

# Bio remedial Process: A Review on Removal of Fluoride from the Waste Water

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## ABSTRACT

Ground water has always been an important and most dependable source of water since prehistoric ages, but with rapid industrialization to meet the needs of growing population has stressed the ground water reservoir. Stress to ground water reservoir is just one problem; industrial waste has also introduced lots of new chemical substances in water bodies. Fluorides are one such pollutant that undermines living life forms especially human beings. There are primarily two sources of fluoride contamination in ground water. Geogenic sources and anthropogenic sources. Talking about the status of fluoride contamination it can be seen in more than 25 countries worldwide. In India itself 19 states and at least 132 districts have witnessed the problem of water contamination, Fluoride contamination is also impacting the health of people adversely. Diseases like skeletal fluorosis, non-skeletal fluorosis, and dental fluorosis are the most common health problem from fluoride contamination. Due to fluoride contamination diseases in plants like Chlorosis, Necrosis is impacting plant body. Thus, to remove fluorine contamination from water we can use bioremediation process. Bioremediation strategies can be classified mainly in two categories in-situ techniques and ex-situ techniques. Its mode of action primarily includes use of microbes in processing the fluoride contamination. This shows that bioremediation has lots of advantages like it's a natural process, cost effective etc. But it too have some disadvantages like they are highly specific and it takes longer time etc. Considering all the merits and demerits of bioremediation, it is the most effective technological tool that holds great value for the future as scientists learn more about its capabilities and the curiosity to find more appropriate methods are still going on. This review article deals with ground water pollution due to fluoride concentration. We have thoroughly reviewed on its impact on health of plants and animals and the bioremediation processes to cure the water contamination

*Key words* : Water contamination, Fluoride concentration, Health hazards, Bioremediation processes, Role of microbes

## Introduction

Ground water has always been the most valuable and purest source of water in our day to day activities and we are heavily dependent on it. But, the boom in the industrial sector and the demand of

rapidly growing population has brought the ground water reservoirs to its peak of exhaustibility. Not just over exploitation of ground water resources is a concerning factor but its toxicities has created an alarming situation all around the world. Many hard water causing substances introduced in the water bodies

has become a prime reason for its contamination. Fluoride is one such pollutant that undermines living life forms especially human beings. Fluoride is the 13<sup>th</sup> most abundant element found in the earth crust they are highly electronegative and cause groundwater pollution. Fluoride contamination in groundwater has impacted the life of human beings and thus it has started gaining importance worldwide. Researchers all around the world are looking at various methods like conventional and non-conventional methods to remove fluoride content in ground water. The Bioremediation technique of different wastewater has been considered as a relatively new technology that has undergone more intense investigations (Singh *et al.*, 2017).

#### Source of Fluoride Contamination:

The Fluoride contamination in ground water can be categorised as:

#### Geo-genic sources

The release of fluoride in the groundwater can be through the fluoride-bearing rocks like Calcium Fluoride, Apatite, Cryolite, Magnesium Fluoride that are found naturally and dependent on the parameters like the solubility of minerals, availability, concentration, pH, and velocity of flowing water. The presence of fluoride is also because of some specific fluoride rich minerals such as Amphiboles and Mica which are common in crystalline rocks and soils (Rajput, 2021). With heavy rainfall, leaching of fluoride occurs from minerals in the rocks and soils. Release of fluoride also increases due to the runoff and slow dissolution from the weathering of these rocks; (Amin, 2013).

#### Ground water is contaminated naturally through fluoride bearing rocks like

- Calcium Fluoride,
- Apatite, Cryolite,
- Magnesium Fluoride, also
- Amphiboles and
- Mica

These are common in crystalline rocks and soils and source of fluoride in water. The amount of fluoride also increases due to the runoff in ground water.

#### Anthropogenic sources

Fluoride can be incorporated into the water through many point and nonpoint sources such as Aluminium Manufacturing Industry, Ceramic Industry,

Enamel Industry, Fibre glass Industry, Pesticide Industry, Fertilizer Industry, Coal, Phosphate Industry etc. These industries release large amount of fluoride content in groundwater. The impact on Groundwater depends on various factors like- (Singh *et al.*, 2017)

- Solubility of minerals
- concentrations
- pH level of the contaminants
- Speed of water.

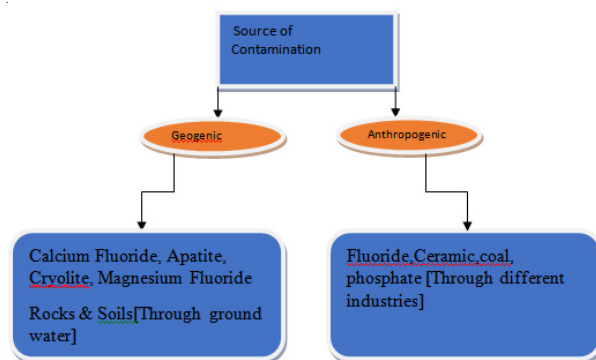


Fig. 1. Sources of Contamination

The main made sources of fluoride such as Aluminium Manufacturing Industry, Ceramic Industry, Enamel Industry, Fibre glass Industry, Pesticide Industry, Fertilizer Industry, Coal, Phosphate Industry etc. These industries release noteworthy quantities of Fluoride in the streams.

#### Status of Fluoride contamination

The problem of Fluoride contamination is all embracing and more than 25 countries worldwide are suffering from it. Countries like India, China, East Africa, Turkey and South Africa have high fluoride concentration in the ground water, because of which there is a high risk of fluorosis in these countries. The focus of fluoride contamination in India is the Indo Gangetic plain, where the fluoride concentration in ground water is very high. In a report published in 2017, Health Ministry has identified that at least 132 districts in 19 states specially Rajasthan, Telengana, Karnataka, Andhra Pradesh, Maharashtra, Bihar are severely affected by high fluoride content in drinking water. India's 11.5 million people are at high risk (Kisku *et al.*, 2020). Fluorosis has affected the lives of people in India; around 1% of all Indians are suffering from Fluorosis (Devi *et al.*, 2007).

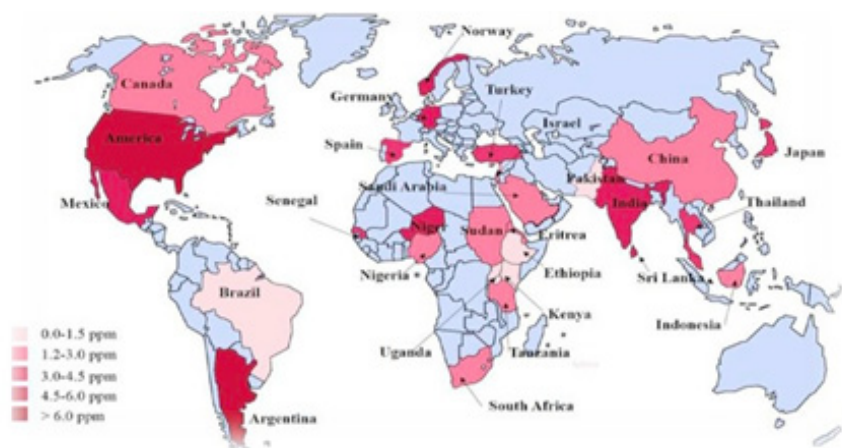
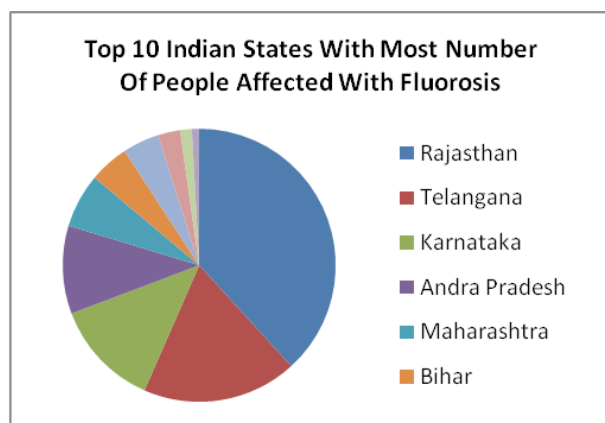


Fig. 2. World Map highlighting countries severely affected by fluoride contamination (Chen *et al.*, 2017)



**Health hazards due to Fluoride contamination in Ground Water**

When the intake of fluoride exceeds the permissible limit, it causes fluorosis. Higher concentration of fluoride has several detrimental impacts on humans. Fluorosis is considered to be a harmful disease; its main cause is fluoride accumulation in soft and hard tissues of the body (Chen *et al.*, 2017)

On the basis of the body parts it affects, it has been categorised as -

**Skeletal fluorosis**

Due to this type of fluorosis, major bones and joints

of the human body such as shoulder, backbone, neck, hip and knee joints get affected. It gives rise to unbearable pain, inflexibility or rigor in joints. Its severity can cause disability. It is endemic in India (Hussain *et al.*, 2012).

**Non-skeletal fluorosis**

This category of fluorosis majorly effects on soft tissues or systems in various ways. The chronic toxicity can weaken the bone strength and can cause ossification of ligaments and tendons. It can also be categorised as gastrointestinal, neurological, muscular, allergic manifestation, effects on foetus, low haemoglobin levels, urinary tract manifestation, ligaments and blood vessel calcification (Zheng *et al.* 2020).

**Dental fluorosis**

It basically discolours and disfigures the teeth. Analysing the condition worldwide, it has been observed that dental fluorosis is more prevalent in the young people as compared to adults. It can also be categorised as Grade-1, Grade-2 and Grade-3 on the basis of its severity (Hussain *et al.*, 2004).

**Effects of fluoride in plants**

Along with its impact on Human body, fluoride is

**Table 1.** Standards set by various organisations for fluoride content in drinking water –

Name of the Organization	Desirable limit (mg/l)
Bureau of Indian Standard (BSI)	0.6-1.2
Indian Council Of Medical Research (ICMR)	1.0
The Committee on Public Health Engineering Manual and code of Practice, Govt. Of India	1.0
World Health Organization (International Standard for Drinking Water)	1.5



Fig. 3. Effect of Fluoride in Teeth

very harmful to plants as well. There are few plant species which show moderately higher level of concentration of fluoride from normal soil. It has been found out that Tea (*Camella sinensis*) is one such example, the leaves of which consist of fluoride above 200 mg/kg. Wheat (*Tritium aestivum*) is another example which gets affected by fluoride contamination (Waghmare *et al.*, 2015) Fluoride can cause:

1. Chlorosis: Causes loss of the normal coloration of leaves of plants.
2. Necrosis: causes Dark watery spots on leaves.
3. Causes affected plant growth
4. Causes burning of leaf tip

### Methodology

Bioremediation was invented by George M. Robinson. Bioremediation is using living microorganisms to eliminate contaminants from the environment with the use of naturally occurring bacteria, fungi or plants to eliminate substances that are not good for human health or environment (Chauhan *et al.*, 2012). It has been demonstrated that this method can be an effective solution to tackle wastewater due to the capability of microorganisms to survive, adapt and thrive within many environ-

ments (Igiri *et al.*, 2018). It is effective on organic pathogen, arsenic, fluoride, nitrate, VOCs, metals and many other pollutants such as ammonia and phosphate. It is effective in cleaning insecticides and herbicides and the salt water intrusion into aquifers (Amin *et al.*, 2013). In spite of using expensive equipment to remove environmental toxic materials and disposing of them elsewhere, we can use Bioremediation process to clean it up.

### Bioremediation Strategies

There are two main categories of Bioremediation -

#### 1. *In situ* techniques

This is done on soil and groundwater at the site without disturbance, it is also cost effective.

It can again be categorised as

- a. Bio venting-  
The stimulating of bacteria by supplying air and nutrients through wealth in soil is called bio venting.
  - b. Bio-sparing-  
It helps in increasing the mixing of upper soil and contact between soil and groundwater.
  - c. Bio-augmentation  
The contaminant site native to various microbes is added with microorganism.
  - d. Phytoremediation-  
It uses different types of plants to remove, transfer or to destroy contaminants that are present in the soil and groundwater (Mukherjee *et al.*, 2015)
- #### 2. Ex-situ techniques
- It is used on the ground water reservoirs on the sites which is removed after digging up the soil. This technique can again be subdivided into-
- a. Land farming  
In this contaminated soil is excavated from its natural site and spread over a prepared bed for periodically tilted until pollutants are degraded.
  - b. Composting  
It involves combining polluted Soil with organic



Fig. 4. Fluorosis in plants



matter like manure or agricultural waste which is non-hazardous.

c. Bio piles

It is the combination of land farming and composting (Lin *et al.*, 2017)

### Bioremediation to remove Fluoride

Osmosis, Niño-Filtration, Electro dialysis Adsorption etc., these are some of the methods that are used to treat ground water with high fluoride concentration (Coelho *et al.*, 2015).

But due to some reasons like high investment, high sludge generation and secondary pollution due to these reasons researchers have been forced to think about Bio remediation as a final path way

### Mode of Action

Microbes and Bacteria have the capacity to develop resistance to their surroundings through the biological process (Mukherjee *et al.*, 2017). To reduce metal groups which have a binding property such as amines, carboxylates and phosphates the Bacterial cellwall are use which facilitates in the interaction with metal ions.

Experimenting with various microbes, it has been found that *Pseudomonas putida* has showed that it can resist fluorides with a high percentage. The maximum percentage of fluoride elimination achieved by its 92.8% at 25 hours of contact period at temperature of 37 degree. *Paenibacillus* removes fluoride up to 73.3% at 40 degree temperature and pH8. *Acinetobactor* has the maximum capacity to remove fluoride of 25.7% at 30 degree having a wide pH range (Zhang *et al.*, 2019).

### Principle of Bioremediation of Enzymes

A microorganism contains enzymes which allow them to use environmental contaminants as food which makes them suitable for the task of contaminant destruction. Enzymes mediate metabolic reactions which belong to the group of ox reductants, leases etc. (Karigar *et al.*, 2011).

### Advantages of Bioremediation

#### Natural Process

It is considered as an acceptable and effective waste treatment process for contaminated water (Saxena *et al.*, 2018).

#### Harmless residues

The residues required for the process of bio

remediation are harmless for ex. Carbon dioxide, water etc. (Dasaiah *et al.*, 2020).

#### Cost effective

This method is very cost effective making it easily approachable on a mass scale comparable to other methods available

#### Less Energy

The energy required is very less compared to other methods.

#### Complete Destruction

Rather than transferring contaminant to other place this process results in complete destruction of contaminated material.

### Conclusion

Reviewing extensive variety of procedures which has been utilised so far to treat the industrial water from fluoride contamination, bioremediation techniques are becoming popular day by day for cleaning and treating contaminated water. The protection of the environment is now becoming a top priority for the authorities all around the world and this has led to series of researches made to cure the problems in the environment. Contamination of water and soil has resulted in disruption in food chain this is further creating an ecological imbalance in the environment. Use of machines and chemicals have so far be the fastest and cheapest means to curb this problem but instead of curbing it is increasing the problem of water and air contamination. Natural processes used in Bioremediation techniques is thus considered as the most efficient means to treat the soil and it will bring down the fluoride contamination and other kinds of metal components in water. Thus this one small step of bioremediation techniques can be a giant leap in curbing the problem of water contamination.

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