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Analysis of Fluoride Ion Concentration in Drinking Water of Karachi in Relation With Conductivity and pH

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Abstract
Worldwide deficiency of safe drinking water is being faced due to high population density. In this context, the availability of safe water has been a global matter that points out researchers to investigate fluoride levels in drinking water. The proposed research aims to investigate fluoride concentration in water sources in different locations of Karachi. In this context, many water samples collected from industrial and residential areas and analyzed for the quantitative determination of fluoride. These results showed that all the samples contained fluoride levels below permissible levels by WHO, i.e., 1.5ppm. In contrast, more than 76% of samples had concentrations below WHO minimum recommended limit (i.e. 0.5ppm). It was observed that the sample having a high fluoride concentration (1.19ppm) showed a relatively high conductivity value (262.4 µs/cm). These results highlight and recommend the fluoridation process of drinking water sources to overcome the imbalance of fluoride in total intake.

Keywords: Fluoridation; Drinking water; Fluorosis; Quantitative; Tooth decay

1. INTRODUCTION
Fluorosis as stemming of teeth was explained earlier by Dr. Frederick McKay and Dr. J.M. Eager in early 1900. Over time, the fact was acquainted that the water supply is the primary source of staining of the teeth. In 1925, Ainsworth examined 4000 children for the study of fluorosis. This research work revealed that children having mottled teeth showed a lower rate of dental decay. ALCOA (the Aluminium Company of America), H.V Churchill also studied drinking water where staining teeth was commonly observed. It was concluded that fluoride ions in drinking water were significantly correlated. It was also mentioned that F^- resulted in fluorosis, and in some cases, it reduces the decaying of teeth. Later, the Public Health organization of the U.S. also investigated that mottled teeth occurrence is rare F^- concentration is under 1ppm. However, a fluoride concentration of more than 1.5 ppm resulted in dental/endemic fluorosis[1]. Following these limitations, access to safe drinking water has become the most decisive and challenging environmental problem. Since groundwater is the primary source of human intake and almost 50% of the population globally depends upon this source of water[1].
Moreover, some researchers have claimed that fluorosis has been a common disease in two hundred million people worldwide. [1]. Fluoride is 13th most abundantly distributed in the world's environment that consists of 0.3g/Kg of earth's crust. [2]. The primary source of fluoride in water is fluoride-bearing rocks. Along with drinking water, toothpaste is also considered to be an excellent source of F- intake. At the same time, some studies have also addressed wheat, cabbage, spinach, carrot, and tea as a source of fluoride intake.[3-6]. The presence of fluoride in natural food products may be due to use of fluoridated water in agricultural fields. [1,7].

Fluoridation is adopted to reduce tooth decay. Besides, a higher concentration of F^{-1} is the primary reason for skeletal and dental fluorosis and may lead to bone cancer. This disease has dominantly been observed in China[8]. The proposed study investigates the drinking water of Karachi for the presence of F^- and compared it with the studies reported in the literature[9].

2. MATERIALS & METHOD
Sterilized plastic bottles (500mL) were used for sampling purposes. A sum of 43 water samples was collected from different locations of drinking water sources in Karachi. The samples represented the zones from South East to North West are using groundwater as a source of drinking water in the adjacent area to coastline due to the extremely high concentration of salts in those groundwaters. Despite the availability of R.O. plants, the groundwater is not utilized for drinking purposes. Therefore, tap water is the preferred source of drinking water. Therefore, Defence Zone was also included as a sample

collection point to represent the coastal region. Groundwater is the only source of water collection through pipeline or suction pumps in the selected domestic zones. The industrial zones comprise Orangi and Landhi SITE. The samples collected from these regions are tested to represent the status of drinking water in terms of F^- contents.

The sampling bottles were initially washed with distilled water before collecting the water sample. After samples collection, bottles were sealed, marked and transferred to laboratory. The samples were then stored at 4°C.
All the samples were initially acidified with 5mL HNO_3 to avoid precipitation and microbial activity. This procedure was adopted as the standard chemical analysis method described by Duncon, [10].

Direct potentiometric technique selective ion electrode was used for quantification of fluoride. Total ionic concentration was also determined using Conductivity Probe (*Vernier*) and logger pro 3.3. This electrode consists of a particular electrode consisting of an ion-sensitive membrane i.e. organic ion-exchanger.

2.1. Experimentation

Initially, 10ppm working standard solution was obtained by diluting 100ppm (Standard fluoride solution). The working standard solution was used for probe calibration before commencing the analysis. Each sample was mixed with TISAB (A buffer solution) with 1:1 (v/v) ratio.

3. RESULTS & DISCUSSION

WHO guidelines for drinking water were followed for comparative analysis of the presence of F^{-1}. However, implementation of the prescribed WHO limit (1.5ppm) is also subjected to climate conditions, amount of water intake, and exposure of $F^{-1}$from other sources in the studied area[11]. In this context, a safe level for F^{-1} in drinking water can only be ensured by the severe concern of authorities to regulate and synchronize all factors. All the water samples were analyzed for concentration of fluoride, pH values & conductivity. The results have been depicted in Table 1.

Table 1: Chemical Analysis of water samples

S#	Sampling Area	pH[a]	C[b]	F[c]	S#	Sampling Area	pH[a]	C[b]	F[c]
1	Landhi Induastial Area	7.78	257.2	0.534	**23**	Golimar	7.37	250.4	0.218
2	Jail Chowrangi	7.59	252.5	0.232	**24**	Punjab Colony, cantonement	7.37	257.1	0.196
3	Hassan Square	7.92	257.7	0.553	**25**	North Karachi, Sector # 14	7.77	262.8	0.878
4	Khadad Colony	8.06	250.1	0.225	**26**	Lasbela , Patel Para	7.72	252.1	0.215
5	Tariq Road(Liberty)	6.82	250.1	0.208	**27**	Banaras Colony	7.49	261.6	0.179
6	DHA-Phase 1	6.40	259.4	0.413	**28**	Garden East	6.8	265.8	0.131
7	Saddar Empress Market	7.50	252.4	0.242	**29**	Jamshed Quarter	7.72	258.7	0.207
8	Jacob Line	7.72	253.0	0.219	**30**	Delhi Merchantile	7.78	263.1	0.798
9	Iqra University	7.95	258.4	0.454	**31**	Soldier Bazar	7.75	253.3	0.233
10	Burns Road	7.09	255.2	0.240	**32**	Jheel Park	7.04	262.4	1.190
11	M.A Jinnah Road,Tower	7.40	259.1	0.254	**33**	Jail Chowrangi	7.06	252.5	0.223
12	Sindhi Muslim Society	7.55	222.9	0.148	**34**	3 coin , Hill Park	7.32	252.2	0.211
13	Qayyumabad	6.43	256.5	0.687	**35**	Sindh Industial Trading Estate, Thana	7.31	258.1	1.010
14	Liaquatabad	7.50	250.0	0.263	**36**	PIDC	7.25	251.1	0.262
15	Baloch Colony	7.59	253.3	0.209	**37**	Jackson Market, Keemari	7.11	255.4	0.222
16	North Nazimabad	7.29	258.2	0.196	**38**	Liaquatabad	6.23	256.4	0.210
17	Café Piyala Gulberg	6.73	258.9	0.277	**39**	Rangoon Wala ,Bahadurabad	7.16	252.4	0.179
18	Gurumander	7.06	252.4	0.252	**40**	Mineral Water, A	7.38	207.3	0.009
19	Pathan Colony, waleeka Site	7.26	253.5	0.231	**41**	Jama Cloth Market	7.04	253.5	0.166
20	Orangi Town # 5	6.48	262.9	0.457	**42**	Boltan Market	7.01	252.8	0.176
21	Dastageer, Block 16	7.44	258.9	0.495	**43**	Alamgir Road	6.40	245.6	0.113
22	Hussainabad	7.42	261.7	0.509					

a = pH [y;f(x)], b = Conductivity [y; f(x)], c = Fluoride in ppm [x]

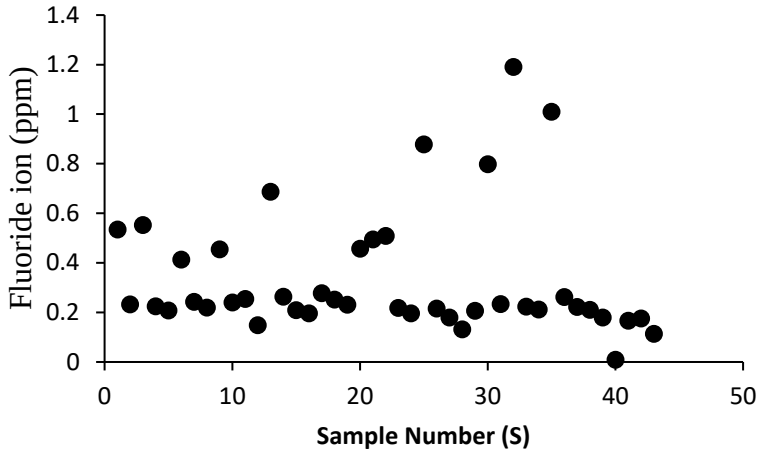

Figure 1: Range of fluoride ion concentration of water samples from different areas of Karachi

WHO recommends 1.5 ppm as the maximum contamination level of fluoride in drinking water. Following the guidelines of WHO, considering the climatic conditions in Pakistan, a study conducted in PCSIR, Karachi [12] was found to have 1.5ppm as a save level of fluoride contamination in water. Based on this data, no sample out of 43 samples was found to be unsafe. However, values of some areas are seen, having relatively high fluoride concentration (Figure 1).

Table 2: Statistical Analysis of Fluoride Concentration

Mean Fluoride Concentration	0.324
Minimum	0.009
Maximum	1.190
Standard Deviation From Mean	0.298
Variance	0.089
Percentage of samples with < 5ppm	76.7

A statistical representation of the results has been reported in Table 2. All samples have a mean value of F^- level (0.324ppm) below the limit of WHO-recommended permissible level.

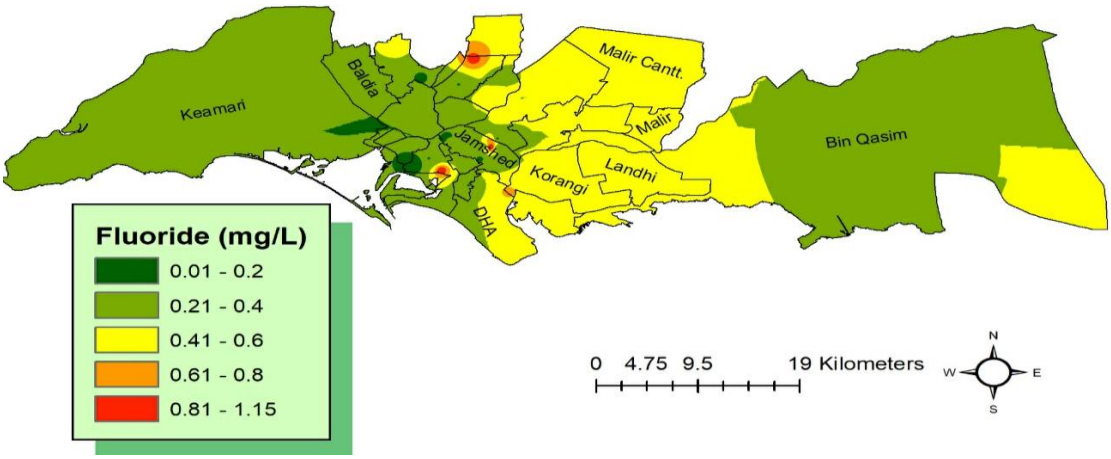

Figure 2: Distribution of fluoride concentration in selected area of Karachi

Concentration of fluoride by WHO limit is between 0.5-1.0ppm[8,13]. In this context, fluoride concentration below 0.5ppm can bring harmful effects to human health. Consequently, more than 75% of total samples containing less than 0.5ug/mL fluoride concentration may be a serious concern. However, these results show that except few samples with high fluoride concentration, most of the samples lying near the mean value, depicted in Figure 2.

The current results are similar to that of Siddiqui et al. [9] who reported the same trend in fluoride concentration in drinking water. This study also indicates that a relatively high fluoride concentration was found in sampling areas 25, 30,

32 and 35 (Table 1). The high concentration of fluoride in sampling area 35 is due to the discharge of fluoride-containing effluents from the ceramic or tiles industries. On the other hand, locations with no industrial exposure or low population density are expected to have low fluoride concentrations. However, in this study, one exception can be seen in sampling area 6 (Table 1) that shows 0.413ug/mL fluoride content in drinking water. However, this excessive amount is not dangerous.

Indus River and Hub Dam are the two sources to fulfill the water demand of a large population. The Indus River is passing through a varied topographical area, including multiple industrial locations. Therefore, high fluoride content was observed in the Indus river, similar to the studies carried out in Mithi and Nagar Parker[14]. On the other hand, the low content of F^- in drinking water in Karachi is due to the absorption and chelation of F^-.

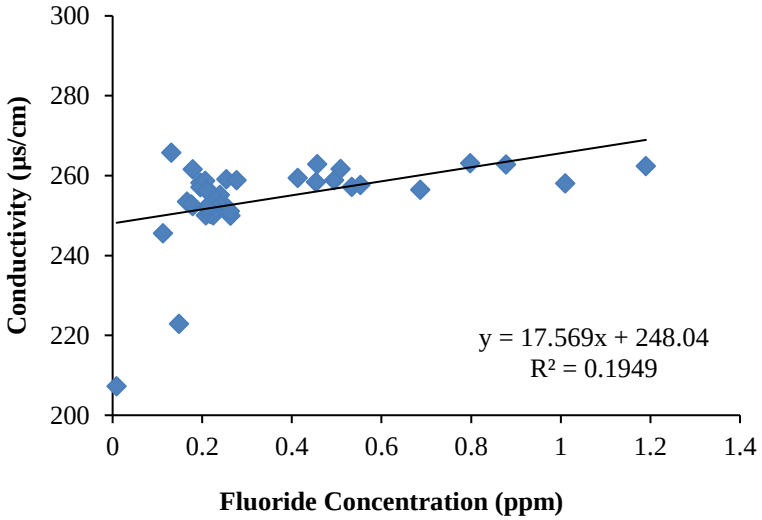

Figure 2: Conductivity vs. Fluoride concentration (ppm)

The samples were also subjected to conductivity analysis to correlate fluoride ion concentration in each sample. The higher conductivity corresponds to the presence of total ionic concentration in water. Therefore, results were compared with respective fluoride concentrations. A regression line was drawn between conductivity and fluoride concentration, depicted in Figure 3. Fluoride concentration in water samples is linearly related to the conductivity (Regression Coefficient 0.195). Sample from Jheel Park (sampling area 32) having a high fluoride concentration (1.19ppm) showed a relatively high conductivity value (262.4 µs/cm). Similarly, sampling areas 12 and 40 having a relatively low concentration of fluoride ion; also showed low conductivity 222.9 and 207.3 µs/cm, respectively.

It is essential to know that the analysis mentioned above is carried out, considering water to be the primary source of fluoride intake. Since most of the samples containing fluoride concentrations below WHO recommended limit, tap and groundwater should be consistently monitored for fluoride content. In this context, fluoridation is a good practice to ensure the quality of drinking water. However, other factors should also be taken into consideration before taking such measures. Such as toothpaste is an important source to fulfill the deficiency of fluoride in water. Some countries with sufficient fluoride content in toothpaste are concerned about decreasing fluoride content during water treatment. The study also considers concerned authorities in Karachi to design the policies depending upon the variable content of fluoride in drinking water before their treatments.

The results obtained from the proposed study[9] slightly differ, but trends of variation in fluoride concentration and the overall significance remain the same. The comparison shows that the interval of one decade has no significant impact on the distribution trend of fluoride in different locations of Karachi. Still, the finding of a relatively higher concentration of fluoride vs. time is more alarming. Therefore, it is more important to take some initiatives to control fluoride concentration in drinking water.

4. CONCLUSION

Karachi is the most populated urban area facing alarming environmental challenges, including contaminations in drinking water sources. The present study depicts that drinking water in various locations of Karachi contains fluoride levels below

the WHO permissible limit (i.e. 1.5mg/L). However, more than 76% of samples had concentrations below WHO recommended limit (i.e. 0.5mg/L). This highlights the importance of fluoridation of water in order to sustain an appropriate fluoride content for the excellent healthcare of people. However, this initiative should be practiced considering all factors as there is a possibility of substantial fluoride intake from different sources such as toothpaste and some food items. The pH values also lie within the range of 6-8, indicating that no water sample was highly acidic or alkaline. On the other hand, pH, conductivity, and fluoride ion concentration are not sufficient to address the quality of drinking water for human consumption. Therefore, the proposed study aims to address the status of fluoride ion concentration in water and drag legislators' consideration towards forming an instance policy for the fluoridation of drinking water.

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