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Fluoride Content Analysis and Impact Investigated in the Groundwater of Some Villages in Ajmer District of Rajasthan, India

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ABSTRACT: Ground water is one of the major sources of water supply in Rajasthan due to absence of dependable surface water sources in the most parts of the state. Due to the scanty rainfall and over exploitation of ground water, in 2020, out of the 230 blocks, only 25 are safe from the ground water availability point of view, rest are declared dark zones. More than 80% of the water supply schemes depend on ground water and a number of tube wells, open wells and hand pumps have been dug over the past few decades. In most cases, the source either becomes dry or starts giving low yield and chemical quality gets degraded, resulting in failure of the water supply scheme. As a result, in most of the districts, ground water quality does not conform to BIS or WHO standards as it contains excessive fluorides, nitrates, chloride and total dissolved solids (TDS).

The problem of fluoride in ground water has primarily existed in the western districts of the state since ages but with increasing demand for drinking water and over exploitation of ground water, it has spread to almost all the 33 districts. People in some of the districts consume water with fluoride level up to 6 mg/L. Though in some of the districts, people learnt rain water harvesting and used rain water for drinking to avoid ill effects of fluoride. Constant efforts by the government have resulted in increased awareness about the problem. In addition to promoting treatment of fluoride at source, government is now shifting its attention to surface water sources to supply safe drinking water. The state of Rajasthan is a classic example of the socio-cultural-environmental aspects of drinking water and the fight of the community against the scarcity and poor quality of ground water. Due to the higher fluoride level in drinking water several cases of dental and skeletal fluorosis have appeared at alarming rate in this region. Fluoride contamination in drinking water due to natural and anthropogenic behavior has been documented as one of the major problems in Rajasthan impressing a serious threat to human health. Fluoride in drinking water has an intense effect to teeth and bones. The fluoride concentration should be up to 1-1.5 mg/L as a permissible limit for drinking. In Ajmer district different blocks or villages showed concentration of fluoride in the level of 1.5-4mg/L resulting in dental fluorosis whereas with prolonged consumption at still higher fluoride concentrations (4-10mg/L) fluoride leads to skeletal fluorosis. High fluoride concentrations in ground water occur widely in many blocks/villages of Ajmer district, Rajasthan.

I. INTRODUCTION

Fluoride in drinking water at low concentrations can prevent tooth decay, but at higher concentrations can be harmful to human health. Fluoride concentrations above the Maximum Contaminant Level (MCL) drinking-water standard of 4 mg/L in untreated groundwater from wells that supply drinking water in various blocks /villages of Ajmer district, Rajasthan. They were infrequent: 1.6% of 16,441 drinking-water wells studied (public-supply and domestic wells combined) and 0.6% of the 11,032 of the drinking-water wells that are domestic wells. On the other hand, more than 85% of drinking-water wells had fluoride concentrations below the optimal concentration of 0.7 mg/L for preventing tooth decay .[1,2]

Fluoride concentrations in untreated groundwater in various blocks /villages of Ajmer district, Rajasthan were generally higher than in the east. The study identified eight factors that affect fluoride concentrations, including mean annual precipitation, pH, and well depth. Knowledge of these factors can be used in models to estimate fluoride concentrations in unmonitored areas, which could benefit domestic-well owners and others concerned with human consumption of well water



with elevated fluoride concentrations. Fluoride is one of important life elements to human health. It is essential for normal mineralization of bones and formation of dental enamel with presence in small quantity. [3,4]

When fluoride is taken up more than permissible limit, it becomes toxic and causes clinical and metabolic disturbance in animals and human beings such as dental and skeletal fluorosis. As groundwater percolates through the weathered rock in the aquifers, it dissolves fluoride-bearing minerals hence releasing fluoride into solution. The main source of fluoride in groundwater is basically from the rocks/minerals. These minerals are commonly associated with the country rocks through which the ground water percolates under variable temperature conditions. Besides these minerals, alkali rocks, hydrothermal solutions may also contribute to higher concentration of fluoride in groundwater. The weathering and leaching process, mainly by moving and percolating water, play an important role in the incidence of fluoride in groundwater. When fluoride-rich minerals, which are present in rocks and soil, come in contact with water of high alkalinity; they release fluoride into groundwater through hydrolysis replacing hydroxyl (OH) ion. The degree of weathering and leachable fluoride in a terrain is more important in deciding the fluoride-bearing minerals in the bulk rocks or soil. Due to weathering of rocks the Ca-Mg / carbonate concentration which forms in arid and semi arid areas appears to be good sink for the fluoride ion.[5,6]

II. STUDY AREA

Ajmer District is a district of the state of Rajasthan in western India. The city of Ajmer is the district headquarters. Ajmer District has an area of 8,481 km², and a population of 2,583,052 (2011 census). Three main religions are; Hindu 1,869,044, Muslim 244,341, Jains 47,812. The district is situated in the center of Rajasthan, and is bounded by Nagaur District to the north, Jaipur and Tonk districts to the east, Bhilwara District to the south, and Pali District to the west. The eastern portion of the district is generally flat, broken only by gentle undulations. The western parts, from north-west to south-west, are intersected by the Aravalli Range. Many of the valleys in this region are sandy deserts, part of India's Thar Desert, with an occasional oasis of cultivation. Some fertile tracts are also present; among these is the plain on which lies the town of Ajmer. This valley has an artificial lake, and is protected by the massive walls of the Nagpathar range or Serpent rock, which forms a barrier against the sand. The only hills in the district are the Aravalli Range and its offshoots. Ajmer is almost totally devoid of rivers. The Banas River touches the south-eastern boundary of the district so as to irrigate the pargana of Samur. Four small streams—the Sagarmati, Saraswati, Khari and Dai—also intersect the district. The district is divided into four subdivisions, Ajmer, Beawar, Kekri and Kishangarh, and further subdivided into nine tehsils, Ajmer, Beawar, Bhinai, Sarwar, Pisangan, Tantoti, Nasirabad, Masuda, Kekri, Kishangarh.[7]

III. MATERIALS AND METHODS

Groundwater samples of a total of different villages/blocks located in Ajmer district in Rajasthan state of India were collected in pre-cleaned polythene bottles with necessary precautions. The fluoride concentration in water was determined electrochemically, using fluoride ion selective electrode. This method is applicable to the measurement of fluoride in drinking water in the concentration range of 0.011,000 mg/l. The electrode used was an Orion fluoride electrode, coupled to an Orion electrometer. Standards fluoride solutions (0.110 mg/l) were prepared from a stock solution (100 mg/l) of sodium fluoride. As per experimental requirement, 1 ml of Total Ionic Strength Adjusting Buffer Grade III (TISAB III) was added in 10 ml of sample. The ion meter was calibrated for a slope of 59.2 ± 2. The composition of TISAB solution was as 385.4 gm ammonium acetate, 17.3 gm of cyclohexylene diamine tetraacetic acid and 234 ml of concentrate hydrochloric acid per liter. All the experiments were carried out in triplicate, and the results were found reproducible with + 2% error.[8]

IV. DISCUSSION

Fluorides in drinking water may be beneficial or detrimental depending on their concentration and the total amount ingested. Fluoride is beneficial especially to young children (below eight years of age) for calcification of dental enamel, when present within allowable/desirable limits (1.0 mg/L). Fluoride, being a highly electronegative ion, has an extraordinary tendency to get attracted by positively charged ions like calcium. Hence, the effect of fluoride in mineralized tissues like bone and teeth is of clinical significance as they have the highest amount of calcium and thus attract the



maximum amount of fluoride which is deposited as calcium fluorapatite crystals. Tooth enamel is composed principally of crystalline hydroxyapatite. Under normal conditions, when fluoride is present in the water supply, most of the ingested fluoride ions are incorporated into the apatite crystal lattice of millions of calciferous enamel tissue during its formation. The hydroxyl ion is substituted by the fluoride ion because fluorapatite is more stable than hydroxyapatite.[9,10] The most common health problems associated with excess fluoride in drinking water are dental and skeletal fluorosis. Endemic fluorosis is known to be global in scope, occurring in all continents and affecting many people. Dental fluorosis leads to pitting, perforation and chipping of the teeth, whereas skeletal fluorosis causes severe pains in joints followed by stiffness, which ultimately leads to paralysis. However, recent studies have proved that the health effects of fluoride are not only restricted to dental or skeletal fluorosis but also cause other ailments such as neurological disorders, muscular and allergic manifestations, and gastrointestinal problems, and may also cause lethal diseases like cancer. The social and economic implications for those people living in endemic areas are enormous. Affected people lead a very Poor Quality of Life that often borders on a vegetative state owing to a deteriorating health condition. They present psychosociological problems for themselves and their families. These problems are further compounded by economic stress.[11,12]

Dental fluorosis is a health problem but it is as much an aesthetic and social problem for those affected discoloured teeth and mouth odour are the bane for a number of individuals in endemic areas. School children who suffer from dental fluorosis are often taunted by their mates. As a result they withdraw into a shell and are barely able to continue their education. With some, the prospect of meeting people from outside is a nightmare.[13,14]

Children suffering from skeletal fluorosis are deprived of Childhood joys. They are unable to more, run and play like other children. Some parents who are affected by fluorosis are unable to continue working with the same capacity as they did earlier. Unfortunately in such a situation education of children takes a backseat. In most situations of dental fluorosis affected person, particularly the younger lot, withdraw into a shell and refuse to talk to anybody. They often find themselves alone with little or no interaction with their peer group.[15]

A major source of worry for the youth is their poor matrimonial prospects. In the case of girls the condition of their teeth is often a serious impediment in matrimonial propositions. They worry about the way they would be treated by the groom's family. Even after getting married they avoid revealing their condition for as long as possible. Marriage is as much a source of worry for men. Those with visible signs of skeletal fluorosis know that the chances of finding a bride are rather dim. Some decide not to marry at all. The issue of marriage weighs heavy in the minds of girls' parents in rural areas. There are economic and social concerns related to the event. But a daughter with fluorosis appears to be a problem with little solution. If they do manage to get her married, sometimes by hiding facts, they are serious consequences. The girl is mostly treated badly by the groom's family. For the younger lot a debilitating illness such as fluorosis can bring disappointments and a loss of hope in terms of work and a bright future.[16]

V. RESULTS

Fluoride concentrations in groundwater of different blocks/villages of Ajmer district were examined. Fluoride concentration in five blocks ranges from 0.10 to 4.30 mg/l of Ajmer respectively. The present survey reveals that out of many villages/blocks of Ajmer district, some villages in which fluoride concentration is below 1.0 mg/l, maximum desirable limit of standards for drinking water recommended by Bureau of Indian Standard (IS: 10500) whereas some villages had fluoride concentration above 1.0 mg/l and below or equal to 1.5 mg/l. As per the desirable and maximum permissible limit for fluoride in drinking water determined by WHO or by Bureau of Indian Standards, groundwater found unfit for drinking purposes. [17]

Some ingested fluoride (about 70%) is absorbed. In an acidic stomach fluoride is converted into hydrogen fluoride (HF) and here up to 40% of the ingested in stomach and remaining in intestine. Once absorbed into blood, fluoride readily distributes throughout the body, with approximately 99% of the body burden of fluoride retained in calcium rich areas such as bones and teeth (dentine and enamel) However, in plasma, fluoride is transported as ionic fluoride and non-ionic fluoride. Ionic fluoride does not bind to plasma proteins, and is easily excreted with the urine. However, in the form of HF, about 35-45% is reabsorbed and returned to the systemic circulation. pH of tubular fluid and urinary flow are the main

factors which influence reabsorption. The amount of urinary fluoride excreted from the body reflects the amount of fluoride ingested. Fluoride (F) is attracted by positively charged calcium ions, due to its strong electronegative charges, in teeth and bones and therefore excessive intake of fluoride cause pathological changes in teeth and bones. [18]

Amount of fluoride in different villages/blocks of Ajmer:-

1. Block-1

The minimum concentration 0.23 mg/l (area-1) was recorded and maximum was (3.37 mg/l) (area-2).

2. Block-2

The minimum concentration 0.20 mg/l (area-1) was recorded while maximum concentration was recorded (4.30 mg/l) (area-2).

3. Block-3

The minimum concentration 0.10 mg/l (area-1) was recorded and maximum was (4.23 mg/l) (area-2).

4. Block-4

The minimum concentration 0.22 mg/l (area-1) was recorded while maximum concentration was recorded (4.22 mg/l) (area-2).

5. Block-5

The minimum concentration 0.37 mg/l (area-1) was recorded while maximum concentration was recorded (3.89 mg/l) (area-2).

VI. CONCLUSION

Fluorosis is not only affects older persons but there is ample evidence that even newborn baby and children of younger age have also been its victims. It not only affects the body of a person but also renders them socially and culturally crippled. There is a need development a well through out strategy to attack this problem which requires an urgent attention from both medical as well as of social workers. Considerable work has been done all over the world on treatment of fluorosis. Unfortunately the results indicated that the effects of fluorosis are irreversible. So, Prevention is better than cure, many potential problems can be prevented by safe guarding the integrity of a drinking water sources. So, fluoride poisoning can be prevented or minimized by:

- Providing defluoridation water for drinking purposes
- Creation of awareness of hazards of high fluoride contamination and the need for restricting the consumption of water and produce having high fluoride concentration.[19]

1. Changing of dietary habits

Defluoridation of drinking water alone shall not bring the fluoride level to a safe limit. It would be necessary to overcome the toxic effects of the remaining fluoride ingested through other sources. This can be done by effecting minor changes in the diet and dietary habits of the population compatible with social system and available resources. The main aim should be to

- Restrict use of fluoride rich food
- Avoiding use of fluoride rich cosmetics

Use of food rich in calcium, vitamin C and proteins. Clinical data indicate that adequate calcium intake is clearly associated with a reduced risk of dental fluorosis. Vitamin C may also act as a safeguard against the risk. Hence, measures to improve the nutritional status of an affected population particularly children appear to be an effective supplement for antidote against fluorosis.

2. Water harvesting (alternative water source)

Fluoride not only affects the people but it also affects the animals. Therefore, it is desirable that the animals should also be provided with fluoride free water for maintaining their longevity. Defluoridation of drinking water for animals will be too costly and not feasible and therefore the only solution of this problem is water harvesting. The water harvesting technologies should be aimed not only to provide fluoride free water to human beings but also to animals. Rain water storage can be a major source of fluoride free drinking water for the animals.



3. Artificial recharge

Any quality improvement right at the source would therefore reduce hassles and provide a better alternative for the end users. Considering the geographic and climatic factors, artificial recharge through recycling the rainwater back into the aquifer appears to be the most suitable technique for water quality improvement. The fluoride levels in groundwater can be brought down by the artificial recharge of groundwater. Borewell water with low concentration (<0.5 mg/L) of fluoride can be blended with high fluoride waters before being supplied for domestic purpose. In areas of high fluoride concentration, easily available local raw materials such as clay, serpentine, and marble can be used to reduce fluoride content.[20]

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