
A REPORT ON

**Measurement of Fluoride concentration in Tap water
samples of Kalpakkam townships**

SUBMITTED TO

Environment Assessment Section, EAD

Indira Gandhi Centre for Atomic Research , Kalpakkam



SUBMITTED BY

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To whom so ever it may concern

This is to certify that Ms. D. Sharmila, (Register No. 39030033) perusing for III year B.Sc, Chemistry in the Department of Chemistry, Sathyabama Institute of Science and Technology (Deemed to be University), Chennai -6000 119) has carried out her internship at Indira Gandhi Centre for Atomic Research under the guidance of S. Chandrasekaran, Scientific Officer (G), Head, Environment Assessment Section, EAD, Indira Gandhi Centre for Atomic Research, Kalpakkam from 01-oct - 2021 to 30-dec- 2021 as partial fulfillment of her degree.

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Indira Gandhi Centre for Atomic Research



Indira Gandhi Centre for Atomic Research [IGCAR], the second largest establishment of the Department of Atomic Energy next to Bhabha Atomic Research Centre, was set up at Kalpakkam, 80 KMs south of Chennai [MADRAS], in 1971 with the main objective of conducting broad based multidisciplinary programme of scientific research and advanced Engineering, directed towards the development of sodium cooled Fast Breeder Reactor [FBR] technology, in India. This is part of the second stage of Indian Atomic Energy Programme, which is aimed at preparing the country for utilization of the extensive Thorium reserves and providing means to meet the large demands of electrical energy in 21st century. In meeting the objectives, a modest beginning was made by constructing a sodium cooled Fast Breeder Test Reactor [FBTR], with a nominal power of 40 MWt, based on the French Reactor, RAPSODIE. The reactor attained its first criticality on 18th Oct, 1985 and has been in operation at its maximum attainable power level of 10.5 MWt with a small core. It is the first of its kind in the world to use Plutonium Uranium mixed carbide as a driver fuel. Over the years, the centre has established comprehensive R & D facilities covering the entire spectrum of FBR technology related to Sodium Technology, Reactor Engineering, Reactor Physics, Metallurgy and Materials, Chemistry of Fuels and its materials, Fuel Reprocessing, Reactor Safety, Control and Instrumentation, Computer Applications etc., and has developed a strong base in a variety of disciplines related to this advanced technology. With the experience and expertise gained by the successful operation of FBTR, the Centre has embarked upon the design and construction of 500 MWe, Prototype Fast Breeder Reactor [PFBR]. Various R & D activities in the areas of Structural Mechanics, Thermal Hydraulics and flow induced vibration, Component Testing in high temperature sodium environment, sodium-water reaction, hydraulic development

of sodium pumps etc., were pursued and the design was completed. The PFBR is under advanced stage of construction and commissioning by BHAVINI.

As a part of efforts for closing the fuel cycle, a Fast Reactor Fuel Reprocessing Plant is under construction.

A 30 KWt, U233 fuelled mini reactor [KAMINI] has been made operational for neutron radiography, neutron activation analysis etc., IGCAR utilizes its expertise and resources in enhancing its standing as a leading Centre of research in various branches of basic, applied and engineering sciences that have a bearing on Nuclear Technology like Structural Mechanics, Heat and Mass Transfer, Material Science, Fabrication Processes, Non-Destructive Testing, Chemical sensors, High temperature thermodynamics, Radiation Physics, Computer science etc.,

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A modern Library comprising 62,000 volumes of books, 28,400 back volumes, about 785 journals and 1.95 lakhs reports in all disciplines caters to the technical needs of the Scientists and Engineers. The Central Workshop is fully equipped with sophisticated machines for the fabrication of precision components.

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Measurement of Fluoride concentration in Tap water samples of Kalpakkam townships

Introduction

Fluorine is one of the most profuse elements in nature, ranking 13th in the world for abundance. Fluorine is easily soluble in water, soil and air, and being one of the most reactive chemical elements, it does not exist on its own in the natural environment but instead as fluoride. Fluoride is a natural component of all natural waters and occurs in the form of dissolved univalent anion F⁻, either complexed/ uncomplexed with organic/ inorganic ligands. Unpolluted fresh groundwater and surface waters are essential for human society as reservoirs for drinking water, irrigation, various industrial purposes and so forth. The chemical composition of natural waters is dependent on factors such as geology (the weathering of minerals present in soil and bedrock), hydrology (residence time, water mixing etc.) and climate (evaporation/ precipitation).

The primary sources of fluoride in water are fluoride-bearing minerals in the rocks, soil, and sediments. Other sources of fluoride in groundwater are volcanic ash, fly ash and use of fertilizers. The major sources of fluoride in groundwater are due to fluoridebearing rocks such as fluorspar, cryolite and fluorapatite. The essential fluoride-bearing minerals and per cent fluoride in the minerals are given in Table 1, as reported.

Table 1: Minerals bearing fluoride

Mineral	Chemical formula	Percent fluorine
Sellaite	MgF ₂	61%
Villianmite	NaF	55%
Fluorite(Fluorspar)	Ca F ₂	49%
Cryolite	Na ₃ AlF ₆	45%
Bastnaesite	(Ce,La) (CO ₃)F	9%
Fluorapatite	Ca ₁₀ (PO ₄) ₆ F ₂	3– 4%

Fluoride is necessary for human life. Excess or deficiency of fluoride in the environment affects human health outcomes. Fluoride deficiency (< 0.5 mg/L) causes adverse health effects. It includes dental caries, lack of dental enamel formation, and deficiency of mineralization of bones, especially in children. Excessive intake of fluoride (>1.5 mg/L) may lead to loss of calcium from tooth matrix, aggravating cavity formation and dental fluorosis. However, epidemiological evidence suggests that higher fluoride content in

drinking water above (1.5 mg/L) increase the risk of dental fluorosis, while progressively higher concentrations increase the risks of skeletal fluorosis. The risk of dental fluorosis increases expeditiously with the rise of fluoride concentration. The effect is predominant compared to dental decay due to the low concentration of fluoride. However, skeletal fluorosis occurs when the fluoride is present in drinking water at a range greater than 4 ppm and the water is being consumed for about 8– 10 years. Generally, outward dental fluorosis was noted in children up to the age of 12 years

Table2: *Impact of fluoride in drinking water on health*

Concentration of Fluoride (mg/l)	Impact on health
Nil	Limited growth and fertility
0 – 0.5	Dental Caries
0.5 – 1.5	Promotes dental health resulting in healthy teeth, prevents tooth decay
1.5 – 4.0	Dental fluorosis (mottling of teeth)
4.0 – 10.0	Dental fluorosis, skeltal fluorosis (pain in neck and back bones)
>10.0	Crippling fluorosis

The main source of drinking water in Kalpakkam Township is Palar river as well as aquifers confined to Palar river basin. Palar River rises in Nandi hills in Chikkaballapura district of Karnataka state. After flowing through 93 Kms in Karnataka, 33 Kms in Andhra Pradesh and 222Kms in Tamilnadu, it joins into Bay of Bengal at Vayalur which is 7 Kms away from Kalpakkam Township.

The objective of the present study is to evaluate the concentration of fluoride levels in tap water in both the townships (Kalpakkam and Anupuram). This study helps to understand whether fluoride levels in drinking water are within the recommended and accepted levels to prevent dental caries and reduce the risk of dental fluorosis.

Study area

Kalpakkam is a small township which is located near Mahabalipuram in Tamil Nadu, India. Kalpakkam township is quaternary alluvium deposit with 7.2m bgl. It lies in Chengalpattu district which is having the average annual rainfall of 1,237 mm.

For Kalpakkam Township, water after treatment has been pumped to Kalpakkam Township from Panakattucheri reservoir where Palar river water is stored. Water from a pumping station in Panakattucheri, located 7 km away from Kalpakkam Township, was pumped daily. Afterwards, additional water treatment was done in the Kalpakkam water treatment plant and was supplied to the township. For Anupuram Township, Palar river water is pumped to a sump which exists near main gate of DAE site. Anupuram Township has eighteen bore wells out of which only seven are operational now. Palar river water mixed along with bore water in caters for the need of the township.

Sampling locations

Water samples were collected randomly from different houses in township in pre-cleaned, airtight high density poly ethylene (HDPE) vials, labelled and brought to the laboratory within one hour of collection. Samples were filtered through 0.45 μ m membrane filter and kept at 4 °C until analysis.

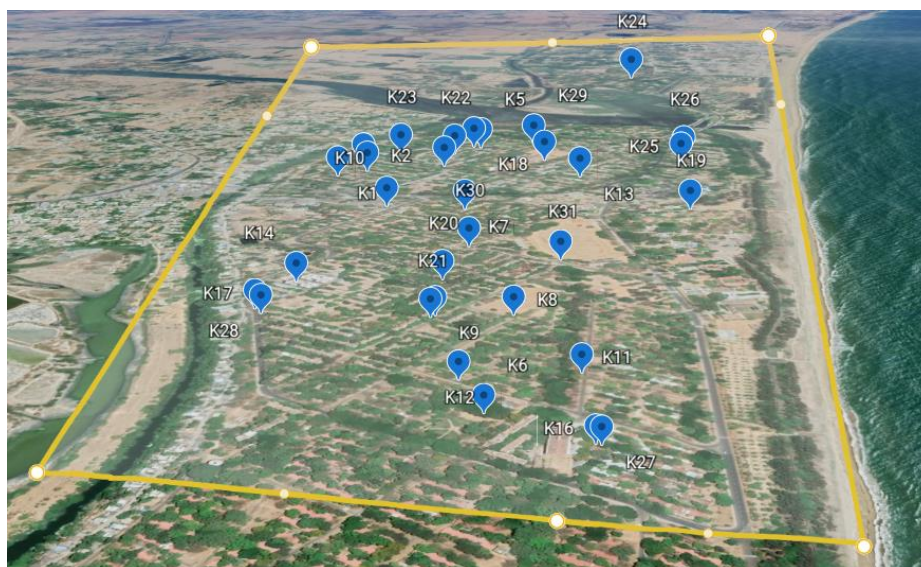


Fig 1: Study area map of Kalpakkam Township

Materials and methods

Fluoride analysis was done using an ion chromatographic (IC-940 Professional IC vario model, Metrohm AG, Switzerland) system coupled with conductivity detector as per APHA 4110B. The system

was equipped with six channel injection valve and low pulsation high-pressure pump. The separation was performed on a Metrosep A Supp 5- 250 column (250 x 4 mm, polyvinyl alcohol with quaternary ammonium groups, 5 µm particle size), Metrosep A Supp 5 Guard/4. In order to keep the baseline signal low, 100 mM sulphuric acid solution was used for regenerated chemical suppression. The optimized chromatographic parameters are presented in table 3.

Table 3: Optimised parameters for ion chromatographic measurement

Data Source	Conductivity detector (940 Professional IC vario)
Channel	Conductivity
Recording time	26.0 min
Column type	Metrosep A Supp 5 – 250/4.0
Eluent composition	Anion Eluent – 3.2 mM Na ₂ CO ₃ + 1.0 mM NaHCO ₃
Flow	0.700 ml/min
Pressure	12.22 MPa
Temperature	30 °C

Eluent used was 3.2 mM Na₂CO₃ and 1.0 mM NaHCO₃ (Merck). Multi ion standard solutions of fluoride, chloride, bromide, nitrite, phosphate, nitrate and sulphate were prepared by appropriate dilution of their anion standard stock solution (Merck Cetipur 1000 mg/L for IC). IC was calibrated for fluoride analysis using the following standards with varying concentration; 0.1, 0.25, 0.5, 1.0, and 2.0 mg F/ L. All solutions were prepared in Milli-Q water, (Merck Millipore; resistivity >18.2 MΩcm). Sulphuric acid (96% Suprapur®, Merck) was used in conductivity suppression regeneration system after appropriate dilution. Before measurements the samples were filtered by MF-Millipore membrane filter with pore size of 0.22 µm (Merck). All the chemicals used were merck with HPLC standard.

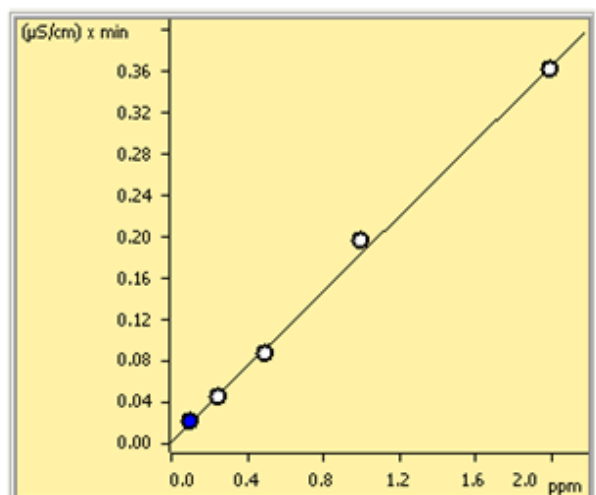


Fig 4. Calibration curve for Fluoride (concentration ranging from 0.1 – 2.0 ppm)
Limit of detection (LOD) and Limit of Quantification (LOQ) of Fluoride ion in water sample is calculated from regression analysis of calibration curve as follows

$$\text{LOD} = 3.3 * (\sigma/S) = 3.3(0.005/0.182) = 0.08 \text{ ppm}$$

$$\text{LOQ} = 10 * (\sigma/S) = 10(0.005/0.182) = 0.27 \text{ ppm}$$

Where σ is the standard deviation of Y intercept and S is the slope of the curve.

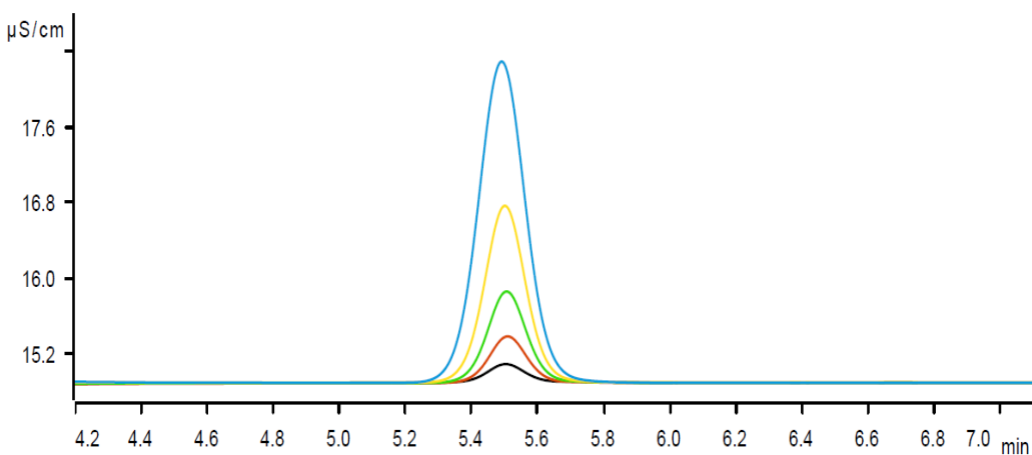


Fig 5. Overlay of F⁻ peak at different concentration (0.1, 0.25, 0.5, 1.0 and 2.0 ppm)

Results and discussions

Total of 69 tap water samples were collected and analyzed for Fluoride content in the first week of September 2021. 31 samples were collected from Kalpakkam Township, 28 samples were collected from Anupuram Township, 4 samples were collected from different houses near Panakattucheri and 6 samples were collected from different houses outside Anupuram Township. Total of 10 samples (5 samples from Kalpakkam and 5 samples from Anupuram) were analysed for Fluoride content continuously for one week on last week of August 2021. Fluoride concentration of different tap water samples collected from both the township is provided in Table 4.

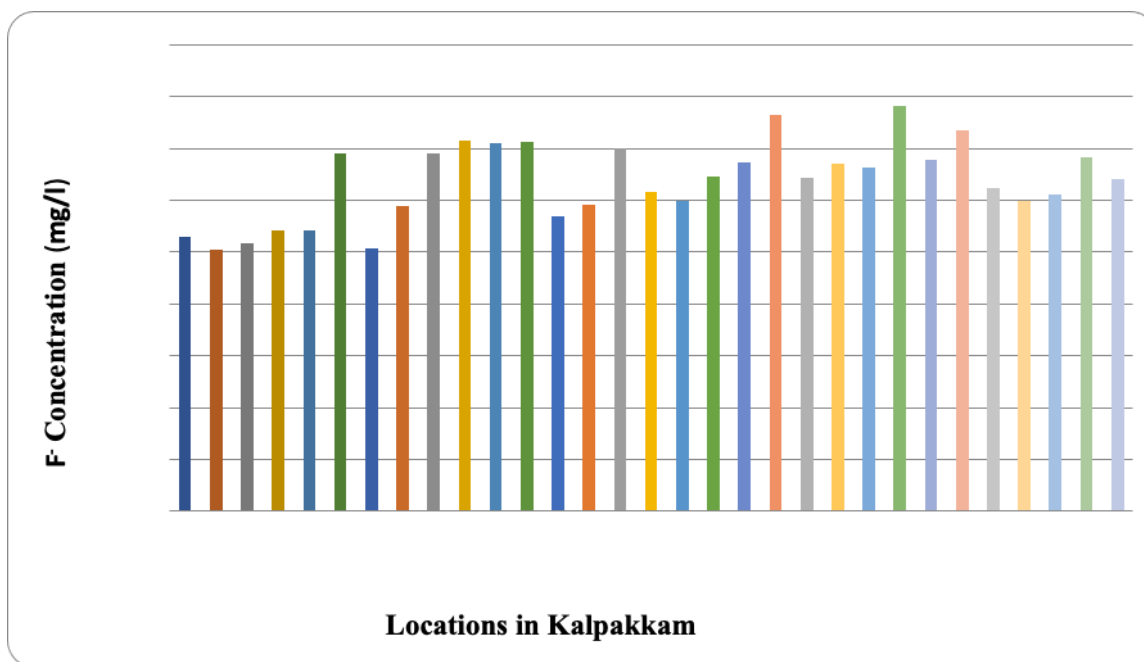
Table 4: Concentration of fluoride collected from different water samples from Kalpakkam Township

Location ID	Fluoride conc (mg/l)
K1	0.265 ± 0.007
K2	0.252 ± 0.007
K3	0.258 ± 0.007
K4	0.271 ± 0.007
K5	0.271 ± 0.007
K6	0.345 ± 0.007
K7	0.253 ± 0.007
K8	0.294 ± 0.007
K9	0.345 ± 0.007
K10	0.358 ± 0.007
K11	0.355 ± 0.007
K12	0.356 ± 0.007
K13	0.284 ± 0.007
K14	0.296 ± 0.007
K15	0.350 ± 0.007

K16	0.308 ± 0.007
K17	0.299 ± 0.007
K18	0.323 ± 0.007
K19	0.337 ± 0.007
K20	0.382 ± 0.007
K21	0.322 ± 0.007
K22	0.335 ± 0.007
K23	0.332 ± 0.007
K24	0.391 ± 0.007
K25	0.339 ± 0.007
K26	0.367 ± 0.007
K27	0.312 ± 0.007
K28	0.299 ± 0.007
K29	0.305 ± 0.007
K30	0.342 ± 0.007
K31	0.320 ± 0.007

Statistical parameter	Fluoride conc (mg/l)
Minimum	0.252
Maximum	0.391
Average	0.318
Median	0.322
Standard deviation	± 0.038

Fig 7: Fluoride levels in tap water samples collected from Kalpakkam Township



The concentration of Fluoride ranged from 0.252 to 0.391 mg/l with a mean of 0.318 mg/l in Kalpakkam Township.

As per the WHO and BIS drinking water guidelines, the desirable range for Fluoride in drinking water is 1ppm and maximum permissible limit is 1.5ppm. But many studies showed that a concentration of fluoride between 0.5 to 1.5ppm is beneficial for dental health. Water containing very low levels of Fluoride (below 0.5ppm) when consumed regularly results in dental carries.

Conclusion

The present study shows the low level of Fluoride content in tap water samples collected from Kalpakkam Township. The concentration of Fluoride ranged from 0.252 to 0.391 mg/l in Kalpakkam Township. All the water samples have fluoride levels well within the prescribed limit as per WHO and BIS drinking water guidelines.

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