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Studies On Groundwater Contamination Of Fluoride In Uttar Pradesh And Contamination Impact Upon Public Health At Agra District

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ABSTRACT

Groundwater plays a major role in the supply of drinking water and it is also used for agricultural land irrigation. Sometimes naturally occurring chemicals from the bedrocks and surroundings contaminate the groundwater. Fluorides and arsenic are the two major elements that contaminate groundwater. An elevated level of groundwater fluoride affects various organs and the condition is known as fluorosis. Several districts in Uttar Pradesh are affected by the fluoride contamination in groundwater. According to a recent report of the Geological Survey of India, 15 blocks of the Agra district exhibited a high level of fluoride in groundwater. In the current study, we like to explore the mechanism of fluoride contamination in groundwater and its consequences on public health in Uttar Pradesh. In this study, we focused on the groundwater fluoride contamination at Agra district Ministry of Rural Development promoted an awareness campaign for Fluorosis. The NPPCF was launched by the Government of India in 2008 for the management and prevention of fluorosis in endemic areas.

Keywords: Fluorides, Fluorosis, Groundwater, Uttar Pradesh, Hydrology

INTRODUCTIONS

Groundwater is one of the major sources of water utilized as drinking water. Other sources of drinking water are rivers, ponds, lakes, fountains. Groundwater is also defined as the hidden sea because it is not only the major resource of water for drinking purposes but also for agricultural land irrigation. Generally, groundwater contains a minimal amount of biological and chemical contamination and needs minimal treatment. Unfortunately, naturally occurring chemicals from the bedrocks and surrounding movements of groundwater contaminated the groundwater. It is important to check groundwater quality and its supply as drinking water [1, 2]. The management of groundwater and its proper utilization has emerged for the community.

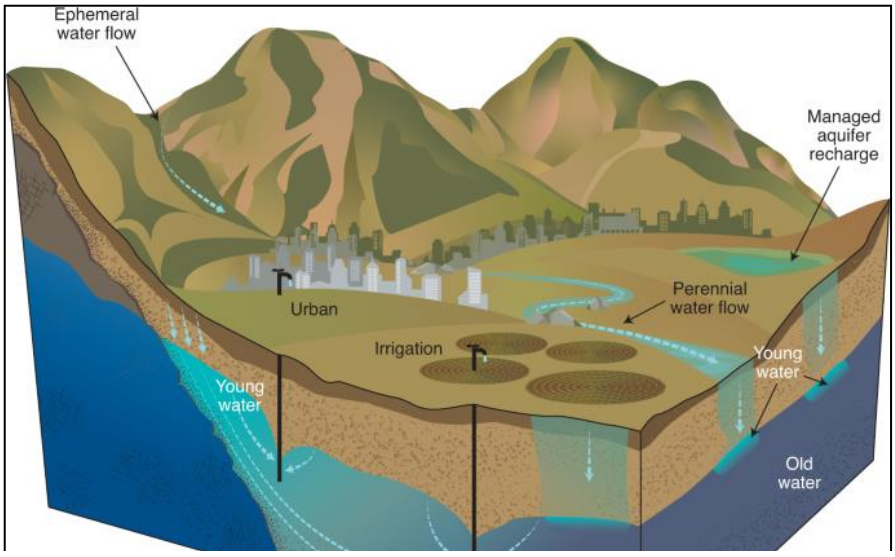

Figure 1 Schematic diagram for natural hydrologic processes. Groundwater age distributions are regulated by various human activities like irrigation, industrialization [3]

Major elements that contaminate groundwater are fluorides and arsenic [4]. These contaminations even at low concentrations lead to an impact on global health. Volcanic activities and the presence of hot water springs are mainly associated with the contamination of groundwater. Fluoride levels in groundwater are associated with bivalent and monovalent metal ions (calcium, magnesium, and sodium)levels in groundwater. Areas with high fluoride in groundwater areas are widespread in several Asian(India, China, Srilanka, Iran, Pakistan) and African counties (Sudan, Uganda, Ethiopia, Kenya, Uganda, and Tanzania) [5,6]. Fluorine is a very common element and is found as fluoride salt due to its high reactivity to other elements. Fluorine is an electronegative element and is reactive to many types of rocks. Minerals like fluorspar, cryolite, fluorite, and Fluorapatite exist in form of fluorides and calcium fluorides are the most common form [7, 8]. A major portion of the fluorides present in groundwater is completely soluble in water and their concentration in water is controlled by various factors (types of rocks, conditions of climate, hydrogeological nature, circulating groundwater, and rock interactions. Dissolution of fluorite by calcite precipitation is an important mechanism for fluoride contamination in groundwater. [8, 9]. Several districts of Uttar Pradesh encountered groundwater fluoride contaminations. A recent report suggested that the groundwater at Raebareli and Agra district of Uttar Pradesh contains a high level of fluoride. In this study, we would like to focus on the major areas of fluoride contamination and its consequences on human health.

REVIEWS OF LITERATURE

GROUND WATER:

Groundwater is one of the major and vital components to support human life and activities. The groundwater resources are used for various human activities like agriculture, manufacturing purposes. The groundwater resources are under stress because of population growth, industrialization, and urbanization. Geogenic and anthropogenic activities are the major concerns for the pollution of groundwater. Groundwater contains several inorganic compounds that interact with other components in the environment. These chemical interactions lead to the release of several elements from the mineral and they are enriched in the water. The suitability of groundwater for drinking purposes is determined by the level of several inorganic salts (Nitrate, Iron, Arsenic, etc) as well as the level of halogens (Chloride and Fluoride)[10, 11].

HYDROGEOLOGY AND HYDROCHEMISTRY

Hydrology is an interdisciplinary stream of science deals with the ecology of water and its relationship with the surrounding environment in the phase of the hydrologic cycle. The hydrologic cycle or water cycle is defined as a continuous process for water mobilization from earth to atmosphere and vice e versa. In this process, water is evaporated from a water body (oceans, lakes, rivers, etc) to the atmosphere and returned back to the earth's surface in the form of precipitations. The major portion of the surface water comes from precipitation infiltrates downward. The soil on the surface has several zones for the preservation of water e.g. unsaturated zone and saturated zone. The upper layer of the soil creates the unsaturated zone where water is not saturating the soils .on the other hand saturated zone i.e. below the layer the spaces between rock particles are saturated with water [11]. Mainly two types of rock formations have been characterized by different hydraulics of groundwater. These two rock formations are 1) Porous Formations and 2) Fissured Formations. Unconsolidated and Semi-consolidated formations are the two major parts of porous formations.

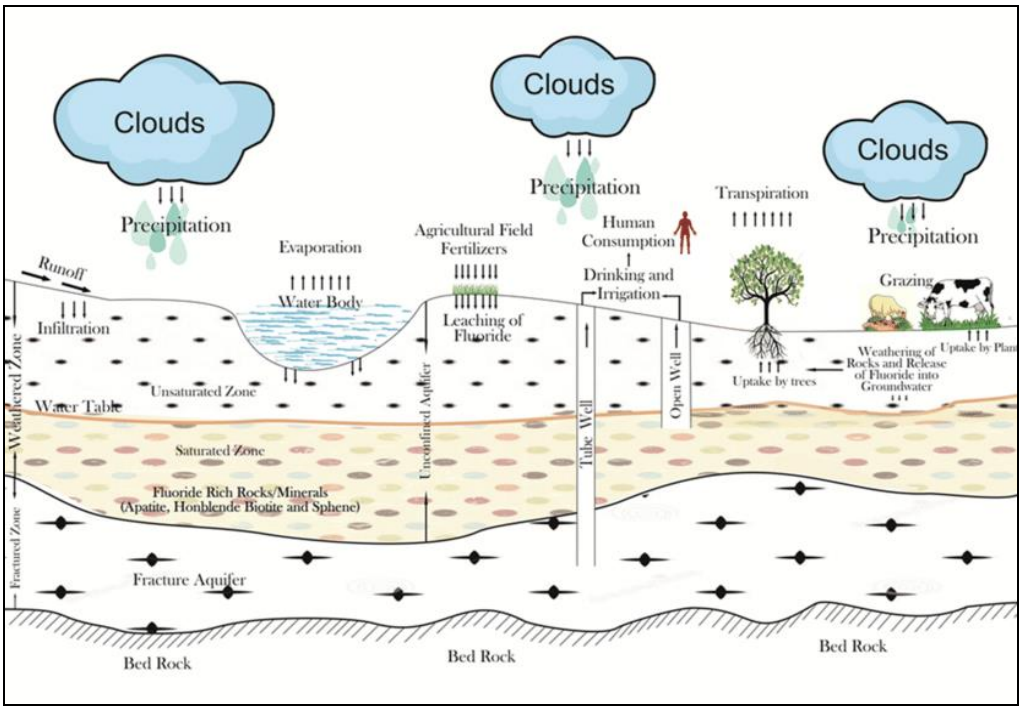

Figure 2: Schematic diagram for the fluoride contamination in groundwater Water from different sources is accumulated. The leaching of fluorides from the minerals contaminates drinking water and water used for agriculture [11].

River basins sediments area, coastal and deltaic tracts areas constitute the most potent large-scale groundwater. The Fissured or consolidated formations constitute around two-thirds of the country. Fissured rocks are mainly four types viz. 1) igneous and metamorphic rocks 2) Consolidated sedimentary rocks 3) Volcanic rocks 4) Carbonate rocks [11]. Hydrochemistry is a multidisciplinary science that addressed the chemistry of water with its natural environment. The main purpose of hydrology is to provide a chemical composition of the water-soluble components and information about the regional distribution of water qualities. Hydrochemistry possesses the potential to trace the origin and history of water [12]. Hydrochemistry can also provide immense information about the water bodies in the system. For the evaluation of hydrochemistry and pollution effect in an ecological niche, it is important to study the overall system like atmospheric water (rainwater), surface water, and groundwater simultaneously.

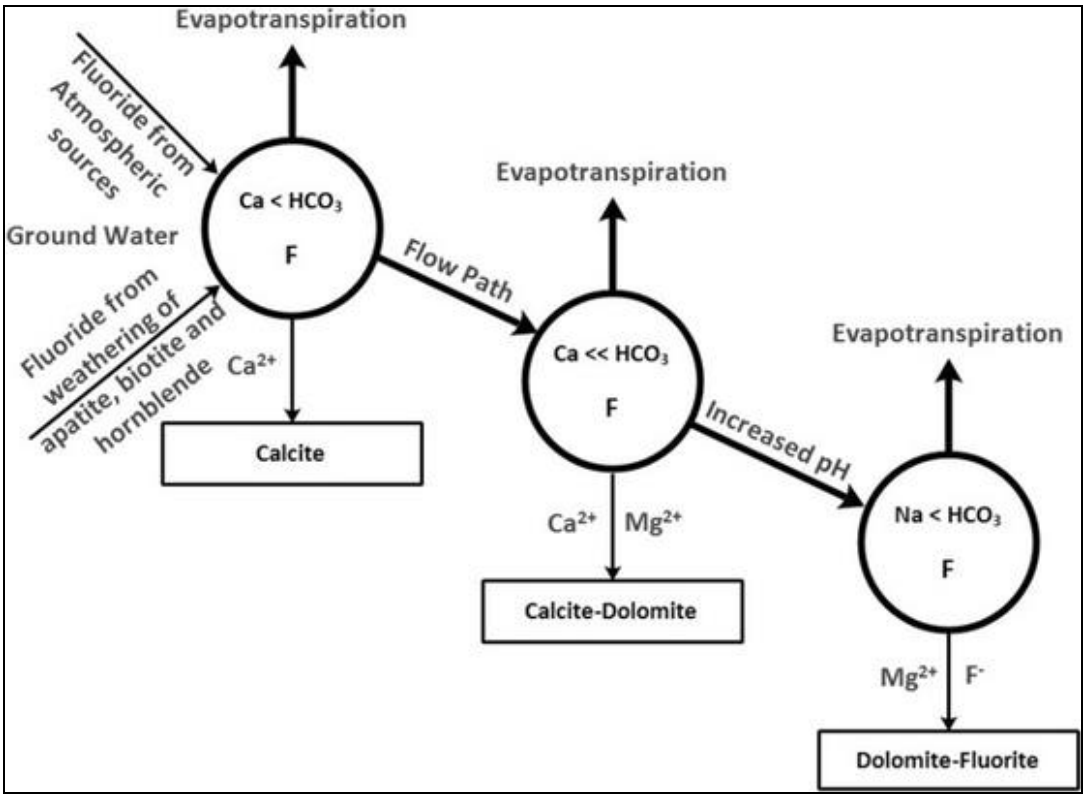

Figure 3 Mechanism of fluoride contamination in groundwater Fluorides come from different natural sources and interact with different minerals present in the groundwater. The complex chemical interactions deposited the minerals as rocks in the bed of groundwater [13].

MECHANISM OF FLUORIDE CONTAMINATION

The World Health Organization (WHO) recommended an upper limit of fluoride in groundwater is 1.50 mg/L. Fluoride contamination in the geographical areas with groundwater is mainly determined by the presence of volcanic bedrocks, crystalline basement rocks as well as arid or semi-arid climatic conditions. Other factors include calcium deficient sodium bicarbonate type groundwater, the long residence time of groundwater, and the distance from the recharge area. Fluorite (CaF_2) and fluorapatite (FAP) have generally been recognized as the components for fluoride contaminated groundwater.

FLUORIDES AND HEALTH HAZARDS:

Fluoride ion is an essential component for humans. A suboptimal level of fluoride compounds is beneficial to the body. In toothpaste one of the components is fluorides and it is used to prevent dental caries. Fluoride is known to affect several parts of our body

mainly in teeth, bone, skeletal muscles, nervous system, and the condition known as fluorosis. The symptoms associated with fluoride poisoning are nausea, diarrhea, salivation, and abdominal pain. Several studies suggested that the uptake of high fluoride causes several socio-economic problems. Fluoride contamination in groundwater also affected the lungs [14]. The excessive fluoride concentration of groundwater causes serious health hazards and affects several factors that are responsible for influencing groundwater fluoride contamination. The factors are pH-dependent dissolution, ionic concentrations in water, rock and water interactions, contact time, atmospheric deposition, and level of carbonate and bicarbonate ions. Generally, NaF or fluorosilicates are used routinely to the water for community water supplies for removing the microorganisms. In this treatment, fluoride levels were maintained in the range of 0.7 to 1.4 ppm for the reduction of dental. According to the Bureau of Indian Standards (BIS) recommendation, the upper desirable limit of fluoride in drinking water is 1.0 mg/l of. BIS also suggested that the upper limit can be extended to 1.5 mg/l in the case of the unavailability of an alternative source of water. In general fluoride concentration of more than 1.5 mg/l in water should not be used for drinking purposes. Several states of India have some regions that exhibited a high level of fluoride in groundwater. Recent surveys and reports suggested that groundwater from the major part of the country used for drinking purposes should be less than 1.0 mg/l [15].

FLUORIDE CONTAMINATION IN GROUND WATER IN UTTAR PRADESH

In India, fluoride contamination in groundwater is mostly studied in the state of southern and western parts of the country. The Indo-Gangetic plain (IGP) constitutes a vast area of northern India which has a vast river basin. Uttar Pradesh is the largest state in India.

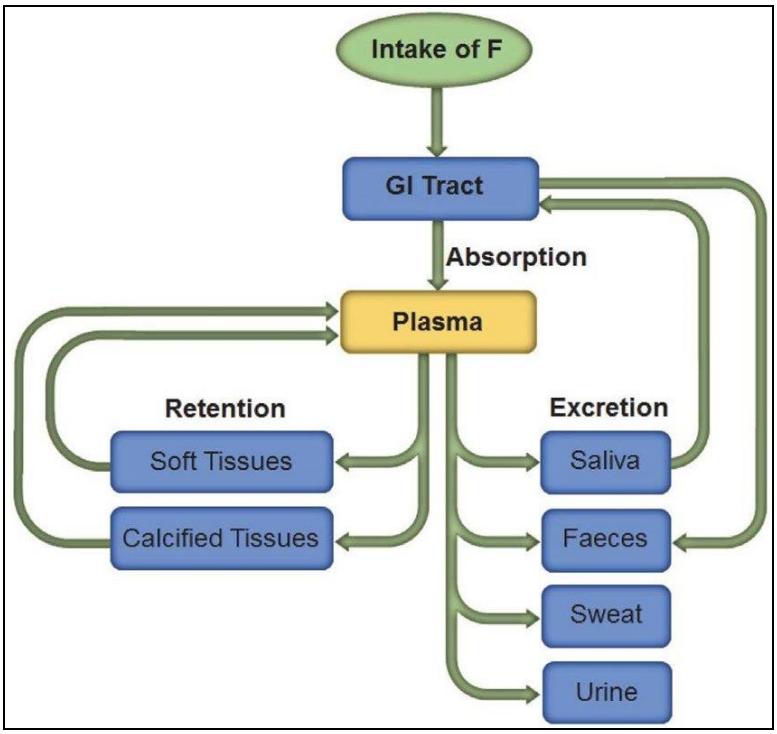

Figure 4: Fluorine is ingested in our body in the form of Fluoride. It is absorbed in plasma and affects the soft tissue sand deposited in the calcified tissues. Excess fluorides are execrated by our excretory systems [15].

It has been reported that the maximum level of fluoride concentration in groundwater is observed in the district of Raebareli, Uttar Pradesh. It indicated the fluoride-bearing minerals present in the aquifer system are the cause for the high fluorides in groundwater. The average elevation of the Agra district is about 171 meters (561 feet). A recent study was performed to analyze the fluoride level of groundwater samples taken collected from various regions of Agra [16]. For these purposes, groundwater samples were gathered from multiple wells with depths of 60 to 90 meters below ground level. The groundwater level in the wells was characterized by the water level recorder and its pH. They found that the groundwater at the Agra district exhibited average fluoride ion concentration in the range of 0.1 and 15 mg/l. Indian standard specifications suggest that the fluoride concentration in drinking water is from 0.6 to 1.2 mg/l. They classified the groundwater samples into four different categories according to their fluoride content in water. According to their survey, 80% of samples of groundwater samples exhibited fluoride concentration of more than 1.5 mg/l. These reports indicate that the area is affected by fluoride contaminations. Another study of fluoride contamination in groundwater was performed at the Bichpuri block of the Agra district. They checked the groundwater fluoride level in 60 different wells and found 90% of the sample are at risk of fluoride poisoning [17]. Defluoridation techniques and rainwater harvesting are needed as remedial measures. Besides this, a calcium and

phosphorus-rich nutritional diet should be provided to the community to decrease the rate of accumulation of fluoride in the human body.

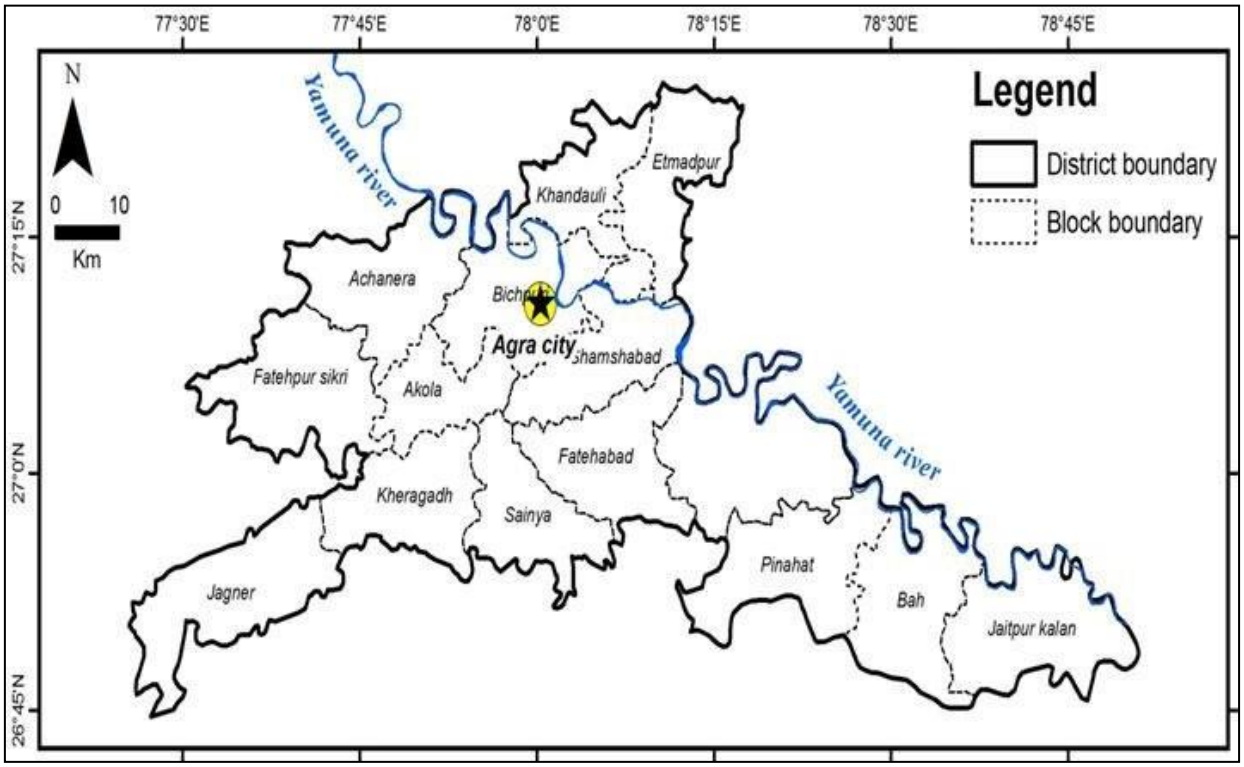

Figure 5: Location of Agra district in Uttar Pradesh.

FLUOROSIS AND PUBLIC HEALTH

Fluorosis is defined as a disease resulting from fluorides depositions in the soft and hard tissues of our body [18]. The most common route of fluoride injection in our body is through drinking water and it affects the bones and teeth. Fluoride in drinking water causes major health problems like fluorosis in skeletal, dental fluorosis, and non-skeletal muscle [19]. In general, it is evident that the effect of fluoride poisoning is reflected much earlier in dental than in the skeletal. Whereas, skeletal fluorosis mainly causes bones affections and major joints of the body and results in severe pain in the body parts like the neck, shoulder, backbone, and knee joints. Fluorosis might be a serious issue if it is untreated or neglected it leads to disability. On the other hand, non-skeletal forms of fluorosis develop long before the onset of the developmental changes that occur in teeth and skeletal bones. The symptoms are sometimes similar or overlap with others. It affects all age groups in the population (men, women, and children). The advanced stages of skeletal and dental fluorosis are permanent and irreversible in nature. These have an

immune impact on the growth and development of the population [20]. Recent studies documented that 250 districts of 19 Indian states have high levels of fluoride in water [21].

CONCLUSIONS

In the last few decades, groundwater fluoride contamination has drawn immense attention because of its toxicity to human health, the capacity of persistence, and its accumulation in various organs in our bodies. Various environmental sources that supply fluoride in the drinking water are the major responsible factors for the availability of fluoride in groundwater including aquifers bearing the fluorides minerals, geological factors (weathering, ion-exchange reaction, leaching of subsurface contaminants), etc. In India, several states are contaminated with high fluoride. Various studies suggested that different districts in Uttar Pradesh are susceptible to fluoride contaminations. Agra and Raiberilie are the most affected and efforts have been at the government level to identify the endemic regions. The Rajiv Gandhi National Drinking Water Mission promotes the awareness to control fluorosis. Ministry of Health and Family Welfare, Government of India launched a program to prevent and Control Fluorosis.

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