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Prevalence and Assessment of Fluoride and Nitrate Contamination in Selected Groundwater Sites of Hingoli, Maharashtra, India

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Abstract: Water is vital component for life. Groundwater is one of the important sources of water in many parts of country. Especially in rural area, sometimes it is the only available source of water for primary use. Contamination of groundwater sources leads to several health problems in humans. The present study conducted in selected groundwater sites from District of Hingoli, Maharashtra, India. Analysis and assessment of groundwater samples for fluoride and nitrate levels was performed as per the standard guidelines from World Health Organization (WHO) and American Public Health Association (APHA). The results illustrate that some of water samples possess excess amount of fluoride and nitrate. The possible reason behind increased levels of fluoride as well as nitrate levels can be due to the use of chemical fertilizers, pesticides and waste disposal leachate.

Keywords: Water, Groundwater, Fluoride, Nitrate, Contamination

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Introduction

Water is one of the natural resources. Water is vital component for life. It is well known fact that about around 70% of the earth's surface is covered with water. Most of the water in the oceans is unusable form while some of them are in frozen forms. Humans highly depend on groundwater sources. In case of India, various

reports showed that majority of population depend on groundwater sources such as wells, boars, tube wells, handpumps etc. because, sometimes groundwater is the only resource available for intake of water (Pawale *et al.*, 2008). This is common scenario found in rural part of India. Quality of groundwater is one of the major

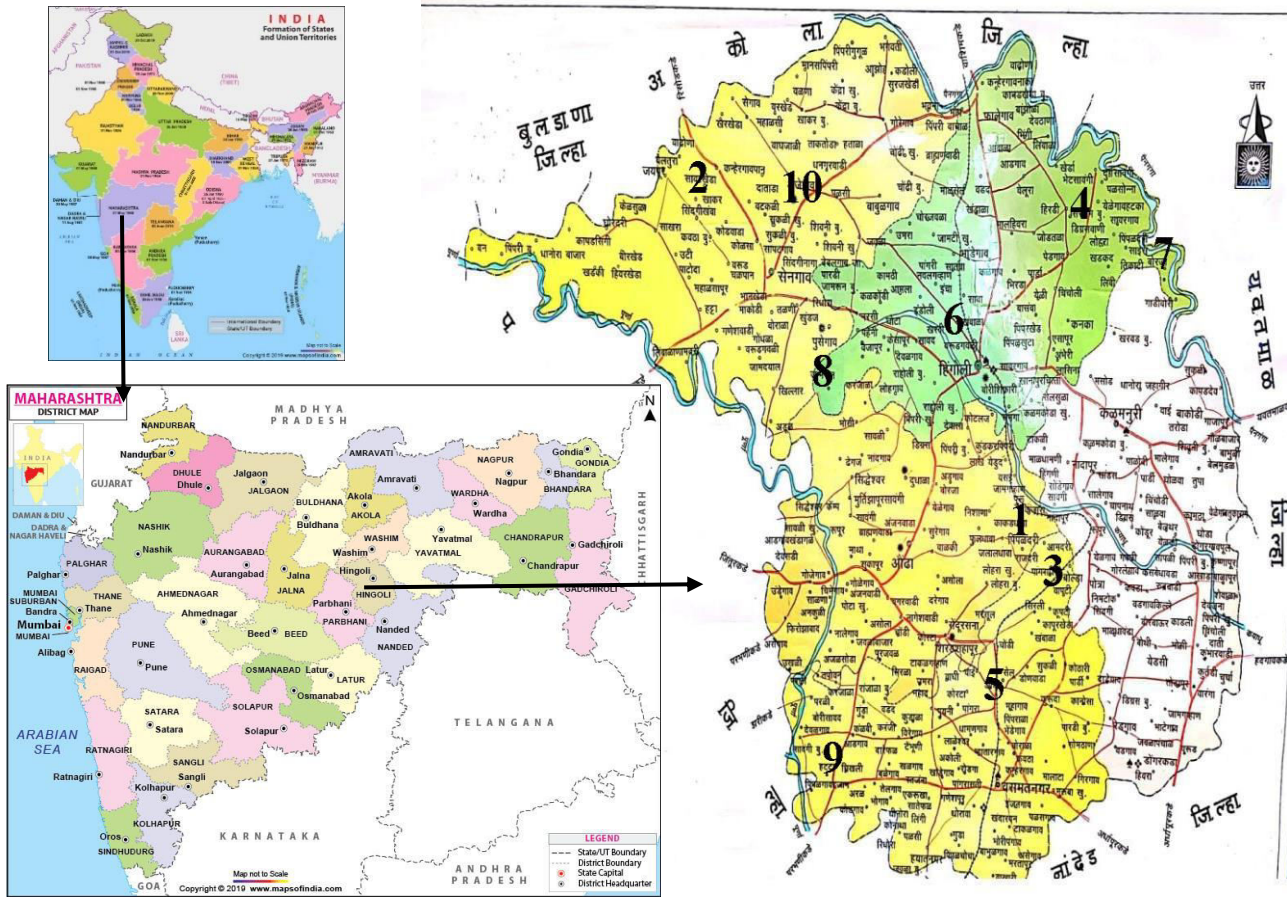


Fig. 1: Study area (Source: <https://hingoli.nic.in/map-of-district/>).

challenges across the globe. Increase of various contaminants in groundwater give rise to serious health impact on humans and other organisms.

Groundwater is used for various purposes which mainly includes drinking and irrigation. Groundwater can be considered as backbone in the arid and semi arid regions across the world (Sunitha *et al.*, 2021). The groundwater contamination is caused due to various geogenic as well as anthropogenic activities (Reddy and Sunitha, 2020). The quality of groundwater is the major concern while choosing the applicability for particular purpose. All around the world, since from 1990s, groundwater contamination by fluoride and nitrate is major concern for public. However, various factors are responsible for the increasing of fluoride and nitrate levels.

Fluoride and Nitrate are the naturally occurring constituents. Various Geogenic and Anthropogenic

activities cause increase in levels of fluoride and nitrite. Less than 1.5 mg/L of fluoride in water is considered as safe for drinking purpose while as per the Indian drinking water standard (BIS) up to 45 mg/L of Nitrate is the maximum permissible limit for drinking (Mukate *et al.*, 2022). Fluoride is naturally occurring mineral found in water. It is often known as double edged weapon, as permissible limit is good for human's body but more than that are harmful for humans. Many health-related problems can occur due to high intake of fluoride such as dental fluorosis, skeletal fluorosis, osteoporosis, etc.

Nitrate is one of the commonly occurring contaminants in groundwater resources. High nitrate concentrations in drinking water pose threat to human and animal health and may cause eutrophication of aquatic systems threatening fish, biodiversity, aesthetics and economics.

Table 1: Villages under study and their geographical position

S. No.	Name of Village	Latitude	Longitude
1	Pimpaldari	19.57272°	77.16820°
2	Sawarkheda	19.71035°	77.18769°
3	Pangra (Shinde)	19.54756°	77.22001°
4	Sirsam	19.84483°	77.24329°
5	Amba	19.45943°	77.17369°
6	Parola	19.78466°	77.14738°
7	Borja	19.61651°	77.08538°
8	Jamrun Tanda	19.78607°	76.95142°
9	Hatta Tanda	19.32982°	76.94211°
10	Ajegaon	19.87529°	76.92209°

Over exploitation of groundwaters in India accompanied by urban development and agricultural intensification will exacerbate nitrate pollution of groundwaters in the country. High levels of nitrate can turn skin to a bluish or grey colour and cause more serious health effects like weakness, increased heart rate, fatigue, and dizziness.

Materials and Methods

The area of study (Fig. 1) selected for present research is located 50 km apart of Hingoli district in between latitudes 19.32982° N and 19.87529° N; longitudes 76.92209° E and 77.24329° E including 10 villages of Hingoli district. Water samples were collected in sterile plastic bottles from different locations as well as sources such as wells, boars, hand pumps etc. Collection of water samples was done as per the standard guidelines by APHA (1995). The presence of fluoride and nitrate in the samples was evaluated by SPADNS spectrophotometric method.

Figure 1 shows graphical presentation of India, Maharashtra and District Hingoli. Table 1 shows names of villages and its geographical position. 10 villages were selected for the detection of amount of fluoride and nitrate.

Results and Discussion

Table 2 illustrates that nine out of ten water samples contained high amount of fluoride where as three water sample showed high amount of nitrate. In the nine water samples the amount of fluoride was slightly higher than the permissible limits, i.e. 1.5 mg/L, only the village - Borja shows 2.01 mg/L of fluoride and it is the highest fluoride concentration observed as compared to other villages where as other eight villages namely, Pimpaldari, Sawarkheda, Sirsam, Amba, Parola, Jamrun Tanda, Hatta Tanda and Ajegaon showed fluoride range between 1.58 and 2.0 mg/L.

On the other hand, three water samples showed high amount of nitrate than permissible values, i.e. more than 45 mg/L. Pimpaldari, Amba and Parola were the villages which showed more than permissible value of nitrate. However, highest nitrate concentration was observed in Amba which is 97.1 mg/L.

The presence of fluoride and nitrate may be because of local situation, anthropogenic/geological reasons. The samples which showed high amount of fluoride (more than 1.5 mg/L) and nitrate (more than 45 mg/L) are unfit for consumption as per the guidelines of World Health

Organization. During the collection of water samples, common phenomenon observed about fluoride and nitrate is its unawareness and this may be one of the reasons behind large number of people facing health problems. During the last few decades, nitrate and fluoride have been one of the burning problems on human health. (Reddy *et al.*, 2022) It is need of time to aware the local people about quality of water and its effects.

Table 3 shows effects of high amount of fluoride on human body. During the study, we also observed that, yellowing of teeth and patches on teeth is one of the common factor in people who are consuming water from these resources. However, people are unaware about the contents in water and reason behind the yellowing of teeth etc.

Excess intake of fluoride may cause several Diseases such as Yellowing of teeth, Dental Fluorosis, Skeletal Fluorosis, parathyroid disorders, abdominal pain, abnormalities in RBC's etc. Dental Fluorosis is one of the widely observed problem due to intake of excess amount of fluoride. Risk causes due to intake of excess fluoride amount leads to several health hazards.

(i) Dental fluorosis: It is a common disorder, characterized by hypo-mineralization of tooth enamel caused by ingestion of excessive fluoride during enamel formation. It appears as a range of visual changes in enamel causing degrees of intrinsic tooth discoloration and in some cases physical damage to the teeth (Singh and Kumar, 2018).

(ii) Skeletal fluorosis: It is caused by excessive accumulation of fluoride leading to weakened bones. In advanced cases, skeletal fluorosis causes painful damage to bones and joints. The serious thing is that as of now, there are no established treatments for skeletal fluorosis patients. However, it is reversible in some cases, depending on progression of the disease (Yadav and Singh, 2021).

(iii) Parathyroid Problems: In some cases, excess of

fluoride can damage the parathyroid gland. This can result in hyperparathyroidism, which involves uncontrolled secretion of parathyroid hormones. This can result in depletion of calcium in bone structures and higher than normal concentrations of calcium in the blood.

(iv) Neurological Problems: Exposure to fluoride before birth could lead to poorer cognitive outcomes in the future. Various reports also suggested that excess of fluoride intake also effects on the intelligence of 10–12-year-old school children.

Excess intake of Nitrate cause following diseases:

(i) Blue Baby Syndrome (methemoglobinemia): Nitrate can affect oxygen carrying capacity of blood. Nitrate can turn hemoglobin (the protein in blood that carries oxygen) into methemoglobin (Munoth *et al.*, 2015). High levels can turn skin to a bluish or gray color and cause more serious health effects like weakness, excess heart rate, fatigue, and dizziness. Nitrate can affect babies more seriously because their bodies interact with nitrate differently. When nitrate levels are high, water should not be given to babies less than 6 months old.

(ii) Birth Defects: High levels of nitrate in drinking water may cause neural tube defects (a type of birth defect). The neural tube turns into the brain and spine in an unborn baby. Neural tube defects can occur very early in pregnancy. When nitrate levels are high, women who are or may become pregnant should immediately stop using the water for drinking and preparing foods that use a lot of water.

(iii) Thyroid Disease: High levels of nitrate in drinking water may increase the risk of thyroid disease. Nitrate can affect the thyroid functions by blocking the uptake of iodine. The thyroid needs iodine to make hormones. Low levels of thyroid hormone levels can cause fatigue, weight gain, dry skin, hair loss, and goiters (enlarged thyroid). When nitrate levels are high, everyone should avoid long-term use of the water for drinking and

Table 2: Amount of fluoride and nitrate per litre and type of groundwater source

S. No.	Name of Village	Amount of Fluoride Per Litre	Amount of Nitrate Per Litre	Type of Groundwater Source
1	Pimpaldari	1.71	46.0	Well
2	Sawarkheda	1.68	15.0	Well
3	Pangra (Shinde)	1.58	13.3	Hand Pump
4	Sirsam	1.72	22.5	Borewell
5	Amba	1.77	97.1	Hand Pump
6	Parola	1.90	47.0	Hand Pump
7	Borja	2.01	42.0	Borewell
8	Jamrun Tanda	1.92	44.0	Hand Pump
9	Hatta Tanda	1.60	25.0	Hand Pump
10	Ajegaon	1.64	12.0	Well

Table 3: Fluoride levels and their effects on human

Fluoride Conc. (mg/L)	Effects of fluoride on human
<0.5	Dental carries.
0.5-1.5	Promotes dental health and prevents tooth decay and cavities.
1.5-4.0	Dental fluorosis, mottling and pitting of teeth.
4.0-10.0	Dental and skeletal fluorosis, pain in the back and all joints.

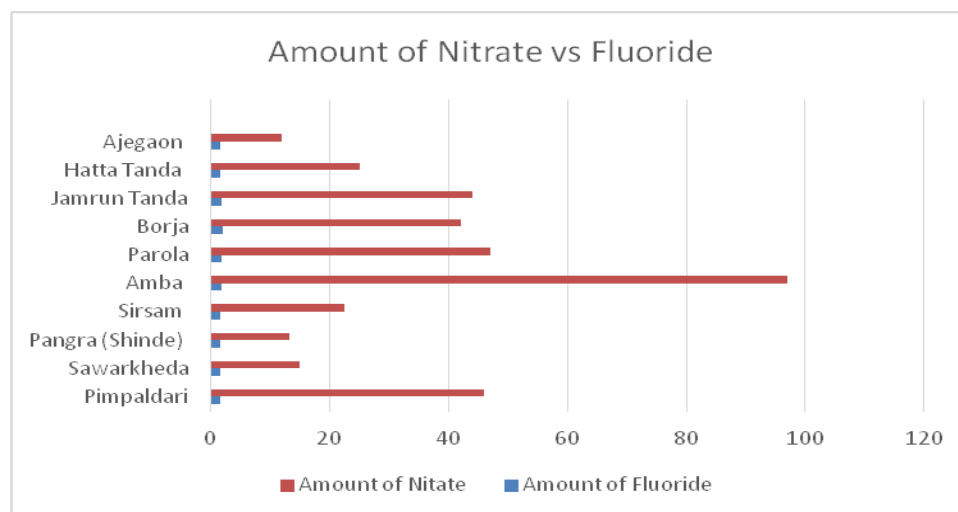


Fig. 2: Amount of nitrate vs fluoride in various villages

preparing foods that use a lot of water.

(iv) **Cancer:** High levels of nitrate in drinking water may increase the risk of colon cancer. Nitrate may enhance the cancer potential of other compounds or may turn into cancer-causing chemicals like the body. Nitrate in drinking water has not been shown to increase the risk of other kinds of cancer.

When nitrate levels are high, everyone should avoid long-term use of the water for drinking and preparing foods that use a lot of water. Figure 2 illustrates amount of nitrate vs fluoride in different villages.

Unawareness is one of the big challenges for water quality related problems. During the study,

we found that majority of people are unaware about quality of water and consequences arises due to it. In rural area where there is depth of underground water sources is high, possibility of prevalence of fluoride and nitrate content also increases. Sometimes, in rural area, underground water sources such as boar wells, wells, handpumps are the only available water sources for drinking or primary use.

Conclusion

The higher amount of fluoride and nitrate observed in various groundwater samples. Nine water samples out of ten showed slightly high amount of fluoride as well as three water samples showed high amount of nitrate than the permissible values. However, the readings of fluoride and nitrate observed are pre-monsoon. Later, due to monsoon dilution of fluoride and nitrate may happen.

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