical insufficiency (Addison's disease).
- **Hypernatremia—** This condition is characterized by an elevation in the serum sodium level. The symptoms include increase in blood volume and blood pressure. It may occur due to hyperactivity of adrenal cortex (Cushing's syndrome), prolonged administration of cortisone, ACTH and/or sex hormones.

Chloride

Chlorine is a constituent of sodium chloride. Hence, the metabolism of chlorine and sodium are intimately related and in normal circumstances it is almost totally absorbed in the gastrointestinal tract.

Sources.

- Best sources— leafy vegetables, eggs and milk, olives, potato, yogurt.
- Other sources— tomatoes, banana, bread, orange etc.

Recommended dietary requirements.

- The daily requirement of chloride as NaCl is 5-10 g/day. Adequate intake of sodium will satisfy the chloride requirement of the body.

Functions of chloride.

- Chloride is involved in the regulation of acid-base equilibrium, fluid balance and osmotic pressure. These functions are carried out by the interaction of chloride with Na^+ and K^+.
- Chloride is necessary for the formation of HCl in the gastric juice.
- Chloride shift involves the active participation of chlorine.
- The enzyme salivary amylase is activated by chloride

Deficiency diseases of chloride.

- **Hypochloraemia—** A reduction in the serum chlorine level may occur due to vomiting, diarrhoea, respiratory alkalosis, Addison's disease and excessive sweating.
- **Hyperchloremia—** An increase in serum chlorine concentration may be due to dehydration, respiratory acidosis and Cushing's syndrome.