Studies on the distribution of fluoride in drinking water sources in Medchal Block, Ranga Reddy District, Andhra Pradesh, India

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Abstract

Detailed investigations have been carried out on the incidence of fluoride in water sources in Medchal Block, in the North Eastern part of Ranga Reddy District, Andhara Pradesh India adjacent to a severe endemic area of fluorosis, the Nalgonda District.

Results indicate high concentration of fluorides in groundwater ranging from 0.3 to 6 mg l^{-1} in this area which increase with alkalinity and decrease with total hardness. The availability of weathered fluoride-bearing rocks is the apparent contributing factor influencing the fluoride content in water.

Introduction

It is widely recognised that about 1 mg l^{-1} of fluoride is the optimum content in drinking water for proper dental health. Higher concentrations of fluorides, viz. 1.5 mg l^{-1} or above, result in staining of the tooth enamel. Even higher concentrations (5–10 mg l^{-1}) of fluoride result in pathological changes such as back stiffness and difficulty in performing natural movements of the limbs. Ingestion of 20–80 mg fluoride per day or more through water over a period of 10–20 years results in crippling and severe osteosclerosis.

Galagan [1] and Richards [2] have studied the relationship between the optimum fluoride level in drinking water and climatic conditions. High fluoride concentrations are found in several parts of India, particularly in Andhra Pradesh [3–5]. In continuation of our studies on the distribution of fluoride in water sources [6, 7] a similar study has been made in the Medchal Block of the Ranga Reddy District, situated adjacent to Nalgonda District, an endemic fluorosis area. This study has the following objectives: (1) to examine the inter-relationship between the chemical constituents and the high incidence of fluoride; (2) to correlate the incidence of fluoride in water to the groundwater table; and (3) to assess the degree of fluorosis.

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Location

The Medchal Block (Fig. 1) is situated in the North Eastern part of the Ranga Reddy District between latitude 17° 27′–17° 45′ N and longitude 78° 20′–78° 45′ E and occupies an area of 795 km^2 with a population of *ca.* 0.5 million.

Climate and rainfall

The area enjoys a pleasant, warm and dry climate. The coldest season is during December/January when the minimum temperature is 8–10 °C and the warmest period is during the months of April/May with a maximum of 40–43 °C.

The area experiences maximum rainfall during the months of June to September under the influence of the south-west monsoon. Little rainfall is experienced during October/November from the north-east monsoon. The average rainfall for the area is 820 mm.

Geology

The area is composed of Archean crystalline rocks consisting of pink and grey granites. The granites occur as massive outcrops, isolated domes and ridges. These are fine- to coarse-grained, porphyritic and equigranular in texture. The granites are intruded by dolerite dykes which stand out as linear outcrops ranging in width from 3–15 m, which run for lengths ranging from 20 to 300 m. Other rock types seen in the area include quartz reefs, pegmatite veins and epidote veins.

Methodology

Samples were collected from the wells and other sources used by villagers for drinking purpose on a grid pattern. One hundred eighty eight (188) samples were collected from open wells (98), borewells (73) and other sources (17) from 89 villages in the area. All the samples were analysed as per APHA standard procedures.

Results and discussion

A fluoride contour map (Fig. 2) has been drawn indicating areas of uniform distribution. The highest concentration of fluoride was observed in Shambipur village (6.9 mg l^{-1}) and the lowest in Suaram village (0.1 mg l^{-1}). Results indicate that out of 188 samples, 89 samples (47%) had a fluoride content less than 1.5 mg l^{-1} whereas 99 samples (53%) had a fluoride content higher than 1.5 mg l^{-1}. Of the 89 villages covered, 32 showed fluoride amounts below 1.5 mg l^{-1} in all the drinking water sources

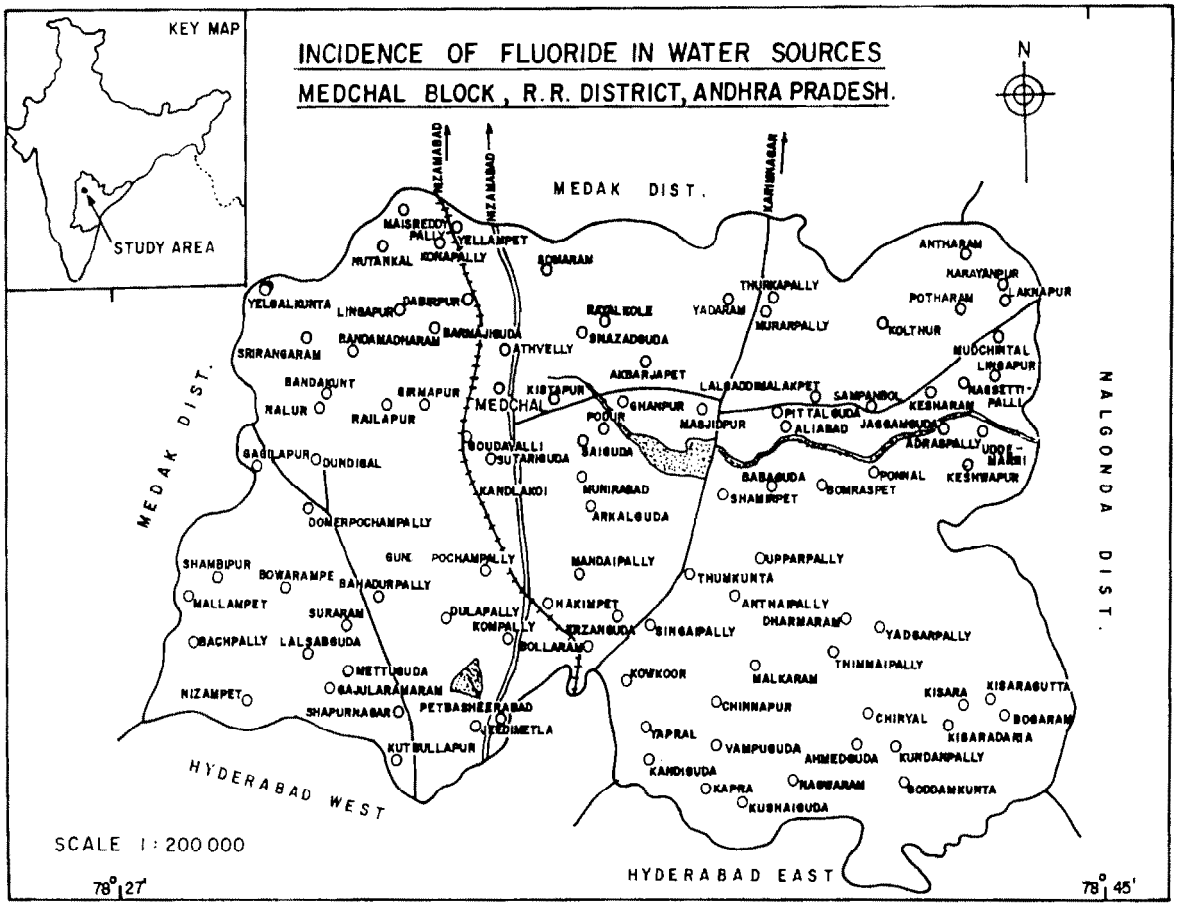

Fig. 1. Location map.

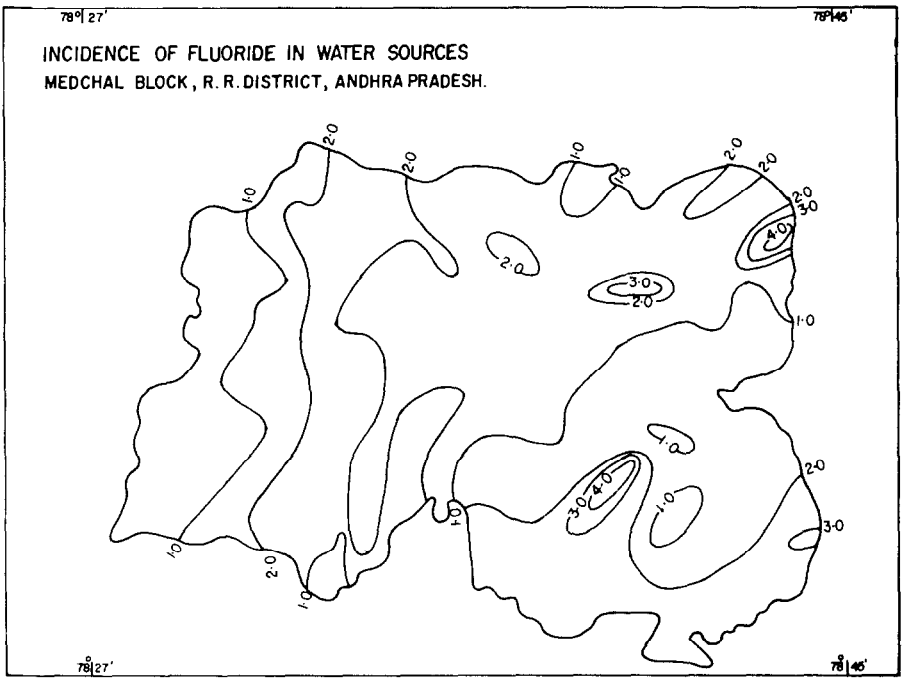

Fig. 2. Fluoride contour map.

presently in use and 15 villages had at least one drinking water source with fluoride less than 1.5 mg l^{-1}. It is interesting to note that the areas adjacent to streams leading to Shamirpet pond and to those leading to Musi river in Nalgonda District had low fluoride (1 mg l^{-1}) levels and that the fluoride content increased away from the streams.

Chemical analysis data presented in Table 1 shows that the fluoride concentration increases with a decrease in total hardness and increases with an increase in alkalinity and pH value (Figs. 3 and 4). This is similar to the observations of Bouwer [8].

The results show that the magnesium content of the water remains constant while the calcium content decreases with an increase in fluoride content and alkalinity. Fluoride present in the rocks and soils is leached out readily by bicarbonate [4] into ground water, and hence the bicarbonate alkalinity can be correlated to the fluoride content. Garrels and Machenize [9] reported that the extent of the availability of the HCO_3 ion in a given environment accounts absolutely for the magnitude of the chemical weathering of the source rock. The changes within the system are represented below:

$$\text{rock} + H_2O + CO_2 = \text{clay} + SiO_2 + \text{cations} + HCO_3^-$$

Under similar physicochemical conditions the fluoride ion is also released into the environment:

TABLE 1

Variation of fluoride with other parameters

No. of samples	Total No. of samples	Fluoride ($mg\ l^{-1}$)		Alkalinity as $CaCO_3$ ($mg\ l^{-1}$)				Hardness as $CaCO_3$ ($mg\ l^{-1}$)			Ca ($mg\ l^{-1}$)	Mg ($mg\ l^{-1}$)	T.A./T.H.	B.A./T.H.	B.A./C.H.	pH	Static water level (m)
		Range	Mean	C.A.[a]	B.A.	T.A.	E.A.	C.H.	T.H.	N.C.H.							
89	47	0–1.5	0.9	45	263	308	–	265	381	73	106	26	0.81	0.7	1.0	7.2	9.3
81	43	1.6–3.0	2.1	54	276	330	–	228	345	15	91	28	0.96	0.8	1.2	7.1	8.9
16	9	3.1–5.0	3.8	73	344	417	132	155	285	–	62	32	1.46	1.2	2.2	7.3	8.2
2	1	5.0	6.2	78	348	426	257	88	169	–	35	20	2.63	2.2	4.0	7.5	8.1

[a]C.A. = carbonate alkalinity; C.H. = calcium hardness; T.A. = total alkalinity; N.C.H. = non-carbonate hardness; B.A. = bicarbonate alkalinity; T.H. = total hardness; E.A. = excess alkalinity.

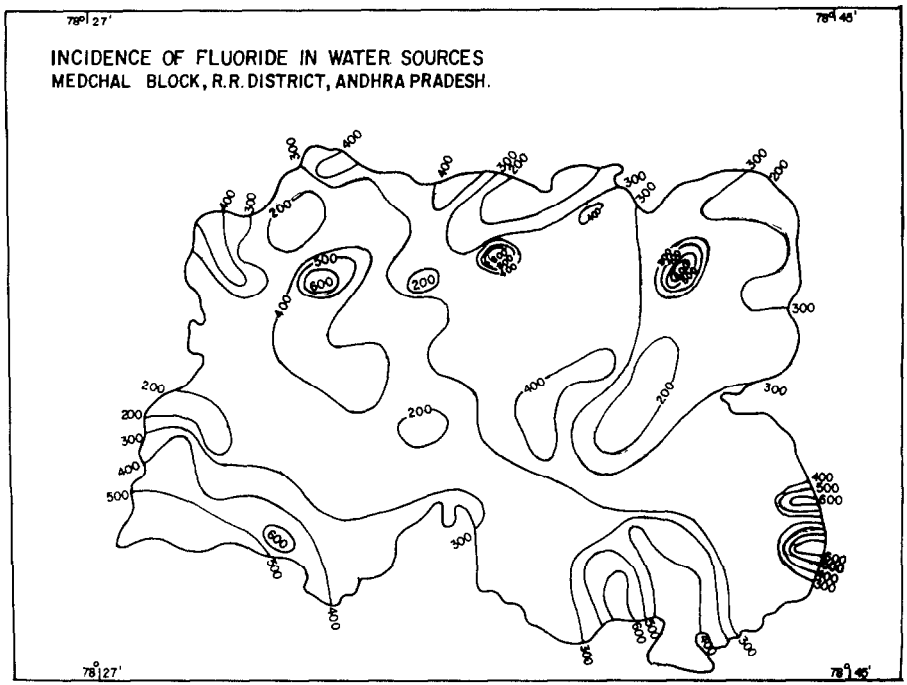

Fig. 3. Total alkalinity contour map.

$$\text{granite} + H_2O + CO_2 = \text{kaolin} + SiO_2 + \text{cations} + F^-$$

The results obtained in the present study confirm this observation. It can also be seen from the table that in samples having a non-carbonate hardness of 73 mg l^{-1}, the fluoride content is found to be less than 1.5 mg l^{-1} and a high fluoride content (more than 3 mg l^{-1}) was observed in samples with excess alkalinity.

It has been reported [4] that a significant number of water sources in Andhra Pradesh, with a ratio of total alkalinity/total hardness of less than 2.0, were found to contain fluoride to less than 2 mg l^{-1}. The present investigations indicate that when the total alkalinity/total hardness ratio is 2.0 the fluoride concentration was more than 5 mg l^{-1}, whilst for the fluoride content to be less than 2 mg l^{-1} the ratio must be less than 0.96.

A direct relationship is observed between the concentration of fluoride and the water table. The fluoride concentration increases with the depth of the water table in the study area.

Earlier reports on the distribution of fluoride in ground waters of Hyderabad and Nalgonda [4–6] indicated that the high fluoride concentration is due to fluoride-containing rocks and the degree of weathering. Since the study area is situated between Hyderabad and Nalgonda, the occurrence of high fluoride concentration in water can be attributed to similar rock types.

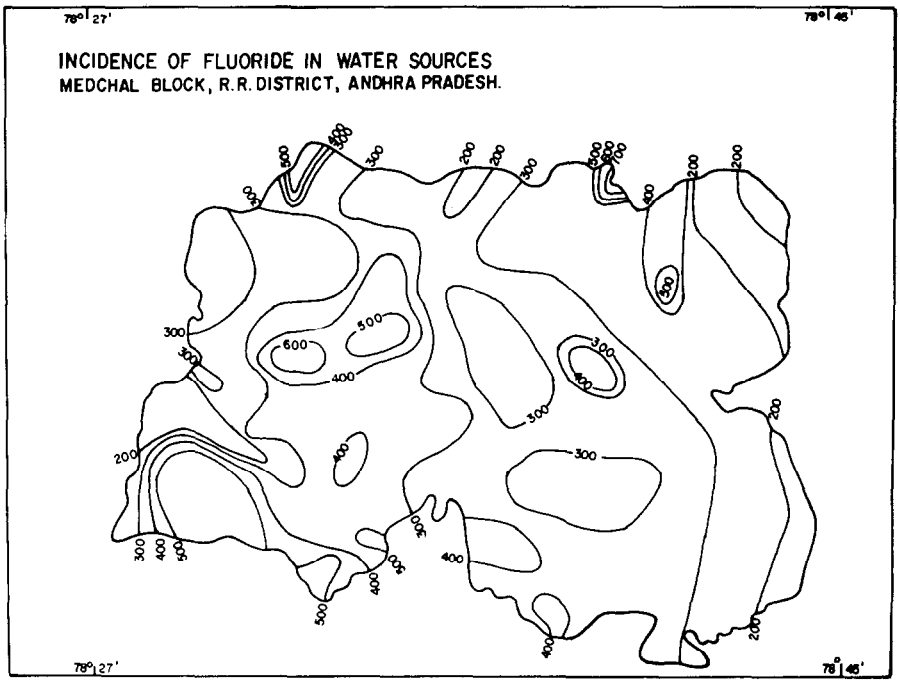

Fig. 4. Total hardness.

Further studies on the distribution of fluoride in soils, water and rocks is under progress. Epidemological and radiogical studies will be carried out to assess the degree of fluorosis amongst children.

Conclusions

Geological factors appear to influence the distribution of fluoride in the study area. Fluoride-bearing pink porphyritic granites with varying degree of weathering, as occur in Nalgonda and Hyderabad, have been located in this area.

The present study has revealed that excess alkalinity is responsible for the high incidence of fluoride, as well as the appreciable concentration of calcium and the high leachibility of groundwater.

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