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Quantitative study of fluoride content and its impact on human health in correlation with various quality parameters of drinking water

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Abstract
Water provides a unique medium to many physical, chemical and Biochemical Processes. Any minute change in water quality parameter may adversely and favorably affect the ecosystem as well as biological and industrial process. Fluoride in low concentration of 0.5 to 1.5ppm is beneficial for human health but its excess amount can cause serious health hazards and can interfere with various industrial synthetic pathway. Different forms of fluoride exposure are of importance and have shown to affect the body's fluoride content and thus increasing the risks of fluoride-prone diseases. Fluoride has beneficial effects on teeth at low concentrations of 1 mg/L by preventing and reducing the risk of tooth decay. Concentrations lower than 0.5 mg/L of fluoride however have shown to intensify the risk of tooth decay. Fluoride can also be quite detrimental at higher concentrations exceeding 1.5 – 2 mg/L of water. High concentrations of fluoride pose a risk of dental fluorosis as well as skeletal fluorosis and osteoporosis. In present study drinking water samples from various recourses of Punjab and northern Rajasthan have been analyzed in triplicate with respect to pH, alkalinity, Total hardness,Cl^-, SO_4^{2-}, $Ca^{2+}Mg^{2+}$, turbidity, content. The area under study is extension of peninsular block and mainly composed of quartzite, sandstone, micaschilt, phyltis etc. which are responsible for high F content in area. In this study F content water sample is correlated with the depth, alkalinity, pH, total hardness and carbonate content. The study will be helpful to many water quality analysts, biologists, ecologists, environmentalists and industrialists.

Keywords: Water quality parameters, fluoride content, correlation analysis

1. Introduction
Water is conceived to be the most precious natural resource on earth. Major part of Indian population is rural and agriculturally oriented, for whom the rivers and ground water are source of prosperity Due to increasing urbanization and Industrialization, contaminant factor in water is constantly increasing which may be inorganic organic, physical, microbial and radiological in nature. It not only creates anxiety to the soil health but also causes massive problems to the quality of ground water. Because of rise in the amount of dumping of municipal waste, industrial waste and heavy use of fertilizers, the properties of ground water have also been constantly changing. Fluoride contamination of ground water has now become a major geo environmental issue in many parts of world due to its toxic effects even if consumed in trace quantities.

A country's ability to collect, clean, and distribute water to its users reflects the health of a country's people. According to the World Health Organization (WHO), 1.1 billion people in low and middle-income countries lack access to safe water for drinking, personal hygiene and domestic use (WHO, Nov. 2004). This numbers represents more than 20% of the world's population. Of this 1.1 billion people, nearly two-thirds live in Asia. In sub-Saharan Africa, 42% of the population is still without improved water. In order to meet the water supply MDG target for 2015, an additional 260,000 people per day should gain access to improved water sources. In one study that was done, it was shown that 34% of the fluoride in black tea remains in the oral cavity (Simpson *et al*. 2001). Toothpaste contains very high concentrations of fluoride up to 1000-1500 mg/kg of toothpaste, however what is accidentally swallowed and ingested may range up to 3.5 mg/day. It has been shown, that with all the human exposure to fluoride that varies from region to region, drinking-water is generally on average the largest single contributor to daily fluoride intake. Due to this fact, daily fluoride intakes (mg/kg of body weight) are based on fluoride levels in the water and water consumption per day per liter.

Drinking Water Standards

There are maximum guiding values for fluoride in drinking water. There are no minimum imposed limits, however there are recommended values to ensure no potential health risks from lack of fluoride within the drinking water. World Health Organization (WHO) places international standards on drinking water that should be adhered to for health purposes, however is not enforceable and each individual nation may place its own standards and conditions on drinking water. This can be seen in the United States, where the Environmental Protection Agency (EPA), the regulatory body for drinking water, places more lenient drinking water standards than that of the WHO. This can be seen in the Table I.

Table I: Drinking Water Standards Internationally and Nationally

Fluoride Guideline Value Drinking Water Standards	Recommended Minimum Value (mg/L)	Maximum Value (mg/L)	Reference
WHO	0.5	1.5	WHO (1993)
USA – Primary Secondary	0.5 0.5	4.0 2.0	US EPA (1985)
Egypt	-	0.8	Egypt – Decree 108 and 301/1995 (1995)
Jordan	-	2.0	Jordan (2001)
Morocco	-	0.7	Morocco (1991)
Kuwait	0.5	1.5	WHO guidelines applied without modifications
Palestine	0.6	1.0	Palestine (1997)
Saudi Arabia	0.6	1.2	Saudi Arabia(2000)

Experimental Methodology

Water samples were collected from different sub-divisions of districts Hanumangarh (Rajasthan) located between $29^0 5$ to $30^0 9'$and $74^0 3$ to $75^0 31'$ F with total area 9656.09 km^2P and Ferozpur (Punjab) located at $30^0 20$ to $74^0 25'$ with total area 5303 km^2.Both districts have semi dry climate with extreme hot during summer and extremely cold during winter with min and max temp 1^0 *and* 49^0*PP*C respectively. Samples were taken from 22 states during January, June, October from different resources such as hand pumps, well, tube wells, DCB, diggi, tanks and water works supply and analyzed in triplicate with respect to pH, alkalinity, turbidity, total hardness, $Cl^-, SO_4^{2-}, Ca^{2+}, Mg^{2+}$, -content and average results are reported in table. Sample no. 1 to 9 are collected from Hanumangarh district and sample no. 10 to 14 from Ferozpur district and results are represented in tables with respect to increasing fluoride content.

Sample No.	F^- (ppm)	Ph	Alkalinity (ppm)	Total hardness (ppm)	Ca^{2+} (ppm)	Mg^{2+} (ppm)	Cl (ppm)
1	1.64	7.0	86	115	60	32	69
2	2.23	7.0	91	149	100	58	55
3	2.30	7.1	128	176	116	91	66
4	2.46	7.3	189	183	114	100	130
5	2.78	7.3	167	356	239	190	183
6	2.80	7.3	265	410	227	183	198
7	2.96	7.3	545	356	220	133	265
8	3.12	7.5	291	616	456	168	533
9	3.26	7.4	181	480	270	210	397
10	3.29	7.3	186	490	340	150	235
11	4.04	8.0	92	160	116	44	90
12	4.28	7.9	110	190	112	78	32
13	4.51	8.6	88	210	120	90	40
14	4.74	8.4	98	125	80	45	28

Results and Discussion

According to WHO, the acceptable limit for pH is 7.0 to 8.5, alkalinity- and total hardness is 200ppm, Turbidity is 1, Cl^- and SO_4^{2-} is 200ppm, $Ca^{2+}$and Mg^{2+} 75 ppm and 30 ppm and for F^- is 1.0 ppm.

Majority of samples show, alkalinity and total hardness above the permissible limit. Very few samples have Cl^-at alarming level. F^- distribution is associated with parameters like depth of water resource, pH, Hardness, alkalinity Ca^{2+}, Mg^{2+} and Cl^-content of water samples. F^-content in the present study ranges from 1.64 to 4.74ppm. Which is much above the permissible limits prescribed by ICMR, WHO,ISI. It is observed that F content is positively correlated with the depth of water resources pH is found to be within permissible limits.

Potential Health Impacts

As mentioned before there are both recommended minimum and maximum values of fluoride needed in drinking water. If there is not enough fluoride content within the water, then this may result in tooth decay and dental caries (Fawell *et al*., 2006). However, if there are high concentrations of fluoride within the water, this may result in dental and skeletal fluorosis (Fawell *et al*., 2006). The severity depends upon the amount ingested and the duration of intake. Dental fluorosis is a condition where excessive fluoride can cause yellowing of teeth, white spots, and pitting or mottling of enamel. Consequently, the teeth become unsightly. Dental fluorosis occurs more frequently in children under the age of 6 due to the fact that the enamel formation has not yet developed. Dental fluorosis occurs more often where teeth are forming under the gums. Skeletal fluorosis is a bone disease exclusively caused by excessive consumption of fluoride, which depending on the degree of fluorosis can cause increase in bone mass, stiffness in joints, and osteoporosis (Fawell *et*

al, 2006). This is more frequent in the later stages in life with ingestion of high levels of fluoride. At drinking water concentrations between 0.9-1.2 mg/L, fluoride may give rise to mild dental fluorosis. Values of 1.5-2 mg/L of fluoride in drinking water gives rise to higher chances of dental fluorosis, while values exceeding 2 mg/L may have very high chances of dental and skeletal fluorosis (WHO, 1994).

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