ESTIMATION OF FLUORIDE IN DRINKING WATER IN SELECTED AREAS OF SOUTHERN LAHORE, PAKISTAN (A Case Study)

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ABSTRACT*: The study investigated the level of fluoride contamination in drinking water sources developed both by Water and Sanitation Agency (WASA) and privately by public. Fifty (50) water samples were collected from all four ports of the village during winter 2013. NOVA-60 Spectrophotometer was used to determine the concentration. Apart from fluoride other parameter investigated in this study included pH, electrical conductivity and turbidity. The study indicated that 34 percent water samples collected from shallower depths in privately developed sources had fluoride concentrations in excess of limit set by National Standards for Drinking Water Quality(NSDWQ).The both sources of public water supply schemes, installed at depth of 400 feet, indicated concentration of fluoride well below the prescribed limits of 1.5 mg/l. However, the water samples collected form houses served by same safe sources had contamination of fluoride. The study indicated presence of fluoride rich top layer of soil, surface ponding of polluted water in street, existing large wastewater pond in western side of village, leaked /broken water supply lines and suction of contaminated water under negative pressure developed in water supply pipes due to long intervals of 16-18 hours of power failure as cause of this type of contamination. In most of the sample collected from study area, the parameters namely turbidity, pH and Electrical conductivity exhibited positive relation with fluoride. The study recommended the need of initiation of water quality surveillance and epidemiological study in area regarding health impacts of fluoride in village. Further detailed investigations on the effects of stagnated wastewater pond on a large area at periphery of village and its impacts with reference to concentration of fluoride at shallower depth were also deemed necessary in the study.*

KEY WORDS: Water and Sanitation Agency (WASA), National Standards for Drinking Water Quality (NSDWQ) Environment Protection Department, Fluorosis.

INTRODUCTION

In Pakistan, around 70% of drinking water supplies comes from aquifers. The overall goal of the National Drinking Water Policy is to improve the quality of life of people of Pakistan by reducing incidence of death and illness caused by waterborne diseases by providing access to safe and sustainable drinking water supply to the entire population of Pakistan by 2025. The main source of drinking water observed in Pakistan Social and living Standard Measurement Survey 2011-12 was the Motor pump. Hand pumps and motor pumps together provide 60 percent of household's drinking water in 2011-12, as compared to 55 percent in 2010-11. Increasing trend of use of motor pump both was observed in urban and in rural areas that is 30 percent in 2011-12, as compared to 27 percent in 2010-11. Around 60 percent of households have arranged their own water sources. However, the survey also highlighted decreasing trend in use of hand pumps and shallow dug wells [1].

Fluoride, due to its adverse health impacts on human health is an element of major concern now a days. Almost all waters contain Fluoride in varying concentrations (shallow groundwater contains high concentrations). Fluoride is a naturally occurring element found in food and drinking water sources. Bedrock wells are at greater risk for high levels of fluoride. Fluoride may also be discharged as by-products from fertilizer and aluminum factories and from there it can enter groundwater. In addition, excessive use of phosphate fertilizers can also release fluoride in the environment which include fluorine as impurity [2,3] and McLaughlin *et al*., 1996 found that impurity of fluorine in phosphate fertilizers varies from 1.3 to 3.0%[4]

Although fluoride is beneficial for human health in small doses to prevent dental caries, higher concentrations of fluoride also cause respiratory failure, fall of blood pressure and general paralysis. Loss of weight, anorexia, anemia, wasting and cohexia and among the common findings in chronic fluoride poisoning. Continuous ingestion of nonfatal dose of fluoride causes permanent inhibition of growth. Fluoride ions inhibit a variety of enzymes often by forming complexes with magnesium ions other metal ions [5].

The survey, conducted by the Punjab Environment Protection Department and UNICEF during 2000-04 shows high concentrations of fluoride in drinking water samples collected from various sites in Lahore, Multan, Bahawalpur, Shiekhupura, Kasur, Gujranwala, Mandi Baha Uddin, Sargodha, Gujrat and Jhelum. No serious effort is being made at the government and local level to address the issue of deadly arsenic contents which have been found in potable water of 10 cities in the Punjab [6].

A number of bone deformity cases surfaced in Manga Mandi, near Lahore, about three years ago due to the consumption of water having fluoride contents. Fluoride was also found in the water samples collected from Lahore, Sahiwal, and Sheikhupura. The surveys pointed out that the defective sewerage system was one of the main reasons of water contamination besides the use of hand pumps whose water often gets mixed with the contaminated subsoil water [7].

EPD, Punjab studied "Sub-soil Water Quality in Punjab". Under this study 280 water samples were collected from all districts. Out of 280 sub-soil water samples collected, 180 indicated that the quality of water was not fit for human consumption in accordance with the WHO guidelines. Fluoride concentration in 74 samples was found exceeding the prescribed value of 1.5 mg/l. Sample collected from Attock, Bhakar, Bahwalnagar, Chakwal, Jehlum, Kanewal, Khushab, Kasur, Lahore, Layyah, Mianwali, Okara, Sahiwal,

Sargodha, Sialkot and Sheikhupura indicated exceeding concentrations of fluoride [8].

Abida Farooqi et al., studied ground water quality of 17 villages in eastern Punjab near Lahore . The study concluded that environmental pollutants and fertilizers which poses serious threats to water quality of aquifer from 20 to 30m depth may be sources of fluoride. Concentrations of fluoride were found high in the shallow-well waters that showed the high EC values >2.0 mS/cm. At shallow depth 20-27m, the 75% of water samples exceeded the WHO guideline value of 1.5 mg/L for fluoride, the middle depth from 40-50m only 37% samples exceeded permissible limits of fluoride and the groundwater samples from the deep wells of 80-200m depths were <1.5 mg/L with the only exception of one sample [9].

Study "Monitoring and Propagation of Measures to mitigate Arsenic and Fluoride in drinking water in Punjab" was carried out by EPD, Punjab during 2007-10. It was focused to ascertain the quality of sources of community drinking water supply scheme in Punjab. In district Lahore, EPA, Punjab collected drinking water samples from 392 tube wells of Water and Sanitation Agency (WASA) installed at depths ranging from 500-800 feet. The study revealed that concentration of fluoride in all water sources in Lahore was far below the National Standards for Drinking Water Quality (NSDWQ) [10].

Fluoride concentration in drinking water below 0.8mg/l needs fluoride supplementation for proper growth of teeth in children, whereas as its concentration from 0.8 to 1.2 mg/l is an optimal range for promoting dental health in children below the age of 12 years. However an intake of fluoride in concentrations 4-6 ppm or even more result in different health implications multidimensional health manifestations, including dental and skeletal fluorisis. Water having higher concentration more than 4 mg/l need defluoridation and consumers may consult a physician for early addressing of health related issues [5,11]. A study conducted by Sadia Rashid et.,al, 2013 pointed out the prevalence of Dental fluorisis in 300 residents of certain areas of Lahore having concentration of fluoride ranging from 0.27 ppm to 7.4 ppm [12].

Negative pressure in municipal water lines can also cause contamination of water, loss of pressure results in potentially sucking of contaminated groundwater into the water supply if there are any cracks in the pipe. In pipes, pressure is carefully monitored with the use of gauges, and is controlled by valves. A survey of over 700 North American distribution systems found that 65% had cross-connections that were susceptible to backflow via backsiphonage, while 35% of the systems had cross-connections that were susceptible to backflow that could be induced via backsiphonage and backpressure. This means that all of the systems surveyed were susceptible to the introduction of non-potable water through backsiphonage, which could occur with a low or negative pressure transient [13].

Friedman *et al*. demonstrated that negative pressure transients can occur, and that the intruded water can travel downstream from the site of entry, in three of seven full-scale distribution systems. Locations with the highest potential for intrusion were sites experiencing leaks and breaks, areas of high water table, and flooded air-vacuum valve vaults [14].

The city of Lahore, like other parts of the country is experiencing long spell of power failure extended from 6-11hours under a load management program of Lahore Electric Supply Corporation. The situation will likely to create negative pressure in water supply lines due to failure of pumps and other appurtenances at various locations [15]. The bone deformities disease that occurred in village Chah Kalanwal, situated about few kilometers from village Thokar Niaz Baig, has developed an increased interest in fluoride concentrations in ground water of village thokar Niaz Baig and its impact to human health, the present study is focused on determining Fluoride levels in the groundwater of shallow and deep aquifers in village Thokar Niaz Baig.

MATERIAL AND METHODS

The village Thokar Niaz Baig is located at 31.47 ^{0} North latitude and 74.24^{0} East longitude. It is 18-Km away from Lahore, between Lahore-Islamabad Motorway (M-2) at left side and main Multan Road at the right side. This area falls under the territory of Union Council 118 (UC-118). The total population of Thokar Niaz Baig village is 35000 persons, including 15,000 males and 20,000 females. Amongst these 20,000 persons are above 18 years of age while 15,000 are below 18 years. The average family size is 6 person per family. Environmental characteristics of village include poor sewerage system and improper solid waste management. Abandoned heaps of garbage, overflowing sewers / drain and stagnated wastewater along periphery are major environmental issues of the village. In addition to the water supply of Water and Sanitation Agency (WASA), Lahore, almost every house has installed its own water source to meet its water demands.

Fifty samples were collected for comparative study. Samples were drawn with a pre-cleaned plastic polythene bottle. Prior to sampling, all the sampling containers were washed and rinsed thoroughly with the ground water. The pH, conductivity and turbidity were measured by using digital meters immediately after sampling. Whereas, NOVA-60 Spectrophotometer was used to determine concentration of fluoride in samples drawn from the study area.

RESULTS

Fifty (50) numbers samples were collected from different areas of Thokar Niaz Baig Village, which were got analyzed for different parameters, namely **Table- 1** exhibits the values of various parameters investigated in this study. **Table-1** exhibits that 34 percent results of various water samples collected from the village had concentrations of fluoride in excess of limit set by National Standards for Drinking Water Quality (NSDWQ) of 1.5 mg/l as well as World Health Organization (WHO) guideline value of 0.5 – 1.5 mg/l (**Figure-1**). Water samples drawn from sources of the shallow depths, i.e. from 80 – 200 feet depth were found having fluoride concentrations ranging from 0.5 mg/l to 3.4 mg/l and mostly exceeded the prescribed value of 1.5 mg/l. Drinking water samples drawn from WASA tube well installed at depth of 450 feet had fluoride concentration of 0.7 mg/l i.e. less than permissible limit (Sample No. 45).

However, it was noted that water samples collected from consumer ends being served by the same source had high

concentrations of fluoride (sample No 46-50). The exact reasons for such phenomenon will may include a fluoride rich top layer of soil, surface ponding of polluted water in streets, existing large wastewater pond in the western side of village, leaked/broken water supply lines and suction of contaminated water under negative pressure developed in water supply pipes due to long intervals of 16-18 hours of power failure.

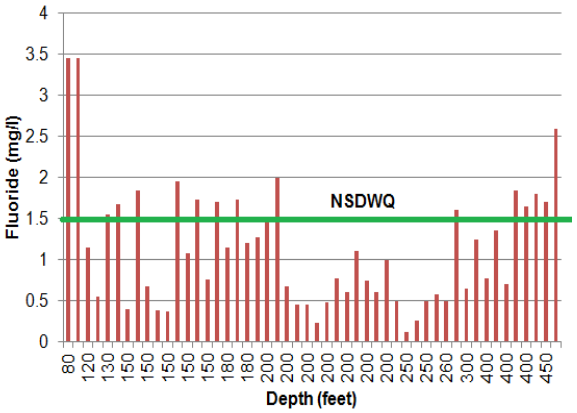

Figure-1 Variation of fluoride with depth

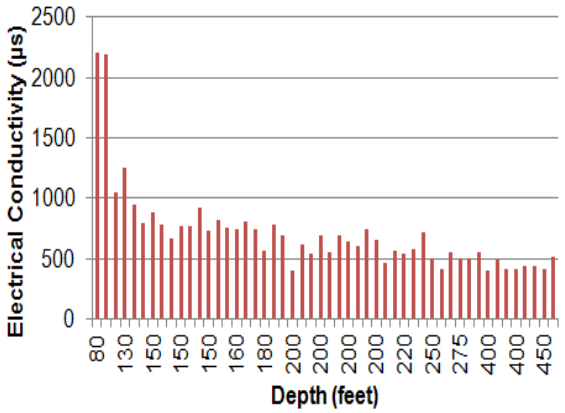

Figure-2 Variation of Electricity with depth

A gradual increase in the pH value of the samples with increase of Electrical Conductivity was also observed (**Figure-2**). The lowest value of Electrical Conductivity was 405 µs against pH value of 6.8 and maximum value Electrical Conductivity 2210 µs was observed against pH of 8.2. This indicates that geological strata in village Thokar Niaz Baig contains basic salts which after dissolving in water increase both electric conductivity as well as pH values.

In most of the sample collected from the study area, the parameters, namely turbidity, pH and Electrical conductivity exhibited positive relation with fluoride which confirmed the findings of the P.D.Pol1, M.C.Sangannavr1 and M.S.Yadawe (2012). A sample collected form shallower depths was having more values of turbidity, though were within prescribed limits. These samples also exhibited high values of fluoride concentration as well as electrical conductivity.

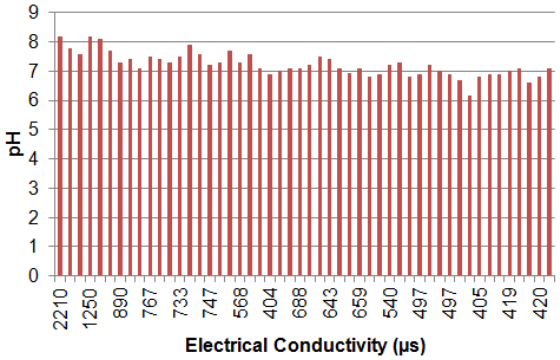

Figure-3 Variation of Electrical Conductivity with pH

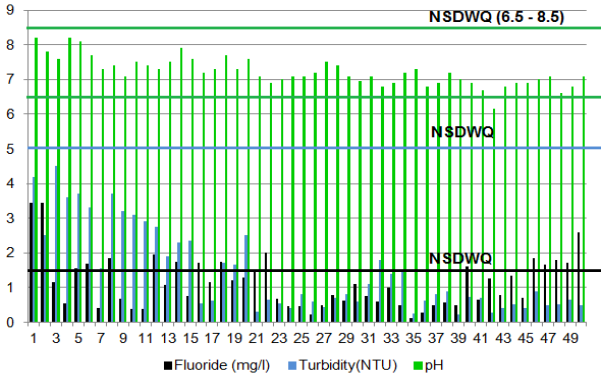

Figure-4 Variations of Fluoride, Turbidity and pH in samples

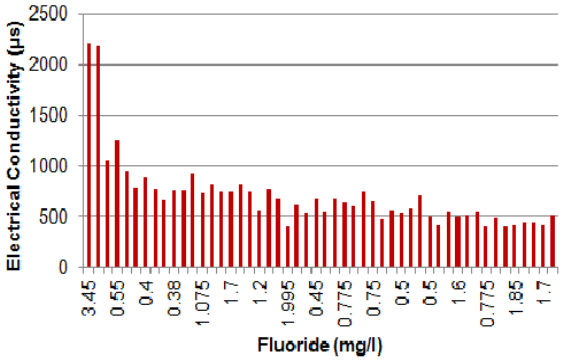

Figure-5 Variations of Fluoride with Electrical Conductivity

The study further recommended initiation of a water quality monitoring program by WASA to indentify sources of contamination in supplies and detailed epidemiological study in village to assess effects of fluoride among villagers.

Table-1 Analysis of Water Samples Collected from various locations in Village Thokar Niaz Baig, Lahore.

Sample Nos.	Address	Source	Depth	F	pH	Turbidity	EC
			(Feet)	(mg/l)		(NTU)	(µs)
1	House in Bhatian wala Chowk	Motor pump	80	**3.45**	8.2	4.2	2210
2	House in Bhatian wala chok	Motor pump	120	**3.45**	7.8	2.5	2190
3	Javed House	Motor pump	120	1.15	7.6	4.5	1049
4	House at Darbar street	Motor pump	130	0.55	8.2	3.6	1250
5	House at Jaanoo Bhattii street	Motor pump	130	**1.55**	8.1	3.7	948
6	Zakir house	Motor pump	140	**1.675**	7.7	3.3	791
7	House in Bhatian wala Chowk	Motor pump	150	0.4	7.3	1.55	890
8	House in, Salamat pura	Motor pump	150	**1.85**	7.4	3.7	778
9	Imam Bargah	Motor pump	150	0.675	7.1	3.2	670
10	House in Jinah Town	Motor pump	150	0.38	7.5	3.1	767
11	House in Jinah Town	Motor pump	150	0.375	7.4	2.9	766
12	Rana House Jinah Town	Motor pump	150	**1.95**	7.3	2.76	919
13	AL-Rehman Clinic	Motor pump	150	1.075	7.5	1.9	733
14	Hadi general store	Motor pump	150	**1.735**	7.9	2.3	818
15	Shahzad milk shop	Motor pump	150	0.76	7.6	2.36	755
16	House in Bhatian wala Chowk	Motor pump	160	**1.7**	7.2	0.53	747
17	Govt. Girls high school	Motor pump	180	1.15	7.3	0.63	812
18	Police Post Street	Motor pump	180	**1.73**	7.7	1.7	743
19	Bhattii wala Chowk	Motor pump	180	1.2	7.3	1.65	568
20	House in Jaanoo Bhattii street	Motor pump	190	1.275	7.6	2.5	777
21	House in Salamat pura	Motor pump	200	**1.5**	7.1	0.31	690
22	Shoukat house	Motor pump	200	**1.995**	6.9	0.65	404
23	Hamza park	Motor pump	200	0.675	7	0.53	619
24	Al-Wahab engg. Office	Motor pump	200	0.45	7.1	0.42	537
25	PCO (Jinah Town)	Motor pump	200	0.45	7.1	0.8	688
26	Mr.M.Asif residence	Motor pump	200	0.225	7.2	0.6	548
27	Vegetable shop (Jinnah town)	Motor pump	200	0.485	7.5	0.43	688
28	Shur Shad town ST # 3	Motor pump	200	0.775	7.4	0.71	643
29	Shur Shad town ST # 3	Motor pump	200	0.61	7.1	0.82	610
30	Shazad Building	Motor pump	200	1.1	6.95	0.6	748
31	Karyana Store	Motor pump	200	0.75	7.1	1.1	659
32	House in Bhattii wala Chowk	Motor pump	200	0.6	6.8	1.8	471
33	House in Bhattii wala Chowk	Motor pump	200	1	6.9	1.4	565
34	Laal Hussain street	Motor pump	220	0.5	7.2	1.5	540
35	Shur Shad town ST # 5	Motor pump	250	0.125	7.3	0.25	578
36	Shur Shad town	Motor pump	250	0.265	6.8	0.63	715
37	High school street	Motor pump	250	0.5	6.9	0.8	497
38	Laal Hussain street	Motor pump	250	0.575	7.2	0.9	419
39	Embroidrory unit, Jinah Town	Motor pump	260	0.5	7	0.21	557
40	Tea Stall (Jinah Town)	Motor pump	275	**1.6**	6.9	0.72	497
41	Al-Rehman public school	Motor pump	300	0.65	6.7	0.7	509

Sample Nos.	Address	Source	Depth (Feet)	F (mg/l)	pH	Turbidity (NTU)	EC (µs)
42	WASA Water Source Salamat pura,	Tube well	450	1.25	6.15	0.28	550
43	WASA water Source near Govt. School	Turbine Tank	450	0.775	6.8	0.42	405
44	Grave Yard, source water supply tank	water supply	450	1.35	6.9	0.52	488
45	Over head tank(Tube well)	Turbine motor	450	0.7	6.8	0.64	420
46	Mr.M.Asif residence water supply tank of WASA	water supply	450	**1.7**	6.9	0.4	412
47	TNB milk shop water supply tank of WASA	water supply	450	**1.85**	7	0.9	419
48	Play ground served by water supply tank of WASA	water supply	450	**1.65**	7.1	0.5	445
49	House near Bhatian wala Chowk, (water supply tank of WASA)	water supply	450	**1.8**	6.6	0.51	440
50	Jamia masjid served by water supply tank of WASA	water supply	450	**2.6**	7.1	0.5	515

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