Defluoridation of different water samples containing excessive fluoride ion concentration by using ocimum tenuiflorum (tulsi leaves)

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***Abstract*: The present study is carried out to know defluoridation capacity of Tulsi leaves on different water samples containing excessive fluoride ion concentration. The presence of fluoride ion does not affect the taste, appearance and odour of drinking water. It is normally accomplished by adding one of three compounds to the water: sodium fluoride (NaF), fluorosilicic acid (H_2SiF_6) and sodium fluorosilicate (Na_2SiF_6)[1]. Two species of Tulsi plant: Ocimum sanctum (Krishna tulsi) and Ocimum tenuiflorum (Rama tulsi) were used in different proportions. Water is an essential part of our life. Consumption of excessive fluoride ions from water can cause adverse health effects. Fluoride ions are present in trace quantities in different water bodies present in nature. The amount of fluoride ion present in the water sample was checked spectrophotometrically using Alizarin red-S [2]. World Health Organization (WHO) suggested that level of fluoride from 0.5 to 1.5 mg/L (milligrams per litre) is safe to consume [6]. This method proves that the leaves of tulsi plant are an effective bio-adsorbent to remove excessive fluoride from fluoride rich water [10]. This technique is economically viable, eco-friendly and easy to understand and can be effortlessly used in rural as well as urban areas.**

***Index Terms*: Defluoridation, fluoride, tulsi, spectrophotometrically, urban.**

I. INTRODUCTION

An excessive fluoride ion concentration in drinking water can come from:

- Water sources in rural areas
- Public water fluoridation
- High concentration of fluoride in natural fresh water
- Untested bottled water
- Inappropriate use of fluoride supplements in the water.

While other sources of fluoride exposure are:

- Food
- In the soil through pesticides
- Toothpaste, mouth wash, dental floss
- Air through fluoride releases from industry

Many rural areas in India do not have access to clean drinking water. Rural areas in India, which have agricultural and domestic water requirements, suffer from many challenges such as water pollution and decreasing ground water availability, etc. [7]. Providing them a clean and safer drinking water is a major challenge [5]. At low concentrations fluoride ions plays an important role in teeth development but excessive level of fluoride ions present in drinking water leads to adverse health effects. The ill effects of the long-term ingestion of fluoride ions via drinking-water are mainly seen on teeth and bones [3]. Dental fluorosis is a defect of tooth enamel caused by excessive fluoride intake. Although fluorosis can be treated, but the damage to the enamel is permanent. Excessive ingestion of fluoride ions causes skeletal fluorosis [8]. Accumulation of fluoride ion on bone tissues leads to weakening of bones, increases the risk of fracture, joint pain etc. [9]. Skeletal fluorosis and dental fluorosis are the two main effects seen due to excessive deposition of fluoride in the body whereas other effects like nerve damage, abdominal pain, muscle stiffness, etc.

Water samples from different sources located in Mumbai and Navi Mumbai were collected and analyzed spectrophotometrically for the concentration of fluoride ion. Since there was no data available for monitoring and analysis; we conducted a survey to initiate a constant monitoring of fluoride concentration in these regions [4]. The quality of the water sample collected was compared with the WHO standards for drinking water.

Since 1958 the World Health Organization have published standards for drinking water, on both the possible adverse dental and skeletal effects of excessive concentration of fluoride in drinking-water, and the dental benefits since they have set guidelines for drinking water quality, now in its 3rd edition (World Health Organization 1984; 1993; 2004; 2006). According to WHO the permissible limit for fluoride ion concentration in drinking water is ranging from 0.5 to 1.5 mg/L [6].

The simple remedy for removal of excessive fluoride ions from water is treating it with tulsi leaves by boiling, shaking or soaking. Tulsi leaves have several medicinal properties. Some of the important constituents of tulsi are oleanolic acid, ursolic acid, rosmarinic acid, eugenol, carvacrol, linalool, β-caryophyllene. Tulsi leaves mostly consists of essential oil eugenol and germacrene with the balance being made up of various trace compounds, mostly terpenes.

II. MATERIALS

1. Chemicals
   - The chemicals used were of A.R. grade.

- Fluoride ion solution of 100 ppm strength was prepared using A.R. grade sodium fluoride (NaF).
- Alizarin red-S and zirconyl nitrate of A.R. grade were prepared in distilled water and stored in a dark cool place.

2. Instruments
   - A systronic double beam spectrophotometer was used for checking the absorbance.
   - Absorbance was measured at a wavelength of 510 nm.
   - Distilled water was used as a blank.

Figure 1: Systronic Double Beam Spectrophotometer

III. METHOD

- Solutions of the concentration 0.5, 1.0, 1.5, 2.0 and 2.5 ppm from the stock solution of 100 ppm were prepared for the calibration curve readings.
- About 5cm^3 of Alizarin red-S was added into each flask, followed by addition of 25 cm^3 of distilled water.
- After an interval of 10 minutes, 5 cm^3 of zirconyl nitrate solution was added into each flask.
- All the standard solutions were diluted up to the mark i.e., 100 cm^3.
- All the solutions were kept aside in dark for 30 minutes for the colour development.
- The absorbance of all the solutions was measured at a wavelength of 510 nm using distilled water as a blank.
- The calibration curve was plotted and used to find the of fluoride ion concentration in different water samples.

Figure 2: Solutions for calibration curve readings

IV. SAMPLING AREAS

Water samples from different regions of Mumbai, Navi Mumbai and suburban areas were collected.

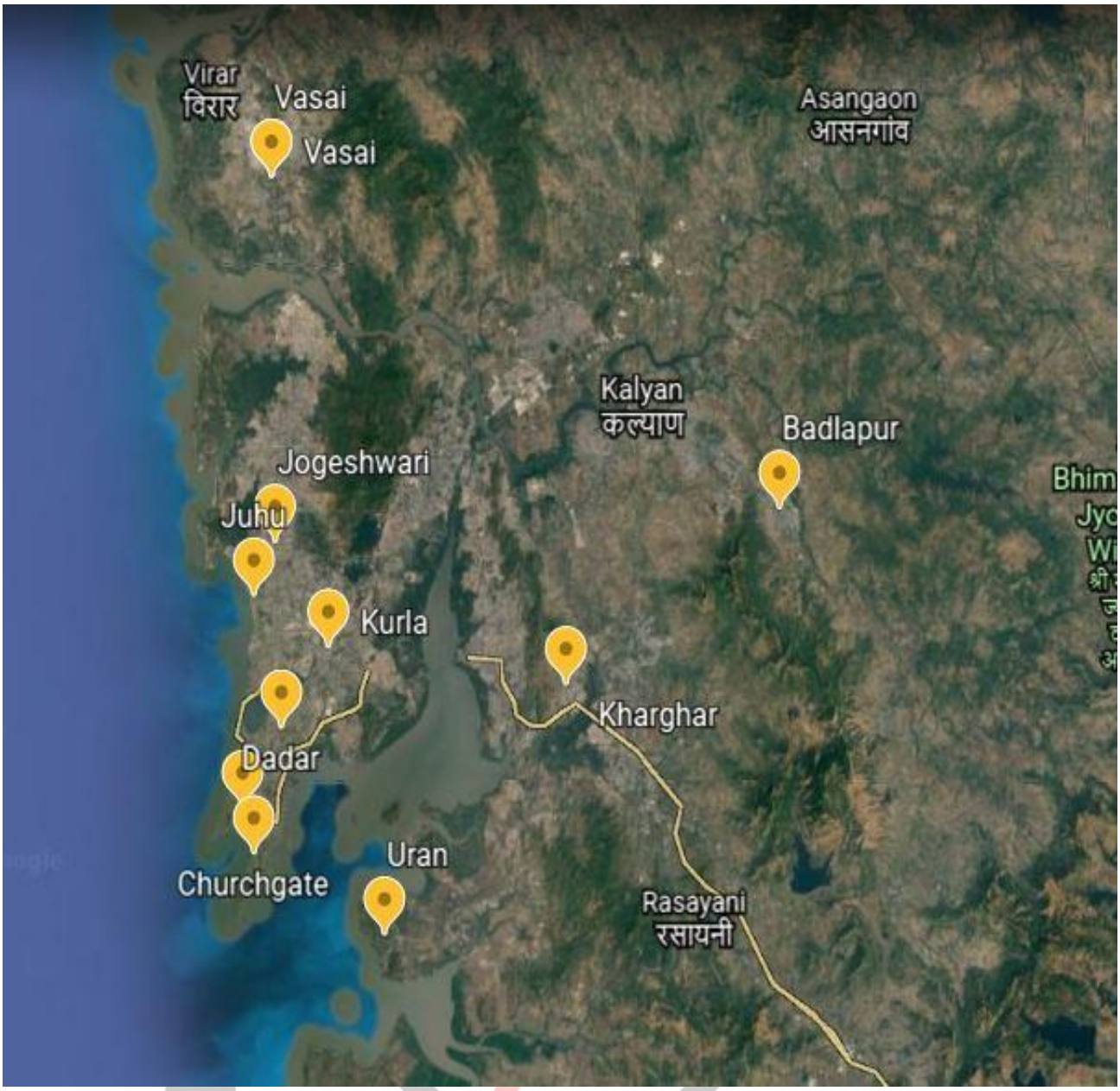

Figure 3: Sampling Area (Courtesy: Google Earth)

Sr. No.	Sampling Area
1	Uran (Tap water)
2	Grant road (Tap water)
3	Churchgate (Tap water)
4	Juhu (Tap water)
5	Dadar (Tap water)
6	Jogeshwari (Tap water)
7	Kurla (Tap water)
8	Kharghar (Tap water)
9	Badlapur (Borewell water)
10	Vasai (Lake water)

Table 1: Sampling Areas

V. Treatment of Water Samples

- The water samples containing excessive fluoride ion concentration were subjected to treatment using tulsi leaves.
- Two species of tulsi plants were used i.e., Ocimum tenuiflorum (Krishna tulsi) and Ocimum sanctum (Rama tulsi).
- Tulsi leaves of varying amounts were used i.e., 25 mg, 50 mg, 75 mg and 100 mg.

Water samples exceeding beyond the range (above 1.5 ppm) were subjected to three different treatment as follows:

1) Boiling – 100 cm^3 of water sample was withdrawn and boiled up to 15 minutes after addition of tulsi leaves. The water was boiled with different quantities of tulsi leaves. The leaves turn black after boiling.

2) Shaking – 100 cm^3 of water sample was withdrawn and tulsi leaves were added. The water samples were subjected to a shaker at 140 RPM (rotation per minute) for 40 minutes. The leaves remain fresh and green.
3) Soaking – 100 cm^3 of water sample was withdrawn in which tulsi leaves were added and soaked for 24 hours. The absorbance of the water samples was checked spectrophotometrically using alizarin red-S before and after the treatment.

VI. Results And Discussion

The results obtained are tabulated in the given table 3. Out of ten samples four samples needed treatment due to presence of excessive fluoride ion concentration in the water samples. The fluoride ion concentration of five different commercial water samples do not need any treatment since it was in the range (0.5- 1.5 ppm). The mean was calculated for three different concentrations.

Sr. no.	Concentration (ppm)	Absorbance
1	0.5	0.292
2	1.0	0.284
3	1.5	0.258
4	2.0	0.249
5	2.5	0.227

Table 2: Calibration curve readings

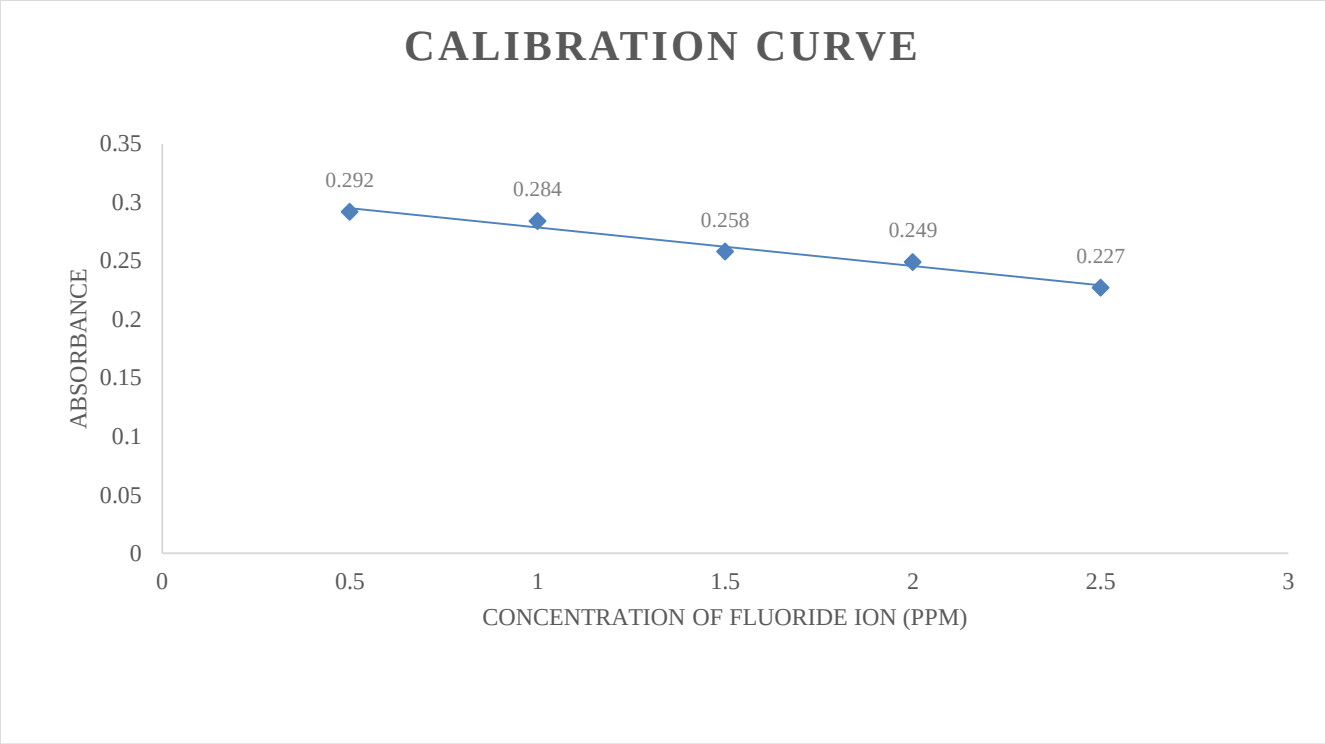

Figure 4: Calibration curve

As shown in the figure 4 the calibration curve is a straight-line graph of absorbance v/s concentration with a negative slope. As the concentration of fluoride ions increases, the intensity of colour decreases, thus the absorbance decreases.

Sr. no.	Sampling area	Concentration of fluoride (ppm)
1	Uran (Tap water)	1.60
2	Grant road (Tap water)	0.60
3	Churchgate (Tap water)	1.00
4	Badlapur (Borewell water)	1.75
5	Dadar (Tap water)	0.85
6	Jogeshwari (Tap water)	1.20
7	Kurla (Tap water)	1.70
8	Kharghar (Tap water)	1.10
9	Juhu (Tap water)	0.95
10	Vasai (Lake water)	1.85

Table 3: Water Sample Readings

No.	Sampling area	Amount of tulsi leaves (mg)	Mean conc. (ppm)	Standard deviation
1.	Uran (tap water)	25	1.40	± 0.012
		50	1.22	0.000
		75	0.98	± 0.010
		100	0.83	± 0.006
2.	Badlapur (Borewell water)	25	1.54	± 0.010
		50	1.39	± 0.004
		75	1.18	± 0.020
		100	1.01	± 0.006
3.	Vasai (Lake water)	25	1.67	± 0.010
		50	1.46	± 0.006
		75	1.25	± 0.010
		100	0.98	± 0.006
4.	Kurla (tap water)	25	1.53	± 0.010
		50	1.36	± 0.004
		75	1.08	± 0.010
		100	0.93	± 0.011

Table 4: Treatment of water samples containing excessive fluoride ion concentration after boiling

No.	Sampling area	Amount of tulsi leaves (mg)	Mean conc. (ppm)	Standard deviation
1.	Uran (tap water)	25	1.51	± 0.010
		50	1.39	± 0.006
		75	1.31	± 0.020
		100	1.18	± 0.010
2.	Badlapur (Borewell water)	25	1.66	± 0.004
		50	1.54	± 0.003
		75	1.43	± 0.010
		100	1.31	± 0.006
3.	Vasai (Lake water)	25	1.74	± 0.020
		50	1.65	± 0.011
		75	1.54	± 0.006
		100	1.43	± 0.006
4.	Kurla (tap water)	25	1.63	± 0.020
		50	1.51	± 0.010
		75	1.43	± 0.010
		100	1.29	± 0.003

Table 5: Treatment of water samples containing excessive fluoride ion concentration after shaking

No.	Sampling area	Amount of tulsi leaves (mg)	Mean conc. (ppm)	Standard deviation
1.	Uran (tap water)	25	1.23	±0.006
		50	0.91	±0.010
		75	0.58	±0.020
		100	0.31	±0.010
2.	Badlapur (Borewell water)	25	1.29	±0.003
		50	0.98	±0.003
		75	0.62	±0.011
		100	0.39	±0.020
3.	Vasai (Lake water)	25	1.42	±0.004
		50	1.10	0.000
		75	0.80	±0.006
		100	0.43	±0.010
4.	Kurla (tap water)	25	1.23	±0.003
		50	0.95	±0.020
		75	0.57	0.000
		100	0.36	±0.010

Table 6: Treatment of water samples containing excessive fluoride ion concentration after soaking

No.	Sampling area	Conc. Before treatment (ppm)	Conc. After treatment (ppm)	Percentage decrease in fluoride conc. (%)
1	Uran (tap water)	1.60	0.83	48.13%
2	Badlapur (Borewell water)	1.75	1.01	42.30%
3	Vasai (lake water)	1.85	0.98	47.02%
4	Kurla (tap water)	1.70	0.93	45.30%
				Mean= 45.70%

Table 7: Percentage decrease in fluoride ion concentration after boiling

No.	Sampling area	Conc. Before treatment (ppm)	Conc. After treatment (ppm)	Percentage decrease in fluoride conc. (%)
1	Uran (tap water)	1.60	1.18	26.25%
2	Badlapur (Borewell water)	1.75	1.31	25.14%
3	Vasai (lake water)	1.85	1.43	22.70%
4	Kurla (tap water)	1.70	1.29	24.12%
				Mean= 24.55%

Table 8: Percentage decrease in fluoride ion concentration after shaking

No.	Sampling area	Conc. Before treatment (ppm)	Conc. After treatment (ppm)	Percentage decrease in fluoride conc. (%)
1	Uran (tap water)	1.60	0.31	80.63%
2	Badlapur (Borewell water)	1.75	0.39	77.71%
3	Vasai (lake water)	1.85	0.43	76.76%
4	Kurla (tap water)	1.70	0.36	78.82%
				Mean= 78.48%

Table 9: Percentage decrease in fluoride ion concentration after soaking

VII. Conclusion

The easiest and accurate method was soaking followed by boiling and shaking. This technique can be adapted in rural areas where most of the people do not have access to clean and filtered drinking water. Since tulsi leaves are easily available and this technique is economically viable. This technique is eco-friendly since it does not harm the environment. And tulsi leaves have variety of health benefits as it enhances the immune system [10]. The percentage decrease in fluoride ion concentration after boiling was 45.70%, after shaking was 24.55%, and after soaking it was 78.48%. Thus, soaking was the most efficient method for removal of excessive fluoride ion concentration from different water samples.

VIII. Acknowledgment

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