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ANALYSIS OF SELECTED FLUORIDE WATER SAMPLES OF DIFFERENT AREAS OF JAIPUR, RAJASTHAN

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Abstract: This study was carried out to assess the fluoride concentration in groundwater in some rural areas of Jaipur city (Rajasthan), India, where groundwater is the main source of drinking water. Due to increased population, urbanization, industrialization, use of fertilizers water is highly polluted with different harmful contaminants. In present analysis a review of fluoride toxicity in drinking water along with the various deflouridation processes has been analyzed. Drinking water quality of 11 different places of Jaipur District was analyzed to identify the fluoride content in water. The drinking water samples were collected in clean polythene one liter cans and subjected for analysis in laboratory.
Keywords: Defluoridation, Fluoride content, Groundwater.
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INTRODUCTION

Fluorine was discovered in 1905. It is the most electronegative of all elements and so, it is the strongest oxidizing agent known to us. In its free state, it is a pale yellow gas with a prudent, irritating odour. Its boiling temperature is –188°C and freezing temperature is –220°C. Fluorine is highly reactive and has a strong affinity to combine with other elements to produce compounds called fluorides.

Optimum concentration of fluoride in drinking water

According to WHO standards, the fluoride in drinking water should be within a range that slightly varies above and below 1 mg/L (Meenakshi *et al.*, 2004). In temperate regions, where water intake is low, fluoride level up to 1.5 mg/L is acceptable. The Ministry of Health, Government of India, has prescribed 1.0 and 2.0 mg/L as permissive and excessive limits for fluoride in drinking water, respectively. The major source of fluoride in the groundwater is fluoride bearing rocks from which it get weathered and/or leached out and contaminates the water. Fluorides occur in three forms, namely, fluorospar or calcium fluoride (CaF_2), apatite or rock phosphate [Ca_3F $(PO_4)_3$ and cryolite (Na_3AlF_6). Concentration of fluorides is five times higher in granite than in basalt rock areas. Similarly, shale has a higher concentration than sandstone and limestone (Figure 1). Alkaline rocks contain the highest percentage of fluoride (1200 to 8500 mg/kg) (Chand, 1998). The geological survey of India has brought out considerable data which reveal that fluorite, topaz; apatite, rock phosphate, phosphatic nodules and phosphorites are widespread in India and contain high percentage of fluorides.

Fluoride in drinking water and its effects on human health

It is well known that the excess fluoride intake is responsible for dental and skeletal fluorosis. The problem of fluorosis has been known in India for a long time. Fluoride enters the human body mainly through the intake of water and to a lesser extents by food. The foods which are rich in fluoride include fish and tea (EPA, 1997). The main objective of the present paper is to aware people of concerned area about the water quality and concerned health hazards.

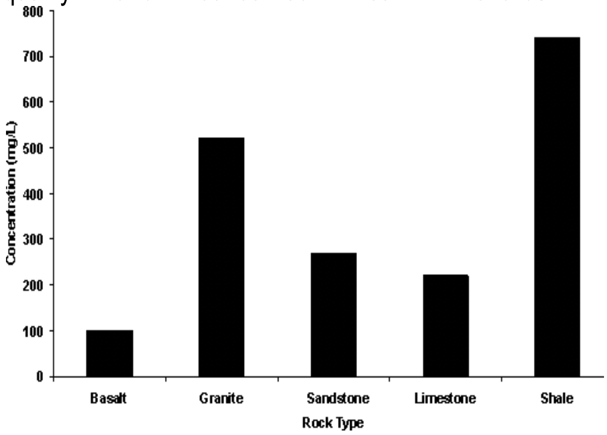

Figure 1: Average Concentration of Fluorine in main rock types

Source: Athavale and Das, 1999

Ingested fluorides are quickly absorbed in the gastrointestinal tract, 35-48% in retained by the body mostly in skeletal and classified tissues, and the balance is excreted largely in the urine. Chronic ingestion of fluoride rich fodder and water in endemic areas leads to development of fluorosis in animal *e.g*. dental discoloration, difficulty in mastication, bony lesions, lameness, de-ability and mortality (Patra *et al.,* 2000). Fluoride is present in the teeth, bones, thyroid gland and skin of animals. It plays an important role on the formation of dental enamel and normal mineralization in bones but can cause dental fluorosis and adversely affect the central nervous system, bones, and joints at high concentrations (Agarwal *et al*., 1997). The fate of fluoride in the soil environment and groundwater is of concern for several reasons. It is generally accepted that fluoride stimulates bone formation (Richards *et al.,* 1994) and small concentration of fluorides have beneficial effects on the teeth by hardening the enamel and reducing the incidence of caries (Fung *et al.* 1999). At lower levels (<2 mg/ml) soluble fluoride in the drinking water may cause mottled enamel during the formation of teeth, but at higher levels other toxic effects may be observed (Weast and Lide, 1990). Excessive intake of fluoride results in skeletal and dental fluorosis (Czarnowski *et al.* 1999). Severe symptoms lead to death when fluoride doses reach 250-450 mg/ml (Luther *et al,*. 1995). It has been found that the IQ of the children living in the high fluoride areas (drinking water fluoride >3.15 mg/mL) was significantly lower (Lu *et al.,* 2000).

Table 1. Concentration of fluoride in drinking water and its effects on human health

S.No.	Fluoride Conc. (mg/L)	Effect
1.	Nil	Limited growth and fertility
2.	< 0.5	Dental caries
3.	0.5 - 1.5	Promotes dental health, prevents tooth decay
4.	1.5 - 4.0	Dental fluorosis (mottling and pitting of teeth)
5.	4.0 - 10.0	Dental fluorosis, skeletal fluorosis (pain in neck bones and back)
6.	> 10.00	Crippling fluorosis

Various Forms of Fluorosis

The various forms of fluorosis arising due to excessive intake of fluoride are briefly discussed below:

Dental fluorosis: This form of fluorosis affects the teeth and mainly occurs in children. The natural shine or luster of the teeth disappears. In the early stage, the teeth appear chalky white and then gradually become yellow, brown or black. The discoloration will be horizontally aligned on the tooth surface as lines or soots away from the gums. Tiny pits or perforations can be seen in the form of cavities on the surface of teeth. Dental fluorosis affects both the inner and outer surface of the teeth. One can become edentulous even as much younger age in the fluoride endemic areas. The disease has mostly cosmetic implications and has no treatment.

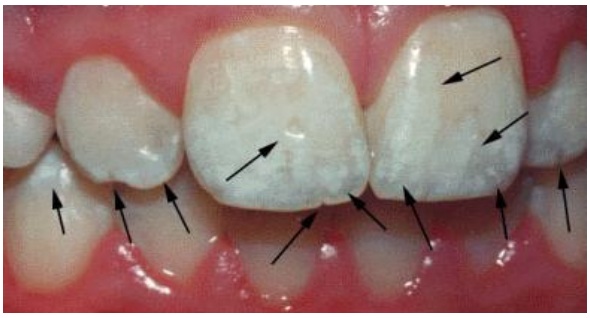

Figure 2. Moderate effects of Fluoridated water (Arrows point to disclosed cracked or pitted areas)

Source: Kumar and Singh 2007

Skeletal fluorosis: Skeletal fluorosis affects the bones/skeleton of the body. Skeletal fluorosis can affect both young and old alike. One can have aches and pain in the joints. The joints which are normally affected by skeletal fluorosis are neck, hip, shoulder and knee that makes it difficult to walk and movements are painful. Rigidity or stiffness of joints also sets in. More worrisome is that skeletal fluorosis is not easily detectable until the disease attains an advanced stage. In severe cases, there is complete rigidity of the joints resulting in stiff spine, called as Bamboo spine and immobile knee, pelvic and shoulder joints.

Figure 3. Skeletal Flourosis Bamboo Spine & Immobile Knee

Non-skeletal manifestations: The soft tissues of the body are may be affected by excessive consumption of fluoride. The symptoms include gastro-intestinal complaints, loss of appetite, pain in stomach, constipation followed by intermittent diarrhoea. Muscular weakness and neurological manifestations leading to excessive thirst tendency to urinate more frequently are common among the afflicted individuals. Cardiac problems may arise due to cholesterol production. Repeated abortions or still birth, male infertility due to sperm abnormalities are also some of the complications.

Fluoride reacts with the stomach acid, Hydrochloric Acid (HCl) to form Hydrofluoric Acid (HF). Because of Fluoride's oxidizing nature, it is immune to the Phase 1 Oxidation reactions in the liver. The Fluoride reaches the bones through general circulation and reacts with the Calcium Hydroxyapatite in bones to form Fluorapatite and the insoluble salt Calcium Fluoride, which is cleared by the body, along with some of the bone matrix. Ironically, this very reaction is used to adsorb Fluoride by using bone char.

Figure 4. Marfan Syndrome Hand Test

Credit: HandResearch.com

EXPERIMENTAL

Study Area: Different areas of Jaipur City shown in location map (Figure 5).

Sample Collection: Water samples from selected sites namely Achrol, Bhanpur, Mansarovar, Kukas, Tonk Road, Gopalpura, Pratapnagar, Vidhyanagar, Raja Park, Vaishali Nagar, Murlipurawere collected and taken in pre-cleaned polyethylene bottles. Samples were analyzed immediately for parameters, which need to be determined instantly and rest of samples were refrigerated at to be analyzed later.

Physico-Chemical Analysis: The collected samples were analyzed for major chemical water quality parameter like content of fluorine in drinking water. Spectrophotometric measurement of fluoride is called SPADNS method. The absorbance was measured between 550 to 580nm for fluoride present in sample solution. The colour is developed as per the concentration of fluoride because of reaction of fluoride and zincronium ions in acidic medium using SPADNS dye.

Preparation of stock fluoride solution: Dissolve 221 mg of anhydrous sodium fluoride solution in distilled water and dilute in 1000mL in a measuring flask. The concentration of this solution is 1mL= 100µg fluoride ions.

Preparation of standard fluoride solution: Dilute 100 ml of stock solution to 1000ml with distilled water so that 1 ml of standard solution has 10 ug fluoride ions.

Preparation of SPADNS solution: Dissolve 958 mg of SPADNS in distilled water and dilute it to 500ml. Solution is stable for 1 year if protected from direct sunlight.

Preparation of acid zirconyl solution: Dissolve 133 mg of zirconyl chloride in 25ml of distilled water. Add 350 ml of concentrated HCL and dilute to 500 ml with distilled water.

Preparation of acid zicronyl- SPADNS solution: Mix equal volumes of SPADNS solution and acid zicronyl solution. This solution is stable for 2 years.

Preparation of sodium arsenite solution: Dissolve 0.5 gm sodium arsenate and dilute it to 1 liter with distilled water. This solution is toxic so use carefully.

Preparation of reference solution: Take 10 ml of SPADNS solution and 100ml of distilled water. Take 7ml of conc. HCL and dilute it to 10 ml with distilled water and this to SPADNS solution .This solution will be used for setting the instrument reference pont (zero) and is stable for about 1 year.

Preparation of calibration curve: Prepare fluoride standard solutions in the range of 0 to 1.40 mg F/L.

i. Take 50 ml of standard solution.
ii. Take 10 ml of acid zicronyl-SPADNS sol and mix it thoroughly with each standard solution.
iii. Switch on the spectrophotometer for sufficient time before taking the readings for proper warm up.
iv. Set the spectrometer to zero absorbance with reference solution.
v. Take absorbance reading for standard solution of Fluoride at 550nm.
vi. Prepare the standard curve of absorbance against concentration of fluoride.
vii. Take absorbance reading for unknown sample solution of fluoride.

RESULTS AND DISCUSSION

The detailed study of fluoride concentration is listed in table 2. It was observed that study area Tonk Phatak, Vaishalinagar and Vidhyanagar are affected by Dental fluorosis (mottling of teeth and Gopalpura, Mansarover, Murlipura and Pratap Nagar are affected by Dental fluorosis (mottling and pitting of teeth) which were under range (1.5-4.0) fluoride content. Study area Achrol, Bhanpur, Kukas and Raja Park is affected by Dental fluorosis, skeletal fluorosis (pain in neck bonesand back), and the fluoride content under range of 4.0-10.0 mg/mL.

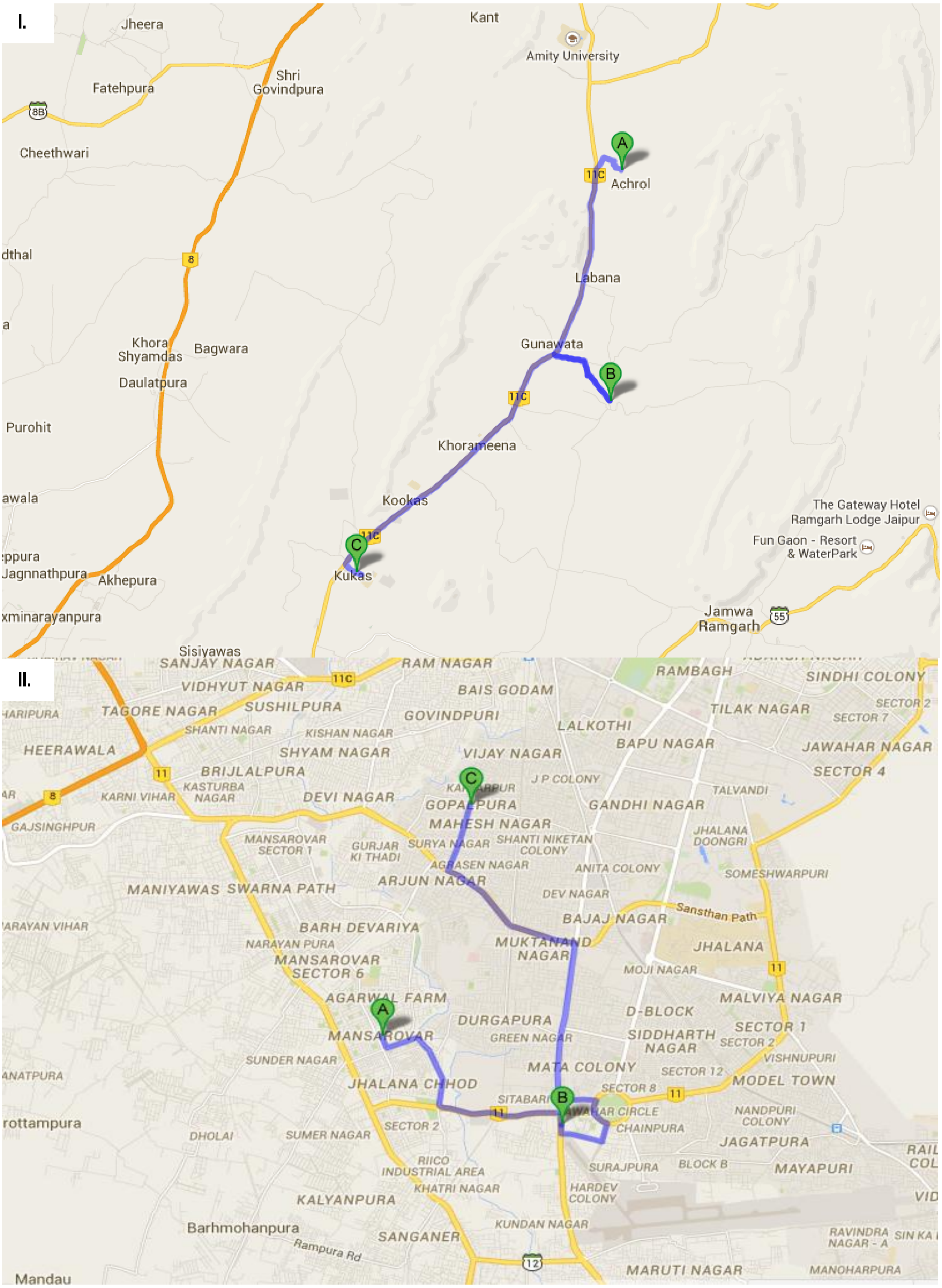

Figure 5. Location map

Table 2. Fluoride conc. at study location

S.No.	Area	pH	Fluoride
S1	Achrol	7.91±0.05	7.06±0.04
S2	Bhanpur Killa	7.99±0.14	7.16±0.06
S3	Gopalpura	7.20±0.42	3.29±0.03
S4	Kukas	7.54±0.07	4.16±0.09
S5	Mansarover	7.09±0.01	3.36±0.04
S6	Murlipura	7.22±0.12	3.45±0.04
S7	Pratap Nagar	7.03±0.11	3.24±0.07
S8	Raja Park	7.32±0.02	4.60±0.08
S9	Tonk Phatak	7.31±0.12	2.89±0.06
S10	Vaishali Nagar	7.05±0.01	2.13±0.14
S11	Vidhyanagar	7.09±0.02	2.91±0.02

Prevention of Florosis

Excessive fluoride ingestion by human beings can be prevented by using the following approaches:

Using alternate water sources: Alternate water sources include surface water, rainwater and low-fluoride groundwater.

Improving the nutritional status of population at risk: Adequate calcium intake is directly associated with a reduced risk of dental fluorosis. Vitamin C ingestion also safeguards against the risk of fluorosis.

Defluoridation: Removing excess fluoride from drinking water using different techniques such as Nalgonda method. This defluoridation method is based on the combined use of alum and lime in a two-step process. Mainly four techniques available for defluoridation are adsorption techniques, ion-exchange techniques, nalgonda techniques and electrolysis techniques.

CONCLUSION

From the current study, we conclude that the study area has high fluoride level which caused florosis in human and we have suggested defuoridation techniques for the particular area.

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