

Determination of Fluoride in Various Samples Using a Fluoride Selective Electrode

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Abstract

Fluoride is widespread in the environment, water, air, vegetation and Earth's crust which can enter ground and surface water by natural process. Fluoride in minute quantities is essential component for human health and help in normal mineralization of bone and formation of dental enamel. The determination of fluoride in some species was performed by using fluoride ion-selective electrode by direct measurement and standard addition method. The concentration of fluoride ion was determined in drinking water (from different place at Kathmandu), toothpaste, various brand of tea and coffees. The range of fluoride concentration in water sample was 0.16 to 0.39 mg/l, tea and coffee samples were 0.011 to 0.084 mg/l and its value of toothpaste was 0.026 to 0.75 mg/l. The concentration of fluoride ion obtained from different sample was compared with the legitimate value given by the world health organization.

Keywords

Fluoride, TISAB, Water, Tea, Coffee, Toothpaste, Fluoride Ion Selective Electrode, Dental Carries

1. Introduction

Fluoride ion is the ionic form of fluorine which is mostly found in various sample and play vital role for human health and environment, but consumption or presence of large amount of fluoride harmful for health and environment [1]. The higher concentration of fluoride is toxic. The optimal range of fluoride is 0.05 - 0.07 mg per kg body weight has been considered. Fluoride ion is mostly formed as the by-product in certain process and enter in the human body by means of food chain (water, juices, tea, and coffee), toothpaste and pollution (air, water). The main source of fluoride in toothpaste, water is sodium fluoride,

stannous fluoride and sodium monofluorophosphate [2]. It has indispensable role in prevention of dental caries [3]. However, the beneficial effect of reduced dental caries is balanced by an increased prevalence of dental fluorosis [4]. Fluorosis is defined as an abnormal condition caused by excessive intake of fluoride as from fluoridated drinking water, characterized chiefly by mottling of the teeth.

Fluorosis appears as marking of the enamel surface of the teeth (enamel defects). Mostly fluorosis appears barely visible white flecks on the tooth surface; with the more severe cosmetically unacceptable form being rather uncommon. Dental fluorosis occurs during tooth development, especially between the ages of 6 months to 5 years. The British Fluoridation Society considers fluorosis as a cosmetic rather than a health problem [5].

Several determination techniques of fluoride in various samples such as direct measurement, standard addition, titration method and anion-chromatography, Ion-Selective electrode etc. are used in this present work. Ion-Selective method is selected for the determination of Fluoride ion in various samples.

Health Hazards of fluoride

Fluoride is an important element for all tissues in the body. Appropriate fluoride consumption is beneficial to bone and tooth integrating and it has important positive impact on oral health and overall health. However, high level of fluoride has been associated with various adverse effects in living beings. The permissible dose to human beings, according to WHO, is 1.5 mgL^{-1} as a safe limit of fluoride in drinking water.

High levels of fluoride in childhood were associated with a reduction in IQ. The author noted that this research is not applicable to the safety of artificial water fluoridation because the adverse effect on IQ were found with fluoride levels that were much higher than typically found in artificially fluoridated water.

Consumption of fluoride at levels beyond those used in fluoridated water for a long period of time causes skeletal fluorosis. In some areas, particularly the Asian subcontinent especially India, Pakistan and Bangladesh skeletal fluorosis is endemic. It is known to cause irritable bowel symptoms and joint pain. Early stages are not clinically obvious and may be misdiagnosed as rheumatoid arthritis or ankylosing spondylitis [6].

Fluoride causes nephrotoxicity in kidney due to toxic levels of serum fluoride, commonly due to release of fluoride from fluoride-containing drugs, such as methoxyflurane. Fluoride-induced nephrotoxicity is dependent on the serum fluoride level, typically serum fluoride level exceeding 50 micromoles per liter (about 1 ppm) to cause clinically significant renal dysfunction [7] [8]. The only generally accepted adverse effect of fluoride at levels used for water fluoridation is dental fluorosis, which can alter the appearance of children's teeth during tooth development; this is mostly mild and usually only an aesthetic concern. As compared to unfluoridated water, fluoridation to 1 mg/L is estimated to cause fluorosis in one of every 6 people (range 4 - 21), and to cause fluorosis of aesthetic concern in every 22 people [9].

2. Experimental

2.1. Determination of Fluoride in Drinking Water and Bottled Water Sample

A combination fluoride electrode was used to determine the fluoride content in drinking water and bottled water. The solution which contained 25 ml of the sample and 25 ml of TISAB solution were mixed with a magnetic stirrer for 3 minute.

The electrode potential of the solution is measured by using fluoride selective electrode. The potential of the sample solution were directly compared with those of fluoride standard solution.

Then 1 mL of the 0.1 M fluoride standard solution was added in to the text solution and placed in magnetic stirrer. Then new electrode potential was measured. Similarly this process was carried out up to 5 mL. The mean concentration of fluoride was determined.

2.2. Determination of Fluoride Content in Toothpaste

For the determination of fluoride in toothpaste, 1 g of the sample was weighted in to the 100 mL beaker. After 25 mL of TISAB solution was added to the sample, the mixture was boiled thoroughly for 2 min. The suspension was completed to 50 mL with distilled water and placed in magnetic stirrer.

The electrode potential of the solution is measured by using fluoride selective electrode. The potential of the sample solution were directly compared with those of fluoride standard solution.

1 mL of the 0.1 M fluoride standard solution was added in to the text solution and placed in magnetic stirrer. Then new electrode potential was measured. Similarly this process was carried out up to 5 mL. The mean concentration of fluoride was determined.

2.3. Determination of Fluoride in Tea and Coffee Sample

1 gm of dried tea sample was placed in to a beaker. Then 100 mL of boiling de-ionized water was poured in to the beaker and 25 mL of the tea liquor was taken after the 5 minute. Then 25 ml of TISAB solution was added and placed in magnetic stirrer.

The electrode potential of the solution is measured by using fluoride selective electrode. The potential of the sample solution were directly compared with those of fluoride standard solution.

1 mL of the 0.1 M fluoride standard solution was added in to the text solution and placed in magnetic stirrer. Then new electrode potential was measured. Similarly this process was carried out up to 5 mL. The mean concentration of fluoride was determined.

3. Results and Discussion

3.1. Results of Fluoride Analysis

3.1.1. Fluoride Concentration of Water and Bottled Water at Kathmandu

The fluoride level was determined in drinking water samples collected from cite

at Kathmandu by direct measurement and standard addition method. A total of 4 different water samples are collected. In the drinking water from all the sample location, the fluoride content was less than 0.40 mg/L. As can be seen from table, the highest fluoride level was observed in tap water about 0.399 mg/L. The natural concentration of fluoride in ground water depend on such factor as the geological, chemical and physical characteristic of the water supplying area, the consistency of soil, porosity of rocks, the pH and temperature. The complexing action of other element and depth of wells. The result obtain indicate that the fluoride level of the drinking water and bottled water are generally low regarding drinking water standards. This lack of fluoride content in the drinking water which are one of the main source of fluoride nutrition for human, may causes health problem for human health especially teeth and bone structure.

Fluoride concentration of water and bottled water at Kathmandu Valley as shown in **Table 1**.

3.1.2. Fluoride Concentration in Toothpaste

The fluoride content of 7 different brands of toothpaste was analyzed by direct measurement and standard addition method. Toothpaste is an ideal form of administration of F as it is routinely used by a very large part of the world's population. For better comparison of divergent formulation as well as for sound interpretation and comparison of data from different laboratories, a potentiometric method for F determination in toothpaste is required.

The total fluoride determination was made on sample by fluoride selective electrode. Analysis shows that all fluoride in toothpaste were in the form of NaF, SnF₂, Na₂PO₃F. Seven brand of toothpaste were analyzed for their fluoride content by this method.

This toothpaste can be classified in to 4 group's non-fluoridated, fluoridated, sodium fluoride, sodium monoflorophosphate and fluoridated with stannous fluoride but there is no independent indication of their quantitative composition.

One of these samples was non-fluoridated. In all probability, concentration is naturally occurring fluoride impurity level in the component of the toothpaste. Out of these other toothpaste were identified on their packaging as containing fluoride added as sodium fluoride and sodium monoflorophosphate. All this group had a fluoride concentration between 0.026 to 0.75 mg/g.

Fluoride concentration in toothpaste as shown in **Table 2**.

3.1.3. Fluoride Concentration in Tea and Coffee

The concentration of fluoride ion in 5 different sample of tea and 2 sample of coffee were analyzed. All samples of tea and coffee were purchased from local market at Kathmandu. The analyzed tea and coffee are commonly used by local people. Tea and coffee infusion were prepared on a customary way of tea and coffee preparation. Fluoride levels were determined in liquors taken at 5 min of infusion. **Table 3** shows the release of fluoride in tea and coffee were 0.0110 to 0.07792 mg/g and 0.083 to 0.084 mg/g respectively.

Table 1. Fluoride concentration of water and bottled water at Kathmandu.

Sample (Water)	Concentration of Fluoride(mg/L) by direct Measurement	Concentration of Fluoride (mg/L) by standard addition method
W1	0.39	0.37
W2	0.28	0.26
W3	0.18	0.17
W4	0.16	0.14

Table 2. Fluoride concentration in toothpaste.

Sample (Toothpaste)	Concentration of Fluoride (mg/L) by direct Measurement	Concentration of Fluoride (mg/L) by standard addition method
T1	0.75	0.73
T2	0.65	0.64
T3	0.35	0.32
T4	0.16	0.15
T5	0.14	0.13
T6	0.05	0.05
T7	0.02	0.03

Table 3. Fluoride concentration in tea and coffee sample.

Sample (Coffee & Tea)	Concentration of Fluoride (mg/L) by direct Measurement	Concentration of Fluoride (mg/L) by standard addition method
C1	0.084	0.083
C2	0.083	0.083
TE1	0.077	0.076
TE2	0.074	0.072
TE3	0.024	0.025
TE4	0.016	0.015
TE5	0.011	0.010

Fluoride concentration in tea and coffee sample as shown in **Table 3**.

4. Conclusions

Measuring performed potentiometrically using a fluoride selective electrode is simple and inexpensive. The fluoride selective electrode has gained prominence over the traditional chemical and colorimetric method due to its sensitivity, specificity, speed of use and ability to response to a wide range of concentration. A

possible matrix effect can be easily eliminated by the addition of TISAB. Traces of fluoride can be determined directly in the liquid media studied (no laborious and time consuming operation of sample preparation such as analytic enrichment are required).

According to WHO, the optimum fluoride intake for human ranges from 2 to 4 mg per days. The total daily intake of fluoride that may causes fluorosis in adults in over 13.0 to 14.5 mg per days. We can see from the results, if daily tea consumption is too high and intake of fluoride from another source is excluded, tooth fluorosis due to the uptake excessive of fluoride may result.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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