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Mitigating Fluoride Toxicity Occurring in Groundwater of Nagaur City (Rajasthan), Employing Various Bioadsorbents

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ABSTRACT

Water samples of 12 locations of Nagaur District were chemically analyzed for determining fluoride ion concentrations. High fluoride containing localities were identified on the basis of fluoride levels of water samples and also on prevalence rate of dental, skeletal and non-skeletal fluorosis of the study area. Water samples containing high fluoride levels were defluoridated with economically cheaper materials prepared from plant byproducts. These materials were found successful in decreasing fluoride ion concentration to a permissible limit (0.5 to 1.5ppm) without disturbing potable water quality standards.
***Keywords**: Defluoridation; UV visible spectrophotometer;Physiochemical parameters; ESC; AAC; PJC; CLC; GAC*

INTRODUCTION

With rising population and dwindling groundwater resources, the groundwater quality of Rajasthan is deteriorating day by day. As per WHO report, 20 per cent of the fluoride-affected villages in the whole world are in India. Out of 33,211 fluoride-affected villages in the country Rajasthan has 16,560 villages, which is more than 51 per cent [1] . From these figures we can draw an inference that nearly 10% of fluoride-affected habitation in the world is in the Rajasthan alone. Drinking water with excessive concentration of fluoride causes fluorosis which progresses gradually and becomes a crippling malady in the long run. It affects young, old, poor, rich, rural, and urban population [2]. It has attained a very alarming dimension. There being no perennial surface source for drinking water, the state is dependent chiefly on groundwater and its level is deeper year-by-year due to over exploitation. As the water table is receding more and more water sources are becoming prone to higher fluoride concentration. The pattern and prevalence of fluorosis in human population are determined by a number of epidemiological factors like water chemistry, demographic and nutritional profile of the community and high mean annual temperature of the area. The high concentration of fluoride in drinking water leads to destruction of enamel of teeth and causes a number of conditions referred to collectively as fluorosis [3].

This disease is slow and progressively crippling malady. At low concentration (<1.0 ppm), fluoride prevents tooth decay, but it has been medically proved that, high fluoride intake by individuals from water, food, air and medicines results in fluorosis. Nagaur district of Rajasthan has been known for excessive concentration of F in groundwater. Due to the lack of surface water resources and semi-arid climatic conditions, increase in groundwater fed irrigated agriculture and erection of a number of groundwater abstraction structure for public water supply, the meagre groundwater resources of the district are in the heavy stress. In the villages of Nagaur district, the effects of high F-concentration are severe. Presence of excess F in groundwater has drawn attention of the society due to its pathophysiological impact on human body [4].

Fluoride could be found in a number of minerals, of which fluorspar, cryolite, topaz and fluorapatite are the most common [5]. Many epidemiological studies of possible adverse effects of the long-term ingestion of fluoride via drinking water have clearly indicated that fluoride primarily produces

effects on skeletal tissues (teeth and bones) [6]. Skeletal fluorosis observed when drinking water contains 3-6mg/L, crippling skeletal fluorosis develops where drinking water contains over 10 mg/L. In India totally 19 states have been reported as fluoride prone areas but severe problem occurred in the states of AP [7], TN [8], Rajasthan [9] and MP [10]. Several methods are in vogue to mitigate fluoride from drinking water[11]. These includes Nalgonda technique, activate charcoal technique, Bone char technique, Capacitative deionization technique, CEDI technique, Reverse osmosis technique and ion exchange technique[9], but the literature survey clearly indicates the material used in the present studies not reported any where.

Aforementioned techniques for defluoridation of drinking water are economically rich and non-applicability on mass scale. The present manuscript present the use and applicability of adsorbent carbon materials prepared from dry fruits of various plant materials and the obtained results were compared with commercially available granulated activated Carbon (GAC) purchased from Ranbaxy Laboratories Lit, India.

GEOGRAPHY OF NAGAUR DISTRICT

Nagaur District is district of the state of Rajasthan in western India.Nagaur city is the district headquarters. Nagaur district is bounded by Bikaner District to the northwest side, Churu District to the north side, Jaipur District to the east side, Ajmer District to the southeast side, Sikar District to the northeast side, Pali District to the south side, and Jodhpur District to the southwest and west side.

Latitude of Nagaur city : 26°25' & 27°40' North **Longitude of Nagaur city :** 73°.10' & 75°.15' East Nagaur is situated amidst seven districts namely Sikar, Jaipur, Ajmer, Bikaner, Churu, Pali, Jodhpur. Nagaur is the fifth largest district in Rajasthan with a vast terrain spreading over 17,718 sqkm. Its geographical spread is a good combine of plain, hills, sand mounds & as such it is a part of the great Indian Thar Desert.

EXPERIMENTAL

Area wise survey was conducted on the residents of the Nagaur district along with the registered medical practitioner to standardize the readings. The Jackson index of dental fluorosis was employed. In this survey people are broadly divided into three categories depending on the age limits between 5 to 15, 15 to 25 and above 25 years of age. In each group total 10 persons were examined and prepared statistical report. After conformation of fluorosis presence totally 20 sample were analyzed for fluoride ion concentration by SPAND'S method [12].

Sample Collection

Water samples were collected from all the existing sources of drinking water in the study area for investigation and chemical examination. For the present investigation, separate samples are

collected for chemical and biological analysis from the source. The bottles for sample collection have been thoroughly cleaned by rinsing with 8M HNO_3 (nitric acid) solution, followed by repeated washing with double distilled water. They are further rinsed with sample water before collection. Physicochemical analysis was done using standard procedure[12].

Material Preparation

Defluoridating materials were prepared from dry fruits, collected from plants *Enterolobium saman (ESC), Acasia Arabica (AAC), Prosopis juliflora (PLC)* belonging to family Mimosideae and Citrus lemon (CLC) belonging to Rutaceae in the plant kingdom. These materials are available as agricultural wastes and carbonized at 400 to 500°C in muffle furnace. The prepared carbons were chemically treated with 0.5M HNO_3 solution and then washed with distilled water and finally sieved in to 75µ particles size.

Defluoridation Method

0.5g of adsorbent was mixed with 100ml of water samples and stirred at 120 rounds/minute speed on Remi shaker for 30 minutes. Solution was filtered through Whatman no 42 filter paper and the filtrate was examined for further fluoride ion concentration on UV visible spectrometer (model no. Elico UV-2600). Experimental conditions were obtained with the above prepared carbon adsorbents in batch mode study as 45 minutes agitation time, 4g/L adsorbent concentration; optimum pH is 7-8. The same conditions were applied in defluoridation of drinking water samples in batch mode study.

RESULT AND DISCUSSION

Groundwater is the only source of potable water for majority of people in the study area. However, the inhabitants here are averse to drink bore well water or water from public water system. They say that water drawn from deep depths is not tasty, hence their preference to open well water or hand pump water. A survey of residents of the selected localities in the study area on the impact of water used for drinking on health of users revealed that, most of residents suffer from dental discolouration, early tooth decay and bone deformations. The practicing physicians of the study area also confirmed our observations. Symptoms of dental fluorosis in female population were more common than the male population. However, this anomaly was observed to be more prevalent between 5 and 15 years of age, which decreases with increase in age. The concentration of fluoride in all samples of study area has varied from 1.4 to 4.5mh/L, 1.57 to 4.21mg/L and 1.06 to 3.5mg/L in hand pumps, bore well and open well water samples respectively. From chemical analysis the study area was broadly classified into five categories depending upon the concentration of fluoride ion. 8 water samples from bore well, 7 samples from hand pump, 5 samples from open well water was fallen within the range of 1.5 to 4.5mg/L concentration of fluoride ion, but only 1 from bore well, 2 from open well water samples having less than 1.5mg/L concentration.

Defluoridation Studies of Potable water Samples

Water samples collected from various locations indicate that samples 1 to 5 of hand pump water, samples 6 to 12 of bore well and samples 13 to 15 of open well water contain excess of fluoride beyond permissible World Health Organization limit 1.5mh/L[6]. Hence the defluoridation studies were carried out on these particular samples employing prepared bioadorbents from ESC, AAC, PLC and CLC. The results were compared with those of GAC. In order to reduce the fluoride content below the permissible limit, optimum condition reported in previous have been adopted. For water samples, which contain fluoride range between 3.0 and 4.0mg/L, the dose of adsorbent is 4.5g/L and for those water samples, which contain fluoride, ranging from 1.5 to 3.0mgL, the dose adsorbent is 4.0mgL. The optimum contact time is 45 minutes with constant stirring at 200 rpm speed. The concentrations of fluoride ion in these samples after defluoridation have also been reported. A comparative study of the results of some physicochemical analysis of water from bore well, hand pump and open well before defluoridation and after defluoridation, indicate that water quality parameters like pH, EC, TDS, PO_4^{3-}, SO_4^{2-}, Cl^-, K^+, etc. values were increased slightly but negligible in many water samples when the adsorbents, ESC, AAC, PJC, CLC and GAC are used for the defluoridation process. Among the adsorbents, ESC, AAC and PJC decrease the fluoride content in potable water samples to a considerable extent without affecting the permissible limits of other

water quality parameters. The order if adsorption capacity in the mitigation of these adsorbents is ESC>AAC>PJC>CLC>GAC.

CONCLUSION

The result of the study indicates that the area under study is fully affected with endemic fluorosis, and the concentration of fluoride ion in all water sources varies from place to place. All of these results may arise due to the nature of rock and soil formation. Especially higher concentrations were observed in bore well and hand pump water. The low cost adsorbents ESC, AAC, and PJC remove fluoride content from potable water to a larger extent compared to the other adsorbent GAC. Hence the adsorbents ESC, AAC and PJC can be used for the defluoridation of potable water at household level. Finally the results also suggest that the area fully contaminated with fluoride is not suitable for drinking purpose and proper care must be taken by the people.

According to nationwide study of New Delhi based Fluorosis Research and Rural Development Foundation (FRRDF), "the occurrence of fluorosis can vary among different locations having almost the same fluoride concentrations in drinking water and can be affected by factors such as climate, individual susceptibility and biological response". The study concluded that "Poor nutrition also plays an important role in aggravating endemic fluorosis", thus explaining why poor people are often the worst affected. Fluorosis is an irreversible disease and there is no cure. The presence of fluoride in groundwater is human made. Over exploitation of groundwater in the last 20 years, is the chief reason for the spread of fluorosis in Rajasthan. With the coming of diesel pump sets things have changed. Farmers have started to dig deeper into the earth's crust and are literally extracting poison. Rajasthan is a classic case of falling water tables and increasing incidence of fluoride in water. Thus it appears that the situation vis-a-vis fluoride is on the rise despite substantial efforts by the Government and NGO's action plans in the field. The situation is grim and warrants a holistic approach to ameliorate the situation and a concerted action accordingly. It is, in fact, one of the most bones seeking acute toxin of notable chemical qualities and physiological properties as well. The main occurrence of fluorine in rocks is in the form of fluoride bearing minerals.

The arid climate with high evaporations and insignificant natural recharge might have accelerated the strengthening of fluoride concentration in the groundwater of this area. In the vast geographical expanse and varied geographical set-up in Rajasthan the cause of fluoridation of groundwater are many. Some natural, some human-made. Over exploitation of water resources in the Nagaur has resulted in the depletion of groundwater table, salination of aquifers and deterioration in chemical quality of groundwater at an alarming rate. Therefore, study area is recommended to adopt adequate measures for conservation and judicious management of groundwater resources.

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