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# A Synopsis of the Role and Significance of the Chemical Elements in Human Body

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**ABSTRACT:** A large number of varied chemical elements are used for different functions in human body. The food and water taken by the body provides source of these elements. As our body uses most of these elements, it is necessary to replace and restore them daily so that human body stays strong and healthy. The elements found in bulk in our body are oxygen, hydrogen, nitrogen, and carbon. These elements form the building blocks of various biological molecules such as carbohydrates, proteins and lipids. They also help in respiration and are important elements of nucleic acids, DNA and RNA. There are some elements present in our body in small amounts than bulk elements called the macro elements like calcium, phosphorous, sodium, potassium, magnesium, sulphur and chlorine. They provide essential ions to the body fluids and play a crucial role in metabolic processes of our body. There are certain elements that are in very small amounts in our body called the microelements or trace elements such as iron, iodine, zinc, copper, cobalt, manganese, selenium, molybdenum, fluorine, chromium etc. They help in enzymatic reactions, hormone synthesis and growth regulation of our body. All the elements found within the body are not essential for life. Some are considered to be contaminants like tin that do not harm but serves no function in our body. There are certain other trace elements like lead and arsenic which are said to be toxic if found in excess. This paper discusses the role and importance of the above mentioned chemical elements including some probably essential trace elements such as nickel, vanadium, silicon and boron and also some toxic and non-essential trace elements such as gold, antimony, mercury, lithium, aluminium and cadmium. There is a need to maintain balance in between required macro and trace elements in our body so as to stay healthy.

**KEY WORDS:** Oxygen, Carbon, Hydrogen, Nitrogen, trace elements, Macro elements

## I. INTRODUCTION

In the universe and across all of Earth's spheres, chemical elements are plentiful. Chemical components comprise every object in our world. Elements are found in nature in a variety of forms, and they are vital for the body to carry out its many tasks. Our existence is made up of fundamental components, or elements. Everything from the air we breathe to the water we drink, the food we consume, and the materials we use in various systems and for purposes is made up of elements combining with one another in varied quantities. Over thirty chemical elements play a vital role in supporting the life and well-being of plants and animals worldwide. Chemical elements are essential to the human body for a variety of metabolic and biochemical activities. Water and food encourage practically all chemical components to enter the body. Every day, they are both inserted into and taken out of the body.[1] In animal, plant, and human systems, different chemical components are employed for various purposes. For example, fluorine strengthens and maintains teeth, and calcium helps our bodies form strong bones. The food, water, and other edibles we consume are the main sources of these elements. Since the majority of the chemical components we get through food are used by our bodies, we must replenish and replenish them daily to maintain our strength and health. [2] Just six elements make up 99 percent of the human body: carbon, calcium, phosphorus, nitrogen, hydrogen, and oxygen. About 0.85% of the remaining mass is composed of the following five elements: magnesium, sulphur, potassium, sodium, and chlorine. These eleven components are all necessary. Trace elements make up the remaining 0.15% of the human body. Elements are found in nature in a variety of forms, and they are vital for the body to carry out its many tasks. For biological, chemical, and molecular processes in cells, trace elements are crucial. These elements serve as centres for stabilising the structures of proteins and enzymes, as well as cofactors for numerous enzymes, mediating essential biological events. Certain trace elements regulate crucial biological functions by attaching themselves to molecules on the cell membrane's receptor site or by flipping the membrane's structure to block the entry of particular molecules into the cell.[3] Vital trace elements are crucial for maintaining human health. They must be obtained from food and nutrition as the human body is unable to manufacture them. The following elements are classified as essential trace elements (also known as minor elements) in the third category of the categorical classification: iron (Fe), molybdenum (Mo), zinc

(Zn), chromium (Cr), cobalt (Co), copper (Cu), iodine (I), and zinc (Zn). With the exception of iodine, they are all metals. The word "trace" describes the necessity of minute amounts (less than 100 mg daily) for maintaining the health and appropriate operation of the human body. Any trace element excess (or deficit, in many circumstances) can affect the structure, bodily fluids, enzymes, high energy molecules, and other components, potentially causing disease or organ failure.[4]

## II. CLASSIFICATION OF THE CHEMICAL ELEMENTS

### 2.1 Categorical classification

Group I: These constituents serve as the building blocks of macromolecules, including lipids, proteins, and carbohydrates. These elemental groups include nitrogen, oxygen, hydrogen, and carbon.

Group II: These minerals are essential for nutrition. They go by the names, major elements or macro elements as well. For an adult human, they need more than 100 mg each day. When these components are lacking, it usually results in death unless appropriate action is taken. This group of elements includes calcium, phosphorus, magnesium, sulphur, sodium, potassium, and chloride.

Group III: The necessary trace elements are present. When an element's daily need is less than 100 mg and a deficit causes diseases or even death, the element is referred to as a trace element. This group of elements includes copper, iron, zinc, cobalt, chromium, iodine, molybdenum, and selenium. Iodine is a nonmetal among these, whereas the rest are metals.

Group IV: Extra trace elements are these. They might be crucial, but their function is unclear. This group of elements includes silicon, tin, nickel, cadmium, and vanadium.

Group V: While not necessary, the presence of certain metals may be hazardous. They are unknown to have any use in the human body. This group of elements includes aluminium, lead, cyanide, mercury, and gold.[11]

### 2.2 WHO classification of trace elements

1. Essential elements : Cr, Cu, Zn, Fe, Se, Mo, I
2. Probably essential elements : Mn, Si, Ni, B, V
3. Potentially toxic elements : F, Pb, Cd, Hg, Al, As, Li

Chemical elements present in human body is represented in figure 1.

### 2.3 Trace elements classification proposed by Frieden

1. Essential trace elements: Boron, cobalt, copper, iodine, iron, manganese, molybdenum, and zinc.
2. Probable essential trace elements: Chromium, fluorine, nickel, selenium, and vanadium.
3. Physically promotive trace elements: Bromine, lithium, silicon, tin, and titanium.[11]

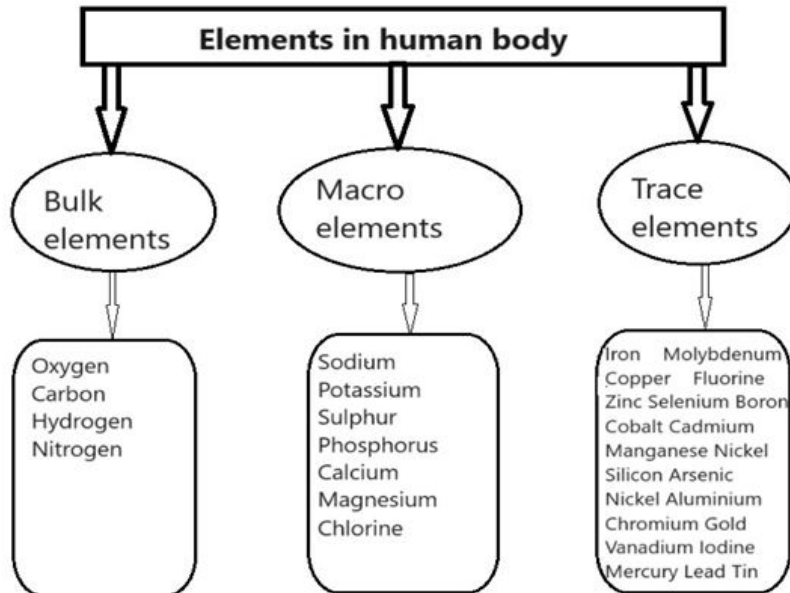


Figure 1 : Chemical elements present in human body

### III. BULK ELEMENTS PRESENT IN HUMAN BODY

Oxygen, carbon, hydrogen and nitrogen are the four bulk elements present in human body. Without these elements survival of the human is not possible. Different bulk elements in human body is represented in figure 2.

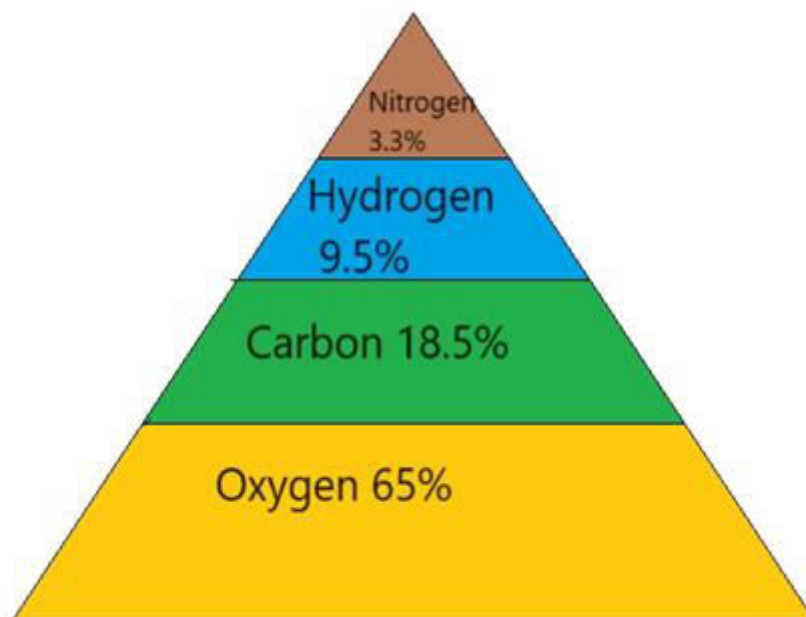


Figure 2 : Bulk elements in human body

### 3.1 Oxygen

It makes up about 65% of the body mass and is the most predominant element in humans. The survival of the human organism depends on oxygen. The majority of the oxygen in the atmosphere is contained in water. The mass of each oxygen atom is significantly greater than the mass of all the hydrogen atoms combined, even though each water molecule is made up of two hydrogen atoms bound to one oxygen atom. Apart from being a constituent of water, oxygen is also necessary for the respiration process within cells. All of the body's major organic molecules, including proteins, carbs, lipids, and nucleic acids, contain oxygen, which is essential for respiration and metabolism. For every tissue and organ in the body to work properly, oxygen is required. While at rest, the human brain requires 20% of the oxygen that the heart pumps out. Of all the tissues and organs, the brain has the highest oxygen need. Cells require oxygen to convert other nutrients, such as glucose, into ATP, or adenosine triphosphate, the primary energy source in cells.[5]

### 3.2 Carbon

Carbon is the second most prevalent element in the body, making up approximately 18% of body mass, since it is an integral part of all organic substances. Proteins, carbohydrates, lipids, and nucleic acids are all composed of carbon. Additionally, carbon dioxide contains it. These molecules are necessary for the body's operations, information transmission, energy storage, and structural support. Our digestive systems absorb carbon from the food we eat. Our diets provide us with glucose and other simple sugars, which our bodies can store as fat or glycogen or use for energy. Fatty acids and glycerol, which can be stored as cholesterol or triglycerides or used as energy, are produced when fats in our diet are broken down. Our diets provide us with amino acids, which can be utilised to make new proteins or transformed into other substances like fat or glucose. The process of breathing allows the body to expel carbon dioxide, a waste product of metabolism. The equilibrium between acid and base in blood and other fluids is also maintained by carbon dioxide. Blood has an average pH of 7.4, which indicates that it is somewhat basic or alkaline. Hydrogen ( $H^+$ ) and bicarbonate ( $HCO_3^-$ ) ions can be produced when carbon dioxide and water react to form carbonic acid ( $H_2CO_3$ ). These ions have the ability to buffer the blood's excess acids or bases. Acid-base imbalances and metabolic problems can be brought on by carbon imbalance. Diabetes mellitus is a disorder characterised by elevated blood glucose levels brought on by inadequate insulin synthesis or function. Coma, ketoacidosis, or hyperglycemia may result from this[2].

### 3.3 Hydrogen

At roughly 10% of the total weight, hydrogen ranks as the third most common element in the human body based on mass. About two thirds of the body is made up of water, which contains the majority of hydrogen. Numerous organic compounds, including proteins, lipids, carbohydrates, and nucleic acids, also contain hydrogen. It is the most common element in the universe and can be found in all bodily fluids, where it helps waste and toxins to be transferred and removed. Our body uses hydrogen to keep its joints lubricated and in good working order. Additionally, it is said that hydrogen has antioxidant and anti-inflammatory qualities, which enhance muscular performance. The intestines absorb and distribute the water we drink throughout our bodies. Water's hydrogen atoms can take part in a number of chemical processes, including hydrolysis, hydration, and acid-base reactions. Dehydration or edoema may result from an imbalance in hydrogen. When the body does not contain enough water, it can cause dehydration, which can cause headaches, exhaustion, dry skin, and kidney failure. Dehydration can be brought on by vomiting, diarrhoea, fever, excessive perspiration, or not drinking enough fluids. Excess water in the body causes edoema, a disorder that can cause swelling, weight gain, dyspnea, or heart failure. Heart illness, liver disease, kidney disease, and excessive salt consumption can all result in edoema.[1]

### 3.4 Nitrogen

With a mass percentage of 3%, nitrogen ranks as the fourth most prevalent element in the human body. Proteins and nucleic acids, which are necessary for the development, maintenance, and repair of cells and tissues, are the primary sources of nitrogen. The synthesis of tissue proteins and the creation of various nitrogenous chemicals involved in a range of processes, including hormones, immunological mediators, neurotransmitters, antioxidant defences, etc., depend on nitrogen, a major component of the body. Composition of the four bulk elements in the human body is represented in table 1. Therefore, to maintain normal bodily processes, the body's nitrogen concentration should be both quantitatively and qualitatively normal as well as normally maintained.[6]

Table 1 : Composition of the four bulk elements in the human body.

Elements	Weight of body mass (kg)	Percentage of the body mass (%)
Oxygen (O)	43	65
Carbon (C)	16	18.5
Hydrogen (H)	7.0	9.5
Nitrogen (N)	1.8	3.3

#### IV. ESSENTIAL MACRO ELEMENTS IN HUMAN BODY

##### 4.1 Sodium

The average adult body has 120 g of sodium in it. This is mostly found in the extracellular fluid. The major mineral in extracellular fluid, sodium, is in charge of preserving the fluid's equilibrium. Body fluids tend to be alkaline when exposed to sodium. The presence of chloride, another mineral, in bodily fluids tends to make them acidic. Together, sodium and chloride in the fluid aid in preserving the proper ratio of acidity to alkalinity in bodily fluids. It facilitates the communication between nerve cells. Moreover, it controls how chemicals enter and exit cells. The main source of sodium in our diet is table salt. A teaspoon of salt has around 2000 milligrams of sodium in it. Green leafy vegetables and pulses are among the plant sources of sodium, while milk, egg white, meat, chicken, and fish are among the animal foods. The human body needs one gram of salt every day. When consumed, sodium is quickly absorbed by the digestive system and utilized by the body for a number of purposes. The body excretes salt that is in excess of what is needed through sweat, feces, and urine. Every time we perspire more, as in hot temperatures, we lose a lot of sodium. Excessive salt loss is a side effect of any illness condition that causes the body to lose water. Excessive sodium loss is harmful because it throws off the body's fluid equilibrium. This needs to be given extra consideration. Increased consumption of salt and fluids is advised during these periods to make up for the lost intake. The kidneys play a vital role in controlling the body's sodium levels by adjusting the overall volume of urine output. Excretion increases with increased sodium consumption and decreases with decreased intake. This procedure aids in maintaining the body's sodium levels within normal bounds. Consuming food high in salt may also increase the amount of blood that passes through your arteries and blood vessels. Blood pressure may momentarily rise as a result of this. The medical word for having too much sodium in the blood is hypernatremia. When the body loses too much water or gains too much sodium, hypernatremia may result. Thirst is the primary symptom of hypernatremia. Lethargy, which is defined as excessive exhaustion and lack of energy, and sometimes disorientation are other symptoms. [10]

##### 4.2 Potassium

In the body, potassium is found in twice the amount as sodium. The body contains about 250g of potassium, the majority of which is found in the intracellular fluid of the cells. There is a lot of potassium in diet. Fish, poultry, and meat are excellent sources. Plant foods that are high in potassium include legumes, fruits, and vegetables, particularly leafy greens. The best source of potassium is, however, the water from tender coconuts. Substantial levels of this mineral can be found in bananas, potatoes, carrots, tomatoes, and lemons, among other fruits and vegetables. Cereals made from whole grains also include some potassium. Adults should take 2.5 g daily, while youngsters should take 10–15 g. Potassium has several uses, such as controlling the ratio of intracellular to extracellular fluid that is potassium and sodium work together to preserve fluid equilibrium both within and outside of cells. The primary mineral found in extracellular fluid is sodium. In contrast, the main mineral found in intracellular fluid is potassium. These two minerals work together to preserve fluid balance. It also entails controlling the bodily fluids' acidity and alkalinity. Similar to sodium, potassium is alkaline. It mixes with acidic chloride and together they help keep bodily fluids both acidic and alkaline. It has a significant impact on muscle activation as well. Potassium plays a major part in cardiac and skeletal muscle action. It facilitates the message transmission that causes muscle tissue to contract. At every level, potassium is required for an organism to function normally. Adults should consume 4700 mg of potassium per day. The amount of potassium in the bloodstream might become excessive for a variety of reasons. We refer to this as hyperkalemia, or elevated potassium. [7]

##### 4.3 Phosphorus

The mineral phosphorus accounts for one percent of an individual's total body weight. Every every cell in the body contains it. The bones and teeth contain the majority of the phosphorus in the body. It strengthens the skeletal system

and benefits the neurological system and brain tissue when combined with other minerals. ensures the kidneys and liver are operating normally. The daily consumption range is 700–1600 mg. Phosphorus is mostly needed for the development of teeth and bones. It is crucial to the way the body metabolizes fats and carbs. The body needs to produce protein in order for cells and tissues to grow, maintain, and repair. In addition, phosphorus aids in the synthesis of ATP, a chemical the body uses as a reserve of energy.[8] The primary dietary sources are processed foods containing sodium phosphate and the protein food groups of milk and meat. Sufficient intake of protein and calcium-rich foods will yield adequate phosphorus. Phosphorus is present in higher concentrations in whole-grain breads and cereals compared to those made with refined flour. Dietary fruits and vegetables are low in phosphorus. The food supply contains so much phosphorus that deficiencies are uncommon. Loss of appetite, anxiety, brittle bones, stiff joints, exhaustion, uneven breathing, agitation, numbness, weakness, and shift in weight are all signs of phosphorus insufficiency. Reduced growth and poor development of the teeth and bones can happen in youngsters. It is actually more frequent and concerning to have too much phosphorus in the body than too little. Most cases of excessive phosphorus in the diet are brought on by kidney disease or by eating too much phosphorus and not enough calcium. [1]

#### 4.4 Calcium

With 1.5% of the body weight, calcium ranks as the fifth most abundant element in the human body by mass. Calcium is abundant in milk and milk products such as cottage cheese, khoa, and curd. A good source of calcium include sea foods like crab and shrimp, as well as dried fish. Ragi is one of the plant sources that is very high in calcium. High levels of calcium can be found in pulses such as soyabean, rajmah, green, black, and bengal gram. Good levels are also found in green leafy vegetables like mustard, fenugreek, colocasia, and amaranth leaves. Gingelly seed is very high in calcium among nuts and oilseeds. Some foods, such as coconut, almonds, and walnuts, are reasonably high in calcium. It is the main component of teeth and bones. Moreover, it is critical for blood coagulation, neuromuscular function, interneuronal transmission, and the preservation of cell membrane integrity. Our bodies continually dissolve and replenish the calcium found in bones, reabsorbing roughly 400 mg of it daily. Calcium ion ( $\text{Ca}^{2+}$ ) content in plasma is tightly regulated by two hormones, parathyroid hormone and calcitonin, at around 100 mg/L. When combined, they aid in the synthesis and mobilization of bone structure. These hormones regulate calcium absorption from the kidneys, calcium reabsorption from the intestines, and calcium release or deposition from the bones. Blood calcium levels typically range from 8.5 to 10.5 mg/dL. Bone and electrolyte issues can result from either an excess or a shortage of calcium. For instance, osteoporosis is a disorder that results in a decrease of bone strength and density, which can cause discomfort, deformity, or fractures. An excessive amount of calcium in the blood is known as hypercalcemia, and it can cause dizziness, nausea, vomiting, kidney stones, and even cardiac arrest. Cancer, hyperparathyroidism, or an overabundance of vitamin D can all lead to hypercalcemia.[29]

#### 4.5 Magnesium

The magnesium content of the human body is between 20 and 25 g. Along with calcium and phosphorus, about 60–70% of this magnesium is found in the bones. The remaining 30–40% is spread among different bodily fluids and tissues, primarily the intracellular fluid. Plant meals contain a lot of magnesium. Nuts such as groundnut, cashewnut, walnut, almond, oilseeds like sesame seeds, pulses, rajmah, moth beans, soyabean, and whole grains like wheat, bajra, and jowar are among the highest concentrations of magnesium. Shellfish is one type of seafood that is very high in magnesium. Appreciable amounts of magnesium can also be found in dark green leafy vegetables, peas, lotus stems, fish, and marine dishes including oysters, crab, and pork. The movement of chemicals into and out of cells, preserving the activity of numerous enzymes, acting as a coenzyme in metabolism, forming teeth and bones, preserving nervous system activities, and other processes are among its primary tasks. It also aids in the body's ability to recover swiftly from traumatic mental experiences, nervous breakdowns, and excessive workload, as well as overexcitement brought on by excessive coffee, alcohol, and nicotine use. Magnesium is required for glycolysis, oxidative phosphorylation, and energy production. It helps build bone structure and is necessary for the creation of DNA, RNA, and glutathione, an antioxidant.[9] Among the ten essential minerals, magnesium has a recommended daily allowance (RDA) of 400 mg for healthy adult males and 320 mg for healthy adult females.[10] Loss of appetite, nausea, vomiting, exhaustion, tingling or numbness, fast heartbeat, delirium, hallucinations, retention of sodium, low levels of parathyroid hormone in the blood, and weakness are some of the early and moderate symptoms of magnesium insufficiency. Insufficient magnesium consumption has been linked to osteoporosis, cerebral infarction, anxiety disorders, headaches, high blood pressure, cardiovascular illness, and recurrent muscular spasms. Additionally, it has shown that hypocalcemia or hypokalemia may also be caused by a severe magnesium deficit.[11] [12]

#### 4.6 Chloride

One of the main minerals that our bodies require in comparatively greater quantities to stay healthy is chloride. The maximum amount of chloride that should be consumed each day is 3.1 g, or about one teaspoon of table salt. About 100 g of chloride are present in the body, the most of which are found in extracellular fluid, particularly blood plasma. The remaining chloride is found within the cell. There is a lot of chloride in all plant-based foods. However, table salt is the main source of chloride in our diet. Though in extremely minute amounts, all unprocessed foods naturally contain chloride. For instance, fruits and vegetables typically have less than 1 mg of chloride per gram of food, whereas raw, uncooked fish and meat might have up to 4 mg. Sodium, potassium, and chloride all have related functions. Many of the processes that make up our bodies include chloride. Like sodium and potassium, chloride forms certain channels in our cell membranes that facilitate the performance of various essential functions. When chloride is combined with sodium and potassium, it helps control the acidity and alkalinity of bodily fluids as well as the fluid balance. Additionally, chloride is necessary for the contraction of the heart and muscles as well as the transmission of nerve signals from the brain to the body via our nerve cells. Furthermore, this mineral is required for red blood cells to exchange carbon dioxide and oxygen in the lungs when they are taking in carbon dioxide and releasing it, as well as in other areas of the body when they are delivering and absorbing carbon dioxide. Last but not least, chloride aids in the creation and release of hydrochloric acid (HCl) in the stomach, which is necessary for the efficient digestion and absorption of food. Chloride deficit is frequently brought on by certain metabolic diseases or medical situations, such as kidney failure or severe diarrhea, which lead our bodies to excrete too much of this mineral. The majority of meals high in sodium also include chloride. Usually, a decrease in the body's level of chloride coincides with circumstances that result in sodium losses. Those that cause the body to lose too much fluid include chronic diarrhea, vomiting, or excessive perspiration. Decreased amounts of chloride can also result from diuretic drugs, which drain fluid through the kidneys. Lower levels of chloride are caused by the kidneys' tendency to flush more water and sodium out of the body when blood glucose spikes unexpectedly, as in the case of diabetics. Dietary toxicity is uncommon in healthy individuals. Hyperchloremia, or excessively high blood chloride levels, can result from extreme dehydration or metabolic disorders such renal illness, which cause the blood to become excessively acidic. An excessive amount of sodium chloride can result from a diet heavy in salt, has been linked to high blood pressure. [2]

#### 4.7 Sulfur

It constitutes 0.25% of the mass of the human body and is found in nerve, bone, and cartilage tissue in addition to skin, hair, and nails. Methionine and cysteine, two amino acids required to synthesise proteins, contain it. Additionally, sulfur can be found in biotin (vitamin H) and thiamin (vitamin B-1). As a component of several amino acids, vitamins, enzymes, and hormones, it plays a crucial role in preserving oxygen balance, enhances the functioning of the nervous system, stabilizes blood sugar levels, boosts immunity, has an antiallergic effect, and has a radioprotective effect. It also engages in metabolic processes and helps to normalize them. Sulfur is present in a number of dietary items and drinks, including drinking water from specific sources. Additionally, different amounts of this mineral are present in some drugs and supplements, including analgesics, antibiotics, and pain relievers. Soybeans, black beans, almonds, Brazil nuts, peanuts, walnuts, pumpkin, and sesame seeds are a few foods high in sulfur. vegetables, primarily turnips, watercress, radishes, leeks, red cabbage, and asparagus. Grains such as wheat, oats, pearl barley, and flour made from these grains. drinks like grape and tomato juice, wine, apple cider, and coconut milk. spices like horseradish, mustard, curry extract, and crushed ginger. It can also be found in cheese and cow's milk. Seafoods and meats also contain it. Sulfur may have health benefits such as reducing inflammation caused by arthritis, curing skin issues, and promoting longevity. Glucosinolates, the primary sulfur-containing chemicals found in cruciferous vegetables, are linked to a decreased risk of heart disease. Despite the fact that sulfur is necessary for life and is present in human cells, consuming too much of it may have certain negative effects. Elemental composition of the macro elements in human body is represented in table 2. Sulfur has a low toxicity level, however eating too much of it might lead to intestinal irritation and diarrhea. These goods should not be consumed by anyone who are sensitive to sulfites, a preservative produced from sulfur that is added to packaged foods and beverages.[1]

Table 2 : Elemental composition of the macro elements in human body.

Elements	Weight of body mass (g)	Percentage of body mass (%)
Calcium (Ca)	1000	1.43
Phosphorus (P)	780	1.11
Potassium (K)	140	0.20



Sulphur (S)	140	0.20
Chlorine (Cl)	100	0.14
Sodium (Na)	95	0.14
Magnesium (Mg)	19	0.03

## V. ESSENTIAL TRACE ELEMENTS IN HUMAN BODY

### 5.1 Iron

The most prevalent metal in the human body is iron (Fe). About 3–4 grams of Fe are present in the body, which is about equal to 40–50 mg of Fe per kilogram of body weight. Rich dietary sources of iron include liver, chickpeas, black-eyed peas, blackstrap molasses, poultry, fish, seafood, leafy greens, watercress, lentils, beans, peas, nuts, seeds, and fortified bread and breakfast cereals. Additionally, teff, farina, and molasses contain trace levels of it. The remaining 75% of Fe is found in muscles, bone marrow, and the liver. The main component that contains iron is heme. It can be found in myoglobin, hemoglobin, and cytochrome, whereas the iron-related enzymes include cytochrome A, B, C, F 450, and cytochrome C reductase. [13] Hemoglobin, an erythrocyte protein that carries oxygen from the lungs to the tissues, contains most of the iron in the body. The red hue of blood is also a result of the iron that is present in hemoglobin. Fe is a necessary part of the protein called myoglobin, which gives muscles their oxygen. In addition, growth, development, regular cellular activity, the creation of certain hormones, and the formation of connective tissue all require iron. An average person needs 1-2 mg of iron per day, which must be supplied by food in the form of 20 mg. Fe insufficiency is a condition that arises when the body's available iron supply is insufficient. Individuals lacking in iron are unable to manufacture enough hemoglobin to meet their body's oxygen requirements.[52] Fe-deficiency anemia is the diagnosis made when the deficiency gets severe. The most typical signs of iron deficiency anemia are pale hands and eyelids from low oxygenated hemoglobin levels and fatigue and weakness from the body's cells not getting enough oxygen. Additional signs include pagophagia, restless legs syndrome, weariness, disorientation, hair loss, twitching, irritability, and brittle or grooved nails. Fe supplements can be used to treat Fe-deficiency anemia. Fe is present in most mineral and vitamin supplements, such as common fumarates, gluconates, and sulfates. The disorder known as hemochromatosis, or iron overload, is characterized by excessive iron storage in the body. Hemochromatosis comes in two varieties, each with a unique etiology. The most frequent cause is a genetic alteration that is inherited. Primary hemochromatosis, inherited hemochromatosis, or classical hemochromatosis are the names given to it. In primary hemochromatosis, abnormalities in the DNA originate from both parents and lead to excessive iron absorption in the body. Overproduction of iron in secondary hemochromatosis is brought on by medical procedures or other illnesses. Anemia, blood transfusions, iron supplements, injections, etc. are a few examples. [14]

### 5.2 Copper

In the human body, copper makes up only 75–100 mg, making it the third most abundant trace element. Plants and animals both require copper as a trace element. [15]For healthy, normal-weight people, the recognized RDA for copper is 2 mg/day. Nearly every tissue in the body has copper, which is mostly stored in the liver, as well as in the brain, heart, kidney, and muscles. After being absorbed in the stomach, copper is carried to the liver attached to albumin. Cu is transported to various tissues in a second phase following digestion in the liver. The majority of the Cu source is carried by the protein ceruloplasmin, which is involved in Cu transport in the liver. Wheat, barley, sunflower seeds, almonds, pecans, walnuts, peanuts, cashews, prunes, raisins, apricots, various dry beans, mushrooms, poultry, and the majority of fish are the finest dietary sources of copper for humans. Cu is a necessary component of many enzymes, including lactase, tyrosinase, ascorbic acid oxidase, catalase, peroxidase, cytochrome oxidase, and monoamine oxidase (SOD). Cu is a vital micronutrient that the neurological and hematopoietic systems require.[16] It is essential for bone growth and construction, the development of myelin sheaths in the neurological infrastructure, the consumption of iron from the gastrointestinal tract, the transfer of iron from tissues to plasma, and the incorporation of iron into hemoglobin. The thyroid hormone thyroxine is also produced, and this process requires copper.[17] Copper is mostly found in the plasma and between the erythrocytes in human blood. The copper-zinc metalloenzyme superoxide dismutase accounts for 60% of the copper in erythrocytes, with the remaining 40% being tethered to other proteins and amino acids. A typical human's average erythrocyte copper is between 0.9 and 1.0 pg/ml of packed red blood cells. [3] Although it is uncommon in healthy adults, babies may experience a cu deficit. The most typical signs of a copper shortage include anemia, lethargy, and a reduction in white blood cells. Sometimes, osteoporosis develops or nerves are damaged. Nerve damage can cause tingling and loss of sensation in the feet and hands. Muscles may feel weak.[18] Overconsumption of Cu, whether through food or other quickly obtained sources, results in diarrhoea, vomiting,

nausea, excessive perspiration, and renal failure. Cu can cause cirrhosis, hepatitis, tremors, mental impairments, hemolytic anemia, GIT hemorrhage, and azotemia when levels are accumulated extremely slowly. Cu has been linked to congenital conditions such as idiopathic fibrosis of the lung, Menke's syndrome, and Wilson's disease.[3]

### 5.3 Zinc

Zinc is a micronutrient that is essential for almost 300 enzymes and is the second most abundant trace element in the human body. It has a role in immune system function, wound healing, DNA synthesis, and cell division. The human body has 2-4 grams of zinc spread throughout it. The prostate, liver, kidney, brain, muscle, and bones are among the tissues that accumulate zinc.[19] It is present in every bodily system, with muscle tissue containing half of it. Zinc has a recommended daily allowance (RDA) of 8 mg for women and 11 mg for males. Zn is actually present in lima beans, walnuts, peanuts, cashews, brown rice, oats, lentils, soybeans, dried peas, and black-eyed peas, cashews, brazil nuts, many cheeses, any kind of liver, and animal flesh such as beef, lamb, chicken, turkey, and various fish and seafood.[20] Additionally, it can be present in most vitamin-mineral supplements as oxide, citrate, or sulfate; these are affordable and readily absorbed forms. It is the only transition metal that is present in every kind of enzyme in an organism, making it the second most common transition metal after iron. Zn is bonded to and transported by albumin (60%) and transferrin (10%) in blood plasma. Because transferrin also carries iron, too much iron might hinder the absorption of zinc, and vice versa. According to[21], zinc is involved in many distinct bodily processes, including metabolism, signaling, transduction, cell development, and differentiation. Zinc is utilized by many proteins to help stabilize their structure and support their functions because of its size and charge characteristics.. The majority of these proteins are factors that regulate transcription and enzymes, which are involved in numerous activities like immune system and growth.[22] Regardless of zinc intake, the content of zinc in the plasma remains largely unchanged. It is crucial for cell division, protein synthesis, DNA synthesis, wound healing, and immune system function. The correct sensation of taste and smell depends on zinc. Additionally, it promotes healthy growth and development in childhood, puberty, and pregnancy.[23], It is also thought to have antioxidant qualities, which may help to prevent premature aging and hasten the healing process following an injury. Even in small quantities, zinc ions have antibacterial activity.[24] Zinc is necessary for many bodily systems to function properly and is involved in a wide range of metabolic processes. An inadequate diet may result in a zinc deficit. In these developing nations, zinc deficiency is considered the primary risk factor for illness, particularly pneumonia and diarrhea in children, which can result in high death rates. Stunted growth and poor development in newborns, children, and adolescents are further indications of serious insufficiency. In addition to these negative effects on immunity and cognition, early zinc deficiency also causes behavioral issues, memory loss, difficulties with spatial learning, and neuronal atrophy. In more extreme situations, zinc deficiency can result in taste anomalies, hair loss, weight loss, delayed wound healing, and mental lassitude.[25]

### 5.4 Iodine

Iodine is an essential vitamin that is needed at every stage of life, with the most crucial periods being during fetal development and early infancy. [3] The adult body has approximately 20–25 mg of iodine, which is extremely little. The thyroid gland, which is situated in the neck area, has the highest proportion of this mineral. One of the elements of the hormone thyroxine that the thyroid gland secretes is iodine. Thyroxine controls how quickly oxidation occurs inside of cells. Growth will be impacted on the physical and mental levels if this regulation is not implemented. It is also thought that iodine contributes to the health of muscular and nerve structures. Most meals have a restricted amount of iodine, and it differs greatly between foods mainly depending on the iodine content of soil and water. Vegetable crops contain significant levels of iodine, particularly those cultivated in coastal areas where the soil has a high iodine content. However, iodine levels in soil and water are low in hilly regions. Thus, there is minimal iodine in the crops that are farmed in these places. Naturally, the iodine level of the food that is a part of the animal's diet determines the iodine content of animal meals like eggs, dairy products, and meat. Seafoods, including fish and shellfish, are excellent providers of iodine. 150–300 mcg of iodine per day is considered normal. Iodides are the form in which dietary iodine is absorbed in the small intestine.[24] The blood transports these iodides to the thyroid gland. The thyroid gland absorbs around one-third of the iodine, excreting the remainder. An insufficient amount of iodine in the body can cause disturbances to the neurological, cardiovascular, and gastrointestinal systems. Women who are expecting are more likely to experience miscarriages and stillbirths. People with thyroid disease who are hyperthyroid or who have a goiter due to thyroid dysfunction sometimes have severe iodine shortage. Iodine deficiency symptoms can include excessive exhaustion, sluggishness, weight gain, facial puffiness, constipation, and lethargy. Mothers who are lacking in iodine may give birth to lanky babies who are challenging to feed. They may end up with cretinism, poor development in general, and mental health issues if they are not treated.[26]

### 5.5 Cobalt

In the body of an adult, cobalt is present in amounts between 1-2 mg. The liver has the highest concentration of cobalt, followed by the kidneys, pancreas, and spleen. [1] It is an organic and inorganic trace element that is necessary for human health. It is a crucial component of vitamin B12 in its organic form and plays a significant role in the synthesis of neurotransmitters and amino acids. Cobalt in its inorganic form is poisonous to humans, and the longer it remains in the body, the more harm it does to cells. Cobalt ions enter the human body through a number of routes, including those through food, the respiratory system, the skin, and lastly as a component of biomaterial. Any of the aforementioned pathways allows cobalt ions to enter the body. Once within the bloodstream, they attach to proteins and are carried by the blood to be deposited in tissues and cells. [27] The water-soluble vitamin B12, sometimes referred to as cobalamin, has the biochemically uncommon element cobalt at the core of a planar tetrapyrrole corrin ring. The food supply is the main way that the general public is exposed to cobalt. The majority of the 5–40 µg of cobalt that are ingested each day come from food. The highest concentrations of cobalt are found in fresh cereals and green vegetables; the lowest concentrations are found in dairy products, refined cereals, and sugar. Cobalt in its inorganic form is poisonous to humans, and the longer it remains in the body, the more harm it does to cells. [28] It has been discovered that deficiencies in cobalt are linked to problems in the synthesis of vitamin B12. It may result in anemia, hypothyroidism, and a higher chance of failure and anomalies in an infant's development. The human body's overabundance of this metal may result in asthma, fibrosis of the lungs, hyperproduction of erythrocytes, and hypothyroidism. [29]

### 5.6 Molybdenum

It is a biogenic microelement, with around 9 mg found in the human body. Bone tissue, the liver, kidneys, brain, pancreas, thyroid, and adrenal glands are the primary sites of its concentration. Molybdenum was named after the Greek phrase molybdos, which meaning lead-like, when it was first mistakenly classified as lead. The body uses molybdenum for a variety of reasons: it helps the body metabolize proteins, fats, and carbohydrates; it activates several enzymes required for the body's development and growth; it strengthens dental tissue, preventing tooth decay and caries; it speeds up the body's breakdown of purines and the elimination of uric acid. [1] Aldehyde oxidase, sulphite oxidase, and xanthine dehydrogenase/oxidase are the three main enzymes that contain molybdenum. The body's molybdenum levels are closely correlated with xanthine oxidase activity. An enzyme that contains molybdenum is involved in the degradation of purines. It also affects the body's development and synthesis of proteins. Reduced blood and urine uric acid concentrations as well as elevated excretion of xanthine and hypoxanthine are associated with molybdenum deficiency. Reduced antioxidant defense is linked to low uric acid levels in the body. Molybdenum at high concentrations is poisonous. Absorption of this element is enhanced by excessive consumption and is lowered at lower dosages of molybdenum. [30]

### 5.7 Manganese

The standard human body has 12 mg of Mn in it. It aids in the synthesis of the thyroid hormone, thyroxine, contributes to the production and exchange of neurotransmitters in the central nervous system, improves the activity of insulin, maintains the stability of cell membrane structure, encourages the restoration of energy balance, strengthens the immune system, and is required for the synthesis of interferon. [1] The skeletal system contains around 43% of it, while soft tissues like the liver, pancreas, kidneys, brain, and central nervous system contain the remaining portion. Mn aids in the formation of bones, connective tissue, and blood clotting components in the body. It also affects blood sugar management, calcium absorption, and the metabolism of fat and carbohydrates. [31]. Many dried beans and peas, nuts and seeds, wheat germ, whole grains like buckwheat, bulgur rice wheat, rye, rolled oat brown rice, and sorghum, lentils, pineapples, tea, parsley, greens that are leafy, root vegetables like sweet potatoes and beets, and sea vegetables are proven to be rich dietary sources of manganese. Additionally, normal brain and nerve function requires manganese. Male adult RDAs for Mn are 2.3 mg/day, whereas female adult RDAs are 1.8 mg/day. [32], Manganese is a component of metalloenzymes and functions as an enzyme activator. They are involved in the metabolism of fatty acids and cholesterol, urea cycle, mucopolysaccharide metabolism, and the process of oxidative phosphorylation. All tissues in mammals contain manganese, ranging in concentration from 0.3 to 2.9 µg manganese/g. Manganese concentrations are typically highest in tissues with a high pigment and mitochondrial content. Manganese concentrations in the liver, kidney, pancreas, and bone are often higher than in other tissues. The bone contains the greatest manganese tissue store. [33] Humans need manganese to survive, yet excessive intake of the mineral can also have negative health effects. It has been demonstrated that neurological conditions like Parkinson's disease are linked to aberrant Mn concentrations in the brain, particularly in the basal ganglia. Conversely, low levels of manganese in the body, or a manganese shortage, have been linked to hypercholesterolemia, poor tolerance to glucose, dermatitis, hair color changes, skeletal deformities, infertility, deafness, and decreased synthesis of vitamin K-dependent clotting components. [34]

### 5.8 Selenium

Meat, onions, and seafood are a few of the sources of selenium. It was discovered that raw foods had significantly higher levels of selenium than cooked and processed meals. It shields the immune system against stressors and free radical oxidation and is a necessary component of various enzymes. The human body has 13–20 milligrams of selenium. This essential mineral has a recommended daily allowance of roughly 70 [35] It is a crucial part of the antioxidant enzymes thioredoxin reductase and glutathione peroxidases. The body may readily absorb and distribute selenium. Vitamins A, E, and C help to improve its absorption. Upon entering the body, selenium is transported throughout tissues by erythrocytes. The excess is eliminated in urine and feces, and it is accumulated in hair and nails. Selenium is highly harmful if consumed in excess, even though selenium deficiency is uncommon in healthy humans. Moreover, it has been suggested that the primary cause of Keshan disease is a deficiency in selenium. However, there is compelling evidence that selenium (Se) protects against certain cancers, including breast, prostate, and colon cancer. [36]

### 5.9 Chromium

An average healthy adult has 0.006 g of chromium in their body, which is a rather low amount. There are three oxidation states for chromium: divalent [Cr(II)], trivalent [Cr(III)], and hexavalent [Cr(VI)]. Trivalent Cr is a necessary trace element that functions as an accomplice to insulin in the metabolism of glucose. As a hazardous industrial contaminant, hexavalent chromium is categorized as a carcinogen with mutagenic and teratogenic qualities.[37] Because the body has very little chromium, it can be challenging to determine whether a person is deficient. It is thought that a severe chromium deficit will be present if serum chromium values are below than the usual range of 0.14–0.15 ng/mL[38] Chromium is the most significant mineral for overweight persons. Furthermore, an essential mineral for regulating fat and blood sugar levels. For adult males, an adequate daily intake of chromium is 35 mg, and for adult females, it is 25 mg.[39], Although Cr is present in food in large quantities, most foods only contain trace levels of it. Egg yolks, whole-grain goods, high-bran breakfast cereals, coffee, almonds, broccoli, green beans, and beef all contain it.[40] The most effective sources of chromium include processed meats, whole grain products, pulses, and spices; dairy products and the majority of fruits and vegetables only have trace levels of the mineral. There is little chromium (2 µg Cr) in animal foods such fish, chicken, and pork. The majority of dairy items have less than 0.6 µg of Cr per serving. The content of Cr/kg in whole wheat and wheat flour is 5–10 µg. Dark chocolate, nuts, and pulses may have higher chromium content than most other foods. Some spices have high chromium contents, including black pepper. The main excretion of chromium is urine, with trace amounts being seen in perspiration, bile, and hair[37] Reduced high density lipoprotein levels are indicative of chromium deficiency, which raises the risk of cardiovascular illnesses. Overconsumption of dietary lipids results in metabolic impairments like increased body mass index, impaired glucose transport, elevation of blood glucose and insulin, decreased chromium depots in liver, alteration of cellular signaling. Increased risk of stomach and lung cancer is associated with environmental chromium overexposure, particularly hexavalent chromium. The kidneys, liver, thyroid, intestines, bones, and cartilages have the highest concentrations of chromium. Treatment for uncommon depression may use chromium-containing formulations, as chromium has been demonstrated to have antidepressant effects through its interaction with glutamine and serotonin receptors.[41]

### 5.10 Fluorine

Drinking water, food, and air all contain fluoride (F<sup>-</sup>), the element fluorine's negative ion. The gastrointestinal tract absorbs 90% of the fluoride that is consumed (up to 25% in the stomach and about 77% in the duodenum). Children keep 50% of F<sup>-</sup>, whereas adults maintain about 36%; 99% of F<sup>-</sup> is found in mineralized tissues like teeth and bone. The majority of the residual fluoride that has been ingested is eliminated through urine. It is crucial to the health of the body's hard tissues, including the teeth and bones. Fluoride has been proposed as a medicinal agent in the treatment of osteoporosis and helps to produce denser bones. It is believed that fluoride activates osteoblastic activity when combined with calcium. It becomes incorporated as fluorapatite into the bone matrix, increasing the resiliency of the bones.[3]. Fluoride can be administered through toothpaste, pills, mouthwash, or lacquers, but the most economical way to get fluoride is to fluoridate communal drinking water, which is done in several countries at a level of 0.7–1.2 ppm.[57] Dental caries is prevented by fluorine's potent anti-enzyme qualities. The anticariogenic activity may be due to enhanced fluoride usage. A hypothetical condition known as fluoride or fluorine shortage could lead to increased tooth cavities and potentially osteoporosis because of a diet low in fluoride. Too much fluoride in the diet can lead to tooth mottling and fluorosis, a disease of the bones. Composition of trace elements in human body is represented in table 3. Elevated fluoride levels lead to lameness, calcification of ligaments, periosteal hyperostosis, and dental diseases.[42] 0.5–0.8 mg is the recommended daily intake (RDI) for drinking water.[43]

Table 3 : Composition of trace elements in human body.

Elements	Weight of body mass (mg)	Percentage of body mass (%)
Iron (Fe)	4.2 g	0.01
Zinc (Zn)	2300	0.00328
Copper (Cu)	72	0.00010
Fluorine (F)	2600	0.00371
Manganese (Mn)	12	0.00002
Molybdenum (Mo)	9.5	0.00001
Iodine (I)	13	0.00002
Selenium (Se)	8	0.00001
Chromium (Cr)	6.6	0.00001
Cobalt (Co)	1.5	0.000002

## VI. PROBABLY ESSENTIAL TRACE ELEMENTS IN HUMAN BODY

### 6.1 Nickel

In the body, nickel (Ni) is poisonous as well as necessary. Iron absorption, bone strength, hormones, lipid, cell membrane, glucose and adrenaline metabolism, and maybe red blood cell synthesis are all enhanced by nickel. [43] All organs in the body absorb nickel, but the lungs, kidney, and bone absorb the most of it. It has been demonstrated that occupational exposure results in increased blood, urine, and tissue concentrations of nickel, with inhalation serving as the primary mode of uptake. It's advised that people with food-related flare-ups of nickel dermatitis follow a low-nickel diet because food is also thought to be a significant source of exposure to nickel. When exposed at work, the primary target organs are the skin and the lungs. [44] It is believed to be somehow connected to the structure or function of proteins because it is present in the body in the highest concentrations in nucleic acids, especially RNA. There has been conjecture that nickel could function as a cofactor in the activation of several enzymes involved in the utilisation or breakdown of glucose. Many foods, including split green peas, beans, cocoa, soybeans, lentils, oats, buckwheat, barley and corn, contain ni. The best sources of nickel are nuts, like hazelnuts and walnuts.[45] Moderate levels of nickel can be found in a variety of fruits and vegetables, including bananas and pears. While the body does require modest amounts of nickel, excessive absorption can pose a health risk to people. Acute exposure to nickel in the human body can result in a number of health issues, including damage to the liver, kidney, spleen, brain, and tissue, vesicular eczema, lung, and nasal cancer. The primary mechanism via which ingested nickel is eliminated is urinary excretion.[46]

### 6.2 Boron

As a trace element, boron (B) is essential for the development of bones, the operation of the central nervous system, and the production of hormones. It is a component in one natural antibiotic (boromycin, derived from *Streptomyces*), and it helps treat arthritis. The amounts of different food groups in the diet can have a significant impact on how much boron a person consumes each day. Plant-based foods are abundant in these, particularly fruits, green vegetables, nuts, and legumes. Dairy products, seafood, and meat are not good sources.[47] In its natural state, it poses no threat to humans or animals, functioning as a trace element. Intakes of less than 0.5g/day, even if taken for extended periods of time, would most certainly, but only produce some toxicity—like digestive difficulties. However, continued doses over 4g/day may be dangerous. Less than 0.1 g/day of intake can cause boron deficiency, which can raise the morbidity of osteoporosis, arthritis, and other degenerative illnesses of the neurological system and skeleton. It might also have a negative impact on hormone regulation, cause memory loss, lower libido, and raise the risk of cancer.[4]

### 6.3 Silicon

The dietary component silicon (Si) is found in a variety of foods, including grains, root vegetables, beans, maize, fruits, dried fruits, nuts, and seeds. Silicon is a trace element that is helpful to eating. There is also a significant silicon content in some alcoholic beverages. The gastrointestinal tract hydrolyzes silicon compounds in food to produce easily absorbed forms of silicic acid in the presence of hydrochloric acid and other stomach acids. [58] Additionally, it enhances the calcification of the bone, the structural integrity of the skin, hair, and nails, regulates the immune system and inflammatory response, quickens the rate of bone mineralization, and lowers the risk of atherosclerosis. [59] As we age, our tissues contain less silicon. Since silicon does not bind to plasma proteins, it is filtered by the glomerulus.

Thus, within 3–8 hours of eating, the kidneys remove 70%–80% of the plasma silicon. [50] Additionally, it has been proposed that silicon could reduce the bioavailability of aluminium by preventing the metal from entering the gastrointestinal system and preventing the metal from being reabsorbed in the kidneys, so shielding the body from aluminium's harmful effects. Insufficient silicon levels in the body can cause striae on the skin, brittle hair or weak nails, and musculoskeletal system irritation. [39]

#### 6.4 Vanadium

Vanadium (V) is found in a wide range of organisms. Vanadium levels in human blood plasma range from 200 nM to 0.3 mg/kg in tissues, with the bones, liver, and kidneys having the highest concentrations. Vanadium is absorbed mostly by food and breathing. [41] The element helps with haemopoiesis and has positive effects on teeth in mammals. It also lowers cholesterol, which is beneficial for treating some ailments. It also inhibits certain types of cancer, albeit its constituents are extremely toxic. [50] Vanadium consumption from food varies greatly and is often in the range of a few tens of ug per day. Mushrooms, shellfish, black pepper, parsley, dill weed, beer, wine, and grain are the finest dietary sources of vanadium. and artificially sweetened drinks. There are several forms of vanadium, such as vanadate and vanadyl sulphate. Supplemental feeding is the most common source of vanadyl sulphate. [51]

### VII. POTENTIALLY TOXIC OR NON ESSENTIAL TRACE ELEMENTS

#### 7.1 Aluminium

Al can be found in the environment naturally as hydroxides, oxides, and silicates. In addition, it combines with biological components to produce compounds and with elements such as fluoride and salt. World-wide, aluminium sulphate  $[Al_2(SO_4)_3]$  is commonly added to drinking water as a "clarifying agent." Aluminium can enter the body through a variety of routes, including the consumption of food and beverages, skin contact with cosmetics, inhalation of dust and other airborne particles, and the use of medications (antacids). Food, inhalation, and other methods all have inadequate absorption of aluminium due to its poor cutaneous absorption. [14] There isn't any conclusive evidence that either animals or humans require aluminium. The only significant factor to take into account is its potential toxicity in the event of excessive exposure. It has been shown that in a sizable percentage of patients with renal failure undergoing chronic dialysis, the high aluminium content of some of the water used to prepare dialysates contributes to dialysis encephalopathy. Aluminium can prevent the absorption of many other elements, including calcium, iron, magnesium, phosphorus, and strontium, when taken in excess. [52]

#### 7.2 Cadmium

Cadmium (Cd) is thought that higher physiological processes and human nutrition do not require the trace metal cadmium. Because cadmium may enter human bodies by ingestion, inhalation, and skin contact, it can be found in food, water, soil, air, tobacco smoke, and other media. The food supply is the main way that nonsmokers are exposed to cadmium. [48] In general, foods high in cadmium include green vegetables like spinach and lettuce, cereals, potatoes, legumes, sunflower seeds, and peanuts. The kidneys have the highest concentration of cadmium, which accumulates there with age in proportion to the body's total cadmium load despite being present in most organs. Another essential organ is the brain. More cadmium excreted in urine is the most important marker of excessive exposure. In people not exposed to high levels of cadmium, urinary excretion is small and constant, usually amounting to one or two ug per day. [47] Cd is well-known for having a strong affinity for biomolecules, particularly for the respiratory chain's enzymes, which can cause oxidative stress and other physiological issues, such as cancer. Cadmium toxicity has also been connected to a number of disorders, including neoplastic diseases and ageing. [49] Glutathione and cysteine are two examples of the organic molecules that may be connected to the transport of Cd into cells. Overexposure to this element has been linked to an increased risk of certain malignancies, particularly liver carcinoma. Additionally, prolonged exposure to cadmium in the liver results in moderate inflammation that is nonspecific. [51]

#### 7.3 Lithium

Lithium (Li) is an inherently occurring substance that is frequently used in clinical settings for mental therapy. A number of studies suggested that micro-dose lithium (e.g., lithium in drinking water) may offer anti-aging and anti-dementia benefits in addition to an anti-suicidal effect, while antimania, psychosis, or anti-cancer effects are yet unclear. A reliable adult dosage of 250–500 mg of lithium per day requires regular monitoring because there is a narrow safety margin and frequent adverse effects, such as thyroid problems and noticeable weight gain. The thyroid gland, kidneys, and parathyroid gland are the three organ systems that lithium use over an extended period of time may

adversely influence. [52]Lithium affects many different metabolic processes and organ functions at both therapeutic and dangerous dosages; however, its exact function and mode of action are still unknown.[39]

#### 7.4 Arsenic

Foods, water, and the environment all contain trivalent and pentavalent arsenic (As). Four species have been shown to exhibit arsenic shortage; extremely low dietary arsenic intakes may be sufficient to satisfy an important role for the element. The chemical form in which arsenic is present has a significant impact on its biological effects; inorganic compounds are more poisonous than most organic ones.[25] By means of methylation, the majority of living things transform the former into a wide range of less harmful organic arsenic compounds, which are subsequently eliminated. The main reason for concern with arsenic is that some of its compounds may be harmful to humans. It is uncommon to get acute poisoning, which is typified by nausea, vomiting, diarrhea, and intense stomach discomfort. Arsenic intoxication has been linked to prolonged consumption of water with 0.8 mg of arsenic/L and a food containing roughly 3 mg of arsenic per day for two to three weeks. If there is a human need for arsenic, most diets can easily provide for an adult's intake, which is likely close to 20 ug per day. [47]Arsenic exposure in humans can occur from food, drink, and the air. Professionals who work with arsenic, people who live on farms where pesticides containing arsenic are used, and residents of homes with any type of preserved wood may be more exposed to it. It is also present in some medications, glass and ceramic manufacturing, and some pharmaceuticals[53]In addition to being an ingredient in numerous cosmetic and skin care items like lotions, arsenic is utilized as a pigment in color cosmetics like lipsticks and eyeshadows. As a result, it manages to enter the body.[33]

#### 7.5 Tin

Tin (Sn) is a common component of many terrestrial and aquatic plants and animals and can be found in the air, water, soil, and landfills. Tin can be found in trace amounts in food since it is naturally present in soils. The tissues in our bodies also contain tin. Tin is not a necessary element for humans, according to the available data. Tin is mostly used in the food sector to line canned goods, which is how most people come into contact with it. For any kind of life, tin in single atom or molecule form is not extremely hazardous. Following oral (eating/drinking), inhalation (breathing in), and dermal exposure (skin contact), tin and inorganic tin compounds are poorly absorbed from the gastrointestinal tract and do not accumulate in tissues. They often have no negative consequences since they are quickly eliminated, mostly in the feces. Acute stomach irritation has been the primary side effect of excessive tin levels in canned beverages (above 150 mg/kg) and other canned meals (above 250 mg/kg) on people.[44]

#### 7.6 Mercury

There are three different types of mercury (Hg): elemental, inorganic, and organic mercury compounds. Mercury can build up in the kidneys, brain, and central nervous system in all three forms.[53] Less than 7% of inorganic mercury compounds are found in food. Moreover, after exposure to inorganic mercury compounds or vapor, the concentration of mercury is highest in the kidneys, while organic mercury has a stronger affinity for the brain, especially the posterior cortex. The measurements of mercury in bodily fluids and tissues, along with the tracking of their correlation with clinical manifestations, are the biochemical indices of mercury toxicity. In adulthood, the crucial outcome is paraesthesia. According to estimates, the most vulnerable individual's typical long-term daily intake linked to harmful health effects is 300ug/day for an adult or 4.3 ug /kg of body weight per day. [47] Mercury toxicity can manifest as altered skin pigmentation, headaches, fever, nausea and vomiting, dyspnea, and thrombocytopenia, depending on the type, length, and route of exposure. On the other hand, breathing in mercury fumes can have detrimental effects on the kidneys, lungs, brain system, digestive tract, chest pain, and even cause coma and death. Inhaling mercury vapor can cause acute exposure, which can lead to central nervous system toxicity and symptoms include paresthesia, hyperexcitability, tremors, mental problems, impaired language learning, memory loss, etc. [53] Mercury a hazardous metal is also found in skin foundations and lightening lotions. Mercury can be found in cosmetics in two forms: inorganic (HgCl<sub>2</sub>), which is used in skin-lightening creams and can be coupled with oxygen, sulfur, and chlorine, and organic (thimerosal), which is used as a preservative. Therefore, chronic use of makeup containing even trace levels of mercury can result in peripheral neuropathy, skin damage such as discolouration or allergic reactions, and kidney damage.[56]

#### 7.7 Antimony

Antimony (Sb) poisoning can happen during treatment or as a result of occupational exposure. Pneumoconiosis, antimony spots on the skin, respiratory irritation, and gastrointestinal problems can all result from occupational exposure. Furthermore, antimony trioxide may cause cancer in people. Antimony is primarily employed therapeutically

to treat schistosomiasis and leishmaniasis. Cardiotoxicity (~9% of patients) and pancreatitis, which is frequently observed in individuals with co-infections of HIV and visceral leishmaniasis, are the most hazardous side effects of antimonials as a result of therapy. When antimonials are used therapeutically, inspection of the quality of each batch of pharmaceuticals manufactured and routine toxicity monitoring are necessary. In aerobic freshwater and marine environments, antimony is mostly found in the pentavalent state; in anaerobic environments and as a consequence of human activity, it is more frequently found in the trivalent state. Workers in firms that produce antimony and antimony trioxide, metal mining, smelting and refining, coal-fired power plants, trash incineration, or indoor firing ranges are the main groups exposed to antimony at work. Respiratory issues, cardiovascular impacts, dermal affects, etc. are among the health consequences.[47]

### 7.8 Gold

The human body frequently contains very little amounts of gold (Au), although there is no proof that the metal has any nutritional advantages. Dermal contact, breathing in dust or tiny airborne particles, acupuncture needle implantation, ear piercing, intracutaneous insertion of gold rings or studs, gold-bearing prostheses, dental repair and reconstruction, or rheumatoid arthritis chrysotherapy are some of the ways that absorption can happen. Food cultivated in polluted soils and drinking water can contain gold traces. Gold is utilized in some upscale candies and beverages but has no flavor or scent. When gold is absorbed into the body, some of the residues are excreted in urine or feces, skin desquamation, hair, nail, and bile, but some of the residues are left in the body and are not usually linked to harmful alterations. One of the biggest toxicological risks associated with mining, gold extraction, and grinding is dust inhalation. Assessing the toxicity of gold after inhalation is a complicated process. Long-term dust inhalation has been linked to a lower life expectancy among miners and those working in gold-related businesses. It also increases the risk of cancers that affect the stomach, liver, and respiratory tract, as well as infectious diseases that are common in the different mining areas. [57]

### 7.9 Lead

Since lead (Pb) has no known vital function in living things, it is considered a non-essential trace element. It has been identified as one of the biggest hazards to human health because of its tremendous toxicity, even at very low exposure levels. Pb is a metal that is used extensively in daily life. Water, paint, electric storage batteries, pesticides, and gasoline are a few typical sources of lead contamination. It enters the human body through ingestion, inhalation, or skin contact, where it is rapidly absorbed into the bloodstream. Three main compartments contain lead distribution in the body: blood, soft tissue (kidney, bone marrow, liver, brain), and mineralized tissue (teeth, bones). Lead has no proven biological or physiological benefits in humans. On the other side, lead has negative impacts on human health. It can affect almost all of the body's systems and organs. It can cause serious damage to the kidneys, brain, nerve system, and reproductive system, which might raise blood pressure. These dysfunctions have led to the conclusion that the nervous system is the organ most vulnerable to lead poisoning. There is no safe amount of exposure to lead; poisoning starts at blood levels of about 40–60 g/dL.[54] High blood lead concentrations may be caused by the use of eye creams and color cosmetics containing lead. Lead is taken up by blood plasma and then finds its way into the blood cells. Ninety percent of the body's lead load is located in the skeleton, with erythrocytes containing 99 percent of the lead present in blood. The most commonly impacted target in Pb toxicity, in both adults and children, is the nervous system.[55]. Dizziness, irritability, lethargy, vomiting, loss of appetite, and a decreased level of awareness that may result in a coma or even death are some of the early signs of lead encephalopathy. Adults who are exposed to lead may also experience long-term negative effects such as anemia, renal impairment, immunotoxicity, hypertension, and toxicity to the reproductive system. However, children are more susceptible to toxicity than adults are, which can lead to behavioral issues, learning disabilities, decreased IQ, etc.[56]

## VIII. RECENT DEVELOPMENTS

Scientists have found that a small number of iron- and sulfur-containing proteins in human cells undergo a chemical reaction that is akin to iron rusting when exposed to too much oxygen. These "rusty" proteins then set off a series of actions that harm tissues and cells. Recent research has shown, for example, that premature infants and heart attack patients may suffer negative effects from breathing too much extra oxygen. Similarly, it has been demonstrated that a major factor contributing to the increased risk of chronic health issues in people with obstructive sleep apnea is the abrupt oxygen bursts that occur during breathing pauses. However, it was still unclear how these effects were produced. Although there was little evidence to support the hypothesis that reactive oxygen species, which are unstable and extremely reactive oxygen derivatives that can harm our DNA and several components within our cells, were likely



responsible for hyperoxia, few studies really showed how excess oxygen impacts certain enzymes and pathways. Because of their qualities and countless applications, carbon materials are finding their way into our daily lives more and more. Wearing smart clothes is not a novel idea. Still, there is discussion to be had concerning the idea of garments made of carbon nanotubes. Flexible carbon nanotube fibres that can be sewn into clothes to serve as wearable health monitors have been successfully created by researchers. The novel thread can be used as an inconspicuous part of clothes because it is robust and highly conductive, yet it is also washable. Known to be an important component of many cosmetic formulas, carbon black is widely used as a colourant in eye and skin care products like lipsticks, mascaras, and eyeliners. According to recent research, carbon nanoparticles enable some of the "active moieties," or ingredients in skincare products, get absorbed into the skin's layers. It is very generally known that CNTs and graphene have been demonstrated to efficiently transport medications to particular bodily tissues and cells; anticancer medications, for instance, can be delivered straight to tumours. Recently, scientists developed a unique sensor based on carbon nanotube sensor technology that can quickly identify SARS-CoV-2 without the need for chemicals or antibodies. This sensor's primary benefit is its ability to bypass numerous laborious processes, like purification and antibody synthesis. In the development of the human embryo, nitrogen is crucial. For the synthesis of new cells, nitrogen is necessary for tissue healing and cell replacement. Nitrogen is utilised in the synthesis of several additional non-protein substances, such as heme, which is a component of haemoglobin, the protein that carries oxygen in red blood cells. It's said that drinking hydrogen water would boost energy, lessen inflammation, and speed up recuperation after exercise. An analysis of multiple studies conducted in 2024 discovered that hydrogen water had potential for lowering fatigue. Since hydrogen is thought to possess antioxidant qualities, it could aid in lowering oxidative stress in the body and shield cells from harm. Additionally, hydrogen has anti-inflammatory properties. Sulphur, oxygen, and methyl groups make form methylsulfonylethane (MSM), which occurs naturally in a range of foods.[40] There is growing interest in the potential benefits of using MSM as a dietary supplement because contemporary farming methods and food processing can drastically reduce the amount present in food. Sulphur can be naturally obtained by MSM use. But because the sulfur-containing amino acids methionine and cysteine supply the majority of the dietary sulphur, sulphur can be overlooked as a key nutrient. It is believed that sulphur affects health through its involvement in antioxidant pathways that reduce inflammation. According to new studies, increasing potassium is essential for controlling blood pressure. Dietary recommendations to manage hypertension, or high blood pressure, have traditionally focused on lowering salt intake; however, a recent study indicates that increasing potassium intake may be just as significant. [49] Higher phosphorus intakes may be linked to a higher risk of cardiovascular disease, according to several studies. Your body will require more calcium as your phosphorus intake increases. For optimal bone density and the avoidance of osteoporosis, a careful balance between calcium and phosphorus is required. Magnesium is essential for maintaining the health and strength of your heart. According to a review, taking supplements of magnesium can help reduce hypertension, which may be associated with an increased risk of heart disease. Significant links between diabetes mellitus (DM) and trace elements resulting from disruptions of overlapping cellular metabolic systems have been discovered by studies conducted in various contexts. Extremely high or low concentrations of zinc, boron, chromium, and selenium may cause changes in cellular metabolism.

## IX. FUTURE CHALLENGES

In their quest for novel materials and procedures, metal toxicology faces new problems in order to meet the demands of emerging technology. More biomarker development is required. The surface features of various bodily components as well as the surface properties of the particles themselves influence the distribution and absorption of metallic nanoparticles within an organism's body. The scientists and researches are constantly making new discoveries to understand the uses and benefits of trace elements. There is conflicting evidence about the association between colon and rectal cancer risk and calcium intake from diet and supplements. According to certain research, men who consume a lot of calcium from dairy products are more likely to get prostate cancer. Therefore, appropriate research on the subject needs to be done. [55]

## X. DISCUSSION

Microorganisms may be found practically anywhere and are highly tolerant of harsh environments, allowing them to thrive in any environment. Biotechnologists use microorganisms in dairy products, traditional fortified meals, beverage preparation, and cutting-edge genetic engineering-based technologies. On the other hand, a large number of dangerous bacteria exist that can kill people, plants, and animals. It is commonly known that certain chronic non-communicable diseases, like respiratory disorders and diarrhoea, are brought on by pathogenic microorganisms. A variety of

physiological and metabolic roles are demonstrated by trace elements. Numerous infectious and non-communicable diseases can be avoided by fortifying diet with trace amounts of vital elements such iron, nickel, vanadium, copper, silicon, zinc, selenium, and chromium. The equilibrium of crucial trace elements required for the body's proper operation is essential to human health. Trace element supplementation needs to be carefully managed. When administered in greater amounts than what is necessary for them to carry out their biological tasks, they will have harmful effects. The national regulatory authorities' dietary reference intakes serve as guidelines for defining the intake, toxicity, and supplementation of trace elements in humans. The human body contains a wide variety of chemical components with a wide range of beneficial uses for our daily existence. For our entire body to work effectively, each of them must be present in a certain level and each exerts a benefit. The chemical components that make up the human body are essential to the organism's proper operation. These elements are essential for maintaining homeostasis, producing energy, synthesizing proteins, and regulating physiological processes. They are found in varying amounts in various bodily fluids and tissues. The building blocks of proteins and nucleic acids, respectively, are amino acids and nucleotides, which contain nitrogen, carbon, oxygen, and hydrogen as necessary elements. Cellular respiration, the mechanism by which cells obtain energy from nutrition, depends on oxygen. The elements that are involved in the production and transmission of nerve impulses are sodium, potassium, and chloride. and in preserving the body's fluid equilibrium. Certain enzymes involved in metabolism and cell growth, the majority of which are engaged in the metabolism of proteins, carbohydrates, lipids, and energy, depend on essential trace elements as a cofactor. In addition, they are required for appropriate cellular function, growth, development, muscle and nerve function, and the manufacture of certain hormones and connective tissue. Understanding the function of trace elements in biological processing could be crucial in determining the cause of some disorders, like cancer. The clear link between trace element content and a number of prevalent diseases can be explained by the trace elements' significant influence in a number of life-sustaining activities, including maintaining homeostasis and preventing damage from free radicals. In an effort to comprehend the nature of the links between cancer and trace elements, research has concentrated heavily on measuring the amounts of trace elements in cancer patients over the past ten years. As a result, the anticipated function of trace elements will make it possible to comprehend the genetic basis of cancer, offer a quick diagnostic tool, and develop efficient treatment options. Maintaining a good balance of these elements through a balanced diet and healthy lifestyle is crucial since deficiencies or excesses of specific elements can have detrimental impacts on health and well-being. [45]

## XI. CONCLUSION

Chemical elements play a vital role in the human body. They are required for the growth development, hormone synthesis and normal functioning of the human body and also they regulate enzyme synthesis and helps in maintaining strong bones and muscles. The effect of them on the human health depends upon age, life-style, dietary style and environmental factors. The normal functioning of the body depends upon the food intake that provides large amounts of nutrients. A good diet rich in minerals is needed for many functions of the body. The concentration of chemical elements in the body may differ in various parts of the body such as blood, organs and tissues. The absence and excess of these elements may cause severe imbalance in the body and also death in some cases. Bulk elements like Oxygen helps in respiration, Carbon in breaking carbon bonds present in carbohydrates and protein, Hydrogen eliminates and transports waste and toxins, Nitrogen is the integral compound of nucleic acids. Nutrients such as calcium helps in building bones and other macro elements like Magnesium, Potassium, Iodine and Sodium are essential for communication in between cells. Trace elements like Zinc will increase resistance of the body to illness, Copper is instrumental in forming RBC and Iodine regulates the normal functioning of the thyroid gland. Some studies have revealed that Gold is found in human body in a very minute amount but there is no evidence in this regard. Study should also be performed with regard to toxicity of some elements like lead and arsenic. Further discovery and studies are needed to fill the gap regarding the knowledge of chemical elements and the pros and cons of their absence and excess and the normal levels up to which they are needed.

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**Author contribution:**

Corresponding author is the sole contributing author of this manuscript.

**Data Availability Statement**

No datasets were generated or analysed during the current study

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