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CONTAMINATION OF FLUORIDE IN GROUNDWATER AND ITS IMPACT ON HUMAN HEALTH IN PONDI-UPRODA BLOCK IN KORBA DISTRICT, CHHATTISGARH

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ABSTRACT

Fluoride is a frequent chemical element present in groundwater. Fluoride can reduce dental caries when taken in modest amounts, increased fluoride concentrations could induce dental fluorosis or tooth decay, In April-May 2021, twenty-four samples were obtained at random from different villages in the Pondi-uproda block of the Korba district. The Ion-Selective Electrode (ISE) technique and TWAD water testing kit were used to assess the concentration of fluoride in groundwater. Fluoride levels ranged from 0.78 to 8.62 mg/l in the groundwater of the study area, according to the findings. The majority of people in these areas depend on groundwater for irrigation, drinking and domestic use. In this location, 66.6% of samples had fluoride that exceeded WHO permitted limits. Dental and skeletal fluorosis is caused by excessive fluoride levels in drinking water; as a result, a suitable defluoridation method for water treatment in this area should be used.

KEY WORDS : Ion-Selective Electrode, TWAD, Water testing kit, Pondi-uproda block, Water treatment.

INTRODUCTION

Almost 85% of the population in India relies on groundwater; thus groundwater quality has to be addressed on a case-by-case basis. Groundwater was largely considered safe and frequently used without appropriate risk evaluation for drinking (Ali *et al.*, 2019). This notion goes against several studies, which have emphasized groundwater contamination through several geogenic and human methods. The fluoride is taken from florid-rich rocks such as CaF_2, Na_3AlF_6 and $3Ca_3(PO_4)_2.Ca(FCl)_2$, which have 49%, 13.5 – 26% and 6.8% correspondingly of the fluoride (Saxsena *et al.*, 2016), if the surface waters percolate in the aquifers via the strata. Fluoride is an essential component of human existence. Fluoride contamination is caused by both natural and human sources in the environment. Fluoride is often found in mineral deposits and is typically discharged into groundwater as a result of the gradual natural decomposition of fluoride-bearing rocks. The solubility of CaF_2 in groundwater, which is influenced by lithology, rock weathering, and other chemical parameters in groundwater, as well as the hydrochemical facies and climate of the location, determines fluoride distribution in groundwater (Girhe *et al.*, 1996) (Dar *et al.*, 2011) (Paul *et al.*, 2011). Fluoride deficiency or excess in the environment is strongly linked to human health consequences (Babu *et al.*, 2016), Fluoride intake of less than 0.5 mg/l causes adverse health effects such as dental caries, lack of dental enamel formation, and deficiency in bone mineralization, especially in children, whereas excessive fluoride intake (>1 mg/l) causes calcium loss from the tooth matrix, aggravating cavity formation and inducing dental fluorosis. As a result, fluoride has a very restricted range of positive and negative effects. As a consequence, the risk of dental fluorosis rises faster than the reduction in dental decay as fluoride concentration rises (Kashyap and Ghosh, 2021). Skeletal fluorosis, on the other hand, occurs when fluoride (>3 mg/l) is present in drinking water and the water is consumed for 8–10 years (Zhang *et al.*, 2003). In general, dental fluorosis symptoms were observed in youngsters up to the age of 12 years (WHO, 1996). Fluoride solubility limits fluoride concentrations in water, thus high element concentrations can be predicted in groundwater from calcium-deficient aquifers (Nawlakhe *et al.*, 1989). Several researchers reported low Ca and Mg contents in water, correlating to high fluoride levels also revealed that high fluoride-bearing groundwater typically has a low concentration of calcium and high concentration of bicarbonates (Apambire *et al.*, 1997) (Edmunds *et al.*, 1996) (Nanyaro *et al.*, 1984) (Maina *et al.*, 1984), which are saturated in both calcite and fluorite.

The issue of excessive fluoride concentrations in groundwater sources has now become one of India's most pressing toxicological and geo-environmental concerns (Teotia and Teotia, 1988). Fluoride contamination in groundwater and fluorosis caused by consumption of this element through drinking water are on the rise in India; however, accurate estimates of the number of individuals at risk of exposure are unclear. The lack of a comprehensive study and definition of fluoride-affected areas is the cause for this. So far, investigations have been conducted in a variety of locations and have not been standardized. The purpose of this report was to provide readers with an overview of fluoride pollution in groundwater, as well as the implications of human exposure and the negative health impacts associated with fluoride toxicity.

MATERIALS AND METHODS

Study area

The Korba district, located between $22^0$01'50" and $23^0$01'20" N latitude and $82^0$07'20" to $83^0$07'50" E longitude, is the state of Chhattisgarh's coal-based thermal power hub. The Korba district is geologically underlain by three different geological formations that range in age from the ancient Archean to the recent. The Korba district region is divided into three geological groups: the Chhotanagpur Gnessic Complex (CGC), the Chhattisgarh Supergroup, and the Gondwana Supergroup of rocks. The Pondi-uproda block, which is the largest in Korba district, is located on the district's middle-north side. The Pondi-uproda block was a study area in this investigation. The study area has forests and small villages.

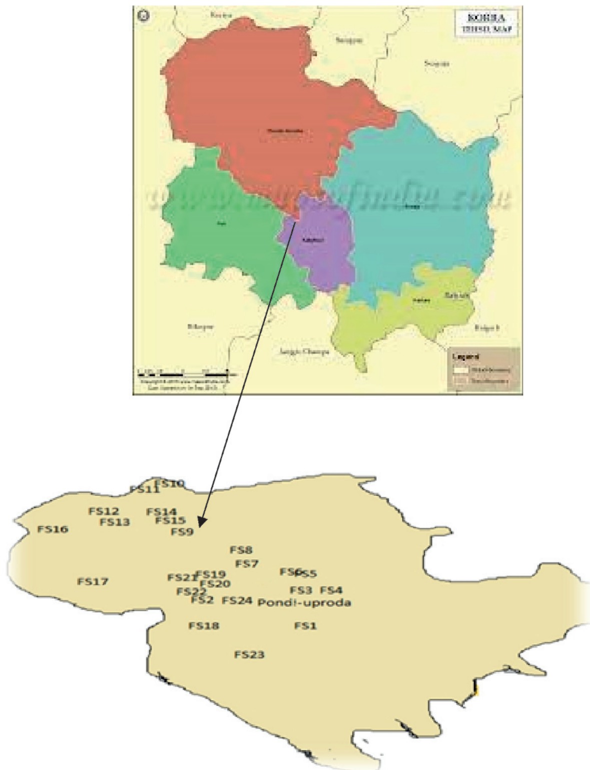

Fig. 1. Groundwater sampling station of study area.

Sampling of Groundwater

Borewells and hand pumps were used to gather field samples in various places around the pondi-uproda block 250-500 ml of each sample was acquired in cleaned plastic cans or bottles and kept at room temperature in the lab for analysis 24 field samples were obtained.

Regents

The Tamil Nadu Water Supply and Drainage Board provided the field fluoride testing kit (TWAD). Each vial of zirconium xylenol orange reagent contains 20 ml. The fluoride measurement method was created at Bhabha Atomic Research Centre and is based on the bleaching of zirconium xylenol orange complex. A color chart with a range of 0–5 mg/l is also included in the package. The user must combine a 5 mL water sample with 1 ml zirconium xylenol orange reagent to complete the test. The fluoride content in the sample determines how the color shifts from pink to yellow. The fluoride concentration in the water may be determined by comparing the color generated with the color chart. Due to human inaccuracy in visual assessment, it is difficult to accurately measure concentration. Furthermore, precisely measuring liquid amounts in the field is challenging, resulting in extra inaccuracies.

The ISE and meter (Thermo Scientific, Orion Star A214), as well as TISAB-III and Fluoride standard 100 mg/l, were fluoride analysis is carried out with this device. In the fluoride analysis, plastic goods were employed.

RESULTS AND DISCUSSION

For this investigation, twenty-four samples were randomly selected from Pondi-uproda block (FS1 to FS24) regions for fluoride analysis of the samples using the ISE method. The fluoride content in this region varied from 0.78 to 8.62 mg/l (Table 1) with a mean of 2.92 mg/l. In this location, 66.66 % of samples above WHO's fluoride maximum permitted levels (1.5 mg/l) (Figure 2). FS19 and FS23 have the highest and lowest fluoride amounts, respectively.

Comparison between Ion Selective Electrode and TWAD water analyzer kit

The results of the TWAD fluoride test kit were equivalent or many different to those of the ISE. The Figure 2 below compares the two fluoride analysis methods using typical samples from the 24 sample tests (Table 1).

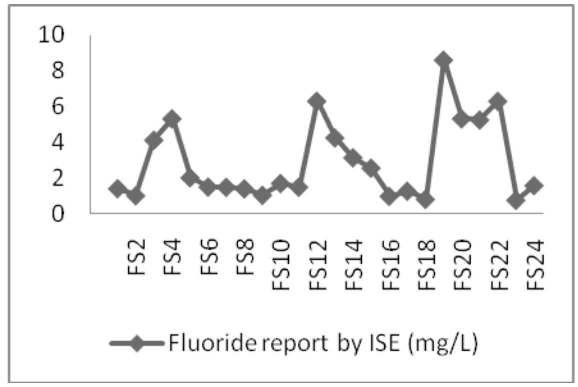

Fig. 2. Fluoride in obtained samples in Pondi-uproda block.

Fluoride contamination in this area is mostly caused by the leaching of fluorine-bearing rocks, as no man-made pollution has been detected. Fluorite, apatite, mica, and other minerals participate in the rock–water interaction, releasing fluoride into the groundwater. Fluoride in drinking water exceeding

Table 1. Fluoride report in mg/l as determined by the ISE and TWAD Fluoride Analyzer Kit.

SN	Sample location spot	Code of groundwater samples	Fluoride report by ISE (mg/l)	Fluoride report by TWAD kit (mg/l)
1	Gursia	FS1	1.43	2.0
2	Jatga	FS2	1.03	2.0
3	Fulsar	FS3	4.14	5.0
4	Fulsar school	FS4	5.34	5.0
5	Korbi	FS5	2.04	4.0
6	Khajur para	FS6	1.52	3.0
7	Vijay west	FS7	1.51	1.5
8	Tanera	FS8	1.42	2.0
9	Kumharidarri	FS9	1.06	1.5
10	Piparia	FS10	1.72	3.0
11	Piparia market	FS11	1.51	3.0
12	Pondikala Basti	FS12	6.32	5.0
13	Pondikala	FS13	4.27	5.0
14	Pandopara	FS14	3.16	5.0
15	Pandopara basti	FS15	2.58	4.0
06	Pasan	FS16	1.0	2.0
17	Lokadha	FS17	1.29	1.5
18	Amlikunda	FS18	0.83	1.0
19	Amatikra basti	FS19	8.62	>5.0
20	Amatikra road	FS20	5.34	>5.0
21	Amatikra school	FS21	5.27	>5.0
22	Amatikra ground	FS22	6.32	>5.0
23	Amaldiha	FS23	0.78	1.0
24	Loribahra	FS24	1.60	2.0

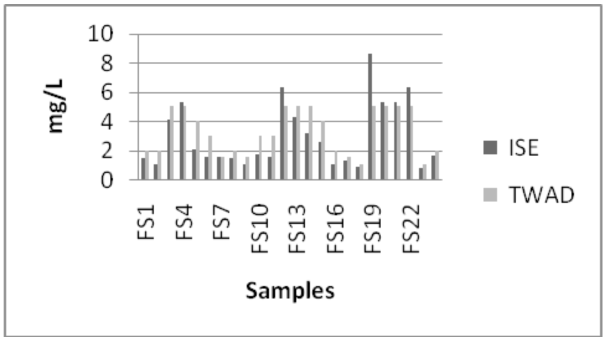

Fig. 3. Comparative fluoride levels by ISE and TWAD kit method in obtained samples in Pondi-uproda block.

1.5 mg/l causes dental fluorosis, which is quite prevalent in this area, but some older individuals in villages like Pondikala, Amatikra, and Fulsar have skeletal fluorosis.

Health impact due to excess of fluoride in groundwater

There is a well-established Connects the presence of fluoride geochemistry with dental and skeletal fluorosis in water. Because the radii of F^- and OH^- are comparable, there is an interchange of these two ions in the context of the environment. Hydroxylapatite is the primary component of teeth and bones (Handa, 1975). When fluoride is present, the OH^- is substitute by F^-, forming fluorapatite, which causes various types of fluorosis. The types of fluorosis are discussed next and show in Figure 4.

White patches or horizontal stripes on the tooth surface indicate dental fluorosis (Agrawal *et al.*,

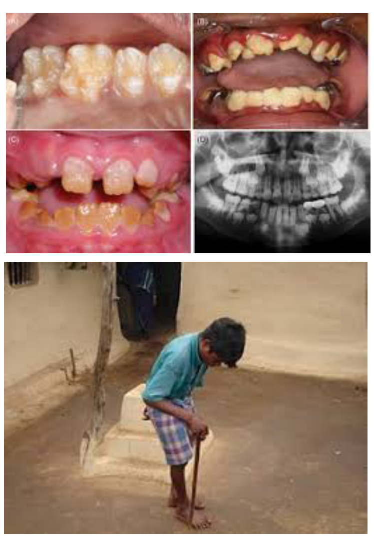

Fig. 4. Health impact after consuming high fluoridated groundwater.

1997). These patches may become discoloured yellow, brown, or even black in moderate to severe dental fluorosis, resulting in pitting. Dental fluorosis symptoms appear in youngsters as young as 12 years old. A health survey of the individuals living in the study area was conducted in addition to water sampling in the villages of Pondi-uproda block. The survey indicated that the fluoride in the groundwater was found to be higher than 1.5 mg/l. Dental fluorosis was afflicting the peasants and their children, and their teeth were rotting. The sample spots were primarily FS3, FS4, FS12, FS13, FS14, FS15, FS19, FS20, FS21 and FS22.

Excessive fluoride levels in groundwater have now become one of the most urgent toxicological and geoenvironmental problems. Fluoride in groundwater is mostly derived from fluoride-bearing minerals found in rocks and sediments. To alleviate the suffering of people living in fluorosis-endemic areas, a variety of remedial or preventative interventions might be implemented.

CONCLUSION

Fluoride in groundwater was measured using the Ion-Selective Electrode (ISE) technique and the TWAD water testing kit. Fluoride levels ranged from 0.78 to 8.62 mg/l in Pondi-uproda area, with a mean of 2.92 mg/l. 66.66% of samples in this site above the WHO's fluoride maximum permissible limits (1.5 mg/l). The fluoride levels in FS19 and FS23 are the highest and lowest, respectively. The fluoride test kit's results were similar to or somewhat different from the ISE's. The quantity of fluoride in the groundwater was determined to be greater than the permissible level. The peasants and their children were suffering from dental fluorosis, and their teeth were decaying, FS3, FS4, FS12, FS13, FS14, FS15, FS19, FS20, FS21, and FS22 were the most common sample locations. Some people in FS12, FS13, FS19, and FS20 have acquired skeletal fluorosis, and treatment is having no effect on them due to daily high fluoride content water intake. Fluoride in groundwater is mostly derived from fluoride-bearing minerals found in rocks and sediments. A number of remedial or preventative measures may be adopted to reduce the suffering of individuals living in fluorosis-endemic areas.

Conflict of Interest

There are no conflicts of interest among the authors in this research.

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