Minerals

Minerals comprise the ash obtained after complete oxidation of organic substances or biological materials. The bulk of total ash from the animal body represents the skeleton minerals. Minerals make up to 3-4% of animal's body.

Classification of mineral elements of animal body

The minerals recognized for performing essential functions and present in fairly large amounts (>70 mg/kg live weight) are called essential or macro nutrients which include Ca, P, K, Na, Cl, Mg and S. These are required at concentrations of more than 100 mg/day.

The principal minerals present in micro quantities (<70 mg/kg live weight) but are physiologically equally important called trace **elements or micro minerals** are Fe, Cu, Co, Mn, Zn, I and Mo. These minerals required in trace amounts (ppm).

General functions of mineral elements:

1. Protective functions:

- Ca and P together with F form the hard enamel and thus protect the teeth from rapid wear.
- Ca has a protective function in helping blood clot formation.

2. Structural function:

- As constitute of bone and teeth they give rigidity and strength to the skeletal structures ex. Ca, P, Mg, F, Si.
- Minerals are constituents of organic compounds such as protein and lipids, which make up the muscles, organs, blood cells and other soft tissues of the body ex. P, S, Zn.

3. Regulatory functions: Minerals occur in body fluids and tissues as electrolytes concerned with the maintenance of osmotic pressure, acid base balance, membrane permeability and tissue irritability.

- Na and Cl maintain osmotic pressure of body fluids.
- Na, K, Ca, Mg and Cl regulate the acid base balance in the body.
- Na, K and Ca regulate heart beat.
- I controls general metabolic rate.

4. General metabolic functions:

- Minerals exert characteristic effects on irritability of muscles and nerves.
- Important in activation of many enzymes.
- Na and Cl required for digestive processes.
- P is essential for carbohydrate, fat and protein digestion.
- Fe in the form of Hemoglobin transport oxygen.

- Cu is required for Hb formation.
- Co is necessary for Vit B12 synthesis. and is responsible for storage of energy by forming high energy phosphate bonds.

DIETARY SOURCE OF MINERALS

Farm animals derive most of the mineral nutrients from:

- Concentrate feed and forages that they consume.
- Mineral supplements such as bone meal mineral mixture, common salt, calcite, shell grit etc.,
- Drinking water – minor source
- Soil contamination of herbage source for grazing animals.

MINERAL ABSORPTION, IMBALANCE AND PREVENTION

Mode and site of absorption of minerals:

- Minerals are mainly absorbed as ions.
- The major site for absorption : Small intestine and anterior part of the large intestine
- Large amounts of minerals entering the digestive tract in digestive juices are reabsorbed together with those originating directly from the food.
- Mode of excretion varies with species of animal
- Ruminant tends to excrete Ca and P in the faeces whereas monogastric species excrete Ca and P mainly in the urine.

Effects of deficiencies and imbalance of minerals on animals and their prevention:

Ingestion of diets that are deficient, imbalanced or excessively high in certain minerals induces changes in their concentration in the animal tissues from below or above the permissible limits affecting physiological functions:

- Retarded growth
- Decreased food utilization and productivity
- Disturbances in fertility and general health
- Surplus of ions in the basic medium of intestine may lead to precipitation of inorganic insoluble salts and decreased availability of respective mineral.
- Ex. Surplus PO_4-Ca ions precipitated, Mo-Cu precipitated

Prevention of mineral deficiencies and imbalances:

Supplementation with concentrated source of one or more mineral elements

- Suitable mineral mixture
- Suitable licks
- Treatment of drinking water with soluble salts
- Injection of slowly absorbed organic compounds
- Appropriate fertilizer treatment of the soil to improve mineral composition of herbage

Calcium

Calcium and phosphorus serve as the major structural elements of skeletal tissue, with more than 99 per cent of the total body calcium being found in the bone and teeth. The normal level of blood calcium in animals ranges from 9 to 11 mg per 100 ml of serum. The cell contains negligible amounts. From 45-50 per cent of the plasma calcium is in the soluble, ionized form, while 40-45 per cent is bound with protein, primarily albumin and other plasma protein. The remaining 5 per cent is complexed with non-ionized inorganic elements depending on blood pH. The plasma of laying hens contains 30 to 40 mg calcium per 100 ml of blood.

Factors affecting the level of blood calcium:

1. **The absolute levels of calcium and phosphorus and the calcium phosphorus ratio of food:** A low intake of either element over long periods of time leads to decreased blood calcium level. A Ca: P ratio of 1:1 to 2:1 is usually recommended.

2. Fat content in the diet: Impaired digestion and absorption of fat causes impaired absorption of calcium because calcium form soaps which are insoluble.

3. Phytic acid and oxalate: Oxalates in certain foods precipitate calcium in the intestine as the insoluble calcium oxalates formed insoluble salt with calcium and makes it insoluble.

4. Acidity relation: Acidic medium in intestine favour calcium absorption.

5. Protein in the diet: Calcium salts are much more soluble in amino acid than water. High protein level increases the absorption of calcium.

6. Vitamin D in the diet: Vitamin D provides acidic medium in the intestine causing more calcium absorption.

7. Parathyroid hormones: Parathyroid hormones regulate calcium level in the plasma.

8. Kidney threshold: In a normal adult any extra calcium absorbed from the kidney is readily excreted in the urine.

9. Sex hormone: Low level of oestrogen hormone causes poor absorption of calcium.

Regulation of Calcium:

The blood levels of Ca regulate secretion of hormones and they in turn regulate deposition and release of Ca from bone. Low levels stimulate parathormone secretion, which promote the release of Ca and P from bone. The Ca is utilized to meet the Ca needs of animal and P is excreted. It also increases calcium absorption in the small intestine by increasing the synthesis of 1,25 dihydroxy cholecalciferol (active form of vitamin D) from 25 hydroxy cholecalciferol in the kidneys, which in turn increases the synthesis of calcium binding protein resulting in increased calcium absorption.

Another hormone that controls blood Ca is calcitonin (from thyroid), which decreases the Ca mobilization from bone and therefore, decreases serum calcium level.

Function of calcium: Calcium is essential for skeletal formation, normal blood clotting, rhythmic heart action, neuromuscular excitability, enzyme activation and permeability of membranes and acid base balance of body fluid and also in curdling of milk. A number of enzymes including lipase, succinic dehydrogenase, adenosinetriphophatase and certain proteolytic enzymes are activated by calcium.

Absorption of calcium: The main site of calcium absorption is the small intestine specially the proximal portion of the duodenum. The percentage of absorption of calcium decreases with age, high dietary level of inorganic phosphorus, phytin phosphorus, Mg intakes, and high Ca intakes or low vitamin D intakes. Its absorption also decreases by oxalates and phytates. The major route of excretion for calcium is through faeces.

Deficiency symptoms: 1. **Ricket:** This symptom occurs in young growing animals. The symptoms of rickets are misshapen bones, enlargement of joints, lameness and stiffness. This condition is called Ricketic rosary. Calcification of normal bone does not take place. In some young animals, such as chicken, Ca deficiency causes reduced growth rate, in swine it has little influence on growth rate, in rat serum Ca drops and it is susceptible to internal haemorrhage and may go into tetany.

2. Osteomalacia: In the adult animals, calcium deficiency results in osteomalacia in which Ca of the bone is withdrawn and not replaced. In osteomalacia the bones become weak, porous and soft. Continuous mobilization of calcium from the bones for the higher demand with a low intake is responsible for this condition. Most acute cases of osteomalacia occur during gestation and lactation in mammals and during egg laying in birds.

3. Osteoporosis: This is characterized by a decreased bone mass. It is due to bone resorption being greater than bone formation. It is prominent in aging, and related to gonadal hormone deficiency. In osteoporosis the mineral content of bone is normal but the absolute amount of bone has decreased.

4. Milk fever (parturient paresis; calcium tetany): Shortly after parturition, high yielding cows may suffer from milk fever. The serum calcium goes down with the result that there are muscular spasms and in extreme cases paralysis. There may be breeding difficulties in pregnant animals and the calves born may be dead or very weak.

5. Birds have a tremendous need for Ca immediately after commencing egg production, and bone reserves are mobilized to meet this tremendous demand for Ca to make egg shells. In laying hens deficiency of calcium results in improper development of the egg-shell which is either not fully formed or easily breakable. The deficiency causes soft bones and beak, curved legs and low egg production.

Source of calcium: Milk and green leafy crops, especially legumes, are good sources of calcium; cereals and roots are poor sources. Animal by product containing bone, fish meal,

meat cum bone meal are rich source of calcium. Dicalcium phosphate, calcium carbonate and calcium phosphate are also good source of calcium.

Calcium content of feed stuff:

Feed Stuff	% Calcium
Barley	0.09
Maize	0.04
Wheat	0.05
Wheat bran	0.16
Sovabean meal	0.36
Cow milk	0.91
Spinach	1.00
Eggs	0.19
Bone meal	27.3
Dicalcium phosphate	23.1
Lime stone	33.8
Oyster shell	38.0
Legume forages	1.42
Grasses	0.37

Requirement

- Dairy cattle : 0.34 % - 0.60% DM
- Pig : 0.9 % DM
- Poultry – Broiler : 1.0 % DM
- Poultry – Layer : 3.5 % DM

Phosphorous

Major portion of phosphorus in the animal body is distributed in the bones. The content of inorganic phosphorus in the blood is 4 to 9 mg per 100 ml depending upon the species and age. Maintenance of inorganic phosphorus level in the blood is also governed by the same factors, which promote calcium and phosphorus assimilation. Whole blood contains about 35-40 mg phosphorus per 100 ml.

Functions of Phosphorus:

1. Phosphorus plays an important role in the formation of bones and teeth along with calcium. The amount of phosphorus present in these structure in about 80 per cent of the total.

2. It maintained the normal level of blood calcium and its proper activity.

3. It plays active role for the formation of phospholipid in the cells, nucleic acid, coenzyme and phosphoprotein.

4. It plays a vital role or in energy metabolism in the formation of sugar phosphate like adenosine di-phosphate (ADP) and triphosphates (ATP).

Deficiency symptoms:

1. Rickets: Deficiency of phosphorus causes ricket along with calcium imbalance in young animals.

2. Osteomalacia: The element causes osteomalacia in adult with deficiency of calcium.

3. Pica (Depraved appetite): Phosphorus deficiency causes a specific symptom in cattle called pica. The affected animals have abnormal appetites and chew woods, bone, rags and other foreign materials. The animals become very weak, if not treated; they may die due to weakness or due to secondary infections, which occur from eating decaying bones and other materials. The depraved appetite (pica) may be known as either allotriophagia (a generalized form) or as osteophagia (craving for bones) and as sarcophagia (craving for flesh).

4. Reproduction: Low dietary intake of phosphorus has also been associated with poor fertility; dysfunction of ovaries causing inhibition, depression and irregularity of oestrus.

Requirements of phosphorus (% of dry matter in feed):

Dairy cows	0.31-0.40
Sheep/ Goat	0.16-0.37
Poultry	0.32-0.50

Sources of Phosphorus:

Animal products like fish meal, meat meal and bone meal are good sources of phosphorus. Cereal grains, wheat bran, rice bran, rice polishing, cake etc. are fairly good sources of phosphorus though poor source of calcium. Leguminous fodders like berseem and lucerne are poor sources of phosphorus. Most of the phosphorus present in the cereals and their by-products is in the form of phytates, which are the salt of phytic acid, a phosphoric acid derivative. Ruminants can utilize the phytate phosphorus due to rumen microbial activity.

Phosphorus content of feed stuffs:

Feed Stuff	Phosphorus %
Barley	0.47
Maize	0.31
Wheat	0.41
Wheat bran	1.32
Sovabean meal	0.75
Cow milk	0.71
Spinach	0.55

Eggs	0.83
Bone meal	13.0
Dicalcium phosphate	18.7
Rock Phosphate	18.0

Calcium rich feeds	Phosphorus rich feeds
Legume seeds	Vegetable protein supplements
Legume roughage	Cereal grains and their byproducts (brans)
Animal by products (bone meal, tankage, meat scrap, fish meal)	Animal protein supplements
Milk and milk products	
Plant leaf meals	

CALCIUM PHOSPHORUS RATIO - NUTRITIONAL SECONDARY HYPERPARATHYROIDISM

- The optimum calcium phosphorus ratio is between 1:1 and 2:1. An excess of dietary phosphorus in relation to calcium may result in a bone disorder called **nutritional secondary hyperparathyroidism (NSH)**. An excess of phosphorus depresses calcium absorption and leads to decrease in blood calcium level which stimulates the release of PTH which mobilizes calcium from the bone. The demineralised bone is replaced by fibrous connective tissue. In horses and monkeys the fibrous connective tissueinvades the area and enlarged facial bones result. Hence the disease is also called **osteodystrophia fibrosa and big head disease.**
- Nutritional secondary hyperparathyroidism occurs in horses that are fed large amount of grains or their byproducts without calcium supplementation. The condition is also referred to as **miller's disease or bran disease.**

Magnesium

About 70 per cent of the total magnesium is found in the skeleton, the remainder being distributed in soft tissues and fluids. Blood serum contain 2 to 3 mg magnesium per 100 ml. Bone contains about 1.5 percent magnesium.

Function of Magnesium:

1. Magnesium plays important role in activating various enzymes such as phosphate transferases, decarboxylases and acyltransferases.

2. Magnesium is an activator of phosphates and takes an active part in the carbohydrate metabolism.

3. It also plays an important role in calcium and phosphorus metabolism for the formation of bone and teeth.

4. Magnesium also plays an important role for the neuromuscular activity of the body.

5. It is essential constitute of bone and teeth.

Absorption of magnesium:

The rumen and reticulum is the major site of Mg absorption in ruminants. It is also absorbed from large intestine. Potassium apparently depresses the absorption of Mg from the rumen. Magnesium is excreted via faeces, urine and milk.

Requirements of magnesium (% of dry matter in feed):

Dairy cows	0.20
Sheep/ Goat	0.04-0.08

Deficiency symptoms:

1. Magnesium tetany in adult animals (Grass staggers, Grass tetany): It is also referred as **wheat pasture poisoning or wheat staggers**. This is observed in cows fed on lush green pasture. There are other factors also which are responsible for grass staggers like hormonal disturbances and faulty interrelationship of calcium, phosphorus and magnesium. Clinical signs of tetany include appetite, increased excitability, profuse salivation and convulsions and death. The affected cattle are nervous, with their heads held high, ears pricked and eyes staring. The animal moves in a stiff manner and stagger when walking.

2. Hypomagnesimia in young calves: This has been reported in India when calves reared on milk diet without any other supplement for a prolonged period.

3. Lactation tetany (hypomagnesemic tetany): is a disease of lactating cows and is characterized by hypomagnesaemia (less than 1 mg %) usually accompanied with hypocalcaemia, muscular spasms and convulsions and death due to respiratory failure. Temperature, pulse and respiration rate are high. Tetany can be produced by feeding excess K and citric acid.

4. Neurological symptoms in rats: In the rats lowering of magnesium to 1.8 ppm resulted in hyper-irritability, convulsion and death. The blood picture showed normal calcium and phosphorus but magnesium content was reduced. In poultry magnesium deficiency causes neurological symptoms like rats.

Sources of Magnesium: Most of the commonly fed roughage and concentrates contain 0.1 percent. Bran, oil cakes and leguminous fodder are rich source of magnesium while milk and animal products are much poorer source.

Sodium

It is an alkaline salt which forms about 93 per cent alkali of blood serum. It is found in body fluids and muscles of the body. The total amount of sodium in the body is about 0.2 percent out of which up to 0.05 percent is deposited in bones. **It is major cation.**

Functions of Sodium:

1. Sodium salt is useful in the metabolism of water, protein, fat and carbohydrate.

2. It controls body fluid concentration, contraction of nerve and muscle fibres, body fluid pH, osmotic pressure and help in maintaining neutrality among body tissues.

Absorption of sodium:

Absorption of sodium takes place in rumen and upper small intestine. It is mainly excreted through urine with small amount is also excreted through faeces and perspiration.

The hormone aldosterone, secreted from the adrenal cortex, regulates the reabsorption of Na from kidney tubules. In the absence of this hormone, Na is excreted in the urine.

Deficiency symptoms:

Excessive loss of Na may occur from vomiting, diarrhoea or profuse sweating. The deficiency of sodium in the body of animals result in loss of appetite, general debility, stoppage of growth and development, fall of body temperature, neuromuscular disturbances, softening of bones, keratinisation of corneal epithelium, impotency in male delayed sexual maturity and impaired estrus rhythm and reproductive processes in female and loss of milk production in lactating animals. In laying hens, a deficiency results in lowered production, loss of weight and cannibalism.

Sources of sodium: The chief source of sodium is sodium cloride or common salt. Most of the feed and forages are poor source of sodium except the herbage which grown on alkaline soil for reclamation.

Potassium

Most of the potassium is found in the cells. Excess of this salt in the body interferes with the absorption and metabolism of magnesium.

Functions of Potassium:

1. Potassium is essential part along with sodium, chlorine and bicarbonate ions, in the osmotic pressure regulation of the body fluids and in the acid-base balance in the animals.

2. Potassium plays an important role in nerve and muscles excitability and activates certain enzymes.

Absorption of potassium:

Potassium is absorbed mainly from the small intestine and to some extent in the large intestine. The majority of potassium excretion is in the urine and also via sweat and milk.

Deficiency symptoms: Decreased use of hay and increased use of grains may result in deficiency of potassium.

1. Potassium deficiency result in slow growth, reduced feed and water intake, lowered feed efficiency, muscular weakness, nervous disorders, stiffness, emaciation, intracellular acidosis and degeneration of vital organs.

2. High intake of potassium may interfere with the absorption and metabolism of magnesium in the animals, which may be an important factor in the etiology of hypomagnesaemic tetany.

Sources of potassium:

Outside the body potassium is available in pasture grasses. Milk also contains potassium. Inside the body it is found in muscles, plasma and blood cells.

Chlorine

It is found in skin, subcutaneous tissues and gastric juices. Out of the total amount present in the body 80-85 percent chloride is found in inorganic form while the rest 15 to 20 percent in organic form. Chloride ion is the major anion of extracellular fluid.

Functions of Chlorine:

1. This mineral is required for the formation of hydrochloric acid of the gastric juice.

2. In the form of sodium chloride it assists in the digestion of food.

3. Chlorine is associated with sodium and potassium in acid base relationship and osmotic regulation. It plays a key role in regulating the pH of body fluids. The movement of Cl from body fluids to erythrocytes known as “chloride shift” is a primary mechanism in regulating pH and osmolarity of tissue fluids.

4. It also helps in cell nutrition, growth and reproduction among animals.

Absorption of chlorine:

Chlorine is absorbed in combination with sodium. It is mainly absorbed from the upper small intestine. It is excreted through urine with small amount in faeces and perspiration.

Deficiency symptoms:

1. A dietary deficiency of chlorine may lead to an abnormal increase of the alkali reserve of the blood (alkalosis) caused by an excess of bicarbonate, since inadequate levels of chlorine in the body are party compensated for by increase in bicarbonate.

2. Deficiency of salt in diet leads to decreased appetite which results in poor growth rate and milk production.

3. Deficiency of salt in poultry leads to feather picking and canabalism.

Sources of chlorine:

With the exception fish and meat meals, the chlorine content of most foods is comparatively low. The chlorine content of pasture grass varies from 3 to 25 g/kg dry matter. The main source of this element for most animals is common salt.

Sulphur

Most of the sulphur in the animal body occurs in proteins containing the amino acids cystine, cysteine and methionine. The two vitamins, biotin and thiamin and the hormone, insulin, also contain sulphur.

Functions of Sulphur:

1. Sulphur is an essential element for protein and vitamin synthesis. Wool is rich in cystine and contains about 4 percent of sulphur.

2. It combined with iron and used for the formation of heamoglobin in red blood cells.

3. It also useful in blood clotting and endocrine function.

4. It also maintained intra and extra cellular fluid and acid base balance.

Absorption of sulphur:

Sulphur is absorbed in the rumen and small intestine. It can be recycled to the rumen with similarities to the recycling system for the urea-nitrogen system. Sulphur is excreted through faeces and urine.

Deficiency symptoms:

1. Deficiency of sulphur in the body results in poor growth and development of the body, loss of weight, weakness, lacrimation and metabolic activities of the body are also disturbed. Microbial protein synthesis is reduced and the animal shows sign of protein malnutrition. There is evidence that sodium sulphate can be by used rumen microorganisms more efficiently than elemental sulphur. 2. In sheep its deficiency causes production of the poor quality wool.

All balanced rations, muscles, wings of the birds, horns, hairs, nails, bile juice, saliva, R.B.C, nervous system and hoof of the animals contain certain amount of sulphur.

Iron

The total amount of iron found in the body is 0.004 percent. Half of this amount remains in combination with R. B.C. in the form of heme associated with red colouring matter or haemoglobin. The remaining portion is found associated with myoglobin, enzyme cytochrome, peroxidase, catalase and other enzymes of the body; liver, spleen and kidney. As a respiratory enzyme it is present in all the tissues of the body. In the form of myoglobin, iron is found in all the muscles.

Functions of Iron:

1. As a part of respiratory pigment and heamoglobin, iron helps in the utilization of oxygen by the blood.

2. It activates enzymes by taking part in the enzyme system and assists in proper functioning of every organ of the body. Iron is also a component of many enzymes including cytochromes and certain flavoprotiens. 4 ppm iron is necessary for the formation of blood and growth of chicks.

3. It occurs in blood serum in a protein called transferrin (siderophillin) which is concerned with the transport of iron.

Absorption and excretion:

The amount of iron absorbed is related to its need by the animal body. The capacity of the body excrete the iron is very less therefore; its absorption is controlled by the body's requirement. There are two hypotheses for the control of iron absorption.

1. Mucosal Block theory: In this case iron is absorbed by the mucosal cells of gastro-intestinal tract during period of need and converted into ferritin. When the cells become physiologically saturated the iron absorption is checked until the iron is released and transferred to plasma.

2. The second mechanism by which iron absorption is controlled is the passage of iron from the mucosal cells to the stream which is controlled by the oxygen tension in the blood. Before absorption, ferrous iron is oxidised to ferric state, following absorption into the mucosal cells there it binds with apoferritin, a protein, to form ferritin. At the blood stream end of mucosal cell the ferric iron is again converted into ferrous form and is detached from the ferrittin. In the blood stream it is again auto-oxidized and is attached to a protein siderophilin, in which form it is transported.

Factors which affect iron absorption:

1. Acidic condition in the gastro-intestinal tract helps iron absorption. Absorption ofiron is more efficient when body stores are low.

2. Ascorbic acid in the diet also helps iron absorption.

3. High level of phosphorous and phytic acid present in the diet reduces iron absorption**.**

Deficiency symptoms:

The deficiency symptoms of iron are lower weight gain, listleness, inability to withstand circulatory strain, laboured breathing after mild exercise, reduced appetite and decreased resistance to infection. Iron deficiency results in hypochromic, microcytic anaemia in pigs and chicken while in calves it is microcytic and normochromic type.

Piglet anaemia

Among farm animals, suckling pigs are highly susceptible for iron deficiency. Piglets kept in confinement to concrete stalls are more susceptible due to their nonaccessibility to greens or soil. Anaemia in piglets is characterized by poor appetite and growth, low Hb content of blood (3-4g/100ml), lack of healthy pink colour of the visible mucous membranes, wrinkled skin and rough coat, breathing becomes laboured and spasmodic and this condition is **called 'thump'**.

Source of Iron: Milk is poor and green forages liver, egg yolk are rich sources of iron.

Q. Why piglets are more susceptible.

- The placental transfer of iron is so poor that the piglet is born with unusually small store of body iron, compared with newborn of most other species.
- The polycythaemia of birth seen in other species is absent in the piglet, so that a source of iron from breakdown of the excess haemoglobin is denied to it.
- Low levels of iron in sow's milk.
- Rapid early growth rate compared with that of the lamb or calf.
- Large litter size.

Piglet anaemia can be prevented or cured in its early stages by drenching the suckling pigs with a saturated solution of ferrous sulphate. Pasting the $FeSO_4$ salt on udder of mother and injection of 100 mg iron – dextran intramuscular or subcut at 4^{th} and 14^{th} day after birth.

Toxicity:

Characterized by excessive deposition of storage forms of iron in tissues (siderosis) accompanied by high plasma iron (hypersideremia) and damage to intestinal mucosal cells.

Copper

Copper is an integral part of cytochrome A and cytochrome oxidase. It appears that copper functions in the cytochrome system in the same way as iron, that is, through a change in valency. The enzymes tyrosinase, lactase, ascarbic acid oxidase, plasma amino oxidase,

ceruloplasmin and uricase contain copper, and their activity is dependent on this element. Copper is present in blood plasma as a copper-protein complex, ceruloplasmin. Copper absorption takes place from the abomasum and small intestine. Dietary phytate, high levels of calcium carbonate, iron, zinc and molybdenum reduce absorption and excreted through faeces. Acidity of the stomach, intestinal secretion and the base content of the diet affect the absorption of copper from gasto-intestinal tract. In metabolism, copper is closely associated with molybdenum. Excess of molybdenum in the body result in poor absorption and storage of the copper salt. Deficiency of molybdenum causes more absorption and storage of the copper in the body.

Functions of copper:

1. Copper acts as catalyst in the formation of heamoglobin and provides oxygen absorption power to red blood cells.

2. As an essential part of enzymes system copper plays important role in various metabolic activities of the body.

3. The element is necessary for the normal pigmentation of hair, fur, wool and skin.

4. It is necessary for iron absorption from small intestine and iron absorption from tissue stores.

Deficiency symptoms:

When copper is deficient in the diet, there is a decreased absorption of iron, a decrease in its mobilization from the tissues. Copper deficiency includes anaemia, bone disorders, neonatal ataxia, **depigmentation and abnormal growth of hair and wool,** impaired growth and reproductive performance, retained placenta, heart failure, gastro intestinal disturbances, immunosuppression and lesions in the brain stems and spinal cord. These lesions are associated with muscular incoordination, and occur specially in young lambs.

Enzootic ataxia: The copper deficiency condition known as enzootic ataxia has been known for some time in Australia. The disorder is these associated with pasture low in copper content (2 to 4 mg/kg DM), and can be prevented by feeding with a copper salt.

Swayback: A similar condition which occurs in lambs occurs in U.K. called swayback. The symptoms of swayback in newborn lambs range from a complete inability to stand, to various degree of in-coordination particularly of the hind limbs.

Ataxia is caused by myelin aplasia rather than myelin degeneration and is associated with degeneration of the motor neurons of the brain and spinal cord. Uncoordinated movements of the hind legs, a stiff and staggering gait with a swaying of the hind quarters, is characteristic of animals as the deficiency develops in the few weeks following birth. Some become completely paralyzed and locomotion becomes impossible.

Salt sick: For many years it had been recognized in Florida that cattle not thrive well due to copper deficiency. They lost their appetite. They become emaciated and weak and their blood was very low in heamoglobin. Young cattle were most affected and often badly stunted many of the animals died from the disease which is called salt sick.

Stringy wool (Steely wool, Falling disease, Baffing disease): Copper plays an important role in the production of crimp in wool. The element is present in an enzyme which is responsible for the disulphide bridge in two adjacent cysteine molecules. In the absence of enzyme the protein molecules of the wool donot form this bridge and referred as stringy or steely wool. This disease is called falling or baffing disease.

Falling disease: The disease is characterized by sudden death due to heart failure because of atrophy of myocardium without any preliminary sign. In this fibrosis of myocardium takes place and macrocytic hypochromic type anaemia appears.

Coast disease (Neck ill, Lickin disease): This disease is caused by the deficiency of copper and cobalt in diet of cattle and sheep.

Lechsucht or scouring disease is a wasting disease of cattle and sheep observed in Northern Europe. Symptoms are diarrhoea, loss of appetite and anaemia. It is also known as copper pine.

Teartness (Peat scours): Certain nutritional disease which are prevented or cured by copper supplement, the forage contains a normal amount of copper. However, the assimilation of copper is apparently prevented by an excess of another minerals. One disease is teartness, a type of sever scouring and unthriftiness which affects cattle pastured on certain area of England and similar conditions are noticed in New Zealand in peat soil pasture known as peat scour.

Sources of copper: The requirements of copper are quite difficult to determine since its absorption and utilization in the animal are markedly affected by several mineral elements and other dietary factors i.e. zinc, iron and molybdenum. Copper is widely distributed in feed. Some soils are deficient in copper in our country. Concentrates are rich sources of copper. Straws are poor source of copper. Cattle require 50 mg of copper per day. Moreover, requirement for sheep is 5 mg per day. Pigs require 5 ppm of copper per kg of diet per day.

Copper-Molybdenum-sulphur interrelation: Certain pasture on calcareous soils in part of England and Wales have been known to be associated with a condition in cattle described as 'teart' characterized by unthriftiness and scouring. A similar disorder occurs on reclaimed peat land in New Zealand, where it is known as peat scour. Molybdenum level in teart pasture are about 20 to 100 mg/kg DM compared to 0.5 to 3.0 mg/kg DM in normal pasture, and teart was originally regarded as being a molybdenosis. In the late 1930, however, it was demonstrated that feeding with copper sulphate controlled the scouring and hence a Molybdenum-copper relationship was established.

A mechanism which explains this interrelationship has recently been suggested. Sulphide is formed by ruminal microorganism from dietary sulphate or organic sulphur compounds; the

sulphide then reacts with molybdate to form thiomolybdate which in turn combined with copper to form an insoluble copper thio-molybdate (eu Mo Su) thereby limiting the absorption of dietary copper. In addition it is considered likely that if thiomolybdate is form in excess, it may be absorbed from the digestive tract and exert a systemic effect on copper metabolism in the animals.

Iodine

Iodine is found in thyroid gland where it is incorporated in the thyroxine, a hormone secreted by the gland. It is also a constituent of di-iodotyrosine.

Functions of Iodine:

1. Iodine is necessary for the proper functioning of the thyroid gland, treatment of simple goitre, control of metabolic activities and for the proper growth and development.

2. The thyroid hormone accelerates reactions in most organs and tissues in the body, thus increasing the basal metabolic rate, accelerating growth and increasing the oxygen consumption of the whole organism.

Absorption of iodine:

Iodine is absorbed from the gastrointestinal tract. The rumen is the major site of absorption whereas abomasums is the major site of endogenous secretion or recently of circulatory iodine into the digestive tract. Iodine is excreted through urine.

Deficiency symptoms:

The deficiency of iodine results in the development of simple goitre (enlargement of thyroid gland). In this condition the thyroxine production is reduced and so thyroid gland become over active and enlarged as a compensatory growth. The thyroid being situated in the neck, the deficiency condition in farm animals manifests itself as a swelling of the neck, 'big neck'.

In pigs, its deficiency causes falling of hair, rough and hard skin, reproductive failure, retarded growth rate, poor mental and sexual development. Calves and piglets from iodine deficient cows and sows are often hairless with thick, pulpy skin. The molting process and pigmentation of feathers can be affected by iodine deficiency in birds. Hairless pups may be produced by bitches on Iodine deficient diets.

Plants of Brassica family like cabbage, rape, kale and also soybeans, linseed, peas and groundnut are rich in goitrogens which cause the goitre even if the animals are receiving the adequate amounts of iodine intake.

Sources of iodine:

Iodine is available in fish meal, cod liver oil and iodized salts such as sodium and potassium iodine.

Cobalt

Cobalt is dietary essential for ruminants because it is necessary for the synthesis of vitamin B_{12} by the gastrointestinal microbes.

Functions of cobalt:

1. Cobalt is necessary for the growth and development of the body as well as for the multiplication of rumen microbes among ruminants.

2. It forms as essential part of the enzyme system and plays an important role in the synthesis of vitamin B_{12} in rumen. About 3 per cent of ingested cobalt is converted into vitamin B_{12} in the rumen.

3. Cobalt is also involved in the synthesis of DNA and the metabolism of amino acids.

4. As a component of vitamin B_{12}, cobalt is involved in propionate metabolism where it acts as a cofactor. Vit B_{12} is metabolic essential for all species but it is not dietary essential for ruminants.

Absorption of cobalt:

Cobalt is utilized by rumen microbes in the rumen and also absorbed in the lower portion of the small intestine. Cobalt is mainly excreted in the faeces with small amount in urine.

Deficiency symptoms:

1. The deficiency of cobalt is seen among animals of that area (Australia and New Zealand) where pasture grass contain 0.04 to 0.07 ppm of cobalt. The ruminant animals suffer more as compared to other animals. Loss of appetite, emaciation, rough coat and paleness of skin, normocytic aneamia, retarted growth or weight loss, weakness and reproductive failure, stumping gait and finally leading to death are the main symptoms of cobalt deficiency. In Australia and New Zealand, the deficiency of cobalt is called coast disease, enzootic marasmus, wasting disease, pining and vinguish etc.

In ruminants, cobalt is required by rumen microorganisms for the synthesis of vitamin B_{12}. Deficiency of cobalt leads to insufficient production of vitamin B_{12} to satisfy the animal requirements. These symptoms can be cured by the injection of vitamin B_{12} in the blood but the cobalt injection does improve the condition. Small amount of vitamin B_{12} also synthesized in caecum of monogatric animals but is not sufficient to meet the requirements of poultry and pigs.

Source of cobalt: Normally the feed and fodders contain traces of cobalt ranging from 0.1 to 0.25 ppm. Leguminous grasses are rich source of cobalt as compared to other animals feed. Cobalt sulphate and chloride are good source of cobalt. Cobalt has been reported to be toxic. Ingestion of 20-25 mg cobalt per 100 kg body weight daily may be toxic to the animals.

Zinc

Zinc has been found in very tissue in the animal body. It is found in higher concentration in skin, hair and wool than other tissue of the body. Zinc is a constituent of several enzyme systems in the body like carbonic dehydrogenase, pancreatic carboxypeptidase, glutamic dehydrogenase and a number of pyridine nucleotide dehydrogenases. In addition zinc act as a co-factors for many other enzymes.

Functions of Zinc:

1. Zinc is an important trace element for the proper growth of body and development of hairs and keratinization of epithelial tissues.

2. Being an essential part of insulin hormone it plays important role in the metabolism of carbohydrates. It is involved in the nucleic acid and vitamin A metabolism and protein synthesis.

3. Zinc play a key role in both cell and antibody mediated immune responses for resistant against infection and also provide protection against liver damage caused by toxins from the fungi.

Absorption of zinc:

The zinc absorption takes place in small intestine. Absorption of zinc involves solubilisation of zinc, which is higher at high acidic pH, dissociation from the source, binding to receptors at the intestinal cell wall and transport into the cell aided by zinc binding proteins. The rate of absorption of zinc varies significantly between various forms within and between organic and inorganic sources (dietary level, amounts, chemical form of zinc). High levels of Ca, phosphate, phytate, Cu and Cd in ration decrease Zn absorption.The inorganic sources have low solubility and poor dissociation and hence often pass through the gut into faeces without appreciable absorption. Zinc is mainly excreted through faeces and a small proportion through urine.

Deficiency symptoms:

1. Zinc deficiency in cattle: On the zinc deficient diet, milk production reduced, poor fertility, loss of hair, lower feed efficiency, loss of appetite etc.

2. Zinc deficiency in calves: Symptoms of zinc deficiency in calves include inflammation of the nose and mouth, stiffness of the joints, swollen feet and parakeratosis.

3. Zinc deficiency in pigs: Zinc deficiency in pigs is characterized by subnormal growth, depressed appetite, poor feed conversion efficiency and parakeratosis. The latter is a reddeing of the skin followed by eruption that develop in to scab. Shin gives the appearance of severe mange. The deficiency symptoms are more common in young one and housed pigs fed ad libitum on a dry diet. High level of calcium in the diet aggravated the condition.

4. Zinc deficiency in chicks: Retarded growth, 'Frizzled' feather, parakeratosis and a bone abnormality referred to as the **'Swollen hock syndrome'.**

Sources of Zinc:

Brans are rich source of zinc. Feed and fodders contain adequate amount of zinc.

Manganese

The amount of manganese present in the animal body is very small, the highest concentrations occurring in the bones, liver, kidney, pancrease and pitutary gland. Excess amount of calcium and phosphorus in the body prevents its absorption from the digestive tract. The mineral is excreted out from the body along with bile in faeces and urine.

Functions of manganese:

1. Manganese plays an important role for the bone development and vital nutrient in the synthesis of chondroitin sulphate which is the organic matrix of the bone.

2. Manganese is important trace mineral for normal growth, reproduction, egg production and for the prevention of perosis among poultry.

3. Manganese is important in the animal body as enzyme activators such as phosphate transferases and decarboxylases associated with the Kreb's cycle.

4. This trace mineral has an active role in immune functions where it helps in detoxifying free oxygen radicals which can cause tissue damage produced by immune cells in response to killing bacteria.

Absorption of manganese:

Manganese is one of the poorly absorbed and retained trace minerals in livestock. High dietary intake of calcium, phosphorous and iron reduces manganese absorption from the small intestine. The mineral is excreted out from the body along with bile in faeces and urine.

Deficiency symptoms:

1. Cattle: Deficiency of manganese show poor growth, leg disorders, skeletal abnormalities, ataxia of the new born and reproductive failures.

2. Swine: In swine deficiency of manganese results in poor growth of bones with shortening of leg bones, enlarged hocks, muscular weakness, increase in back fat and irregular oestrus cycle.

3. Poultry: In young chicks a deficiency leading to perosis or slipped tendon in young birds, a malformation of the leg bones of growing chicks may be aggravated by high dietary intakes of calcium and phosphorus. The hock joint becomes swollen and the Achilles tendon slips from its condyle. A shortening of the leg bones was involved. In severe form the birds are reluctant to move, walk upon their hocks and soon die. When hens are fed manganese

deficient diets, abnormalities shown up in the embryo (chondrodystrophy) and in newly hatched chick (ataxia characterized by a **star gazing position**). Embryo chicks develop **"Parrot beaks".** Manganese deficiency in breeding birds reduces hatchability and causes retraction in chicks.

Sources of manganese: Forages are rich in manganese as compared to cereals. In feed it is available in maize, oat, wheat, green fodder and brans.

Fluorine

The amount of fluorine in common feed stuffs is 1 to 2 part per million. Presence of 100 ppm fluorine in the ration on dry matter basis, and above 3 ppm in drinking water is toxic to animals.

Functions of Fluorine: In very small amount the mineral is essential for the growth and proper development of the bones and teeth. It reduces the incidence of dental caries.

Deficiency symptoms: Deficiency of fluorine causes dental caries.

Toxicity of fluorine: The major clinical signs of fluorine toxicity are found in teeth and bone. It is slowly being deposited in the body and produces ill effect afterward. The bone become thick and soft with dirty colouration, teeth loss their normal shining appearance. Finally they become soft and very weak. They look quite bad and are unable to bear cold water. Sometime yellow and black spots are also visible on the teeth. It results in loss of appetite, growth and production.

Selenium

The presence of selenium in roughages and concentrates is harmful to the animals. In soils it may be present upto 40 ppm. Selenium is present in all cells of the body but concentration is normally less than 1 ppm. Toxic concentration in liver and kidney are normally between 5 and 10 ppm. Most important role of selenium in livestock is prevention of liver necrosis in rat and exudative diathesis in chicks.

Functions of Selenium:

1. Selenium is essential for growth, reproduction, prevention of various diseases and protection of the integrity of tissues. The metabolic function of selenium is closely related with vitamin E and acts as an antioxident and required for adequate immune response.

2. It is essential for prostaglandin synthesis and essential fatty acid metabolism.

3. It has a strong tendency to complex with heavy metals and exerts a protective effect against the heavy metals.

4. Selenium is important part of an enzyme glutathione peroxidase. This enzyme destroys peroxides before they can damage body tissues.

5. Selenium is also important in sulphur amino acid synthesis. Sulphur amino acids protect animals against several diseases associated with low intakes of selenium and vitamin E. This protection is due to the antioxidant activity of selenium.

Deficiency symptoms:

1. Deficiency of selenium in the diet causes myopathies in sheep and cattle.

2. In hens selenium deficiency reduces hatchability and egg production. Exudative diathesis, a haemorrhagic disease of chick and dietary liver necrosis in pigs are prevented by either selenium or vitamin E.

3. Bilateral paleness and dystrophy of the skeletal muscle, mottling and dystrophy of myocardium (mulberry heart disease) are noticed in pigs. Mulberry heart disease is most common when cereal based diets contain less than 0.05 ppm selenium.

Toxic effect: Selenium toxicity is known as 'alkali disease' and 'blind staggers' which is characterized by stiffness of joints, lameness, loss of hair from mane and tail and skin lesions on the legs. In some parts of Haryana and Punjab, the animals suffer with selenosis, the disease is known as Degnala.

Molybdenum

This mineral is available in pasture grasses, liver, intestinal tissues and milk of the animals.

Functions of Molybdenum:

1. As a component of the enzyme xanthineoxidase, especially important to poultry for uric acid formation.

2. As a constituent of nitrate reductase it also helps in the utilization of nitrate.

3. It also takes parts in purine metabolism and stimulates action of rumen microorganism.

4. Molybdenum participates in the reaction of the enzyme with cytochrome C and also facilitates the reduction of cytochrome C by aldehyde oxidase.

Absorption of molybdenum: Molybdenum is absorbed from the intestine. It is excreted through urine with a small amount in bile and milk.

Deficiency symptoms: Deficiency symptoms under natural condition have not been reported.

Toxic effect: In the molybdenum toxicity (molybdenosis) in ruminants suffer from extreme diarrhoea, loss in weight and reduced milk yields. The condition is known as teartness.

Chromium

Chromium has been found in nucleoproteins isolated from beef liver and also in RNA preparation. It may plays role in the maintenance of the configuration of the RNA molecule. Chromium has also been shown to catalyze the phospho-glucomutase system activates the

succinic dehydrogenase-cytochrome system. Chromium influences metabolism of glucose, lipid and protein. Chromium is a primary active component of glucose tolerance factor (GTF) which makes the metabolic action of hormone insulin, more effective in regulating energy utilization, muscle tissue deposition, fat metabolism and serum cholesterol levels. As an integral part of GTF, it helps in binding insulin to cell membrane receptors sites and subsequent transport of glucose and amino acids in side the cells.

Interaction of minerals:

Minerals may interact with each other and with other nutrients and non-nutrient factors. This interaction is of two types:

1. Synergistic interaction: The interaction elements, which mutually enhance their absorption in the digestive tract and meet out the requirements of the body, are called synergistic interaction. The synergism of essential minerals is described as:

• Calcium is synergigm with phosphorous.

• Phosphorous with calcium, sulphur, iodine, copper and cobalt.

• Sodium, chlorine and potassium with each other.

• Sulphur with cobalt, magnesium and phosphorous.

• Zinc with molybdenum

• Manganese with copper, molybdenum, cobalt and iron.

• Copper with manganese, iodine, cobalt, iron and phosphorous.

• Iron with copper and manganese.

• Molybdenum with manganese and zinc.

• Magnesium with sulphur.

• Iodine with copper, cobalt and phosphorous.

• Cobalt with iodine, copper, manganese, sulphur and phosphorous.

Elements	Synergism with other minerals
Calcium	P
Phosphorus	Ca, S, Cu, I, Co
Sulphur	Co, Mg, P
Zinc	Mo
Manganese	Cu, Mo, Co, Fe, P
Copper	Mn, I, Co, Fe, P
Iodine	Cu, Co, P
Molybdenum	Mn, Zn
Cobalt	I, Cu, Mn, S, P

Iron	Cu, Mn
Magnesium	S

2. Antagonistic interaction: The interaction in which minerals inhibit the absorption of each other in the digestive tract and produce opposite effects on any biochemical functions is called antagonistic interaction. Antagonism may be one sided or two sided:

a. **One sided antagonism**: One-sided antagonism means one mineral is antagonize the other but other can not. Potassium inhibits the absorption of zinc and manganese but zinc and manganese may not.

Elements	Antagonism with other minerals
Calcium	Zn, Mn, Cu, I, Mg, Fe
Sodium	Zn, Mn
Chlorine	I
Sulphur	Cu, Se
Zinc	Co
Molybdenum	I, P
Potassium	Zn, P

b. Two sided antagonism: In two-sided antagonism both the mineral inhibit the function of each other. Phosphorous and zinc inhibit the absorption of each other. Similarly, zinc and copper antagonize with each other.

Elements	Antagonism with other minerals
Phosphorus	Zn, Mn, Fe, Mg
Zinc	Mo, Fe, P
Manganese	Mg, P
Copper	Zn, Mo
Molybdenum	Cu, Zn
Iron	P
Magnesium	P, Mn

Interaction of minerals with other nutrients: Minerals are not only interacting with each other but also interact with other nutrients like protein, vitamins, carbohydrates, fats and feed additives like antibiotics, alkaloids, antioxidants and glucosides etc. Vitamin D affects the absorption of Ca, P, Mg and Zn. Vitamin E is anteracts with trace mineral selenium. The minerals may form new bonds with organic compounds and form chelates. Such mineral organic complex chelates may stimulate or inhibits the absorption of minerals.

• Fat affects the absorption of Mg and Ca.

• The protein level and their sources determine the degree of utilization of P, Mg, Zn, Cu and other minerals.

• Excess Mo stimulates the elimination of urea nitrogen and reduces the biosynthesis of muscle protein.

S.No	Mineral	Deficiency symptoms
1.	Calcium	• Ricket (in young) • Osteomalacia (in adults) • Osteoporosis (decrease bone mass) • Milk fever (parturient paresis; calcium tetany) • In laying hens improper development of the egg-shell which is either not fully formed or easily breakable.
2.	Phosphorus	• Rickets • Osteomalacia • Pica (Depraved appetite) • poor fertility; dysfunction of ovaries causing inhibition, depression and irregularity of oestrus • Nutritional Secondary Hyperparathyroidism or osteodystrophia fibrosa and big head disease or miller's disease or bran disease
3.	Magnesium	• Magnesium tetany in adult animals (Grass staggers, Grass tetany) • Hypomagnesimia in young calves • Lactation tetany (hypomagnesemic tetany)
4.	Sodium	• **major cation** • vomiting, diarrhoea or profuse sweating • loss of appetite, general debility, stoppage of growth and development, fall of body temperature, neuromuscular disturbances, softening of bones, keratinisation of corneal epithelium, impotency in male delayed sexual maturity and impaired estrus rhythm and reproductive processes in female and loss of milk production in lactating animals. In laying hens, a deficiency results in lowered production, loss of weight and cannibalism.
5.	Potassium	• slow growth, reduced feed and water intake, lowered feed efficiency, muscular weakness, nervous disorders, stiffness, emaciation, intracellular acidosis and degeneration of vital organs • High intake may interfere with the absorption and metabolism of magnesium in the animals
6.	Chlorine	• Major anion • abnormal increase of the alkali reserve of the blood (alkalosis) • Deficiency of salt in poultry leads to feather picking and canabalism • Fright reaction and titanic spasm in chicks
7.	Sulphur	• poor growth and development of the body, loss of

		weight, weakness, lacrimation • Microbial protein synthesis is reduced • production of the poor quality wool
8.	Copper	• anaemia, bone disorders, neonatal ataxia, **depigmentation and abnormal growth of hair and wool,** impaired growth and reproductive performance, retained placenta, heart failure, gastro intestinal disturbances, immunosuppression and lesions in the brain stems and spinal cord. • Enzootic ataxia or Swayback disease in lambs • Salt sick • Stringy wool or Steely wool • Coast disease (Neck ill, Lickin disease) in cattle and sheep • Lechsucht or scouring disease or copper pine • Teartness (Peat scours) • Enlarged heart in chicks and poults
9.	Mangnese	• poor growth, leg disorders, skeletal abnormalities, ataxia of the new born and reproductive failures • In swine poor growth of bones with shortening of leg bones, enlarged hocks, muscular weakness, increase in back fat and irregular oestrus cycle • Poultry perosis or slipped tendon, in newly hatched chick (ataxia characterized by a **star gazing position**). Embryo chicks develop **"Parrot beaks".**
10.	Cobalt	• Loss of appetite, emaciation, rough coat and paleness of skin, normocytic aneamia, retarted growth or weight loss, weakness and reproductive failure, stumping gait and finally leading to death • deficiency of cobalt is called coast disease, enzootic marasmus, wasting disease, pining and vinguish
11.	Iron	• lower weight gain, listleness, inability to withstand circulatory strain, laboured breathing after mild exercise, reduced appetite and decreased resistance to infection. Iron deficiency results in hypochromic, microcytic anaemia in pigs and chicken while in calves it is microcytic and normochromic type **Piglet anaemia** • poor appetite and growth, low Hb content of blood (3-4g/100ml), lack of healthy pink colour of the visible mucous membranes, wrinkled skin and rough coat, breathing becomes laboured and spasmodic and this condition is **called 'thump'**
12.	Iodine	• simple goitre (enlargement of thyroid gland) • In pigs, its deficiency causes falling of hair, rough and hard skin, reproductive failure, retarded growth rate, poor mental and sexual development. • Hairless pups

13.	Zinc	• In cattle milk production reduced, poor fertility, loss of hair, lower feed efficiency, loss of appetite • in calves include inflammation of the nose and mouth, stiffness of the joints, swollen feet and parakeratosis • in pigs is characterized by subnormal growth, depressed appetite, poor feed conversion efficiency and parakeratosis • chicks: Retarded growth, 'Frizzled' feather, parakeratosis and a bone abnormality referred to as the '**Swollen hock syndrome**'
14.	Flourine	• Deficiency causes dental caries • **Toxicity:** The bone become thick and soft with dirty colouration, teeth loss their normal shining appearance, Sometime yellow and black spots are also visible on the teeth
15.	Selenium	• Deficiency causes myopathies in sheep and cattle • In hens reduces hatchability and egg production, Exudative diathesis • **Toxicity:** 'alkali disease' and 'blind staggers' or Degnala disease in Haryana and Punjab
16.	Molybdenum	• **Toxicity:** from extreme diarrhoea, loss in weight and reduced milk yields (teartness or Peat scour)