

TOXICOLOGICAL EFFECTS OF FLUORIDE ON HUMAN HEALTH

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Introduction: Fluoride is found naturally in soil, water, and food items. Fluoride has long been used as rodenticides and pesticides to kill mice and pests which is a very acute poisoning that is more toxic than lead and less toxic than arsenic. Fluoridation of water has been banned in many important countries such as France, Germany, Austria, Belgium, Denmark, and Greece. The presence of fluoride is found in water, foods, and crops. Fluoride in drinking water poses health problems when intake exceeds mg per liter, that is, the human body has the ability to tolerate fluoride content to a limit. The Bureau of Indian Standards and the World Health Organization set a maximum fluoride limit of 1.5 ppm (Li, 2003). The amount of fluoride in foods depends mainly on soil type, salts present in the soil, and available water. High fluoride-rich water increases the amount of fluoride in food and vegetables (Ortiz-PD et al., 2003).

Fluorosis occurs when a person continues to practice soluble fluoride-rich drinking water more than the standard limit (Mohanty and Rao, 2010 ; Gao et al., 2014; Mahmoud et al., 2020; Dehghani et al., 2020;). In addition to drinking water, fluoride enters the human body mainly through food, air, medicines, and cosmetics), Peckham et al. 2014). It has been observed that fluoride enters the human body through tea, fluoride-containing toothpaste, and highly soluble fluoride-containing drinking water. Fluoride also reaches our body through cold drinks). It becomes even more difficult to estimate his mental instincts. When the amount of fluoride in ordinary drinking water is high, fluoride in the human body accumulates itself by removing hydroxide from the bones and gives rise to bone fluorosis (Dehghani et al., 2021 Hedman et al., 2006 Balzar Ekenback et al., 2001 Marthaler and Petersen, 2005; Moss and Kumar 2021) and (Gao et al., 2014; Amini et al., 2016; Dehghani et al., 2019). It has been observed that fluorosis disease develops very quickly in uneducated, poor, and malnourished villagers (Dehghani et al., 2018 Buzalaf and Whitford, 2011; Anbazhagan et al., 2019; ; Yousefi, Ghalehaskar et al., 2019). In the grip of fluorosis, a man starts to grow untimely, his waist starts tilting and he becomes helpless by walking (Dehghani et al., 2016 Fawell et al., 2006;). Fluoride is a neurotoxin, affecting mental development all over the world, such as autism, attention deficit disorder, and other malformations and other similar industrial side products and the relationship between them is now clear. Its effects on health have caused serious concerns to mankind, including fatal diseases such as problems with bones, teeth, cancer, reproductive, gastrointestinal, endocrinological, and neurological development. This fluoride is also the cause of intestinal ulcers, impotence in men, and infertility in women due to repeated miscarriages. For all these reasons, the body's resistance to power decreases when drinking fluoride-containing water continuously (Sarkar and Pal, 2014 Basha et al., 2011). It is well known that most toothpaste contains fluoride. Mouthwash is also a type of fluoride-containing water that absorbs fluoride in the bloodstream within minutes.

Health effects of fluoride Fluoride is a type of double-edged sword, that is, the amount of fluoride in the body is as harmful as the large amount. Fluorine is a very important element for the human body because with the help of fluorine the normal saliva of bones and enamel of teeth are formed. The human body contains about 96% of the total fluoride and is mostly found in bones and teeth. But their quantity beyond the standard limit causes adverse effects on health and serious diseases are born. The microscopic amount of

fluoride in drinking water is essential for the safety of the enamel of the teeth, while if its soluble quantity exceeds the standard limit, the human suffers from severe illness. After fluorosis is found, it is found that there is no cure and as a result, dental fluorosis, deformity of bones, and serious illnesses related to muscles and muscles go home forever (Srivastav and Kaur, 2020; Hjortsjö et al., 2014; Qin et al., 2006). Some enzyme processes are either slowed or accelerated by low amounts of fluoride and chemical processes are performed with other organic and inorganic elements. The highest amount of calcium is found in bones and teeth in the body. Calcium is an electrically positive element and by its positive effect, the maximum amount of electrically negative fluoride is found (Chinoy NJ et al., 1992). Thus, fluoride accumulates in the form of “calcium fluoapatite crystals.” The deposition of this crystal is the root cause of the disease called fluorosis in the human body. In this way, some amount of fluoride gets collected in the body tissues. Some amount of fluoride is released from the body through sweat, urine, and defecation. Some of the effects are on Tooth loss, Reduction in tooth texture, Decreased normal mineralization of bones. Health problems in cold countries like Russia, United States, UK, etc., are related to the intake of small amounts of fluoride. In the above countries, fluorine is added to the water to prevent health problems. In some places, adding fluoride to water has reduced dental problems (Wang et al., 2009). The adverse effects like Excess intake of fluoride has adverse effects on human based on the amount of fluoride present in drinking water and excess alkaline drinking water and calcium deficiency. Pregnant women and lactating mothers are the most vulnerable to the effects of fluoride as fluoride in these women enters the baby’s body through ovulation and lactation. Due to excess of fluoride, hormonal irregularities also start in the body. The hormones required for the formation and functioning of healthy bones are calcitonin, parathyroid hormone, vitamin-D, and cortisone. Fluorosis is of three types: Dental fluorosis, Skeletal fluorosis, Non-skeletal fluorosis. The primary symptom of dental fluorosis is the gradual disappearance of the whiteness and brightness of the upper surface of the teeth (Enamel). Subsequently, the yellow spots on the teeth become darker and take the form of brown and black spots respectively. The intensity of fluorosis depends on the amount of fluoride ingested in the process of tooth formation (Palmero et al., 1995). Dental fluorosis can be divided into three stages: early stage, middle stage, and final stage. Fluorosis affects the outer and inner surfaces of the teeth equally. Permanent teeth (incisors) and molars are the teeth most affected by fluorosis (Pezzi et al., 2001).

Symptoms: (1) Initial condition—white teeth start becoming yellow and the teeth shine. (2) Moderate state—this yellow color starts to appear on the teeth as smooth or in the shape of the line and gradually the flat lines grow on the teeth, which become yellow, brown, and black, respectively. (3) Final stage—all teeth can be black. After this, there are pits or holes in the teeth and they break. Breaking of teeth at an early age occurs in areas where fluorosis spreads like an epidemic.

Dental effect: fluoride in drinking water is up to 1.0 mg/L, which prevents tooth decay and does not affect human health (Prystupa, 2011). But when the limit of 1.0 mg/L is exceeded, the human tooth is affected by fluorosis. In this disease, it is common to have spots and pits in the teeth. Children fall under its arrest immediately. Adults also fall under its control if its quantity in drinking water reaches 1.5 mg/L. Even a little more than this (up to 4.0 mg/L) in the human body, after going through long-term drinking water, the physical suppleness starts, which causes stiffness in the bones and joints (Viswanathan et al., 2020; Warren, 2021; Cettour et al., 2005). The main function of enamel is the protection of dentin and protecting it from decay and infection, but in the state of dental fluorosis, the protection cycle is broken and there is a serious impact on the structure of teeth. The natural brightness and beauty of teeth are destroyed when dental fluorosis occurs (Jin et al., 2000;). In the initial stage, the tooth becomes rough like chalk, which gradually turns yellow, brown, and black. It looks like a thick streak on the surface of teeth slightly away from the gums. When the disease becomes old, small holes are formed on the surface of the teeth, which cannot be filled.

Musculoskeletal effects: Severe fluoride results are seen on the musculoskeletal system. Fluoride overdose, mainly from skeletal fluorosis and bone fracture type, has adverse effects on the human body. Fluoride slowly reaches the human body and easily gets incorporated into the crystalline structure of bones.

Bone fractures: Bone fluorosis affects the basic bone structure or bones in the human body. This can happen to both young and adult. Due to its effect, various joints of the body cause pain. The various joints where its effect is greater are the neck, arms, and knees, due to which walking becomes difficult and there is unbearable pain. If the solubility of fluoride is reduced to 10–40 mg/L in drinking water, then the person suffers from bone fluorosis (Al-Hiyasat et al., 2000;

The flexibility of joints and bones is removed and there are stability and stiffness. The most surprising and worrying thing is that bone fluorosis is very difficult to detect in Choi et al., 2012 the early stages and is only recognized when it reaches its peak. In the end, the joints become completely stiff and the spine becomes straight like bamboo. In such a situation, neither man can bend nor bend. He cannot even bend the shoulder and fully grab the bed. He cannot do anything without external support. Sometimes it has also been observed that the waist of a person affected by fluorosis is twisted at right angles and cannot stand upright (Grandjean and Landrigan, 2006;). If a person continues to consume high fluoride water, the symptoms of bone fluorosis are visible on the Shivaprakash et al., 2011 body. This causes distortion in the structural/skeletal system of the person. It increases bones, inertia in joints, joint pain, and joints flexibility end. Fluoride poisoning causes acute pain, stiffness, and inertia in the cervical (neck) and lumbar (lumbar) joints, the joints of the knees, and the joints of the hip bone. This is due to abnormal growth in bones and excessive accumulation of fluoride on bones and abnormally increased or shrinking space between the links of bones (Bergc and Slayton, 2015;).

Quabriplegia: paralysis in both arms and legs. Folded flexion of the knee joint (asthenia), astro-fluorosis affects both children and the elderly alike.

Symptoms: Neck, spinal cord and joint pain, neck, spinal cord and joint stiffness, and acute hip pain and firmness. Osteoporotic fluorosis is an irreversible process.

Skeletal fluorosis: Its effect is also reflected on the soft tissues of the human body which is caused by frequent drinking of fluoride-rich drinking water. Common symptoms seen in nonbone fluorosis affected patients are intestinal problems, loss of appetite, leg pain, intermittent diarrhea with constipation, excessive muscle weakness, excessive thirst, frequent urination, can go a state of heart attack due to increased cholesterol has also been observed. For this reason, signs of miscarriage have also been seen.

Reproductive and developmental effects: High amounts of fluoride reproduction and developmentally adversely affects the human body, reducing the amount of protein in the liver, muscles, and small intestine. Acrosomal damage and deflation, sperm acrosomal acrosine, and hyaluronidase are deficient in the body. Structural and metabolic changes and reduced activity of enzymes in sperm result in a decrease in sperm count and a significant decrease in reproductive rate. Nervousness occurs in men due to spermatozoa being affected by fluorosis. Deficiency or absence of sperm in semen causes disease. Lack of testosterone in the blood of those in dominant areas is a common problem. Drinking water with more fluoride is consumed here (Chiba et al., 2012).

Neurotoxicity and neurobehavioral effects: An overdose of fluoride directly or indirectly affects the nervous system in the human body, known as neurotoxicity. Increased amounts can produce neurotoxic disease by interfering with metabolic processes. Severe consequences such as loss of quality of life, lack of academic achievement, behavioral disturbances result from brain disability. Nervousness, mental depression, tingling, and tremors in the hands and toes, excessive thirst, frequent urination, etc., sometimes while urinating, the amount of urine is less, urine is yellowish red, and there may be irritation (Bergman et al., 2013; Vandenberg et al., 2012).

Endocrine effects: Fluoride and affects the endocrine system leading to serious consequences such as decreased thyroid function, increased calcitonin activity, increased parathyroid hormone activity, secondary hyperparatoidism, impaired glucose tolerance (Li et al., 2020; Liu et al., 2021).

Some other effects: Excess fluoride has affected organ systems like liver, kidney, gastrointestinal system, and immune system. Fluorosis not only affects bones and skeletons but also affects muscles, red blood cells, digestive system, and ligaments. Fluoride also has its effect on the soft limbs and the nerves of the body. There are limitless human studies on drinking water containing an excess limit of fluoride in which gastrointestinal effects are documented. Fluoride also causes various changes in the muscles, resulting in the destruction of the filaments called actin, and myosin in the muscle. The creative association of mitochondria begins to fade. Due to which the patient feels tired and lack of energy in the muscles (Marinho et al., 2003; Philippe, 2019).

Gastrointestinal system: Fluoride in the stomach (stomach) combines with hydrochloric acid (HCl) to form hydrofluoric acid which is a highly corrosive destructive acid. As a result, the mucous membranes of the stomach and intestines are destroyed and the cells dry up and burst (Mahmoud et al., 2020). The following symptoms usually occur in affected patients: When fluoride is ingested in the body, it also gets collected in the membranes of red blood cells. As a result, calcium content from the membranes of red blood cells starts to shrink and the membrane shrinks and takes an irregular shape.

Conclusion: Fluorosis is a serious disease that arises from the accumulation of fluorides in the hard and soft tissues of the body due to long-term excessive intake of fluoride through drinking water/food products/industrial pollution. This results in dental fluorosis, skeletal fluorosis, and no skeletal fluorosis. Easy identification of fluoride in water can help prevent public health hazards. Other effects include loss of reproductive capacity, miscarriage, birth of a dead baby, loss of sperm, and so on. Fluoride can cause kidney failure, kidney stone, retarded intelligence, diabetes, high blood pressure.

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