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Abundance of fluoride and its source in drinking water of Kheshki and surrounding area, district Nowshera, N.W.F.P., Pakistan

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ABSTRACT: *Fluoride, if present in minute amount in human body, is beneficial for the growth of bones and teeth. Its excess is, however, very harmful and usually causes skeletal fluorosis. Few cases of skeletal fluorosis are reported in Kheshki and surrounding areas in N.W.F.P. The drinking water of study area has been, therefore, analyzed for the fluoride contents. It is noticed that this water has high concentration of fluoride. The source of fluoride enhancement in the drinking water of the area needs to be unraveled. For this purpose the water of Kabul river, rocks of Nowshera Formation and the lacustrine and soil samples of the area have been analyzed for fluoride. These media show elevated amounts of fluoride. The study suggests that in the lacustrine and soil deposits of the Kheshki and surrounding area the detrital minerals, which accommodate fluoride in their structure, are the main contributors of fluoride to the drinking water.*

INTRODUCTION

Fluoride is an important element of nutrition because it is regularly present in minute amounts in human bones and teeth and prevents dental caries as well. However, chronic ingestion of excessive amounts of fluoride causes dental and skeletal flourosis. The chief source of fluoride is usually drinking water with 1 mg/l of fluoride. Average water intake is about 1 to 2 liters per day thus one ingests between 1 to 2 mg of fluoride daily. Compared with that in water, the fluoride content in food-stuff is of little importance.

The absence of fluoride in drinking water causes a disease called "Osteoporosis" in which bones and teeth degenerates (Bernstein, et al., 1960). On the other hand the presence of high fluoride in drinking water causes deposition of fluoride in teeth and bones. It is estimated that >1.5 mg/l of fluoride in drinking water causes dental fluorosis (mottling and staining of teeth) (Pindborg, 1970) and >5 mg/l fluoride causes skeletal fluorosis. According to Steinberg et al. (1955), X-ray density of bones in lumber spine, pelvis and elsewhere, increases in skeletal fluorosis. In addition to this, there may be an enormous increase in new bone formation as well as an increase in the width and number of osteoid (organic matrix of bone). Crippling fluorosis occurs when the water supply contains 10 mg/l fluoride (Weatherell & Wiedmann, 1959).

The inhabitants of Kheshki and surrounding area in districts Nowshera and Charsadda of Pakistan are well known throughout North West Frontier Province (N.W.F.P.) for the yellow coloration of their teeth (yellow coloration is indication of dental fluorosis). A general survey of the Kheshki and surrounding area indicated that nearly 70% of the population is suffering from varied degrees of dental and skeletal Fluorosis. Therefore, a detailed study was carried out in this area to evaluate the chemistry of water (surface as well as underground), soils and rocks, in order to determine the fluoride concentration in water, and to find out the source(s) contributing to elevated levels of fluoride.

GEOLOGY OF THE AREA

The Peshawar basin, a broad low lying depression showing small topographic relief, is bounded in the north by the foothills of Swat and Mardan and in the south by Attock Cherat ranges. The sediments of Peshawar basin include lacustrine, deltaic, fluvial, alluvial, flood plain and loess deposits. The deposition of these sediments started about 2.8 Ma when the deformation processes of Attock Cherat ranges ended (Burbank & Tahirkheli, 1985). Besides these sediments, some isolated outcrops of rocks are exposed in Nowshera and Swabi area.

The current study has been carried out in an area of ~300 km² between latitude 34°-00'-92" to 34°-50'-03" North and longitude 71°-45'-00" to 72°-00'-90" East with Kheshki as its main settlement. Charsadda is lying in the immediate west, Doshera in the north, Pir Sabak in the east and Kabul river is flowing along its southern boundary. This area is located about 50 km northeast of Peshawar and 5 km northwest of Nowshera cantonment.

A major portion of the area under investigation is covered by lacustrine/alluvial deposits. These deposits consist of clay and sand beds. The clay is buff in color and exhibits parallel lamination, graded and horizontal bedding. These deposits are considered to have formed in lakes originated due to the temporary blockage of drainage system of the Peshawar basin during Quaternary period (Burbank, 1983). Older outcrops, except the rocks of the Nowshera Formation, are absent from the study area. The Nowshera Formation consists of light grey to pink recrystallized limestones, dolomite and calcareous quartzite and has been dated as of Lower Devonian age (Barnett et al., 1966).

SURFACE AND GROUND WATER SUPPLIES

Kabul river is the only river flowing through the study area. Several channels of Kabul river separate from it downstream of the Warsak dam and rejoin with the main river near Nisatta (Fig. 1). Since 1953, under the Kheshki uplift scheme, the water of the Kabul river is pumped into two canals called Kheshki and Dheri Zardad Khan distributories which irrigate most of the study area.

Groundwater in this area occurs in the permeable sandy and silty horizons of the lacustrine deposits. Malik and Riaz (1990) have carried out a detailed work on the groundwater resources of the area. Water table in the area is 1-10 m deep, with maximum depth noticed in the vicinity of Kheshki. However, there are localities where water logged conditions are prevailing. Malik and Riaz (1990) have reported minor variations, between 0.2 to 0.5 m annually, in the depth of the water table of the study area from June 1988 till June 1990, with a maximum spike in monsoon. The groundwater flow direction is determined to be from north to southeast and ultimately falling into the Kabul river.

FLUORIDE CONTENTS OF DRINKING WATER

Fourteen groundwater samples of dug wells from Kheshki and surrounding area, were collected for detail geochemical studies. Detailed data is documented by Danishwar (1995). Here the values of pH, electrical conduc-

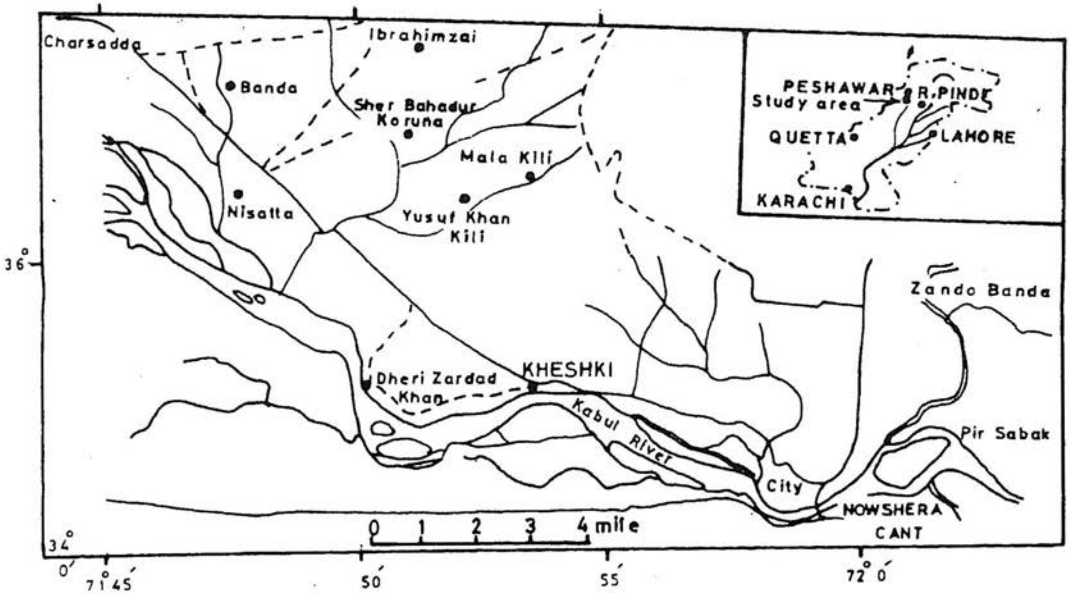

Fig. 1. Location map of the study area.

tivity, total dissolved solids and fluoride for these samples are presented in Table 1. Fluoride (F) was determined by the method of SPANDS as recommended by American Public Health Association (1985).

Except two samples (from Charsadda and Pir Sabak), the rest of the analytical data of groundwater of the study area show multifold higher fluoride contents (3.5-41.25 mg/L) when compared with Maximum Contaminant Level (MCL; 1.5 mg/L) of WHO (1984) (Table 1; Fig. 2). The highest concentration noticed east of Nisatta is 27 multiple of the MCL of WHO. Other significant areas of elevated fluoride concentration are Nowshera city (23.5 mg/l), Zando Banda (23.7 mg/l) and Kheshki village (18.1 mg/L). Such concentrations seem to be a serious threat to the general health of the inhabitants, who already show high incidence of skeletal and dental fluorosis (Dr. Najeeb-ul-Haq, personal commun.).

SOURCE OF HIGH FLUORIDE

In order to find out possible source (s) of elevated level of fluoride in the groundwater of the Kheshki and surrounding area, the fluoride contents in the water samples of Kabul river, rocks of the Nowshera Formation and soils and lacustrine deposits were determined.

Kabul river

Water of Kabul river is extensively utilized for irrigation in the area under investigation. In order to check if this river represents one of the possible source of fluoride contamination in aquifer system, samples of the river water from Nisatta (upstream of Kheshki), Kheshki and Pir Sabak (downstream of Kheshki) were analyzed for fluoride (Table 1; Fig. 2). The data show no fluoride at Nisatta, while fluoride is maximum (i.e., 16 mg/l) downstream of Kheshki. Further downstream near Pir Sabak, fluoride decreases to 6.75 mg/l. This indicates the Kabul river to be recipient and not the source of fluoride contamination in the drinking water of the area.

TABLE 1. FLUORIDE CONTENT OF DRINKING WATER OF KABUL RIVER, ROCKS OF NOWSHERA FORMATION, LACUSTRINE AND SOILS DEPOSITS OF KHESHKI AND SURROUNDING AREA AND ITS COMPARISON WITH THE RECOMMENDED VALUES OF THEIR COUNTERPARTS

Sample No.	Locality	F (mg/l)	pH
1.	Deri Farm	24.10	7.57
2.	Kheshki	16.20	7.97
3.	Kheshki	21.00	7.67
4.	Kheshki	18.20	8.80
5.	Dheri Zardad	10.50	7.48
6.	Nisatta	25.00	8.36
7.	East of Nisatta	41.25	7.60
8.	Mala Killi	5.20	7.57
9.	Nowshera city	23.70	7.61
10.	Zando Danda	23.70	7.80
11.	Charsadda	0.00	7.74
12.	Dosehra (Dwa Saree)	3.50	8.39
13.	Risalpur	7.25	8.58
14.	Pir Sabak	0.00	8.34
	River Kabul		
1.	at Nisatta	0.00	8.00
2.	at Kheshki	16.00	8.24
3.	at Pir Sabak	6.75	8.02
	Nowshera Formation		
NWA–1	Nowshera	552	
NWA–2	Nowshera	696	
NWA–3	Nowshera	700	
NWA–4	Nowshera	564	
	Lacustrine Deposits		
	Kheshki	632 (5)	
	Soil Deposits		
	Kheshki	758 (2)	
	Dheri Zardad	497)3)	
	Nisatta	624 (3)	
	Dosehra	616 (2)	
	Standard values of various medium		
	MCL of WHO for drinking water	1.5	
	Normal dolomite	260	
	Normal limestone	220	
	Normal soil	300	

632 (5) = Average of five samples

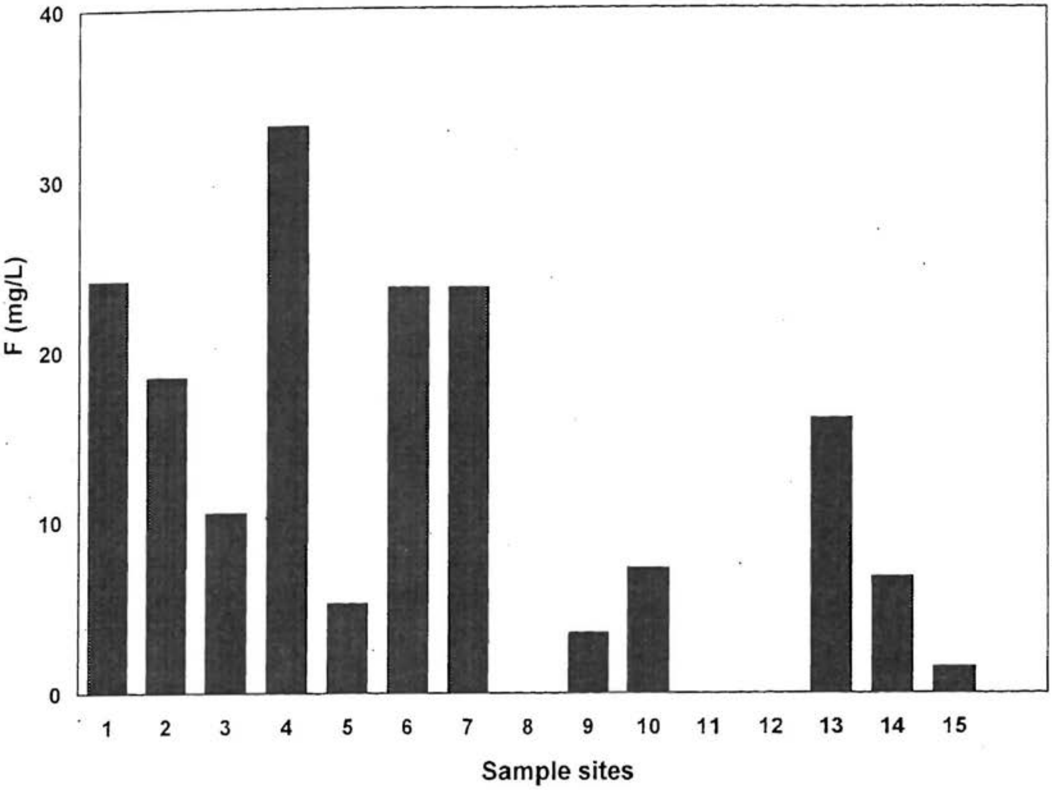

Fig. 2. Fluoride contents in water samples of Kheshki and surrounding area and Kabul river, compared with the MCL of WHO (1984).

Rocks of Nowshera Formation

In order to check the chemical influences of the rocks of the Nowshera Formation on the chemistry of the groundwater in the study area, four representative samples of Nowshera Formation were studied in detail. Petrographic study indicates that these samples are dominantly composed of finely crystalline dolomite, quartz, secondary calcite and 5-10% of bioclastic material. No fluoride bearing mineral was noticed in the petrographic study.

Chemically determined fluoride concentration of 4 petrographically studied samples stand highly elevated (552-700 mg/l) when compared with the fluoride contents of normal dolomite and limestone (Table 1). This comparison shows the Nowshera Formation to be the possible source of fluoride in the groundwater of the study area. The possible material containing fluoride in the Nowshera Formation could be phosphatic shells of conodonts etc. (Bernett et al., 1996). The impervious nature of the Nowshera Formation restricting any flow of groundwater towards the aquifer of the study area and, therefore, defy the above assumption. However, fluoride from Nowshera Formation might have been added to the lacustrine deposits at the time of deposition.

Lacustrine and soil deposits

A major portion of the area under investigation is covered by lacustrine deposits which also serve as parent material to the soils of the area. Five samples of lacustrine deposits were collected from a stratigraphic section near Kheshki whereas five samples of soil were collected from Kheshki, Dheri Zardad, Zando Banda, Nisatta and Doshera.

Mineral phases in these deposits were determined by X-ray Diffractometer at the National Center of Excellence in Geology, University of Peshawar. Minerals identified within these deposits are quartz, calcite, albite, orthoclase, illite, chlorite, hornblende, tourmaline, lepidolite, vermiculite, fluorite and apatite.

Fluoride analyses were carried out in both acid (HF, $HClO_3$) digested soil samples and water soluble soil samples. Results of fluoride in these samples are shown in Table 1. Lacustrine deposits on average have 632 mg/l of fluoride in the acid digested samples and 69 mg/l in the water soluble samples. Fluoride varies from 497 to 758 mg/l in acid digested soil samples and 10 to 24 mg/l in water soluble soil samples. It is obvious that the fluoride contents in both lacustrine and soil samples are almost double than that of normal soil of Adrinao (1986). The possible source of this high fluoride content in the soil samples may be the mineral phases such as fluorite, tourmaline, hornblende, muscovite and lepidolite.

The source of fluoride bearing detrital minerals in both lacustrine deposits and soils of Kheshki and surrounding areas can be the Kabul river and or Nowshera Formation. The former might have carried these minerals form Warsak area, 30 kms upstream of the study area, where alkaline rocks are exposed. The latter may have supplied fluoride, left in the residual clays, that could have been added to lacustrine deposits either as clay minerals or, fluoride precipitation as CaF_2.

The pH of surface and groundwater in the studied area is high (Table 1) which increases the solubility of fluoride in water. This phenomenon is the main factor for the fluoride toxicity in the area. The high solubility rate of fluoride in the soil is not only increasing the fluoride content of drinking water but makes more fluoride available to plants for absorption.

CONCLUSIONS

The drinking water of Kheshki and surrounding area has hazardous amount of fluoride. It is, therefore, recommended that proper remedial work should be carried out in the area. The lacustrine and soil deposits of the area are playing major role in contributing fluoride to the groundwater system. Fluoride bearing detrital minerals (e.g. hornblende, tourmaline, fluorite and illite) identified in these deposits might have been the main source of fluoride. These minerals might have been contributed to the soil deposits by both river Kabul and residual clays of the Nowshera Formation.

REFERENCES

Adriano, D. C., 1986. Trace elements in the terrestrial environment. Springer-Verlag, New York.

American Public Health Association., 1985. Standard method for water and waste water analyses. Washington DC., 1266p.

Barnett, S. G., Kohut, J. J., Rust, C. C., & Sweet, W. C., 1966. Conodonts from Nowshera reef limestone (Upper Silurian or Lowermost Devonian) West Pakistan. Jour. Paleont., 40, 435-438.

Bernstein, D. M., Sadowsky, N., Hegsted, D. M., Guri, C. D. & Stare, F. J., 1960. Prevalence of osteoporosis in high and low fluoride areas in North Dakota. Jour. Amer. Med. Assoc., 498, 499-504.

Burbank, D.W., 1983. Multiple episodes of catastrophic flooding in the Peshawar basin during the past 700,000 years. Geol. Bull. Univ. Peshawar, 16, 43-49.

Burbank, D. W. & Tahirkheli, R. A. K., 1985. The magnetostratigraphy, fission track dating and stratigraphic evolution of the Peshawar intermontaine basin, northern Pakistan. Geol. Soc. Am. Bull., 96, 539-552.

Danishwar, S., Majid, M., Shah, M. T. & Haq, N., 1994. Fluoride abundance in drinking water and related health hazards: a case study from Kheshki area, Nowshera district, N.W.F.P. Geol. Bull. Univ. Peshawar, 27, 113-116.

Danishwar, S., 1995. Geochemistry of water and soil samples from the Kheshki and surrounding area, Nowshera and Charsadda districts N.W.F.P., Pakistan. Unpubl. M. Phil. Thesis, Univ. Peshawar.

Malik, Y. M. & Riaz, M., 1990. Groundwater resources of Kheshki area, N.W.F.P., Pakistan. Hydrogeology Directorate WAPDA, Pakistan Technical Report No. V-4A.

Pindborg, J. J., 1970. Pathology of the dental hard tissues. Munskgaard, Copenhagen.

Steinberg, C. L, Gardner, D. E, Smith, F. A. & Hofge, H.C., 1955. Comparison of rheumatoid (ankylosing) spondylitis and crippling fluorosis. Ann. Rheum. Dis., 14, 378-384.

Weatherell, J. A. & Wiedmann, S. M., 1959. The skeletal changes of chronic experimental fluorosis. Jour. Path. Bact., 78, 233-241.

World Health Organization (WHO) 1984. Guide line values for drinking water, Geneva, 1.