

# *MINERAL METABOLISM*

*Presented By*

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# *INTRODUC TION*

- Minerals are **inorganic compounds** that are required for the body as one of the nutrients.
- The inorganic elements (minerals) constitute only **small proportion** of the body weight.
- Human body needs a number of **minerals for its functioning.**

# *FUNCTIONS*

- Minerals perform many vital functions which are essential for existence of organism-
1. Calcification of bones
  2. Blood coagulation
  3. Neuromuscular irritability
  4. Acid-base equilibrium
  5. Fluid balance
  6. Osmotic regulation

# *CLASSIFICATION OF MINERALS*

## Macrominerals

Required in excess of  
100mg/day

Ca<sup>++</sup>, P, S, Mg, Cl,  
Na, K.

## Microminerals

Required in amounts  
less than 100mg/day

Fe, Cu, Zn, Mo, I, Fl,  
Cr, CO, Mn

# *Role Of Minerals In Life Processes:*

## *1. Calcium*

### Functions of Calcium

1. Formation of bones
2. Muscle contraction
3. Blood clotting
4. Neuromuscular mechanism
5. Metal co-factor for different enzymes.



# INTRODUCTION TO CALCIUM



- The most abundant mineral found in human body is **CALCIUM**.
- Calcium is essential for your body's overall nutrition and health.
- Calcium makes up approximately **2%** of your total body weight and contributes to many basic body functions, including disease prevention and absorption of other nutrients.
- Human body contain **about 1-1.5 kg of calcium**.
- **99%** of which is present in **bones , teeth** and **1%** in **extracellular fluid**.

## *Source of Calcium*

- **Milk is a good source for calcium.**
- Calcium content of cow's milk is about 100 mg/100 ml.
- Egg, fish and vegetables are medium sources for calcium.
- Cereals (wheat, rice) contain only small amount of calcium.



*Daily  
Requirement  
&  
Disorders of  
Calcium  
metabolism*



|  |   |   |
|--|---|---|
|  |  |  |
| Children<br>(1-18years)<br>1000mg/day  | Adults<br>(men & women)<br>500-800mg/day  | Pregnancy<br>and lactation<br>1500mg/day  |





# *Excretion of Calcium*



# *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  $\text{Ca}^{2+}$  & P** or both.
- The concentration of serum  $\text{Ca}^{2+}$  & P may be **low or normal**
- An increase in the activity of **alkaline phosphatase** is a characteristic feature of rickets.



# Osteoporosis



- Characterized by **demineralization of bone** resulting in the progressive loss of bone mass.
- After the age of 40-45, **Ca<sup>2+</sup> absorption is reduced & Ca<sup>2+</sup> excretion is increased**; there is a net negative balance for Ca<sup>2+</sup>
- After the age of 60, osteoporosis is seen.
- There is **reduced bone strength & an increased risk of fractures**.
- Decreased absorption of vitamin D & reduced levels of parathyroid hormone/parathyroid-related protein can contribute to the development of osteoporosis.

# *Iron*

Iron required for different processes

1. DNA synthesis
2. Formation of RBCs
3. Formation of myoglobin
4. Oxidoreductase enzyme electron carrier

# *Excretion of Iron & Deficiency of Iron*





# Sodium



*Addison's disease*

- Adult human body contains about 100 mg of sodium mainly in extracellular fluid of body.
- Functions are regulates osmotic pressure, acid base balance.
- The loss of sodium in Addison's disease, prolonged DM.
- Its supplied to body in the form of fish, meat, milk and salt.
- Daily requirement is 2-5 g.
- Excess sodium excreted via urine.

# Potassium



- Adult human body contains about 250 g of potassium.
- Vegetables contains large quantity of potassium.
- It regulate osmotic pressure and acid base balance.
- Its deficiency causes paralysis, diarrhoea and excessive sweating.

# Phosphorous



- Large quantity of phosphorus is associated with calcium in bones.
- It play important role in acid-base balance in cytoplasm.
- It required during growth, pregnancy and lactation.
- It present in phospholipids like milk, casein, nucleic acid.
- Deficiency of phosphorus GI disorders, renal failure, diabetes.

# Chloride

- In diet chloride is present as sodium chloride.
- Daily intake is 10 g.
- Adult body contains about 100 g of chloride ion.
- It transfer carbon dioxide from various tissues to lungs.

# Magnesium



- Daily requirement is 220 mg for adult and 400 mg during pregnancy and lactation.
- 60 % is present in bones.
- It required by various enzymes like ATPase, DNA polymerase.
- Excess of magnesium causes depression of CNS, cardiovascular system.
- Deficiency leads to excess urinary excretion in diabetic acidosis,

## Zinc



- Zinc is cofactor in number of enzyme system.
- It required for the formation of nucleic acid (RNA), maturation of spermatozoa and working of prostate gland.
- Number of diseases are associated with low zinc such as hepatic porphyria, proteinuria.
- Deficiency leads to poor wound healing, immune system failure, hyperpigmentation.



# *Trace Elements*

## *Iodine*

- Total body iodine contain about 20 mg.
- 80 % present in thyroid gland.
- It also present in muscles, salivary glands and ovaries.
- Its important for biosynthesis of thyroxin hormone in thyroid gland.
- Important functions are synthesis of thyroid hormone.
- It excreted through urine, skin, and Saliva.
- Deficiency of iodine leads to goiter.
- Deficiency in pregnant women results in impaired fetal growth and brain development.



# Goiter

- Abnormal increase in size of the thyroid gland is known as goiter.
- Decreased synthesis of thyroid hormones .
- Characterized by swelling of thyroid gland.
- Its is due to failure in regulation of T3 and T4.
- Caused due to deficiency or excess of iodine.



# *Copper*

- Copper is cofactor of number of enzymes.
- Like tyrosine, ascorbic acid oxides, cytochrome.
- Its widely distributed in all tissues.
- Daily requirement for adult is 1-2 mg.
- Highest concentration found in liver, kidney, with significant amount of bone and muscles.
- Deficiency are neutropenia, anemia, joint abnormalities.

# Menkes syndrome or Kinky-hair disease

- Its rare disease
- Inherited a sex linked disorder.
- Characteristic findings include kinky hair, growth failure, and nervous system deterioration.
- disorder caused by mutations in genes coding for the copper-transport protein.



# Manganese

- Is a cofactor for a number of important enzymes.
- Deficiency of dietary manganese leads to growth retardation, reproduction.

# Selenium

- Total body content of selenium 10 mg.
- Mainly present in liver.
- Selenium was found to prevent liver cell necrosis & muscular dystrophy.
- Deficiency causes hepatic necrosis, structural abnormalities.

## *Cobalt*

- Vitamins B12 contains cobalt, called as cyanocobalamin.
- Its daily requirement is 3 mcg hence called as micronutrient.
- It involved in various cell function, production of RBC and prevents infections.
- Deficiency causes anaemia, tiredness, neurological disorders.



# Water



- Most abundant compound in the body (65-95%) of water.
- Water is more essential than food, death usually results when about 20% body water is lost.

## Properties of Water

- Water is more polar
- Its good insulator & control the heat loss
- It has high dielectric constant
- Interact with variety of molecule by H bonding.

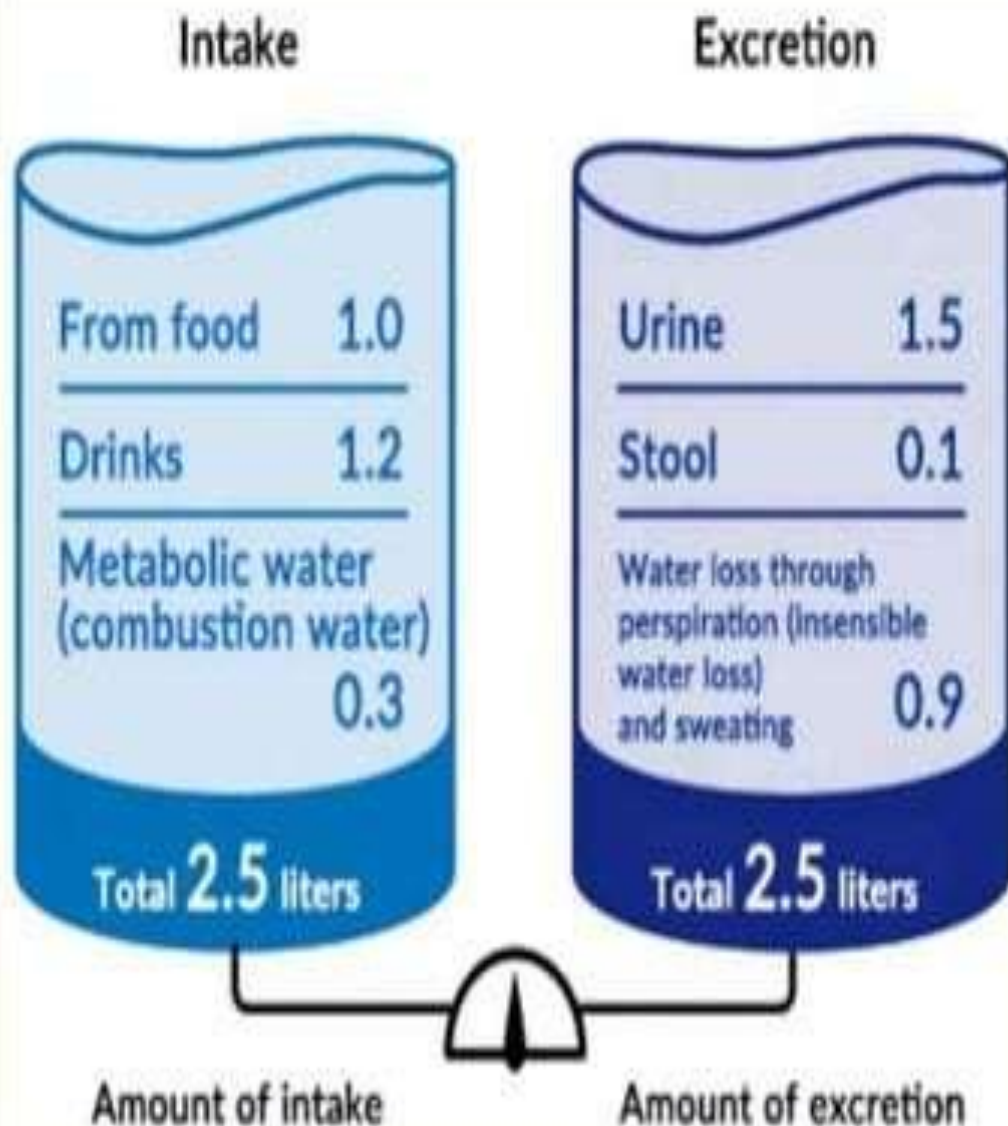
## *Source of Body water*

- Fluids of the diet.
- Solid which contain water.
- Water produced by oxidation reaction in the body.

## *Water excreted by major channel*

- Lung ( water vapours)
- skin (sweating )
- Kidney (urine)
- Intestinal canal (faeces)
- Lactation (milk)
- Eyes (tears)

# *Water Balance of Normal Individual*



# *Water in Life Processes*



## **Body Fluid, Electrolytes and Acid-Base Balance**

- Body fluid refer to body water & dissolved substances.
- The dissolved sub. are proteins, salts, metabolites, vit. etc.
- Two third of the total body is within in cells termed as ICF (intra cellular fluid).
- Other one third present in body termed as ECF (Extra cellular fluid).
- Water is main component of all body fluids.



## *a) Osmosis*

- Its primary method of water movement in and out of body compartment.
- Most solutes are electrolytes.
- Electrolytes give dissociates ions.

## *b) Electrolytes*

- Electrolytes give dissociates ions.
- Ex. Sodium chloride, potassium chloride, etc.





# *Functions of Electrolytes*

1. Essential minerals ( $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Mg}^{++}$ ,  $\text{Ca}^{++}$ ).
2. It controls osmosis and volume of various fluids.
3. It maintained acid-base balance.
4. They carry electric current which produce action potential which required for nerve impulse transmission.

# *Concentration of Electrolytes*

- It expressed in equivalent per litre.
- 1 equivalent is +ve or -ve charge equal to 1 mol of hydrogen ion ( $H^+$ ).
- Milliequivalent is 1 thousandth of an equivalent
- Its denoted as ( m Eq/ lit).
- Mole means mol. weight of sub. in gram per litre.
- Ions such as  $Na^+$ ,  $K^+$ ,  $Cl^-$ ,  $HCO_3^-$  which have single +ve or -ve charges.
- The no. of milliequivalent per lit. (mEq/lit) is equal to m mole/lit.

- Divalent ions like  $\text{Ca}^{++}$ ,  $\text{Mg}^{++}$  will twice the no. of m moles/ lit.
- Milliosmoles its per litre.

## *c) Osmotic Pressure*

- It depends upon the concentration of electrolytes in fluid.
- Each 1mOsm/litre is equal to 19.3 mm of Hg.

# *Sodium*

- Its common cation of extracellular fluid.
- Normal concentration of sodium is 136-142 mEq/lit.
- It required for conduction of action potential & electrolytic balance.
- It controlled by antidiuretic hormone (ADH), aldosterone and arterial natriuretic peptide (ANP).
- Plasma sodium increase with ADH and aldosterone. ANP reduce blood sodium.

# *Hyponatremia* (*loss* *of* *sodium*)

It caused due to

- a) excessive perspiration
- b) Vomiting and diarrhoea
- c) Diuretic drugs
- d) Burn wounds

**Symptoms:-**

- Muscular weakness, headache, dizziness, hypotension.
- It results in mental confusion, coma and stupor.



# *Hypernatremia ( increase sodium concentration)*

- It caused due to,
  - a) Water loss
  - b) Water deprivation
  - c) Sodium gain
  - d) High sodium causes hypertonicity of ECF, it leads to cellular dehydration.

## **Symptoms:-**

- Intense thirst, fatigue
- Restlessness, Coma.

# Chloride

- Major extracellular anion.
- It easily diffuses between extra and intracellular fluid because plasma membrane contains few chloride channels.
- Chloride balance osmotic pressure.
- *Hypochloraemia* caused due to vomiting, dehydration.
- It causes alkalosis and depressed respiration.

# *Potassium*

- It is intracellular cation.
- Its required for cardiac functioning, regulation of pH and resting potential.
- Mineral corticoid and aldosterone regulate the potassium concentration.
- Hyperkalaemia caused anxiety, abdominal cramps, diarrhoea, weakness, irritability and abnormal sensation.
- Prolonged caused of hyperkalaemia is fibrillation of hart

# *Hypokalaemia*

- It is caused due to vomiting, diarrhoea, high sodium intake, kidney malfunctioning.
- Deficiency of potassium results into cramps, flaccid paralysis, nausea, mental confusion , increase urine output.

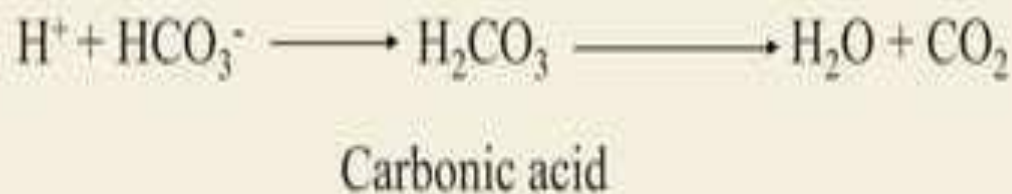
# *Acid-Base Balance*

- pH of body fluid is kept constant with help of buffer system, exhalation of  $\text{CO}_2$  and excretion via kidney.
- pH of body fluid is 7.35- 7.45.
- The regulation of pH called as homeostasis of acid-base balance.
- 3 major mechanism to regulate pH of body fluid are,
  1. Buffer system
  2. Exhalation of  $\text{CO}_2$
  3. kidney excretion



# 1. *Buffer System* *(carbonic acid* *&* *bicarbonate buffer)*

- It regulates the pH of extracellular fluid.

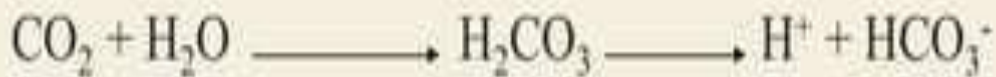


*When  $[\text{H}^+]$  is less,*



## **Phosphate Buffer**

- It regulates pH of cell cytoplasm i.e. ICF.



## 2. *Exhalation of Carbon Dioxide*



### *3. Kidney*

- It eliminates  $H^+$  ions.
- It facilitates reabsorption of bicarbonate.
- Its most important buffer in ECF.
- It also produce new bicarbonate by removing  $H^+$  ions.

# *Importance of Hydrogen Ion Concentration*

- Biological reactions are highly sensitive to hydrogen ion concentration.
- Small change in H ion concentration suddenly change in physiological process.
- Change in pH change in catalytic activity enzymes.
- Many organism required H ion for optimum rate of cell division and growth.

# *Strong and Weak Acids*

- Acids are the substance which on ionization give rise to protons ( $H^+$ ).

Ex. HCl, acetic acid, sulphuric acid, etc.



- Dissociation of sulphuric acid,



- Strong acid which dissociates completely.
- The acid which dissociates called as weak acid.





## *Concept of pH*

- Hydrogen ion concentration is expressed by pH.
- pH defined as negative logarithm of H ion concentration.

$$\text{pH} = -\log [\text{H}^+]$$

# *Ionic Product of Water*



$$K_c = \frac{[\text{H}^+][\text{OH}^-]}{[\text{H}_2\text{O}]}$$

$$K_w = [\text{H}_3\text{O}^+][\text{OH}^-]$$

$$= [1 \times 10^{-7}][1 \times 10^{-7}]$$

$$= 1 \times 10^{-14}$$

# Henderson- Hasselbalch Equation

- Let us consider weak acid HA,



An especially convenient form of the equilibrium equation is obtained by re-writing the equilibrium expression using logs -

$$\log_{10} K_a = \log_{10} [\text{H}^+] + \log_{10} \frac{[\text{A}^-]}{[\text{HA}]}$$

$$-pK_a = -\text{pH} + \log_{10} \frac{[\text{A}^-]}{[\text{HA}]}$$

$$\text{pH} = pK_a + \log_{10} \frac{[\text{A}^-]}{[\text{HA}]}$$

Henderson-Hasselbalch  
Equation

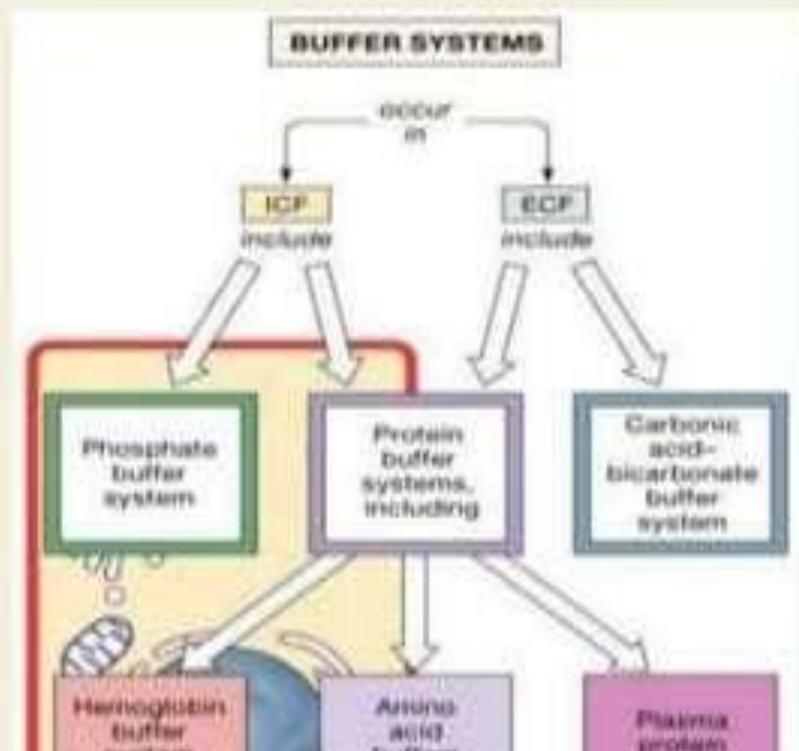
## *Concept of Buffer*

- Buffer is mixture of salt or acid.
- It resists the change in pH on dilution or acid or alkali is added in small amount.
- Common buffers used are acetates, citrates, phosphate, glycine hydrochloride.

$$\text{pH} = \text{pK}_a + \log \frac{[\text{conjugate base}]}{[\text{acid}]}$$

# Buffer in Biological System

- ECF and ICF of living organisms contain conjugated acid-base pairs.
- It act as buffer at normal pH of fluids.





# *Buffering Action in Carbon Dioxide Transport*

- The major intra cellular buffer is bicarbonate and extra cellular buffer is phosphate.
- The protons, amino acids, peptide also act as buffer.



Thank  
you