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Bhupen Acharya
Department of Chemistry,
Malyagiri Mahavidyalaya,
Pallahara, Angul, Odisha, India

Nigamananda Jyotish
Malyagiri Mahavidyalaya,
Pallahara, Angul, Odisha, India

Priyadarsini Mohapatra
Malyagiri Mahavidyalaya,
Pallahara, Angul, Odisha, India

Fluoride level in drinking water in Angul district of Odisha and its impact on health: A brief review

Bhupen Acharya, Nigamananda Jyotish and Priyadarsini Mohapatra

Abstract

Drinking water we take must be as safe as practicable. The ground water the major resource gets badly polluted due to human interferences. Fluoride is the major chemical pollutant in the drinking water. As per WHO the fluoride limit allowed is 1.5/L. Angul district located in Odisha is having high concentration of fluoride. The health impact of fluoride was reviewed using search engines to inform the medical professional and to suggest Government for remedial measures. Including some beneficial effects of fluoride like dental carries it has many toxic effects as the concentration level is more than necessity. Angul district is drastically concerned by fluorosis. 07 blocks of the district are confronting fluoride threat out of which Angul block is highly endemic. The populace of these areas are experiencing dental and skeletal fluorosis. Fluoride in overabundance in a biological system has been found to have possibly unsafe consequences for the body systems. The presence of fluoride in concentration above the acceptable limits in the man and animals body creates a lot of diseases and disorders.

Keywords: Fluoride concentration, drinking water quality in Angul, health efficacy of fluoride

1. Introduction

Water is essential to sustain life, and a satisfactory (adequate, safe and accessible) supply must be available to all. Improving access to safe drinking-water can result in tangible benefits to health. Every effort should be made to achieve drinking-water that is as safe as practicable [1]. The rural population of India comprises more than 700 million people residing in about 1.42 million habitations spread over 15 diverse ecological regions. It is true that providing drinking water to such a large population is an enormous challenge. Our country is also characterized by non-uniformity in level of awareness, socio-economic development, education, poverty, practices and rituals which add to the complexity of providing water [2].

As per the census data of 2011 there are eight classified sources of water. These are tap water from treated source, tap water from untreated source, covered well, uncovered well, tube well/Bore. Water from these sources are contaminated and polluted by different means. There are different parameters in assessing the drinking water quality. These are under microbiological aspects, chemical, radiological, physical and aesthetic aspects [3]. Nevertheless, the major part of the developing nations like India rely on upon ground water to fulfill their every day necessities beginning from drinking to agricultural purposes. Currently, this ground water resources are not safe and get badly polluted due to human interferences such as industrialization, urbanization as well as dissolution and mixing of chemical elements from natural mineral resources available in the earth itself. Fluoride is one of the chemical pollutants available in water that comes into water by dissolution of fluoride containing rocks by their weathering and leaching or discharge by agricultural and industrial activities during manufacturing glass, electronics, steel, aluminum, bricks, tiles, ceramics, pesticide and fertilizer [7]. Fluoride content in groundwater is mainly due to natural contamination, but the process of dissolution is still not well understood [5, 6]. Fluoride, an electronegative element, is highly reactive, therefore, almost never occurs in elemental state in natural water. It combines with most of the elements to form ionic or covalent fluorides. Areas with semi-arid climate, crystalline igneous rocks and alkaline soils are mostly affected [5].

As per WHO standards for drinking water quality, the limits have been fixed for different parameters which are depicted in Table-1 [4]. The fluoride limit is 1.5 mg/litre.

Correspondence
Bhupen Acharya
Department of Chemistry,
Malyagiri Mahavidyalaya,
Pallahara, Angul, Odisha, India

Angul district is located in the center of the state of Odisha and lies between 20° 31 N & 21° 40 N latitude and 84° 15 E & 85° 23 E longitude. The altitude is between 564 and 1187 metres. The district has an area of 6232 km². It is bounded by Dhenkanal and Cuttack district in the east, Deogarh, Kendujhar and Sundargarh district in north, Sambalpur, Sonepur in west and Boudh and Nayagarh in the south side. The district is abundant with natural resources. Angul, The district headquarters is about 150 kilometers from the state capital Bhubaneswar [11].

In Odisha, drinking water in 27 districts is heavily contaminated with fluoride. The districts are; Puri, Khurda, Nuapada, Bargarh, Kalahandi, Jajpur, Bolangir, Dhenkanal, Deogarh, Jharsuguda, Phulbani, Kendrapara, Angul, Nayagarh, Boudh, Balasore, Bhadrak, Cuttack, Sundaragh, Ganjam, Gajapati, Jagatsinghpur, Keonjhar and Nabarangpur. Out of these around 18 districts are influenced by fluorosis. The circumstance is additionally disturbing in Balsingh-Singhpur in Khurda district, Karlakote in Nuapada a district, Gohiriapadar in Kalahandi District, Krushakpalli in Bargarh district and Balgopalpur Industrial Estate in Balasore districts [11].

Fluoride is protoplasmic poison [7, 8]. The deleterious effect it has on human and animals are very well known. Fluorosis is a crippling disease caused by the intake of water having higher concentration of fluoride i.e. > 1.5, ppm [6]. The existence of fluoride bearing ground water and fluorosis in India have been reported by many workers.

2. Aim of the study

The aim of research was to review of literatures about fluoride level in drinking water in Angul district and its health impact and to inform dentists, physicians and public health specialists, whether fluoride use is useful and safe and suggestions to prescribed Government for appropriate remedies.

3. Materials & Methods

Data used in this review were systematically searched from articles published until 2018 utilizing the key words including combinations of “fluoride” or health impact of fluoride” or “water fluoridation” or “fluorosis” or “dental fluorosis” or “caries” or “fluoride toxicity” or “fluoride impact on health” or “health efficacy of fluoride” or “drinking water quality in Angul” in five search engines. The current researches from the databases of data.gov.in and FAN are also included. The searches included the few official pages from World Wide Web and bibliographies of all included studies. The literatures w.r.t. different regions of Angul district of Odisha are mainly focused. Any of the duplicate data are removed.

The search was conducted between 15th August 2018 and 28th February 2018. The data were consolidated to draw conclusions.

4. Beneficial effect of Fluoride

Dental caries remains the most common chronic disease of childhood in the world. Fluoride has proven effectiveness in the prevention of caries and providing maximum protection against dental caries while minimizing the likelihood of enamel fluorosis. Regular fluoride exposure during the time of teeth development contributes to long lasting protection against enamel fluorosis and dental decay. Enamel is a calcium-deficient, carbonate-rich hydroxyapatite. In its stable state, there is sufficient Ca²⁺, PO₄³⁻, OH⁻ and F⁻ ion in the immediate vicinities of the crystals to maintain equilibrium

with the surrounding fluid. During cariogenic acid attack, plaque bacteria form organic acids from carbohydrates as the acids dissociate releasing H⁺ ions and lowers pH in the surroundings of the tooth. The H⁺ ions protonate phosphate ions (PO₄³⁻) present in plaque fluid to HPO₄²⁻ and particularly to H₂PO₄⁻. This process also maintains neutrality and finally leads to the release of calcium from hard tooth substance [8]. Small amounts of fluoride in solution around the tooth inhibit demineralization more effectively than incorporated fluoride and have a much greater caries-protective potential than a large proportion of fluorohydroxyapatite in enamel. The hypothesis behind this protection is the free fluoride ions in solution around the tooth or enamel crystals play a much more important role in caries prevention than fluorides incorporated in the enamel crystals. Under these conditions, fluoride ions are in part adsorbed onto the crystalline surface and are in dynamic equilibrium with the fluoride ions in solution in the immediate environs. This leads to an equilibrium or supersaturation relative to fluorohydroxyapatite and hence to reprecipitation of minerals. Additionally, the adsorption of fluoride, on the crystals offers direct protection from demineralization. The enamel crystals can be locally dissolved during an acid attack if fluoride is absent for the long time. These low fluoride concentrations are also attained after consuming foods containing fluoridated table salt, since the F⁻ content of saliva significantly increases for about 30 minutes after such meals [9]. It can be inferred that fluoridated drinking water and table salt also function according to this mechanism, since the formation of CaF₂ at these low concentrations is quite unlikely. Fluoride has antimicrobial effect too.

5. Fluorosis

Ingestion of excess fluoride, most commonly in drinking-water, can cause fluorosis which is of three kinds namely dental fluorosis, skeletal fluorosis and non-skeletal fluorosis.

5.1 Dental Fluorosis: Dental fluorosis is more inclined in the youngsters up to the age of 8-10 of fluoride influenced areas where fluoride concentration is more than admissible farthest point of 1.5 mg/l. Because of intemperate fluoride intake, enamel loses its radiance. The gentle type of dental fluorosis is described by white, opaque areas on the tooth surface while in extreme structure yellowish brown to black stains and severe pitting of teeth are showed up. The grown-ups are likewise get influenced by dental fluorosis however the harm appearance are not visible when contrasted with milk teeth.

5.2 Skeletal Fluorosis: The skeletal fluorosis in intense to endless structure has happened because of draw out intake of fluoride contaminated water with concentration more than 3 – 6 mg/l. The disabling skeletal fluorosis may happen in individuals who have ingested 10 to 20 mg of fluoride for every day more than 10 to 20 years. The significant source of fluoride bringing about skeletal fluorosis originates from ground water, blazing of coal and different industrial activities. It influences the people as well as creatures encouraged with fluoride rich water and fodder. Skeletal fluoride spread among youngsters and grown-ups with same side-reactions. Additionally harmed the foetus – if mother devoured fluorinated water and foods amid pregnancy or breast feeding, newborn child mortality because of calcification of blood vessels can likewise happens. Fluoride for the most part gets kept in the joints of neck, pelvic and shoulder bones and makes it hard to move or walk.

The side effects of skeletal fluorosis are like spondylitis or arthritis. Early indications incorporates sporadic pain, burning like sensation, pricking and tingling in the limbs, muscle weakness, chronic fatigue, abnormal calcium deposits in bones and ligaments. The propelled stage is osteoporosis in long bones and bony outgrowths may happen. Vertebrae may combine and inevitably the casualty may be disabled. It may even prompt an uncommon bone cancer; osteosarcoma and lastly spine, significant joints, muscles and nervous system get harmed [17, 18].

5.3 Non-skeletal fluorosis/Other problems: Aside from dental and skeletal fluorosis, other wellbeing's issues happen because of wxorbitant utilization of fluorides from different sources is muscle fibre degeneration, low haemoglobin levels, disfigurements in RBCs, unreasonable thirst, migraine, skin rashes, nervousness, neurological sign, depression, gastrointestinal issues, urinary tract failing, nausea, abdominal pain, tingling sensation in fingers and toes, reduced immunity, repeated abortions or still births, male sterility, and so on. Fluoride additionally influences or changes the functional mechanism of liver, kidney, digestive system, respiratory and excretory system, central nervous system, reproductive system and destruction of around 60 enzymes.

The protestations with the G-I system in endemic ranges are presently settled as ahead of schedule cautioning indications of fluoride poisonous quality. Fluoride is known not with hydrochloric acid of the stomach and is changed over to hydrofluoric acid. Hydrofluoric Acid is exceptionally destructive and henceforth the stomach and intestinal lining (mucosa) is annihilated with loss of microvilli [20, 21].

It is presently realized that when fluoride is ingested, it will likewise gather on the erythrocyte membrane, which thus looses calcium content. This change causes development of echinocytes. The life span of these echinocytes is not exactly the typical life span of RBC, and subsequently early demolition of the RBCs as echinocytes reasons iron deficiency [22].

Fluoride in abundance anyplace in an biological community has been indicated to have conceivably unsafe impacts on the body systems. Each of the three parts of bone and teeth that is collagen, proteoglycans and calcium are unfavorably influenced by ingestion of high amount of fluoride for delayed span [23, 24].

The net consequence of this prompts corruption of collagen and ground substance in bones and teeth and along these lines prompts side of fluorosis like, delayed eruption of teeth, dental fluorosis, clinical fluorosis, premature aging and so on [25].

In view of the adjustments in ground substance because of high fluoride intake, elevated content of glycosaminoglycans (Mucopolysaccharides - synonymous with the term - Seromucoidll utilized by Winzler) [22] in bone and its reflection in serum is appearance is serum is considered as a file to evaluate fluoride harmfulness and fluorosis at ahead of schedule stages [23, 24].

6. Reviews with respect to Angul district

Most of the ground water samples in study area were found within the drinking water quality standard (IS: 10500 and WHO, 1996). The study revealed that rock-water interaction is the major source of fluoride in ground water and very much influenced by local lithology. But in post-monsoon season, besides the weathering processes, anthropogenic activities also play a significant role in the incidence of fluoride in

ground water. The samples (*Gotamara* village, *Nuasahi* village, *Tulsipal* village, *Longipeda* village, *Gadrakhai* village, *Girang* village water and *Banarpal* chowk) around the Aluminium smelter and thermal power plants of NALCO are evidenced to excess fluoride concentration in ground water. The fluoride contamination to the ground water during the post-monsoon season is mainly due to the seepage, moving and percolation of fluoride contaminated water nearby industrial complexes [13].

The aluminum smelter plant of NALCO situated at Angul Hqrs. was commissioned in the year 1987. Within the gap of so many years of production time the highest fluoride concentration in the ground water has been reached to a maximum of 4.13mg/l in nearby localities. Moreover many cases of dental and skeletal fluorosis have already been observed among the men and animals, so necessary treatment methods are to be adopted to check high fluoride concentration in the effluent drain of aluminium smelter plant [10].

The study assessed the water quality between river water, tap water & tube well water. Data were compared with surface water quality standards IS: 2296 & drinking water quality standard IS: 10500 and NSF water quality index in order to classify the quality of water. The parameters were taken for analysis of the water quality; among them two parameters exceed the maximum permissible limit. The physico-chemical data indicate that intensive use of waste dumping and the industrial activities have impacted greatly on the quality of drinking water in Talcher region. Sampling stations variations were found significant in Sodium, DO, TS, Alkalinity, Chloride, Hardness, Nitrate and Fluoride contents; the seasonal significant variations were observed in temperature, COD, Sodium and Alkalinity content. As a conclusion, in this present work we have documented the fact that the region has medium quality drinking water as well as bad quality tube well water in two sampling stations as per NSF water quality index.

In Angul district the affected blocks are Angul, Athmallick, Banarpal, Chendipada, Kaniha, Talcher and Pallahara. Angul district of Odisha comes under highly endemic zone on fluoride concentration.

Surface and ground water in Angul district in Odisha have been found to be contaminated by fluoride. In the absence of organized water supply, people depend on ponds, tube wells and dug wells to meet their water needs. The untreated waste water contaminated with fluoride discharged from industrial units are either allowed to accumulate in the lagoon or discharged to the river without adequate treatment. As a result, ground water gets contaminated by percolation through the soil. According to a study done by Central Pollution Control Board, Kolkata, 57% of tube wells and 67% of dug wells in the district are affected by fluoride. About 10% of tube wells and dug wells were found to have fluoride concentration of more than 1 mg/l. It was also observed that the level of fluoride in pond water varied from 0.49 to 3.70 mg/l. The contamination of pond water may be due to deposit of airborne particles containing fluorides emitted from the industrial units. A large number of villagers reported fluoride induced symptoms like pain in the lower leg. While Angul is among the worst affected, there are other districts where the problem has assumed serious proportions [14].

It has already been found that higher concentration of fluoride has been observed in the ground water in shallow as well as deeper aquifer. The SPCB, Odisha has already reported excess fluoride in the soil samples from 11 villages

surrounding the NALCO smelter plant area in Banarpal block. But as per the findings of studies carried out by CGWB on different occasion, the occurrence of higher fluoride in isolated locations and does not show any pattern. Also any adverse effect of effluent discharged from mining and industries, on the ground water quality has not been noticed yet ^[15].

In areas like Angul-Talcher industrial belt, *Balasingh-Singhpur* in Khurda district, *Gohriapadar* in *Kalahandi* district and *Krushakpalli* in *Bargah* district, the fluoride problem has assumed alarming proportions. In many of these areas, the fluoride content in drinking water is as high as 10 mg/l or more when the permissible limit is just 1 mg/l ^[16].

7. Effect of Fluoride as per current research.

7.1 Effect of fluoride on Brain: Fluoride's ability to damage the brain is one of the most active areas of fluoride research today. Over 300 studies have found that fluoride is a neurotoxin (a chemical that can damage the brain). This research includes:

Over 100 animal studies showing that prolonged exposure to varying levels of fluoride can damage the brain, particularly when coupled with an iodine deficiency, or aluminum excess; 53 human studies linking moderately high fluoride exposures with reduced intelligence; 45 animal studies reporting that mice or rats ingesting fluoride have an impaired capacity to learn and/or remember; 12 studies (7 human, 5 animal) linking fluoride with neurobehavioral deficits (e.g., impaired visual-spatial organization); 3 human studies linking fluoride exposure with impaired fetal brain development. Based on this accumulating body of research, several prestigious reviews — including a report authored by the U.S. National Research Council, a meta-analysis published by a team of Harvard scientists, a review published in *The Lancet* and a 2017 U.S.-funded 12-year study that found a link between fluoride in the urine of pregnant women and lower measures of intelligence in their children - have raised red flags about the potential for low levels of fluoride to harm brain development in some members of the population ^[28].

7.2 Effect of fluoride on Diabetes: Diabetes mellitus is a potentially life-threatening disease, in which the body fails to properly regulate blood sugar levels. Diabetes mellitus affects nearly 26 million people in the U.S. alone-with 7 million of these remaining undiagnosed, and therefore untreated.

Fluoride has been shown to increase blood glucose levels and impair glucose tolerance, likely by inhibiting insulin production or secretion. Impaired glucose tolerance, often a precursor to type 2 diabetes, has been found to occur in humans with fluoride intakes of only 0.07-0.4 mg/kg/day-a dose that can be reached in areas of “optimally” fluoridated water. Current fluoride intake, therefore, may contribute or exacerbate some types of diabetes. According to the National Research Council (2006), “any role of fluoride exposure in the development of impaired glucose metabolism or diabetes is potentially significant.” Diabetics also generally drink more water than nondiabetics, and thus can consume substantially more fluoride from water and other beverages on a daily basis. Diabetics are therefore considered to be a “sensitive subpopulation” with regard to fluoride exposure, and may suffer disproportionately from fluoride's adverse effects ^[28].

7.3 Effect on gastrointestinal disorder: It is well established that fluoride ingestion can cause a range of gastrointestinal (“GI”) symptoms, including nausea, pain, and vomiting. It is

not yet understood, however, what level of fluoride in the stomach is necessary to cause these symptoms, and how much this level varies based on the sensitivity of the individual. In 2006, the National Research Council called for more research to explore these issues ^[28].

7.4 Current Fluoride Exposures Linked to Osteomalacia in Dialysis Patients:

Recent research shows that dialysis patients still face elevated risks of fluoride-induced osteomalacia, not because of the dialysis itself, but because of everyday fluoride exposures from water and other dietary sources. In 2004, researchers from Toronto, Canada reported that dialysis patients with osteomalacia have notably high levels of fluoride in their bone (avg. 3, 400 ppm), even when compared to other dialysis patients (2, 400-2, 700 ppm). Further, the researchers reported that the level of fluoride in the patients' bone was significantly correlated to the quantity of osteoid, a type of unmineralized tissue. An excessive quantity of osteoid in bone is the hallmark of osteomalacia. According to the researchers: “Fluoride interfered with bone mineralization and increased osteoid content, which was most evident in osteomalacia and the mixed bone disorder.” (Ng 2004) ^[28].

7.5 In Bone fracture-For many years, however, fluoride advocates believed that fluoride, under controlled conditions, could benefit bone due to its ability to increase bone mass. In the 1960s, scientists began using fluoride as an experimental drug for the treatment of osteoporosis. Instead of reducing the number of fractures, however, numerous clinical trials reported that the fluoride treatment increased the rate of fractures (particularly hip fractures) and caused a number of other side effects, including gastric distress and joint pain. Based on these results, the FDA rejected the use of fluoride as a medical treatment for treating osteoporosis ^[28].

7.6 Cancer: In addition to osteosarcoma, a number of studies of fluoride-exposed workers have found associations between airborne fluoride exposure and both bladder and lung cancer. Fluoride can cause cancer has been fueled by evidence linking it to a serious form of bone cancer known as osteosarcoma. This evidence includes a government animal study as well as several studies of human populations living in the United States ^[28].

7.7 Male Fertility: Consistent with the in vitro and animal research, studies of human populations have reported associations between fluoride exposure and damage to the male reproductive system. Most notably, a scientist at the Food & Drug Administration reported in 1994 that populations in the United States with more than 3 ppm fluoride in their water had lower “total fertility rates” than populations with lower fluoride levels. (Freni 1994). While 3 ppm is a higher concentration than used in water fluoridation programs (0.7 to 1.2 ppm), it is still considered a “safe” level by the EPA. To date, no U.S. health agency has attempted to replicate Freni's findings. However, three studies of highly fluoride-exposed populations in China and India have found that high fluoride exposure is associated with reduced male fertility. (Chen 1997; Liu 1988; Neelam 1987). In addition, five studies from China, India, Mexico, and Russia have found that high-fluoride exposure is associated with reduced male testosterone levels. (Hao 2010; Ortiz 2003; Susheela 1996; Michael 1996; Tokar 1977).

Table 1: WHO Drinking water standards for few parameters.

Parameter	Unit	Limit
Aluminium	mg Al/l	0.2
Arsenic	mg As/l	0.05
Barium	mg Ba/l	0.05
Beryllium	ug Be/l	0.2
Cadmium	ug Cd/l	5.0
Calcium	mg Ca/l	200.0
Chromium	mg Cr/l	0.05
Copper	mg Cu/l	1.0
Iron Total	mg Fe/l	0.3
Lead	mg Pb/l	0.01
Magnesium	mg Mg/l	150.0
Manganese	mg Mn/l	0.1
Mercury	ug Hg/l	1.0
Selenium	mg Se/l	0.01
Sodium	mg Na/l	200.0
Zinc	mg Zn/l	5.0
Chlorides	mg Cl/l	250.0
Fluorides	mg F/l	1.5
Nitrates	mg NO ₃ /l	10.0
Nitrites	mg NO ₂ /l	-
Sulphates	mg SO ₄ /l	400.0
Suphides	mg H ₂ S/l	0
Hydrocarbons	mg/l	0.1
Anionic Detergents	mg/l	0
pH		9.2
Total dissolved solids	mg/l	1500
Total hardness	mg/l	500
Alkalinity	mg/l	500
Total Bacteria	Count/ml	100
Coliform	Count/100ml	0
Salmonella	Count/100ml	0

8. Results & Discussion: It is evident from the study that fluoride is essential for the prevention of dental carries which will be an essential data for dentist. Due to higher concentration of fluoride fluorosis occurs and diseases like diabetes, cancer, bone fracture, male fertility, osteomalacia, GI disorder, depression occurs which will be highly beneficial for the physicians, specialists and other medical professionals. The review is limited to the some areas of the Angul district as systematic study is required for Pallahara.

9. Conclusion

The nature of drinking water is critical for open security and the personal satisfaction^[26, 27]. The tainting of drinking water with fluoride ions is a genuine wellbeing issue, particularly in parched and semi-dry zones where geography gives wellsprings of fluoride ions. Its everyday use in concentrations present in beverages for dental hygiene is safe. Fluoride can be toxic in extremely high concentrations. Angul district is drastically concerned by fluorosis. 07 blocks of the district are confronting fluoride threat out of which Angul block is highly endemic. The populace of these areas are experiencing dental and skeletal fluorosis. Fluoride in overabundance anyplace in a biological system has been demonstrated to have possibly unsafe consequences for the body systems. The presence of fluoride in concentration above the acceptable limits in the man and animals body creates a lot of diseases and disorders. A lot of fluoride gets bound in these tissues and just a little sum is discharge through sweat, pee and stool. This review will support strongly for the future investigations towards drinking water quality and the impact of fluoride for the areas where detail study is yet to be required. Moreover further research can be

conducted for drug development, impact of fluoride towards other diseases which have not be revealed yet.

The concerned Department of Government of Odisha and Government of India is hereby suggested to take action like FAN (Fluoride Action Network- FlourideAlert.org) for the benefit of the public.

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