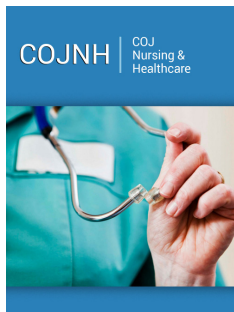


Consumption of Milk from Fluorosed Animals Poses a Threat to Children's Health in India: A Brief Review

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Abstract

In India, especially in rural areas, most children, adults, and the elderly are exposed to fluoride from drinking water and industrial fluoride pollution. In these areas, most drinking water sources, such as hand-pumps, bore-wells, and deep-wells, are contaminated with fluoride to varying degrees. Most of these sources contain fluoride above the national and international recommended levels of 1.0ppm and 1.5ppm, respectively. Therefore, thousands of people of various ages in rural areas of the country suffer from chronic fluoride intoxication in the form of fluorosis due to drinking this fluoridated water. In many rural areas of the country, people are also suffering from fluorosis due to exposure to industrial fluoride pollution. In rural areas, thousands of domesticated animals, especially cows (*Bos taurus*), buffaloes (*Bubalus bubalis*), goats (*Capra hircus*), and sheep (*Ovis aries*) are also affected by fluorosis, which is caused by long-term exposure to fluoride through drinking fluoridated water and industrial fluoride pollution. The milk of such fluorosed animals also contains varying amounts of fluoride, depending on the fluoride content of the drinking water. In a recent study, the fluoride content of fluoridated cow, camel, goat, and buffalo milk was reported to be 4.128 ± 2.804 , 5.379 ± 1.732 , 5.216 ± 1.271 , and 6.034 ± 1.837 , respectively. If children consume such fluoridated milk of fluorosed animals for a long time, it can pose a serious risk to their health. Long-term fluoride exposure in children from drinking fluoridated milk can not only lead to osteo-dental fluorosis but also impact mental health. In the present communication, focuses on the consumption of milk from fluorosed animals and its potential adverse health or toxic effects on children. This review is useful for researchers in India to do an advance research work on this fluoride-related health problem in children. This communication will also draw the attention of the concerned health department so that a health policy can be made to prevent children's health from being harmed by drinking animal milk containing fluoride.

Keywords: Adverse health effects; Children; Chronic fluoride exposure; Dental fluorosis; Fluoride poisoning; Fluorosed animals; Mental health; Milk; Skeletal fluorosis; India

Introduction

Fluoride is a mineral found naturally or through human intervention in varying amounts in water, soil, rocks, air, and food. From a health perspective, it is safe and effective when consumed at or below the recommended levels (1.0ppm or 1.5ppm) as per guidelines from the Indian Council of Medical Research (ICMR), the Bureau of Indian Standards (BIS), and the World Health Organization (WHO) [1-3]. In general, it is beneficial in growing children and adults by preventing tooth decay, strengthening tooth enamel, helping to rebuild weakened enamel, and fighting harmful bacteria. It also plays an important role in the mineralization of growing bones, strengthening them [3]. When children consume or are exposed to high levels

of fluoride over a long period of time, it becomes toxic and acts as a slow poison [3], causing various pathological changes in the teeth, bones, and brain of growing children [4-6]. These pathological changes caused by fluoride are commonly referred to as fluorosis [3].

In India, especially in rural areas or villages, most children, adults and elderly people are usually exposed to fluoride from drinking groundwater. Studies have shown that in rural areas of the country, most of the drinking water sources, such as hand-pumps, bore-wells, and deep dug-wells, are contaminated with fluoride to varying degrees. Water from most of these sources contained fluoride above the prescribed or recommended levels of 1.0ppm or 1.5ppm [7,8]. Therefore, thousands of people of different age

groups in rural areas of the country are suffering from chronic fluoride poisoning in the form of fluorosis disease (Figure 1) due to drinking fluoridated water [9-16]. Not only humans but various species of domesticated animals, such as cattle (*Bos taurus*), water buffaloes (*Bubalus bubalis*), sheep (*Ovis aries*), goats (*Capra hircus*), horses (*Equus caballus*), donkeys (*Equus asinus*), and dromedary camels (*Camelus dromedarius*) are also found to be suffering with fluorosis in the rural areas of the country due to drinking of water from these domestic drinking water sources [17-25]. In villages, bore-well water is also used for agricultural irrigation. This often leads to fluoride contamination of crops or feed [26]. Fluoride-containing agricultural products and feed are often fed to domesticated animals, which can also lead to chronic fluoride poisoning or fluorosis in animals.



Figure 1: Rural children afflicted with severe dental (a) and skeletal (b) fluorosis due to chronic fluoride exposure.

In India, not only people but also domestic animals are exposed to industrial fluoride pollution, which is caused by numerous coal-burning brick kilns and thermal power stations, as well as factories manufacturing steel, iron, aluminum, zinc, phosphorus, chemical fertilizers, bricks, glass, plastics, cement, and hydrofluoric acid. Fluoride from these industries is emitted into the surrounding areas or atmosphere in both gaseous and particulate/dust forms, creating industrial fluoride pollution [3]. This industrial fluoride contaminates not only the surrounding soil, air, and water, but also vegetation, agricultural crops [27], and many other biological communities on which domesticated bovine animals typically depend for food and water. When animals consume fluoride-contaminated food (fodder) and water and exposed to fluoride pollution for a long time, they develop fluorosis [28-36]. The milk of these fluorosed animals is also likely to contain fluoride. Although research on this issue has not been done extensively in India, research is needed from a health perspective. In the present communication, focuses on the consumption of fluoridated animal milk and its potential adverse health effects on children. This review is useful for researchers in India to do an advance research work on this fluoride-related health problem in children. This communication will also draw the attention of the concerned health department so that a health policy can be made to prevent

children's health from being harmed by drinking animal milk containing fluoride.

Fluoride in milk of domesticated animals

The milk from fluorosed animals contains varying amounts of fluoride. However, fluoride content in milk of animals is much more depending on the fluoride levels in their drinking water and feed. Typically, cow and buffalo milk from non-fluorosed areas contains approximately 0.09mg/L (ppm) of fluoride. However, this level can reach 0.4 to 0.8mg/L in areas with high fluoride levels in drinking water (approximately 10-30mg/L) [37]. A recent research study jointly conducted by the Indian Council of Agricultural Research (ICAR) and the National Institute of Nutrition (NIA, ICMR) in rural areas with high fluoride levels in drinking waters (>2.0ppm) in the states of Rajasthan, Punjab, and Haryana revealed truly shocking results, which are also very important from a health perspective. The milk of domestic animals (cows and female buffaloes) in these areas contained high fluoride levels of 0.8-1.2ppm. Vegetables from these areas also have higher fluoride levels of 2.0-3.0mg/k [38]. In the recent study, the fluoride content in cow, camel, goat, and buffalo milk has been observed and reported to be 4.128±2.804, 5.379±1.732, 5.216±1.271, and 6.034±1.837, respectively [39]. In fact, from a health perspective, these data are truly disturbing.

Consumption of fluoridated animal milk and its adverse health effects on children

In Indian villages, children are mostly exposed to fluoride through drinking water. Therefore, most of these children are found to suffer from osteo-dental fluorosis [6]. However, skeletal fluorosis is more dangerous and children affected by this disease (bone deformities) suffer from lameness throughout their lives. Several studies have shown that children are comparatively more sensitive

and highly susceptible to fluoride toxicity [13,14]. This is why they develop dental and skeletal fluorosis more quickly. However, most parents do not know that their growing infants and children (Figure 2) are also exposed to fluoride by drinking milk from fluorosed animals in rural areas. Consuming animal milk with high fluoride content over a long period of time is not safe and can be detrimental to the health of developing infants and children. Depending on the fluoride content of the animal's milk, it can cause mild to severe fluoride toxicity or osteo-dental fluorosis.



Figure 2: Fluoridated animal milk can be a good source of fluoride exposure for growing infants and children.

The worst part of fluoride poisoning from drinking fluoridated milk is that it can damage brain neurons, which can ultimately affect the mental development and health of children [5]. This cannot be denied. Therefore, there is a need for extensive research on this topic in India to protect the mental health of growing children from fluoride poisoning. Once fluoride enters the body from any source, it is carried to various tissues and parts of the body through the blood circulation. More than 50% of absorbed fluoride is usually excreted through urine, faeces, and sweat. Interestingly, fluoride can cross the placental barrier and reach the growing foetus. It also has the remarkable ability to cross the Blood-Brain Barrier (BBB) and ultimately reach the brain [40]. Furthermore, fluoride can be excreted through cerebrospinal fluid drainage to maintain a relative balance of fluoride concentrations in the brain. However, long-term exposure to high concentrations of fluoride can lead to fluoride accumulation in the brain, resulting in various morphological, structural, and functional changes or pathological damage to brain tissue in both humans and animals [41]. Whatever the case, fluoride-induced neurological changes in brain tissues such as the cerebral cortex, hippocampus, and cerebellum ultimately significantly affect physiological brain functions such as learning, memory, Intelligence

Quotient (IQ), emotion, behaviour, etc. In India, neurological manifestations such as memory loss, headache, dizziness, tremors, paralysis, and ataxia were also reported in children living in high fluoride endemic areas [42]. All these children suffered from fluoride poisoning or fluorosis. Since then, a growing number of experimental studies have focused on the effects of fluoride on cognitive abilities [43-47]. These studies show that long-term exposure to high levels of fluoride can significantly impair learning and memory in animals. In India, several epidemiological studies conducted on schoolchildren living in various fluorosis-prone areas also support the finding that long-term fluoride exposure significantly impacts mental health, including reduced IQ and learning and memory abilities [48-53]. Whether the severity of these neurological disorders is due to fluoride exposure is not clear. However, the severity of fluorosis in children is greatly influenced by several factors, such as fluoride concentration, constituents in water, age, sex, food nutrients, environmental factors, individual susceptibility or tolerance and genetics, etc. [54-64]. Several other neurological disorders associated with fluoride exposure, such as headache, paralysis, quadriplegia, lethargy, insomnia, depression, polydipsia, polyuria, etc., have also been observed and reported in

children as well as animals [65-75]. Thus, high fluoride exposure may lead to impaired learning and memory, lower IQ, mental impairment, and an increased risk of dementia in children. These neurodegenerative toxic effects of fluoride on the central nervous system are multifaceted and are likely due to oxidative stress and inflammation in neurons and microglia cells, neuronal apoptosis, neurotransmitter imbalances, disruption of metabolic regulation, synaptic function, and disruption of the blood-brain barrier. However, the specific mechanisms of fluoride on brain damage are still unclear. Therefore, it is important to better understand how long-term fluoride exposure causes brain damage. If these mechanisms are identified, it could be a major health breakthrough in preventing physical and mental health problems in children living in fluorosis-prone areas of the country. However, more scientific research studies are needed in India to assess the health effects of children consuming fluoridated animal milk. The results of these studies will be more effective in protecting children from fluoride poisoning.

Conclusion

Long-term consumption of fluoridated animal milk in rural areas of the country can harm children's health and lead to fluoride poisoning. Most people know that drinking fluoridated water and exposure to industrial fluoride causes fluorosis. However, many parents are unaware that when their growing infants and children are exposed to fluoride through milk from fluorosed animals, their teeth, bones, and brain can be affected. In fact, milk from fluorosed animals may even have high fluoride levels (>1.0ppm). Most villagers are aware of dental and skeletal fluorosis, but they are still unaware that fluoride can also cause mental health problems in their growing children. Therefore, parents should be cautious and avoid drinking milk from animals living in fluoride endemic areas. Otherwise, their growing children may develop dental and bone deformities (osteo-dental fluorosis) and neurological disorders. However, for confirmation, large scale research is needed on this topic in India. This communication will also draw the attention of the concerned health department so that a health policy can be made to prevent children's health from being harmed by drinking animal milk containing fluoride.

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