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FLUORIDE IN DRINKING WATER AND HEALTH HAZARDS: SOME OBSERVATIONS OF FLUORIDE DISTRIBUTION IN SAHARA TEHSIL OF BHILWARA DISTRICT, RAJASTHAN

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ABSTRACT

Fluoride concentration of groundwater samples from 152 villages of Mandal tehsil of Bhilwara district of Rajasthan was determined. In the tehsil 90 villages (60%) were found to have fluoride concentration more than 1.5 mg/l which is maximum desirable limit of drinking water standards IS, 10500, 1999. 57% population of these villages have possibility of fluorosis. 11% population of tehsil living in 13 villages of intakes more than 5.0 mg/l fluoride with each liter of drinking water. In these villages there is a maximum possibility of dental and skeletal fluorosis. The maximum fluoride concentration in tehsil is recorded 8.3 mg/l in groundwater of Delas village.

Keywords: Fluoride, Fluorosis, Groundwater, Fluorosis affected zones, Bhilwara, Rajasthan

INTRODUCTION

According to Greek medieval philosophy, matter consists of 4 elementary substances, namely water, air, stone and fire. Indian medieval also opines that the matter is composed of Five Panch Mahabhut (Five elementary substances) namely water, air, light (fire), earth (stone) and sky (space). The quality of water is of vital concern for mankind since it is directly linked with human welfare. Water on Earth is found as surface and ground water. 94% of the earth water rest in the oceans and seas at high level of salinity. The ground water makes about two third of fresh water resource of the world. However, the ground water is more than a resource. Groundwater is one of the nation's most important natural resources. It provides about 40% of the Nation's public water supply. In addition, more than 40 million people, including most of the rural population, supply their own drinking water from domestic wells. As a result groundwater is an important source of drinking water in every state. Groundwater is also the source of much of the water for irrigation. It is the Nation's principal reserve of freshwater and represents much of the potential future water supply. Water is required for a variety of functions in human body including regulation of body temperature as a solvent and as a vehicle in the transportation of nutrients and waste product through the vascular system, and through inner and intra cellular spaces. The ground water available from every ground water source contains a variety of substances either in suspension or in solution in varying concentration. Calcium, magnesium, sodium, potassium, iron, coablt, zinc, copper, chloride, nitrate, fluoride, sulfate, and a variety of other substances may found in different concentration. The optimum concentration of each and every ion and other substance has been fixed by for safe drinking water by various health agencies and health organization. Fluoride is essential for health especially to prevent dental carries for calcification and formation of enamel. According to safe drinking water quality standards, the concentration of fluoride should be in the range 0.75 to 1.50 and beyond the upper level; it leads to harmful effects on the body. The problem of high fluoride content in the underground water is common in about 15 states of India and according to a sub-mission set up by Government of India under Technical Mission (1987) and about 25 million people are suffering from Fluorosis at various stages while another 25 million are reported to be prone to it. According to Susheela[1], 2003 in Rajasthan its all 32 districts are endemic

to fluorosis. Therefore, in the present investigation an attempt is made to find out distribution of fluoride in groundwater of Sahara tehsil.

Effect of fluoride on human health

Fluoride contamination is a major health hazard in many parts of the world. Fluoride is considered beneficial to human health if taken in limited quantity (0.5 to 1.5 mg/ml). Fluoride prevents tooth decay by enhancing the remineralization of enamel that is under attack, as well as inhibiting the production of acid by decay causing bacteria in dental plaque. Fluoride is also a normal constituent of the enamel itself, incorporated into the crystalline structure of the developing tooth and enhancing its resistance to acid dissolution. But it is also known to cause dental, skeletal fluorosis, osteosclerosis, thyroid, kidney changes and cardiovascular, gastrointestinal, endocrine, neurological, reproductive, developmental, molecular level, immunity effects, if concentration is higher than 1.5 mg/ml in drinking water[2]. Smith and Hedge[3], 1959 have shown the correlation between fluoride and biological effect (T able - 1).

Table - 1 : Concentration of fluoride and biological effects

S. No.	Fluoride in drinking water mg/l	Effect
1.	0.002 mg/l in air	Injury to vegetation
2.	1 mg/l in water	Dental caries reduction
3.	2 mg/l or more in water	Mottled enamel
4.	3.1 to 6.0 mg/l in water	Osteoporosis
5.	8 mg/l in water	10% osteoporosis
6.	20-80 mg/day or more in water or air	Crippling skeletal fluorosis
7.	50 mg/l in food or water	Thyroid change
8.	100 mg/l in food or water	Growth retardation
9.	More than 125 mg/l in food or water	Kidney change
10.	2.5-5.0 gm/l in actual dose	Death

Effect on dental enamel

The beneficial and the detrimental effects of fluoride present in water were well established in early 1940. High levels of fluoride upto 1.5 mg/lit may cause dental fluorosis, yellowish or brownish strain or mottling of the enamel while fluoride concentration less than 0.1 mg/l in associated with high levels of dental decay[4]. Fluoride mottles teeth (dental fluorosis) when ingested in excess amounts during tooth development (1-8 years of age). During development of the deciduous and permanent teeth, excessive fluoride intake produces a malformation of the enamel surface, which then becomes stained[5]. Fluoride causes mottled enamel by impairing the work of ameloblast cells. Dental fluorosis is caused in human being consuming water containing 1.5 mg/l or more of fluorides, particularly from birth to age of eight. Mottled enamel usually takes the shape of modification to produce yellow brown strains or an unnatural opaque chalky white appearance with occasional striations patting. The incidence and severity of mottling was found to increase with increasing concentration of fluoride in drinking water.

In extensive studies, Dean and coworkers[6-9] have correlated the appearance and severity of dental fluorosis to different fluoride levels in the drinking water with the aid of a special classification and weighing of severity of the lesion. Distribution of dental fluorosis at different levels of fluoride in drinking water may be assessed by a mottled enamel index of the community, which is defined in terms of the degree of severity of mottled enamel observed clinically (Table - 2). There is possibly no such data available in India to evaluate community index of fluorosis and in the absence of this permissive or excessive limits of fluoride in drinking water are only arbitrary.

Osteoporosis

Fluoride above 4 mg/l in drinking water may cause a condition of dense and brittle bones known as osteoporosis. It affects tens of million of people worldwide and is responsible for as many as 75% of all fractures in people over the age of 45. Costly and disabling fractures of spine, hip, wrist and other bones can be preceded by years of undetected bone loss. What's more, as many as 20% of those who suffer from osteoporosis related hip fractures

Table - 2 : Dental fluorosis categorization[9]

Normal	The enamel presents translucent, semi-vitriform type of structure. The surface is smooth, glossy and usually pale creamy white colour.
Questionable	Seen in area of relatively high endemicity, occassional cases are borderline and one would hesitate to classify them as apparently normal or very mild.
Very mild	Small, opaque paper-white area seen, scattering irregularly over the labial and buccal tooth surface
Mild	The white opaque areas involve at least half of the tooth surface and faint brown strains are sometimes apparent.
Moderately	Generally all tooth surfaces are involved and minute pitting is often present on the labial and buccal surfaces. Brown stain are frequently a disfiguring complication.
Moderately severe	Pitting is marked, more frequent and generally observed on all tooth surfaces. Brown strains if present are generally of greater intensity.
Severe	The severe hypeoplasic affect the form of the teeth and stains are wide spread, and vary in intensity from deep brown to black.

die within 6 months. Women are at four times greater risk of developing osteoporosis than males.

Skeleton fluorosis

The chronic toxic effects of fluoride on the skeletal system have been described from certain geographical regions of the world where drinking water contains excessive quantities of natural fluoride. At higher levels of ingestion from 2 to 8 mg daily when signs of fluorosis appears in teeth mineralized during the ingestion period, certain other factors (climatic conditions, malnutrition, age, storage, other constituents of water and possibly individual variations in absorption) may be involved. Under such conditions and over a number of years, skeletal fluorosis may arise characterized by an increased density of bone and demonstrated in adults radiographically. The data put forward by Mc Clure *et al.*[10] although no longer regarded as accurate indicate that the limit of total fluoride which may be ingested daily without hazardous body storage is of the order of 4-5mg daily. Fluoride replaces hydroxides and deposited in bones causing chronic effect known as skeleton fluorosis. The dental and skeletal changes in endemic fluorosis prove important clinical diagnostic criteria. Whereas, dental fluorosis is easily recognized but the skeletal involvement is not clinically obvious until the advanced stage of crippling fluorosis. However, radiological changes are discernible in the skeleton at a much earlier stage and provide the only means of diagnosing the early and relatively asymptomatic stages of fluorosis.

Such early cases are usually in young adults whose only complaints are vague pains noted most frequently in the small joints of the hands and feet, in the knee joints and in the joint of spine. These cases are frequent in the endemic areas and may be misdiagnosed as rheumatoid or osteoarthritis. In later stages, there is an obvious stiffness of the spine with limitation of movements and still later, the development of kyphosis. There is difficulty in walking due partly to stiffness and limitation of the movements of various joints and partly to the neurological lesions of advanced cases. Similarly, some of the patients complain of dyspnoea on exertion because of the rigidity of the thoracic cage. In Roholm's[11] series of industrial fluorosis cases, the gastrointestinal symptoms of lack of appetite, nausea and constipation were as frequent as the symptoms of stiffness of joints, but the former have not been described in the different studies of endemic fluorosis.

Deformities and crippling fluorosis

The advanced stage of fluorosis intoxication results from the continuous exposure of an individual to 20-80 mg of fluoride ion daily over a period of 10-20 years. Such heavy exposure is associate with a level of at least 10 mg/l in the drinking water supply. The crippling fluorosis is seen in such numbers in endemic areas of Punjab and Southern India. The Crippling deformities are due partly to mechanical factors and partly to the immobilization necessitated by pain and paraplegia. The commonest deformities are

kyphosis, flexion deformity of the hips, flexion deformity of the knees and fixation of the chest in the position of inspiration due to calcification of cartilage. The quadriplegic patient bent with kyphosis and with morledly-restricted movements of his spine, with contractures of hips and knees.

Cardiovascular effects

The cardiovascular effects of fluoride have been attributed to hypocalcemia and hypercalcemia caused by high fluoride levels. Fluoride can bind with serum calcium if the dose is sufficient and cause hypocalcemia. Calcium is necessary for the functional integrity of the voluntary and autonomic nervous systems. Hypocalcemia can cause tetany, decreased myocardial contractility, and possibly cardiovascular collapse[12]. Hyperkalemia has been suggested as the cause of the repeated episodes of ventricular fibrillation and eventual death that are often encountered in cases of fluoride poisoning[13].

Gastrointestinal effects

The primary gastrointestinal effects following both acute and chronic oral exposure to fluoride consist of nausea, vomiting, and gastric pain. The irritation of the gastric mucosa is attributed to fluoride (as sodium fluoride) forming hydrofluoric acid in the acidic environment of the stomach[14-15]. The uncharged hydrogen fluoride molecule can then penetrate cell membranes and enter the neutral environment of the cytoplasm.

Endocrine effects

In the endocrine system where the intermediary metabolism and synthesis of highly sensitive hormones involves enzymatic action, it is expected that interferences with the mechanism by chemical agents would produce early and pronounced clinical effects. Considerable attention has consequently been given of recent years to the behaviour of fluoride in hormone chemistry and to the possible clinical disturbances of endocrine function, particularly the thyroid gland. Significant increases in serum thyroxine levels were observed in residents of North Gujarat, India with high levels of fluoride in the drinking water (range of 1.0-6.53 mg/L; mean of 2.70 mg/L)[16]. No significant changes in serum triiodothyronine or thyroid stimulating hormone levels were found. Increases in serum epinephrine and norepinephrine levels were also observed. It is unclear if nutritional deficiencies played a contributing role to the observed endocrine effects.

Immunological and lymphoreticular effects

A request to the American Academy of Allergy was made by the U.S. Public Health Services for an evaluation of suspected allergic reactions to fluoride as used in the fluoridation of community water supplies[17]. The response to this request included a review of clinical reports and an opinion as to whether these reports constituted valid evidence of a hypersensitivity reaction to fluoride exposure of types I, II, III or IV, which are respectively, anaphylactic or reaginic, cytotoxic, toxic complex, and delayed type reactivity. The Academy reviewed the wide variety of symptoms presented (vomiting, abdominal pain, headaches, scotomata (blind, or partially blind areas in the visual field), personality change, muscular weakness, painful numbness in extremities, joint pain, migraine headaches, dryness in the mouth, oral ulcers, convulsions, mental deterioration, colitis, pelvic hemorrhages, uricaria, nasal congestion, skin rashes, epigastric distress and hematemesis) and concluded that none of these symptoms were likely to be immunologically mediated reactions of types I-IV. No studies were located that investigated alterations in immune response following fluoride exposure in humans. No studies were located that investigated alterations in immune response following fluoride exposure in human. In a study with rabbits administered 4.5 mg fluoride/kg/day as sodium fluoride for 18 months, decreased antibody titers were observed[18]. These results were observed after 6 months of treatment; the authors hypothesized that a threshold level is reached at which time the immune system is impaired. However, as only one dose level (4.5 mg flouride/kg/day) was tested, no dose-effect.

Neurological effects

The neurological manifestations have been exclusively reported from India. Credit for the earliest description of neurological complications in fluorosis must be given to Shortt *et al.*[19], 1937, who reported ten such cases from the Nellore district of Madras. Fluoride has been shown to interfere with glycolysis. Because the central nervous system relies heavily on this energy source, hypotheses have been advanced as to a mechanism for fluoride effects on the central nervous system. Although effects on glycolytic enzymes could explain the neuromuscular symptoms seen frequently in cases of fluoride poisoning (*e.g.* tetany, paresthesia, paresis, convulsions), studies tend to indicate that hypocalcemia caused by fluoride binding of calcium causes these symptoms[20]. The decreases in intelligence were reported in children living in areas of China with high levels of fluoride in the drinking water, as compared to matched groups of children

Table - 3 : Fluoride distribution in Sahara tehsil

Category I (Below 1 mg/l)	Category II (1 to 1.5 mg/l)	Category III (1.5 to 3.0 mg/l)	Category IV (3.0 to 5.0 mg/l)	Category V (Above 5 mg/l)
Arnota (0.9), Atawara (1), Baghera (1), Bagpura (0.4), Bharak (0.8), Bhootela (0.8) Diyas (1), Gathila (0.9), Ghangras (1), Girdia (1), Gowalia (1), Gumanpura (0.9), Kala dhunda (0.4), Kangani (0.6) Khankhla (1), Lakhola (1), Mahander garh (0.6), Mahendi (0.5), Makaria (0.2), Mandpiya (0.8), Meghras (1), Nagdiya ka khera (0.8), Rooparel (1), Salaywari (1), Sangas (1), Soniyana (1), Tiloli (0.6)	Adsipura (1.5), Aloli (1.3), Amali (1.4), Bhoonas (1.5), Chapri (1.1) Chawandia (1.1), Chirkhera (1.2) Fookia (1.2), Gudda ka khera (1.1), Jabarkiya (1.2), Kala khera (1.2), Khajuria (1.5), Khera kali Mangri (1.2), Kosithal (1.2), Lakamaniyas (1.5), Manjawas (1.1) Nandsa (1.1), Neem Khera (1.4) Pithoria Khera (1.4), Rampuria (1.1) Sahara (1.4), Salera (1.1) Santliyas (1.1), Sar Gaon (1.2), Saturia (1.2) Sirohi Khera (1.1), Thekla (1.3), Udliyas (1.3), Ullai (1.1), Unchkiya (1.3)	Arjunpura (1.9), Arnia Jagir (2.9) Arniya Khalsa (1.8), Bikrai (2.1) Chatar Singh Khera (1.6) Delana (1.6), Dhoser (1.9), Galodia (1.7) Ganesh Pura (2.5), Ganeshpura jagir (2.2), Gathila Khera @ Dhanna ka khera (2.1), Gudha (1.9), Jai Singh Pura (2), Khati khera (1.9), Laxmi Pura (1.6), Matoonia (1.8), Nath ka Khera (2.1), Palra (1.6), Potla (2.4), Ragunath pura (1.6), Sivrati (1.9), Surawas (2.1) Tapria Kheri (2.3), Umaidpura (1.8), Vijaipura (1.6)	Jhoompura (3.4), Karnaji ki Kheri (3.6), Raithaliyas (3.9) Surajpura (3.2)	Rooppura (5.6)

living in areas with low levels of fluoride in the drinking water[21-22], but these studies are weak in as much as they do not address important confounding factors.

Reproductive effects

There are limited data on the potential of fluoride to induce reproductive effects in humans following oral exposure. A meta-analysis found a statistically significant association between decreasing total fertility rate and increasing fluoride levels in municipal drinking water[23]. Annual county birth data (obtained from the National Center for Health Statistics) for over 525,000 women aged 10-49 years living in areas with high fluoride levels in community drinking water were compared to a control population approximately 985,000 women) living in adjacent counties with low fluoride drinking water levels. The fluoride-exposed population lived in counties reporting a fluoride level of 3 ppm or higher in at least one system. The weighted mean fluoride concentration (county mean fluoride level weighted by the 1980 size of the population served by the water system) was 1.51 ppm (approximately 0.04 mg fluoride/kg/day), and 10.40% of the population was served by water systems with at least 3 ppm fluoride. The mean weighted mean fluoride concentration in the control population was 1.08 ppm (approximately 0.03 mg fluoride/kg/day). However, this meta-analysis relied on a comparison of two quite disparate data sets, inasmuch as the fluoridation population often did not correlate well with the population for whom health statistics was available. Furthermore, other studies have not found a similar correlation. Another study found significantly decreased serum testosterone levels in 30 men diagnosed with skeletal fluorosis and in 16 men related to men with fluorosis and living in the same house as the patient[24]. The mean drinking water fluoride levels were 3.9 ppm (approximately 0.11 mg fluoride/kg/day), 4.5 ppm (0.13 mg fluoride/kg/day), and 0.5 ppm (0.014 mg fluoride/kg/day) in the patients with skeletal fluorosis, related men, and a control group of 26 men living in areas with low endemic fluoride levels. No correlations between serum testosterone and urinary fluoride levels or serum testosterone and serum fluoride levels were found. One limitation of this study is that the control men were younger (28.7 years) than the men with skeletal fluorosis (39.6 years) and the related men (38.7 years). In addition, the groups are smaller and potentially confounding factors are not well addressed.

Developmental effects

Fluoride crosses the placenta in limited

amounts and is found in fetal and placental tissue[25-26]. The available human data suggest that fluoride has the potential to be developmentally toxic at doses associated with moderate to severe fluorosis. The human and animal data suggest that the developing fetus is not a sensitive target of fluoride toxicity. Analysis of birth certificates and hospital records for over 200,000 babies born in an area with fluoridated water and over 1,000,000 babies born in a low fluoride area found no difference in the incidence of birth defects attributable to fluoride[27]. Exposure to high levels of fluoride has been described together with increased incidence of spina bifida[28]. The occurrence of spina bifida was examined in a group of 50 children aged 5-12 years living in an area of India with high levels of fluoride in the drinking water (4.5-8.5 ppm) and manifesting either clinical (bone and joint pain, stiffness, and rigidity), dental, or skeletal fluorosis. An age-and weight-matched group of children living in areas with lower fluoride levels (#1.5 ppm) served as a control group. Spina bifida was found in 22 (44%) of the children in the high fluoride area and in six (12%) children in the control group. This study did not examine the possible role of potentially important nutrients such as folic acid, however, and had other study design flaws.

Effect of molecular level

The acceleration of the aging process by fluoride occurs at the biochemical level through of

Enzyme inhabitation
Collagen break down
Genetic damage
Disruption of the immune system

Fluoride damage enzymes, and results in a wide range of chronic diseases. Fluoride as low as 1 mg/l causes breakdown of collagen, the most abundant of the body protein at 30%. It leads to irregular formation of collagen, which serves as a major structural component of skin, ligaments, tendons, muscles, cartilage, bone and teeth. A number of studies revealed that fluoride causes genetic damage. The mechanism cannot be exactly pinpointed because fluoride interferes with a number of physiological processes. Most evidence indicates that it acts on the DNA Repair Enzyme system. It may also interfere with DNA synthesis. If the unprepared DNA damages occur in a cell, producing a sperm or egg it will be replicated in every cell of the offspring body and leads to birth defects. Un repaired damage of a segment of DNA is responsible for control of cell growth and may cause tumors or cancers.

Effect on immunity system

Fluoride interacts with the bonds of protein molecular required to maintain the normal shape of proteins. The fluoride effect the immune system through the following means:

1. Damage the immune system by inhibiting the migration rate of white blood cells to infected means.
2. Interferes with phagocytosis (destruction of bacteria and other foreign agents by white blood cells)
3. Induces the release of super oxide free radicals in resting white blood cells.

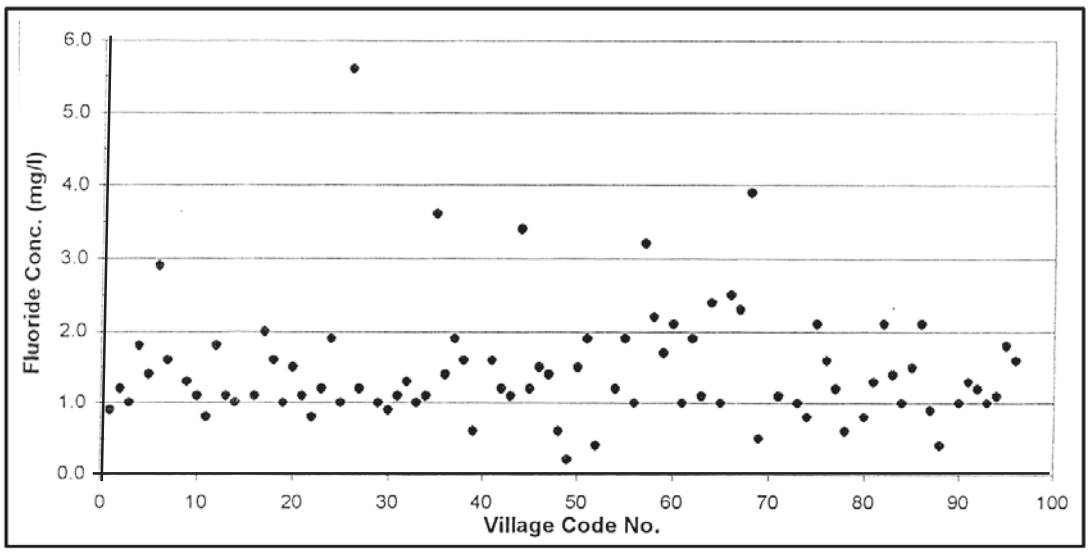

Figure - 1 : Fluoride concentration in Sahara tehsil

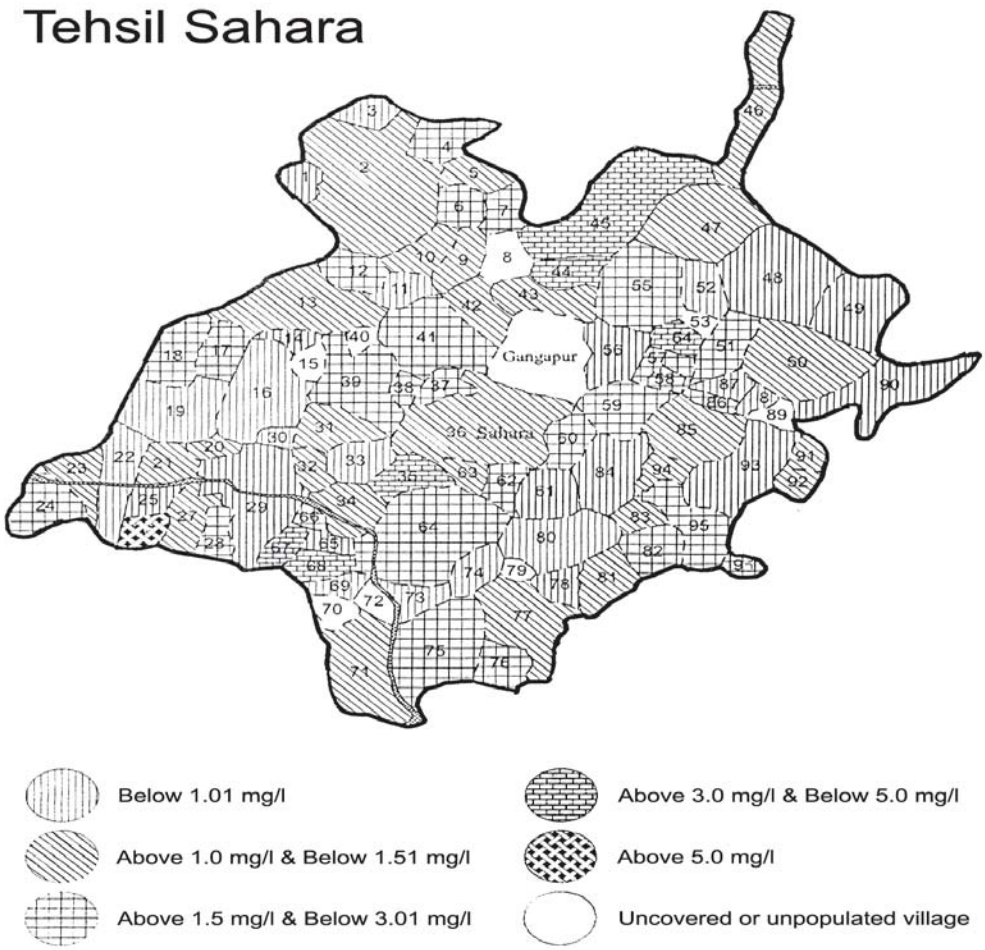

Figure - 2 : Distribution of fluoride in groundwater of Sahara tehsil

The fluoride induced interference leads to an increased and more prolonged exposer of the body to foreign material and releases free radicals damaging the body.

Fluoride as carcinogen

Fluoride was found to be an equivocal carcinogen by the National Cancer Institute. Toxicological effects due to excess of fluoride is 6.9 fold and cause bone cancer in young males. Several epidemiological studies are available on the possible association between fluoride in drinking water and cancer rates among the population IACR evaluated these studies on fluoride and carcinogenicity in humans[29-30].

Numerous epidemiological studies have examined the issue of a connection between fluoridated water and cancer. The weight of evidence indicates that no such connection exists. However, all of the investigations were ecologic studies, and the sensitivity limit of even the most sensitive analysis in these studies appears to be a 10-20% increase. Since any carcinogenic effect of fluoride at the levels found in water supplies would probably be below this level of sensitivity, a National Toxicology Program (NTP) cancer bioassay was conducted to assess the effect of fluoride on cancer incidence in animals[31-32]. The NTP study found equivocal evidence of a fluoride related increase in osteo-sarcomas in male rats, and no evidence of any fluoride related neoplasm in female rats or male or female mice. A study sponsored by Proctor and Gamble (Maurer *et al.* 1990) found no evidence of fluoride carcinogenicity in either male or female rats. Boths studies contain limitations that preclude strong conclusions. The NTP is presently carrying out additional experiments on the relationship, if any, between fluoride and cancer. The International Agency for Research on Cancer (IARC) reviewed the literature on fluoride carcinogenicity in 1982. It concluded

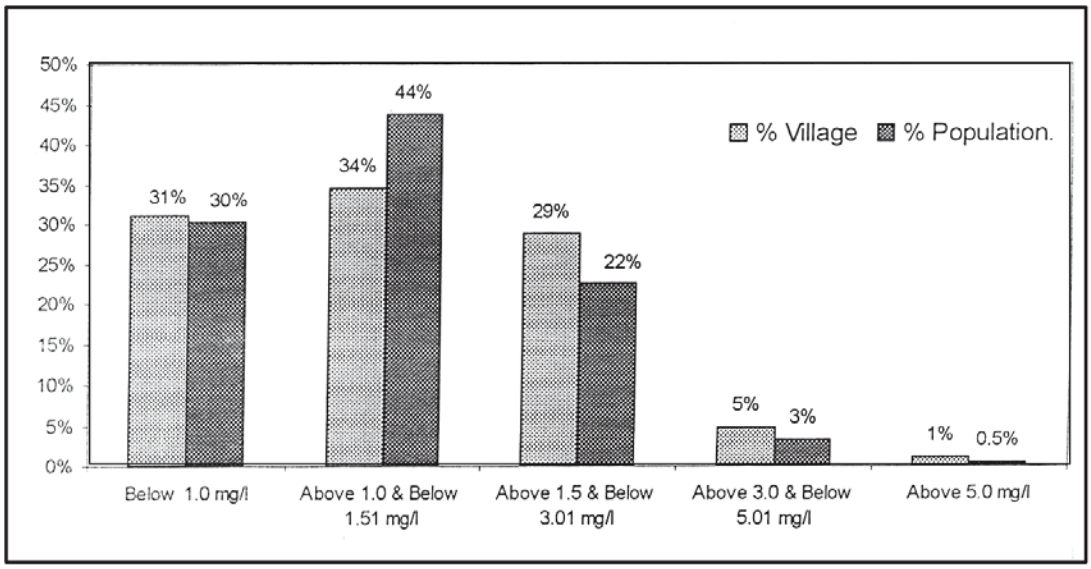

Figure - 3 : Percentage distribution of village & population in various concentration range

that there is no evidence from epidemiological studies of an association between fluoride ingestion and human cancer mortality, and the available data are inadequate for an evaluation of the carcinogenicity of sodium fluoride in experimental animals.

MATERIAL AND METHODS

Groundwater samples of 87 villages located in Sahara tehsil of Bhilwara district, were collected in pre cleaned polythene bottles with necessary precautions[33]. The samples were brought to the laboratory and fluoride concentration was determined by ion selective electrode method[34].

RESULTS AND DISCUSSION

Fluoride concentration in groundwater of 87 villages of Sahara tehsil was examined. The village code wise concentration of fluoride is shown in Figure 1. All the villages were categorized according to following concentration range (Table - 3).

1. Category I: Fluoride concentration below 1.0 mg/l
2. Category II: Fluoride concentration between 1.0 mg/l and 1.5 mg/l
3. Category III: Fluoride concentration between 1.5 mg/l and 3.0 mg/l
4. Category IV: Fluoride concentration between 3.0 mg/l and 5.0 mg/l
5. Category V: Fluoride concentration above 5.0 mg/l

In Figure 2, the distribution of fluoride in ground water of Sahara tehsil is shown. In Sahara tehsil, fluoride concentration ranges from 0.2 mg/; to 5.6 mg/l. The minimum concentration was recorded in one village (Makaria) and the maximum was recorded from village Rooppura. From the Table 1, it is clear that 27 villages (31%) fall in category I. In these villages fluoride concentration is below 1.0 mg/l which is maximum desirable limit of standards for drinking water recommended by Bureau of Indian Standard (BIS)[35] in IS: 10500, 1991. There is no possibility of fluorosis in these villages. Fluoride is beneficial, when present in this limit, for calcification of dental enamel especially for the children below 10 year age. Once fluoride is incorporated into teeth, it reduces the solubility of the enamel under acidic conditions and there by provides protection against dental carries.

30 villages (34%) of the tehsil have fluoride concentration between 1.0-1.5 mg/l (Category II). 1.5 mg/l is the maximum permissible limit of standard for drinking water (IS: 10500; 1991). In 44% population (Figure 3) in tehsil living in these villages the per day fluoride intake through drinking water is more than 4 mg/D hence 1st and 2nd degree dental fluorosis may be visible in local residential.

In 25 villages (29%), the fluoride is between 1.5 - 3.0 mg/l (Category III). This concentration is above the maximum permissible limit as recommended by BIS. These villages contribute

22% population of this tehsil (Figure 3). Dental fluorosis may common visible sign of overexposure to excessive fluoride in these villages. At this concentration level, teeth loose their shiny appearance and chalky black, gray or white patches develop on them known as mottled enamel[9]. In some consumer, the pre-stage of skeletal fluorosis may occur after 45 years age[36-37].

In 4 villages (5%) fluoride concentration in groundwater is above 3.0 and below 5.0 mg/l. The per-day intake of fluoride in these villages is very high. 3% population of tehsil (Figure 3) may have all degree of dental fluorosis (Mild, moderately, moderately severe, severe fluorosis) including skeletal fluorosis after 30 year age in local residential, but the probability of 2nd stage skeletal fluorosis after 45 years age may be common[38].

Only one village (1%) (Rooppura) fall in Category V, these villages contributes 0.5% population of Sahara tehsil (Figure 3). In these villages fluoride concentration is above 5.0 mg/l at such a high concentration level all types of fluorosis may occur. However, final degree of dental fluorosis is the visible sign of over exposure of fluoride. The second clinical stage (in which pain in bones become constant and some of the ligaments begin to calcify) may be common in the local residential. In some villagers the advance skeletal fluorosis, (in which the extremities become weak and moving of joints is difficult) may be found[39]. At this concentration, the vertebrae partially fuse together, crippling the patient, this stage of fluorosis is also called "crippling skeletal fluorosis". According to some studies high doses, fluoride is actually toxic to man pathological exchanges including hemorrhagic gastroenteritis acute toxic nephritis and degree of injury to the liver and heart muscles[40]. McGown and Suttie[41], reported significant increase in plasma epinephrine and hyperglycaemia induced by fluoride. Fluorosis is accompanied by adverse effect on the other system and organs of the body namely liver, kidney, muscles, heart, lungs, blood and the hormonal functions[42-45]. The kidney is the principle organ through which maximum concentration of fluoride is excreted. High fluoride causes impaired kidney functions.

The present studies have shown occurrences of high fluoride content in the groundwater of several villages of Sahara tehsil. The villages, which do not have alternate water sources, should be provided with defluoridation plants to eliminate the problem. The reports on villages wise distribution of fluoride in drinking water may help in implementation of health and water supply schemes by the central and state government.

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