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DISTRIBUTION AND SOURCES OF FLUORIDE IN INDIAN GROUNDWATER

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Abstract:

Contamination of water is one of the main public health impacts in India. Water fluoride contamination is a big concern worldwide, with health risks such as dental fluorosis and skeletal fluorosis. The rocks rich in fluoride are the principal source of fluoride in groundwater. The presence of high fluoride ion concentration in groundwater is a big problem and it renders the water unsafe for drinking purposes. Fluoride abundance in groundwater suggests various geochemical processes and groundwater pollution in a specified area. Highly responsible for the availability of fluoride in groundwater are fluoride bearing aquifers, geological factors, weathering rate, ion-exchange reaction, residence time, and leaching of subsurface pollutants. The relatively high-fluoride-contaminated states in India are Rajasthan, Andhra Pradesh, Telangana, Tamil Nadu, Gujarat and West Bengal. Unwanted fluoride levels in groundwater are one of the most common groundwater quality problem affecting large portions of India's arid and semi-arid regions. Chronic consumption of heavy doses of water rich in fluoride contributes to fluorosis on humans and animals.

Background:

Water is important for the entire human, animal, and plant kingdom related physiological activities. Groundwater is the primary source of drinking water, adding 0.6 per cent of all water supplies to freshwater. Hence, sustaining earthly life is an essential natural source. Rapid growth in industrialization and urbanization and growing population have increased the pressure on the environment, and intensive use of groundwater for domestic, agricultural and industrial purposes has changed the chemical composition of groundwater over the last few decades. Owing to the variation in the interactions between water and soluble minerals, sparsely soluble minerals, and salts, both natural and anthropogenic, the water quality is poorly known. Pollution of fluoride in groundwater is becoming a leading concern worldwide as the causes of the pollution are normal and inevitable. Throughout the

world, there are many sources of fluoride and various routes to get into the drinking water supply, which are responsible for possible effects on human health. The causes may be both gelogenic, such as the presence of rocks and sediments of fluorine-bearing minerals as well as anthropogenic, such as pesticide use and industrial waste. The rate of weathering of geological contaminants is dependent on the lithology and climate factors. It was reported that geogenic sources are the main cause of population exposure due to the consumption of fluoride-contaminated groundwater. Landfills, chemical effluent, on-site sewage systems and the use of phosphatic fertilizers often contaminate the groundwater. Several studies have confirmed that high-fluoride-containing water consumption is responsible for chronic and emerging human health epidemics. Dental fluorosis (mottling of teeth) and skeletal fluorosis (bone deformities) are typical chronic health effects due to the ingestion of water polluted with high fluorides.

Fluoride contamination in soil-sources:

Fluoride is the Earth's 13th most abundant element in the crust. Fluoride is typically a natural product that is commonly distributed in the atmosphere and makes up about 0.32 per cent of the earth's crust. It is present primarily as NaF or HF which can be found in fluorspar, apatite, fluorapatite, topaz, sellaite, and cryolite minerals. Fluoride-bearing mineral weathering is the first major natural source of inorganic fluorides in the groundwater, while volcanic eruption is the second major natural source, and marine aerosols are the third major natural source. Fluorine is usually found in most rock in the range of 100−1300 mg/kg, but fluoride content in soils typically varies in the range of 20−500 mg/kg. Exceptionally higher fluoride presence was observed in rock-derived soils with high fluorine content or in cultivated soils affected by anthropogenic inputs, such as application of phosphate fertilizers, sewage sludge intrusion, mining, pesticide and brick kiln use, and industrial contamination. The major anthropogenic causes of degradation of fluoride in groundwater are the unscientific use of phosphatic fertilizers. Evapotranspiration increases the salinity of soil solutions which eventually contributes to higher fluoride content entering groundwater.

Specific chemical factories (like phosphorous fertilizer plants, steel, aluminum, zinc, smelting factories, etc.), glass and ceramic industries, and power plants are the main anthropogenic sources of fluoride contamination in soil. High levels of fluoride produce various negative impacts on plants, such as germination inhibition, ultrastructural malformations, reduced photosynthetic efficiency, altered membrane permeability, reduced productivity as well as biomass, and other physiological and biochemical disorders produced. Fluoride has a major

impact on certain physiological processes resulting in chlorosis, leaf necrosis, leaf tip burning, change in plant body biochemical ratio, etc. Knowing the sources of fluoride in the water is very essential to recognize the mechanisms of fluoride mobility in groundwater. In this section, we discussed the potential fluoride sources and associated natural and anthropogenic activities through which fluoride enters the environment. Schematic diagram of the fluorine hydrogeochemical cycle is shown in Fig. 1.

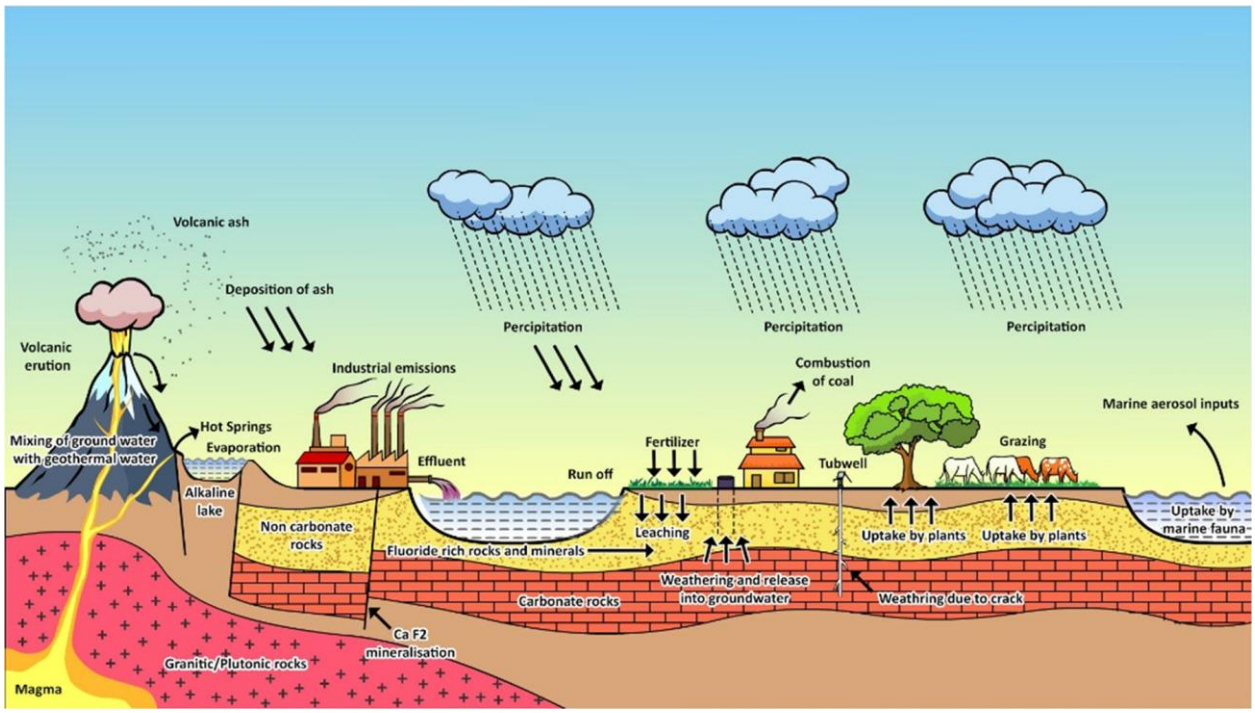

Fig. 1 Modified schematic diagram of fluorine hydrogeochemical cycle (Edmunds and Smedley 2005)

Distribution of Fluoride In India:

A rapid population growth, industrial development, intense farming activity, low rainfall, declining surface water resources, and climate change in recent years have caused significant stress on surface / lake water supplies especially in Indian states. Thus, people are forced to depend on groundwater for their everyday needs. Soil water eventually becomes more vital water resource mainly for drinking, domestic and other uses in our India. The areas that are most seriously impacted are Andhra Pradesh, Punjab, Haryana, Rajasthan, Gujarat, Tamil Nadu and Uttar Pradesh. The highest concentration seen in India to date is 48 mg/L in Haryana District of Rewari. In India several fluorides influenced districts. Figure 2 displays the map of India with all districts displaying concentration of fluoride in drinking water. A survey conducted by the human rights organization (NGO) on human population

health hazards found that the dental and skeletal disorders in many parts of India are due to fluoride content in groundwater.

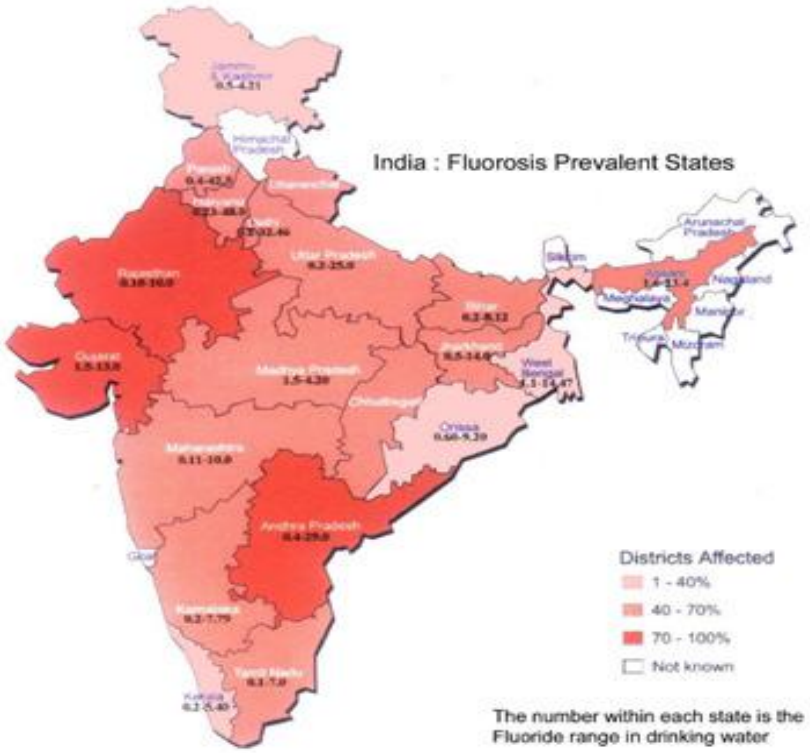

Fig.2 Map showing Fluorosis prevalent states

In most cases, however, geological conditions are primarily responsible, naturally, forincreased concentration of fluoride in groundwater. Therefore, understanding the geological features and mechanisms of fluoride mobility in these regions is very essential. In this study, we digitized various geological maps of relatively high-fluoride-contaminated states to understand the relationship between fluoride from the groundwater and its geology. In India, groundwater accounts for over 85 per cent of supplies of drinking water. In India, for domestic needs about 80 percent of the rural population and 50 percent of the urban population depend directly on the groundwater resource. Elevated fluoride levels in groundwater are one of the most natural groundwater quality problems affecting large portions of semi-arid Indian regions.

Table 1. Fluoride concentrations reported in groundwater of India (*Yadav et al. (1999)*).

Region/State	Fluoride concentration (mg/L)	Maximum severity of fluorosis observed
North-West India	0.4 – 19	Severe
Central India	0.2 – 10	Moderate
South India	0.2 – 20	Severe
Deccan Province	0.4 – 8	Moderate

Fluoride flow from irrigation water to cultivated crops

Plants transport fluoride to various organs, mainly the leaves, via xylematic flow. Various researchers have shown bioconcentration of fluoride in plants at different levels. The bioaccumulation of fluoride had been established to cause chronic toxicity in grazing animals and humans. The chronic toxicity can ultimately damage the bones and cause wear of the dents. Leafy vegetables are susceptible to air borne fluoride and shows wide variations in the fluoride level cultivated in different areas.

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