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Effect of Fluoride on Human Beings

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ABSTRACT: Fluoride is found naturally in soil, water, and foods. It is also produced synthetically for use in drinking water, toothpaste, mouthwashes and various chemical products.
Water authorities add fluoride to the municipal water supply, because studies have shown that adding it in areas where fluoride levels in the water are low can reduce the prevalence of tooth decay in the local population.
Tooth decay is one of the most common health problems affecting children. Many people worldwide cannot afford the cost of regular dental checks, so adding fluoride can offer savings and benefits to those who need them.
However, concerns have arisen regarding fluoride's effect on health, including problems with bones, teeth, and neurological development.

KEYWORDS: fluoride, effect, human beings, water, health, bones, teeth

I. INTRODUCTION

Fluoride comes from fluroine, which is a common, natural, and abundant element.
Adding fluoride to the water supply reduces the incidence of tooth decay.
Fluoride protects teeth from decay by demineralization and remineralization.
Too much fluoride can lead to dental fluorosis or skeletal fluorosis, which can damage bones and joints.
Exposure to high concentrations of fluoride during childhood, when teeth are developing, can result in mild dental fluorosis. There will be tiny white streaks or specks in the enamel of the tooth.
This does not affect the health of the teeth, but the discoloration may be noticeable.
Breastfeeding infants or making up formula milk with fluoride-free water can help protect small children from fluorosis.[1,2,3]

Children below the age of 6 years should not use a mouthwash that contains fluoride. Children should be supervised when brushing their teeth to ensure they do not swallow toothpaste.

Excess exposure to fluoride can lead to a bone diseaseTrusted Source known as skeletal fluorosis. Over many years, this can result in pain and damage to bones and joints.

The bones may become hardened and less elastic, increasing the risk of fractures. If the bones thicken and bone tissue accumulates, this can contribute to impaired joint mobility.

In some cases, excess fluoride can damage the parathyroid gland. This can result in hyperparathyroidism, which involves uncontrolled secretion of parathyroid hormones.

This can result in a depletion of calcium in bone structures and higher-than-normal concentrations of calcium in the blood.

Lower calcium concentrations in bones make them more susceptible to fractures.
In 2017, a report was published suggesting that exposure to fluoride before birth could lead toTrusted Source poorer cognitive outcomes in the future.

The researchers measured fluoride levels in 299 women during pregnancy and in their children between the ages of 6 and 12 years. They tested cognitive ability at the ages of 4 years and between 6 and 12 years. Higher levels of fluoride were associated with lower scores on IQ tests.

In 2014, fluoride was documented as a neurotoxin that could be hazardousTrusted Source to child development, along with 10 other industrial chemicals, including lead, arsenic, toluene, and methylmercury.

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According to the International Association of Oral Medicine and Toxicology (IAOMT), an organization that campaigns against the use of added fluoride, it may also contribute to the following health problems:

- acne and other skin problems
- cardiovascular problems, including arteriosclerosis and arterial calcification, high blood pressure, myocardial damage, cardiac insufficiency, and heart failure
- reproductive issues, such as lower fertility and early puberty in girls
- thyroid dysfunction
- conditions affecting the joints and bones, such as osteoarthritis, bone cancer, and temporomandibular joint disorder (TMJ)
- neurological problems, possibly leading to ADHD
- One review describes fluorideTrusted Source as an "extreme electron scavenger" with an "insatiable appetite for calcium." The researchers call for the balance of risks and benefits to be reconsidered.
- Acute, high-level exposure to fluoride can lead to:
- abdominal pain
- excessive saliva
- nausea and vomiting
- seizures and muscle spasms

This will not result from drinking tap water. It is only likely to happenTrusted Source in cases of accidental contamination of drinking water, due, for example to an industrial fire or explosion.

It is worth remembering that many substances are harmful in large quantities but helpful in small amounts.
Flouride exists in many water supplies, and it is added to drinking water in many countries.
It is also used in the following dental products:

- toothpaste[4,5,6]
- cements and fillings
- gels and mouthwashes
- varnishes
- some brands of floss
- fluoride supplements, recommended in areas where water is not fluoridated

Non-dental sources of flouride include:

- drugs containing perfluorinated compounds
- food and beverages made with water that contains fluoride
- pesticides
- waterproof and stain-resistant items with PFCs

Excess fluoride exposure may come from:

- public water fluoridation
- high concentrations of fluoride in natural fresh water
- fluoridated mouthrinse or toothpaste
- untested bottled water
- inappropriate use of fluoride supplements
- some foods

Not all fluoride exposure is due to adding the chemical to water and dental products.
Some geographical areas have drinking water that is naturally high in fluorideTrusted Source, for example, southern Asia, the eastern Mediterranean, and Africa.

Side effects
Possible side effects of excessive fluoride intake include:

- discoloration of teeth
- bone problems

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Benefits
The American Dental Association (ADA) says fluoride in water benefits communities because it:
- reduces tooth decay by 20 to 40 percent
- protects against cavities
- is safe and effective
- saves money on dental treatment
- is natural

Fluoride is present in natural water. Adding fluoride, says the ADA, is like fortifying milk with vitamin D, orange juice with calcium, or cereals with B vitamins and folic acid.

Studies continue to show that adding fluoride to water supports dental health.
A Cochrane review published in 2015 found that when fluoride was introduced to water:
- Children had 35 percent fewer decayed, missing, or filled baby teeth.
- There was a 15-percent increase in children with no decay in their baby teeth.
- The proportion of children with no decay in their permanent teeth rose by 14 percent.

Applying fluoride on children's teeth can prevent or slowTrusted Source decay.[7,8,9]
How does it work?
Fluoride prevents tooth decay by:
- changing the structure of the developing enamel in children under the age of 7 years, so that it is more resistant to acid attack
- providing an environment where better quality enamel is formed, which is more resistant to acid attack
- reducing the ability of bacteria in plaque to produce acid

This involves the following processes:
Protection from demineralization: When bacteria in the mouth combine with sugars, they produce acid. This acid can erode tooth enamel and damage our teeth. Fluoride can protect teeth from demineralization that is caused by the acid.
Remineralization: If acid has already caused some damage to the teeth, fluoride accumulates in the demineralized areas and begins strengthening the enamel. This is remineralization.
Who benefits the most?

Everyone can benefit from added dental protection, but those who can benefit particularly are people who:
- enjoy snacking
- have poor dental hygiene
- have little or no access to a dentist
- follow diets that are high in sugars or carbohydrates
- have had bridges, crowns, braces, and other restorative procedures
- have a history of tooth decay or cavities

Most public health authorities and medical associations worldwide recommend that children and adults receive some fluoride, to protect their teeth from decay.

II. DISCUSSION

Here are some facts supporting the use of fluoride:
- From 2000 to 2004, 125 communities in 36 states of the U.S. voted to adopt fluoridation.
- In the right amounts, fluoride helps prevent dental decay.
- It is similar to adding vitamins to foods.
- Using fluoride in water to protect teeth reduces the need for costly dental procedures.[10,11,12]
- Over 100 national and international health and other organizations recognize the benefits of added fluoride.

Here are some arguments against its use, from the IAOMT:
- Fluoride is a neurotoxin which, in high doses, can be harmful.
- Excessive exposure can lead to tooth discoloration and bone problems.
- There is enough fluoride in the water already, without adding more.

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- People have the right to choose whether or not they take medications.
- Different people need different amounts of substances such as fluoride.
- Current levels of fluoride in the water may not be safe.
- It may be harmful for the environment.

Controversy
The controversy continues over whether it is a good idea to add fluoride to water or not.
In 2000, German researchers reported that tooth decay fellTrusted Source in cities where fluoride ceased to be added to the water.

However, they called for further investigation into the reasons for this decline, which they said could be due to improved attitudes toward dental health and easier access to dental health products, compared with the years before fluoride was added.

They suggested that their findings might support the argument that caries can continue to fall if the concentration of fluoride is reduced from 1 part per million (ppm) to below 0.2 ppm.

How much fluoride is recommended?
The Department of Health and Human Services (DHHS) sets the optimal level of fluoride for preventing tooth decay at 0.7 ppm, or 0.7 milligrams (mg) in every liter of water.

The previous figure, in force from 1962 to 2015, was 0.7 to 1.2 ppm. In 2015, it was revised to the lower limit.
The aim of this optimal level is to promote public health.

What does the WHO say?
The World Health Organization (WHO) notes that long-term exposure to drinking water that contains more than 1.5 ppm fluoride can lead to health problems. The WHO's guideline limit is 1.5 ppmTrusted Source.

How much does the EPA allow?
The Environmental Protection Agency (EPA) aims to protect people from over-exposure to toxic chemicals.
It sets the maximum allowable level at 4 ppm, and a secondary maximum level at 2 ppm. People are asked to inform the EPA if levels are above 2 ppm. Levels above 4 ppm could be hazardous.

In areas where water naturally contains higher levels of fluoride, community water systems must ensure that the maximum level is no higher than 4 ppm.

Fluoride is known to be used for stimulating the formation of bone cells, for preventing tooth decay. Fluoride shows its presence naturally and artificially but drinking water, food, dental products, and pesticides are major sources of fluoride that affect the human body in many ways, such as metabolic and nutritional disorders. Dental effect, musculoskeletal effects such as skeletal fluorosis, bone fractures, reproductive and developmental effects, neurotoxicity, and neurobehavioral effects, endocrine effects, genotoxicity and carcinogenicity, and some other effects like gastrointestinal system, kidneys, liver, and immune system are the effects on human health due to fluoride.

Fluorine (fluorum) is a cyclic element that is very widespread in nature. It is the 13th most abundant element in the Earth's crust and is a component of many minerals, such as fluorite, cryolite, fluorapatite, and topaz. It exhibits strong poisonous properties, and due to its high electronegativity and activity, it reacts with almost all elements, noble gases, and organic and inorganic compounds. For this reason, in a natural state it does not exist in an elemental form but in the form of compounds. In the air, the main form in which it can be found is hydrogen fluoride (HF) [1,2,3]. Fluorides enter the atmosphere during volcanic eruptions and from anthropogenic sources related to the development of industry and civilization, i.e., coal-fired power plants, steel and aluminum works, glass factories, brickyards and enamel factories, and plant-producing phosphorus fertilizers. Rotationally from the atmosphere, they return to the ground along with dust, snow, rain, or fog, and they can seep into ground and surface waters, as well as accumulate in soil and plants [1,4,5]. Plant protection agents and phosphorus fertilizers additionally enrich the soil with fluorides. Its level in nature determines the nature of the parent rock, chemical composition and pH, and ranges from several dozen to several hundred parts per million (ppm) [1,6]. The exceptions[13,14,15] are the areas of endemic fluorosis, where this value can be exceeded many times over 8000 ppm [1,2]. Recently, there has been a disturbingly high increase in fluoride

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levels in the superficial soil layers. The reason is probably the widespread use of phosphorus fertilizers and the contamination associated with the emission of these compounds into the atmosphere [1].

Fluoride is also classified as a micronutrient, and in mammals it is present in the amount of 500 mg/kg DM (dry weight) [2]. It is related to the structure of the supporting tissue, and the hard tissues of the teeth, skin and hair. Taken up by bone tissue, it can be released therefrom, especially from the superficial layers based on iso and heteroionic exchange. As an element with high biological activity, it influences a number of processes taking place in living organisms. Fluorine ions are inhibitors or, less frequently, activators of many enzymes, and they influence the process of protein biosynthesis and carbohydrate and lipid transformations, thus modifying some biological functions of living organisms [1,3,5,7]. Fluoride has a strong antibacterial effect due to its inhibition of many enzymes, the most important of which are: enolase, F-ATPase, sulfatase, catalase, phosphatase, phosphoglucomutase, and others. In the case of bacterial enolase, fluorine is likely to combine with the magnesium found in the enzyme, thereby reducing glucose transport into the bacterial cell [8]. Another property is the exchange of the hydroxyl ion with the fluorine ion, thanks to which fluorapatite is formed, which is more resistant to the acidic environment than hydroxyapatite and also facilitates the remineralization of tooth tissues, especially enamel and dentine. Combined, these properties determine the meaning of their supply in order to prevent caries [9].

Fluoride is an element that is taken up by the human body either with food or the air we breathe. In exceptional cases, it can penetrate the body through the skin layers. Absorption by airways occurs mainly in the presence of high concentrations of fluoride in the form of HF occurring in occupational exposure cases. In turn, the absorption of fluoride compounds in the gastrointestinal tract begins in the oral cavity (about 1%), in the stomach (40–50%), and then in the small intestine (20–30%). It was found that after an hour, it reaches the maximum concentration in the blood, and then it is mainly absorbed in the body by calcified tissues (99%), in addition to a small (about 1%) amount of soft tissues, i.e., kidneys, lungs, and brain. After 24 h from the consumption of fluoride, about 50% is excreted from the body, mainly in the urine but also in feces, sweat, saliva, and milk [1,2,3,5,7].

Fluorine compounds supplied to the body have beneficial biological effects, as long as they are not supplied in excess. Their supply in an unintended or uncontrolled manner, taking into account both the metabolism of fluoride, the chain of its transformations in the environment, as well as its increasing importance in industry and economy, may cause its accumulation in the body and the occurrence of side effects [12,13].

Most acute poisoning with fluoride compounds is caused by accidental ingestion. The most common fluoride compounds are sodium fluoride, sodium fluoroacetone, ammonium hydrofluoride, sulfuryl fluoride, hydrofluoric acid, and fluorosilicates. One example of mass poisoning was the 1943 report by Lidbeck, which documented the consumption of cockroach poison, which was added to scrambled eggs instead of powdered milk at Oregon State Hospital. Out of the 263 poisoned people, as many as 47 died. In the 1990s, as many as 296 people were poisoned in Alaska with fluoridated drinking water with a fluoride content of 150 ppm. The literature also describes several cases of deaths in children as a result of the consumption of fluoride-containing agents used as part of caries prophylaxis [3,4,5,14]. The toxic dose causing the early symptoms of poisoning is 1 mgF/kg body weight, the probably toxic dose is 5 mgF/kg body weight, and the safely tolerated dose is estimated at 8 mgF/kg. Regarding fluoride in dental products, Whitford's safety considerations estimate the lethal dose as 14–28 mgF/kg body weight, while a certain lethal dose is defined at 32–64 mgF/kg body weight in adults and 15 mg F/kg body weight in children [15,16,17,18].

Some authors argue that as little as 5 mgF/kg of body weight can cause a serious threat to life requiring immediate treatment [3,4,5,7]. At the same time, it was found that human susceptibility to fluoride poisoning increases in dry and hot climates, due to higher water intake and thus a higher supply of fluoride [1,2,19,20]. The pathomechanism of the toxic effect of fluorides is based on the formation of insoluble calcium fluoride in the body, which causes a significant decrease in blood calcium levels, i.e., hypocalcemia, and a simultaneous increase in potassium levels [3,4,5,16]. The symptoms of acute poisoning depend on several factors, such as the dose, the pH of the substance, the method of administration, the patient's age, acid–base balance, and the degree of absorption. They usually appear shortly after the poison is ingested. There are four groups of disorders in this type of poisoning: 1. inhibition of enzymatic processes; 2. production of calcium complexes; 3. Shock; and 4. organ damage. Patients initially experience nausea and vomiting (they may even be bloody), followed by severe, diffuse abdominal pain and diarrhea. Additionally, there may be some non-specific symptoms, such as salivation, lacrimation, nasal discharge, weakness, cyanosis, damp and cold skin, shortness of breath, and headaches. The developing hypocalcemia leads to severe limb cramps and even tetany convulsions, arrhythmias, ventricular fibrillation, and disturbances in hemostasis leading to mucosal bleeding. An

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increase in plasma potassium levels, in turn, impairs functioning at the cellular level. As the poisoning progresses, the symptoms worsen. There is a drop in blood pressure, and arrhythmia, as well as respiratory and metabolic acidosis, appear, resulting in respiratory and cardiac arrest. If fluoride compounds come into contact with the skin or mucosa, chemical burns appear, such as deep, slowly healing, bleeding and sometimes abscessing lesions, ulcerations, or necrotic foci [1,3,4,5,7,15,16,17]. Gaseous fluoride (over 0.05 mgF/m^3) after getting into the respiratory tract may cause coughing, dyspnea, chills, pathological respiratory murmurs, and even pulmonary edema [16,17,18]

Chronic fluoride poisoning occurs as a result of the long-term and continuous exposure of the body to fluoride compounds. The reason may be high concentrations of fluoride in drinking water, an excessive consumption of them from sources other than water, the not fully developed swallowing reflex in preschool children, use of supplementation, environmental contamination, and occupational exposure, as well as calcium deficiency, malnutrition, and disorders of the acid–base balance. Today, however, environmental pollution is an increasingly common cause of fluoride poisoning as industry develops and industrialization increases. The effects of such poisoning depend on the age at the time of exposure, duration of exposure, dose, kidney condition, and diet

Dental fluorosis is the best-known type of systemic disorder caused by excessive fluoride intake. It is defined as a pathological condition resulting from excessive exposure to fluoride compounds during the development of enamel. Disease can result from exposure to either a large single dose or to smaller multiple doses, or it can be the result of continuous exposure to low levels of these compounds that disturb natural detoxification mechanisms [1,4,14,15,16,17]. Figure 2 shows various changes in teeth caused by too much fluoride intake.

III. RESULTS

For years health experts have been unable to agree on whether fluoride in the drinking water may be toxic to the developing human brain. Extremely high levels of fluoride are known to cause neurotoxicity in adults, and negative impacts on memory and learning have been reported in rodent studies, but little is known about the substance’s impact on children’s neurodevelopment. In a meta-analysis, researchers from Harvard School of Public Health (HSPH) and China Medical University in Shenyang for the first time combined 27 studies and found strong indications that fluoride may adversely affect cognitive development in children. Based on the findings, the authors say that this risk should not be ignored, and that more research on fluoride’s impact on the developing brain is warranted.
The study was published online in Environmental Health Perspectives on July 20, 2012.
The researchers conducted a systematic review of studies, almost all of which are from China where risks from fluoride are well-established. Fluoride is a naturally occurring substance in groundwater, and exposures to the chemical are increased in some parts of China. Virtually no human studies in this field have been conducted in the U.S., said lead author Anna Choi, research scientist in the Department of Environmental Health at HSPH.

Even though many of the studies on children in China differed in many ways or were incomplete, the authors consider the data compilation and joint analysis an important first step in evaluating the potential risk. “For the first time we have been able to do a comprehensive meta-analysis that has the potential for helping us plan better studies. We want to make sure that cognitive development is considered as a possible target for fluoride toxicity,” Choi said.

Choi and senior author Philippe Grandjean, adjunct professor of environmental health at HSPH, and their colleagues collated the epidemiological studies of children exposed to fluoride from drinking water. The China National Knowledge Infrastructure database also was included to locate studies published in Chinese journals. They then analyzed possible associations with IQ measures in more than 8,000 children of school age; all but one study suggested that high fluoride content in water may negatively affect cognitive development.

The average loss in IQ was reported as a standardized weighted mean difference of 0.45, which would be approximately equivalent to seven IQ points for commonly used IQ scores with a standard deviation of 15.* Some studies suggested that even slightly increased fluoride exposure could be toxic to the brain. Thus, children in high-fluoride areas had significantly lower IQ scores than those who lived in low-fluoride areas. The children studied were up to 14 years of age, but the investigators speculate that any toxic effect on brain development may have happened earlier, and that the brain may not be fully capable of compensating for the toxicity.

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“Fluoride seems to fit in with lead, mercury, and other poisons that cause chemical brain drain,” Grandjean says. “The effect of each toxicant may seem small, but the combined damage on a population scale can be serious, especially because the brain power of the next generation is crucial to all of us.”

December 19, 2014 — As a follow-up, Philippe Grandjean, adjunct professor of environmental health at Harvard School of Public Health (HSPH), Anna Choi, research scientist in the Department of Environmental Health, and colleagues have published a pilot study of cognitive functions in Chinese children exposed to different levels of fluoride from drinking water.

The new paper, entitled “Association of lifetime exposure to fluoride and cognitive functions in Chinese children: A pilot study,” has been published online and in the January-February 2015 issue of Neurotoxicology and Teratology.
Epidemiological investigations on the effects of fluoride on human health have examined occupationally exposed workers employed primarily in the aluminium smelting industry and populations consuming fluoridated drinking-water. In a number of analytical epidemiological studies of workers occupationally exposed to fluoride, an increased incidence of lung and bladder cancer and increased mortality due to cancer of these and other sites have been observed. In general, however, there has been no consistent pattern; in some of these epidemiological studies, the increased morbidity or mortality due to cancer can be attributed to the workers’ exposure[19,20] to substances other than fluoride.

The relationship between the consumption of fluoridated drinking-water and morbidity or mortality due to cancer has been examined in a large number of epidemiological studies, performed in many countries. There is no consistent evidence of an association between the consumption of controlled fluoridated drinking-water and increased morbidity or mortality due to cancer.

IV. CONCLUSION

The potential health risks generated from exposure to these sources of fluoride are often overlooked. Additionally, age, gender, genetic factors, nutritional status, weight, and other factors are known to influence each person’s unique reaction to fluoride.

For example, children’s exposure to fluoride is extremely important to consider, and this issue was made evident in recent news about a study linking fluoride exposure in utero with lower IQs. As another example, fluoride was recently identified as one of 12 industrial chemicals known to cause developmental neurotoxicity in humans.

Exposure to excess fluoride can result in dental fluorosis, a condition in which the teeth enamel becomes irreversibly damaged. Additionally, the teeth become permanently discolored, displaying a white or brown mottling pattern and forming brittle teeth that break and stain easily.

Dental fluorosis is recognized as the first visible sign of fluoride toxicity. It is likewise a warning signal of the human health risks associated with fluoride exposure. According to 2010 data from the Centers for Disease Control and Prevention (CDC), 23% of Americans aged 6-49 and 41% of children aged 12-15 exhibit fluorosis to some degree. An assessment of the CDC’s data further demonstrates that 58% of children aged 6-19 have fluorosis.

Increased sources of fluoride exposure are accompanied by increased human health risks. Therefore, it has become a necessity to reduce and work toward eliminating avoidable sources of fluoride exposure, including water fluoridation, fluoride-containing dental materials, and other fluoridated products.[20]

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