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Effect of Fluoride Level on Aquatic Organism and their Life

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Abstract

The toxicity of fluoride in aquatic organism increases with the rise in level of fluoride concentration, duration of exposure, and water temperature, while it diminishes with an increase in intraspecific size and the water levels of calcium and chloride. Freshwater invertebrates and fishes, particularly net spinning caddisfly larvae and migrating adult salmon, are more susceptible to fluoride toxicity compared to estuarine and marine species. In soft waters characterized by low ionic content, even a fluoride concentration as minimal as 0.5 mg F−/l can significantly harm invertebrates and fishes, prompting recommendations for safe levels below this threshold to safeguard freshwater organisms from fluoride contamination. Fluoride toxicity is becoming increasingly prevalent in various regions globally. Elevated fluoride levels in water jeopardize aquatic life, just as excess fluoride in drinking water poses risks to both animals and humans. Fish inhabiting freshwater contaminated with fluoride suffer adverse effects. Fluoride infiltrates and accumulates within their bodies, subsequently entering the food chain. While low fluoride levels are not life threatening, persistent bioaccumulation leads to toxic consequences in living organisms, which can have fatal outcomes. A comprehensive understanding of fluoride exposure and toxicity is essential for devising effective control and preventative strategies against fluoride pollution. Managing fluoride intoxication in fish is crucial to mitigate health risks for humans consuming fluoride affected fish and to enhance aquaculture yields.

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Introduction

The contamination of water bodies with fluoride is a critical ecological concern in contemporary times. Globally, the issue of fluoride pollution in aquatic environments has been extensively examined. Fluoride infiltrates water through several routes. One significant pathway of fluoride pollution in aquatic settings comes from mineral deposits containing fluorine found in soil and rocks (Camargo, 2003). A further prominent source of fluoride contamination is through agricultural pesticides and industrial waste. The toxic effects of fluoride pose serious risks to aquatic ecosystems. Freshwater species tend to suffer more severely than those in brackish environments. It is noted that the availability of fluoride ions diminishes as the hardness of water increases. Fluoride is known to permeate and accumulate within the bodily tissues of fish. Research indicates that fluoride can build up in both the bones and tissues of fish (Arthur, 1971).

Given its high electronegativity, fluoride is drawn towards the positively charged calcium ions in skeletal structures. Fish constitutes a staple source of nutrition in many regions of India. Moreover, fish is widely consumed as a dietary component across various

countries globally. The fluoride accumulated within fish can enter the human body through the consumption of fluoride laden fish. While studies indicate that a small quantity of fluoride is beneficial for preventing dental decay, excessive fluoride intake not only leads to dental issues (such as dental fluorosis) but also poses a threat to the overall health of living organisms. Reports suggest that fluoride pollution levels below permissible thresholds can negatively impact the health of invertebrates and fish (Arthur, 1971). Evidence suggests that fish incorporated into diets are significant contributors to the occurrence of dental fluorosis in humans (Ganta, 2015).

As fluoride ion concentrations in water rise, the adverse effects of fluoride toxicity on fish and other aquatic species intensify. Additionally, the duration of exposure plays a crucial role in the incidence and severity of fluoride toxicity.

Conversely, higher levels of chloride and calcium ions can mitigate the effects of fluoride toxicity in fish. Fluoride infiltrates the fish's system and disrupts various enzymatic functions. It primarily impacts enzymes, thereby hindering their functionality. As a result, crucial metabolic processes are disrupted (Pamela, 2011). Metabolic functions such as glycolysis are vital for maintaining the normal physiology of fish (Barbier, 2010).

In this review, we primarily concentrate on the repercussions of fluoride toxicity on the health of freshwater fish. We have also proposed potential strategies to mitigate fluoride pollution and its toxic effects on freshwater species. Since fluoride is a highly transportable inorganic pollutant, it enters the body of the fish through the skin or gills.

Bioaccumulation depends on the presence of water sediments, temperature and pH (Piero, 2014). Common carp such as *Cyprinus carpio*, redfish (*Carassius auratus* gibelin) and two predatory fish: pike (*Esox lucius*) and European perch (*Perca fluviatilis*) accumulate fluoride in various organs and tissues (Palczewska, 2016). The accumulation of F- in fish tissues increases according duration of exposure. However, the harmful effects differ between species with accumulation in predatory fish.

Other controversies regarding tissue accumulation have also been reported. Once in the body of *Acipenser baerii*, fluoride accumulates in several organs, mainly in the bones, skin, gills, then in the liver, intestines and muscles (Shi, 2009). However, Cao *et al.,* (2003) reported that the accumulation of fluoride was higher in the gills, followed by the liver, brain, kidneys, muscles and intestinal tissues of the carp (*Cyprinus carp*).

Fluoride level in Indian water

In many state of India like Andhra Pradesh, Bihar, Rajasthan, Gujrat, Haryana, Karnataka, Uttarpradesh, Kerala, Maharastra and Madhya Pradesh, fluoride content is above the permissible levels of 1.5 ppm. It has been found that 65% of Indian villages are exposed to fluoride toxicity (Kumar and Shah, 2006). In India, about 25 million people are affected by fluorosis, especially in the states of Andhra Pradesh, Bihar, Delhi, Gujarat, Haryana, Jammu and Kashmir, Kerala, Madhya Pradesh, Maharashtra, Punjab, Rajasthan and Tamil Nadu.

In India, about 66.62 million people are at risk of fluorosis (Susheela, 1993). According to a recent study conducted by the International Water Management Institute (IWMI) in North Gujarat, the results showed that 42% of the people in the sample survey (28,425) were affected, while 25.7% and 6.2% were affected by dental fluorosis, and musculoskeletal fluorosis, respectively. 10% were affected by both types of fluorosis.

General mechanism of toxicity

A study by Barbier *et al.,* (2010) described a number of cellular processes in which fluoride can have adverse effects. Effects identified by various experimental studies include alteration of gene expression, disruption of enzyme activity (mainly inhibition), inhibition of protein synthesis and secretion, and generation of reactive oxygen species (ROS).

Fluorine disrupts enzyme activity by binding to the amino acid functional groups surrounding the enzyme's active site. This consists in the enzymatic inhibition of the glycolytic pathway and the Krebs cycle (Murphy *et al.,* 1992). At micromolar and millimolar concentrations, fluoride can act as an anabolic agent and promote cell proliferation and an enzyme inhibitor respectively (Kawase *et al.,* 1989).

This is illustrated by the study of). This is an example of phosphatases, which play an important role in the ATP (cellular energy) production cycle and in cellular respiration (Mendoza-Shulz *et al.,* 2009). Fluoride disrupts signaling pathways involved in cell proliferation

and apoptosis, and subsequently causes inhibition of protein synthesis and secretion (Nopakun *et al.,* 1990). Fluorine has been associated with oxidative stress, which can lead to a decrease in mitochondrial capacity and degradation of cell membranes. The increase in oxidative stress leads to an increased expression of genes responsible for the stress response (Rubel, 1983).

Toxicity to algae and aquatic plants

Fluoride can inhibit or promote algal population growth, depending on the fluoride concentration, exposure time, and algal species. Some algae are able to tolerate inorganic fluoride levels up to 200 mg F−/l.

The toxic effect of fluoride on algal growth may be due to the fact that fluoride ions can affect the metabolism of nucleotides and nucleic acids that regulate cell division processes in algae (Antia and Klut, 1981). Rather, it stimulates the growth of certain algae

Bioaccumulation in aquatic invertebrates and fish

Aquatic animals such as fish and invertebrates can absorb fluoride directly from water or to a lesser extent through food (Neuhold and Sigler, 1960). This absorption of fluoride is a function of the concentration of fluoride in the aquatic environment, exposure time and water temperature (Neuhold and Sigler, 1960).

Toxicity to aquatic invertebrates

The toxic effect of fluoride on the health of aquatic (and terrestrial) animals lies in the fact that fluoride ions act as enzyme poisons, inhibiting enzyme activity (e.g. phosphatase, hexokinase, enolase, succinic dehydrogenase, pyruvic oxidase) and affect the important metabolic process of carbohydrate metabolism like glycolysis and protein synthesis (Wang *et al.,* 2004). However, the actual mechanism at the molecular level by which inorganic fluoride prevents enzyme activity and disrupts metabolism.

Toxicity to fish

The toxicity of fluoride to fish increases with increasing fluoride concentration in the aquatic environment, exposure time, and water temperature (Neuhold and Sigler, 1960). Conversely, the toxicity of fluoride decreases with increasing intraspecific fish size and the calcium and chloride content of the water (Neuhold and Sigler, 1960).

Ecological risk assessment

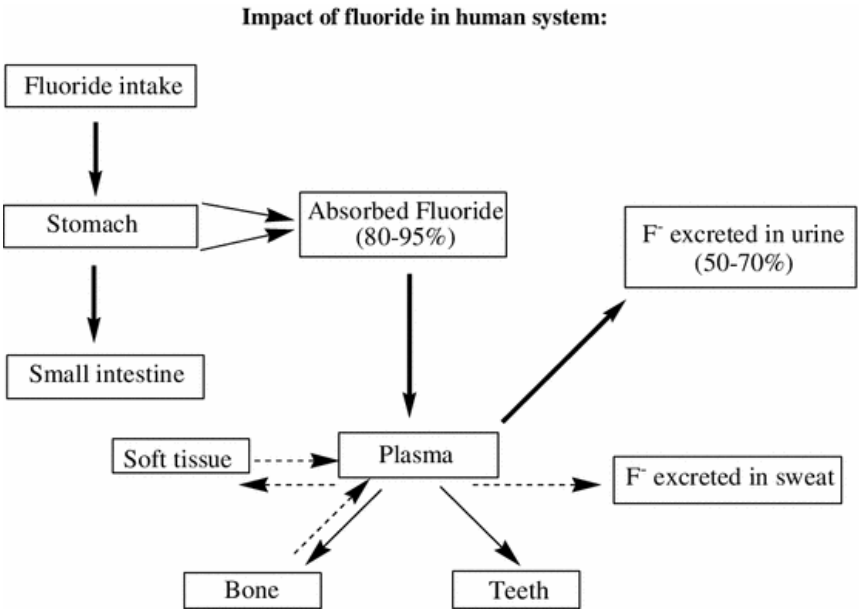
Human activities, such as aluminum smelters, fluoridated municipal water discharges, and factories producing bricks, ceramics, glass, and fluorine-containing chemicals, can cause significant increases in fluorine concentrations.

Transmission floride of toxicity from aquatic animal to man

Fluoride is known to be beneficial at low circulating concentrations. Skeletal absorption of fluoride is limited to low circulating fluoride concentrations and the observed effects are beneficial. There is no documentation of any disease in humans due to fluoride deficiency (Peckham *et al.,* 2014). However, fluoride is toxic to health at higher circulating concentrations. High circulating concentrations lead to increased skeletal absorption of fluoride (Charles *et al.,* 1995).

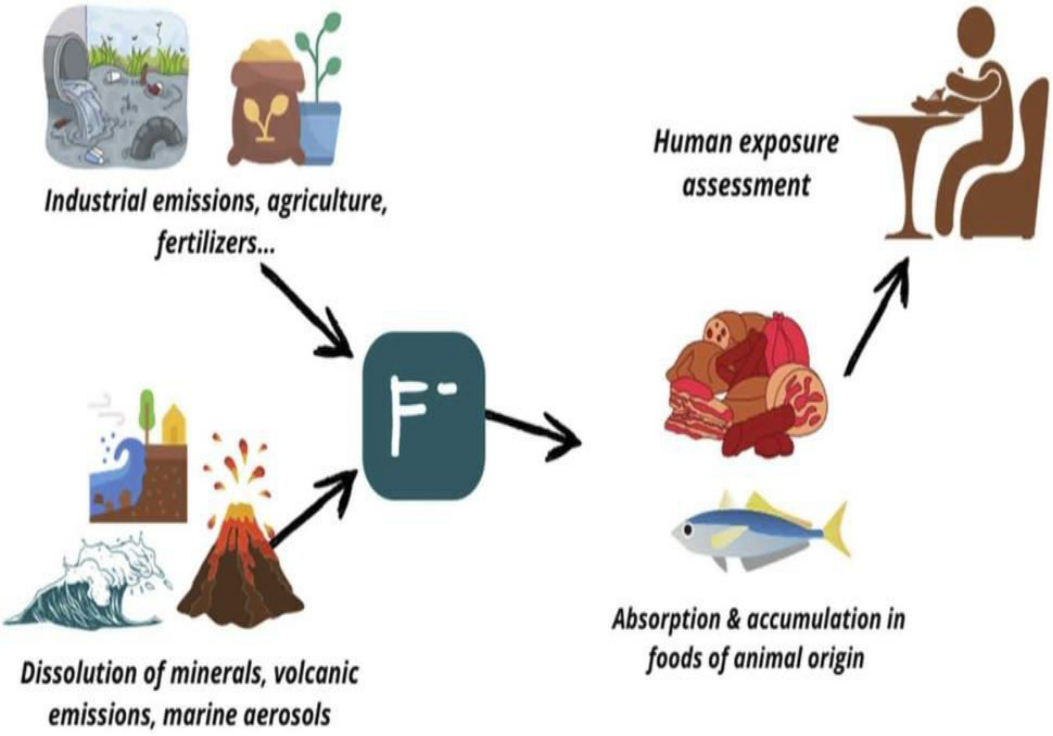
Fluoride enters the human body through the fish it contains, consumed as food. Excess fluoride is not used in our body and begins to accumulate in our body with the successive and regular consumption of fish poisoned with fluoride. Fluoride that is not absorbed by the body is easily eliminated with feces. The plasma fluoride concentration level reaches its peak in 20 to 60 minutes after ingestion. Then, gradually, the plasma fluoride level begins to decrease due to excretion in the urine and absorption of fluoride in calcified tissues. Fluoride can enter our body mainly through foods such as fish that contain fluoride, but studies show that potential fluoride toxicity can also occur from oral medications that contain fluoride (Ullah *et al.,* 2017). After entering the body, fluoride in high concentration causes significant negative health effects {Fig.1}. Fluoride has been found to have a detrimental effect on the cognitive development of children. Fluorine toxicity in humans has been reported to cause dental fluorosis, skeletal fluorosis, worsening dental caries, brittle and mottled teeth, and etc. Fluorine has been reported to interact with and poison various enzymes. After entering the body, fluorine interacts with metal ions present in the enzymes and disturbs the normal physiology by disrupting the normal functions of the enzymes. Fluoride is also known to cause hypocalcaemia in humans. Thus, the ingestion of fluoride by fish, when fish poisoned by fluoride are regulated consumption in the daily diet, leads to some significant health risks in humans [Fig.2.]. Adequate measures should be taken to avoid consumption fish from fluoride-contaminated water.

Figure.1 Impact of fluoride in human system



Impact of fluoride in human system:
Fluoride intake
Stomach
Absorbed Fluoride (80-95%)
F- excreted in urine (50-70%)
Small intestine
Soft tissue
Plasma
F- excreted in sweat
Bone
Teeth

Figure.2



Conclusion

The toxicity of fluoride in fish is a major concern to ensure good health for people who consume fish. The most effective way to prevent fluoride toxicity in fish is to prevent exposure of fish to fluoride. This is only possible to prevent contamination of water with fluoride or a substance containing fluoride or to remove fluoride from water already contaminated with fluoride. To remove fluoride from water, it is necessary to know the level of fluoride in the water, as well as the source of fluoride contamination. Until the fluoride is removed from the water or the water pollution is stopped, the fish farming in this water must be stopped and the fish that have thrived in this contaminated water must be immediately moved to a separate tank with fresh water and treated for drowning.

This review considers the importance of fluoride and argues that high intake of fluoride, via ingestion or inhalation from various sources, can cause toxicity in humans and animals, including dental, skeletal and non-skeletal fluorosis. Fluoride toxicity can be acute or chronic depending on the level and duration of fluoride intake. presence of high concentrations of fluoride in the soil affects plants and aquatic life and leads to soil and water pollution. Types of plants susceptible to soil contamination by potassium fluoride can be significantly damaged. In addition, potassium fluoride pollution can have a devastating effect on soil microbial activity and disrupt soil ecology.

References

Arthur, B. D. Biologic Effects of Atmospheric Pollutants, Fluoride.Washington DC, US: National Academy of Science; 1971.

Barbier, O., Arreola-Mendoza, L. and Del Razo, L. M. Molecular mechanisms of fluoride toxicity. Chemico-Biological Interactions. 2010; 188:319-333. https://doi.org/10.1016/j.cbi.2010.07.011

Camargo, J. A. Fluoride toxicity to aquatic organisms: a review. Chemosphere 2003; 50(3):251-64. https://doi.org/10.1016/s0045-6535(02)00498-8.

Cao, J. Zhao, Y. Liu, J. Xirao, R. Danzeng, S. Daji, D. and Yan, Y. Brick tea fluoride as a main source of adult fluorosis. Food Chem Toxicol. 2003; 41:535–542 https://doi.org/10.1016/s0278-6915(02)00285-5.

Charles, Y. C., Joseph, P. and Zerwekh, E. Anabolic effects of fluoride on bone. Trends in Endocrinology and Metabolism 1995; 6(7):229-34. https://doi.org/10.1016/1043-2760(95)00111-t

DenBesten, P. and Wu Li. Chronic Fluoride Toxicity: Dental Fluorosis. Monogr Oral Sci. 2011; 22: 81–96. https://doi.org/10.1159/000327028

Ganta, S. Yousuf, A. and Nagaraj, A. Evaluation of Fluoride Retention Due to Most Commonly Consumed Estuarine Fishes Among Fish Consuming Population of Andhra Pradesh as a Contributing Factor to Dental Fluorosis: A Cross-Sectional Study. J Clin Diagn Res. 2015; 9(6):ZC11-5. https://doi.org/10.7860/JCDR/2015/12271.6035

Kawase, T. and Suzuki, A. Fluoride-induced cytoplasmic acidification: possible role of protein kinase c in BCECFloaded L929 cells. Pharm Toxicol. 1989; 64:426–428. https://doi.org/10.1111/j.1600-0773.1989.tb00680.x

Klut, M. E., Bisalputra, T., and Antia, T. Abnormal Ultrastructural Features of a Marine Dinoflagellate Adapted to Grow Successfully in the Presence of Inhibitory Fluoride Concentration. The Journal of Protozoology, 1981; 28 406-414. https://doi.org/10.1111/j.1550-7408.1981.tb05311.x

Kumar, M. D. and Shah, T. (2006). Groundwater pollution and contamination in India: The emerging challenge. Vallabh Vidyanagar, Gujarat, India: IWMI-TATA Water Policy Research Program.14p.

Mendoza-Schulz, A., Solano-Agama, C., Arreola-Mendoza, L., Reyes-M.rquez, B., Barbier, O., Del Razo, L. M. and Mendoza-Garrido, M. E. The effects of fluoride on cell migration, cell proliferation, and cell metabolism in GH4C1 pituitary tumour cells, Toxicol. Lett. 2009; 190: 179–186. https://doi.org/10.1016/j.toxlet.2009.07.014

Murphy, A. J. and Coll R. J. Fluoride is a slow, tight-binding inhibitor of the calcium ATPase of sarcoplasmic reticulum. JBC. 1992; 267:5229–5235.

Neuhold J. M. and Sigler W. F. (1960). "Effect of sodium fluoride on carp and rainbow trout". Trans Am and Molecular Biology, 40(3); 382-395.

Nopakun, J. and Messer, H. H. Mechanism of fluoride absorption from the rat small intestine. Nutr Res. 1990; 10:771–779. https://doi.org/10.1016/S0271-5317(05)80826-7

Palczewska-Komsa, M., Kalisińska, E., Stogiera, A, and Szmidt, M. Fluorides in the human bones – selected issues. Pomeranian Journal of Life Sciences. 2016; 62(1):53-59.

Peckham, S. and Awofeso, N. Water fluoridation: a critical review of the physiological effects of ingested fluoride as a public health intervention. Scientific World Journal. 2014;2014:293019. https://doi.org/10.1155/2014/293019

Piero, S. D. Masiero, L. and Casellato, S. Toxicity and bioaccumulation of fluoride ion on Branchiura sowerbyi, Beddard, (Oligochaeta, Tubificidae). Zoosymposia 2014; 9: 044–50. https://doi.org/10.11646/ZOOSYMPOSIA.9.1.9

Rubel, J. F. The removal of excess fluoride from drinking water by the activated alumina method. In: Shupe, J. L., Peterson, H. P. and Leone, N. C. Eds., Fluoride effects on vegetation animals and humans. Paragon Press, Salt Lake City. 1983; 345-349.

Shi, X., Zhuang, P., Zhang, L., Feng, G., Chen. L., Liu J. and Wang, R. (2009). Growth inhibition of Siberian Sturgeon (II) from dietry and waterborne fluoride. Research Report. Fluoride. 2009; 137-141.

Susheela, A. K., Kumar, A., Betnagar, M. and Bahadur, M. Prevalence of endemic fluorosis with gastrointestinal manifestations in people living in some north-Indian villages, Fluoride. 1993; 26: 97-104.

Ullah, R., Zafar, M. S, and Shahani, N. Potential fluoride toxicity from oral medicaments: A review. Iran J Basic Med Sci. 2017; 20(8):841-848. https://doi.org/10.22038/IJBMS.2017.9104

Wang, A., Xia, T., Ru, R., Yuan, J., Chen, X. and Yang, K. (2004). Antagonistic effect of selenium on oxidative stress, DNA damage, and apoptosis induced by fluoride in human hepatocytes. Fluoride, 37: 107-116.

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