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Defluoridation of Water using Corn Cobs Powder - An effective Risk Reducing agent

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***Abstract*— The presence of a unique chemical called Flouride in water, has a major impact on human health. In many places, ground waters are the primary source of water and is found to be with high concentrations of flourides. Most of the adsorbents used for the removal of fluoride from drinking water are activated carbon based mate-rials and is found to be most expensive. There is a need for an alternative, effec-tive, efficient and cheaper adsorbent material. Hence in the present work, an at-tempt has been made to remove the fluorides in drinking water using agricultural waste i.e., corn cobs powder as a natural adsorbent material along with fabricated filter. The results are verified with the limits recommended by Bureau of Indian Standard (BIS: 10500-2012). The water samples were collected from different places namely Uppinahally, Doddagatta and Yadapura villages in Arsikere taluk of Hassan district. Parametric studies were performed and comparative results were presented. It is observed that, filtration with corn cobs powder reduces the fluoride content for the samples from Uppinahally, Doddagatta and Yadapura from 2.5**

***Keywords*— *Corn cobs powder, Fluoride removal, Water Filteration*.**

I. Introduction

Groundwater is an important source of drinking water and it is estimated that more than 200 million people worldwide are drinking groundwater with fluoride concentrations greater than the WHO guideline value of 1.5mg/l. The majority of these cases occur in the developing world. Ground waters are much more vulnerable to fluoride enrichment than surface waters because of the greater impacts of water-rock reactions in aquifers.

Fluoride is one of the very few chemicals that have shown to cause significant effects in people through drinking water. Fluoride is found in all natural waters at some concentration. Sea water typically contains about 1mg/l while rivers and lakes generally exhibit concentrations less than 0.5mg/l. In groundwater's, however, low or high concentrations of fluoride can occur, depending on the nature of the rocks and the occurrence of fluoride-bearing minerals. High fluoride concentrations may therefore be expected in groundwater's from calcium-poor aquifers and in areas where fluoride-bearing minerals are common. Fluoride with inadequacy causes dental carries, while if it is in excess amount (>1mg/l) causes dental fluorosis and skeletal fluorosis which has no cure. Since fluorosis is an irreversible process, prevention of this is the only solution to protect against diseases. This can achieve by adopting defluoridation method by simple techniques.

A. Fluoride Metabolism

Approximately 75-90% of ingested fluoride is absorbed. In an acidic stomach, fluoride is converted into hydrogen fluoride (HF), and up to 40% of ingested fluoride is absorbed from stomach as HF. High stomach pH decreases gastric absorption by decreasing the concentration uptake of HF. Fluoride is later absorbed in intestine but is unaffected by pH at its site. Once absorbed in the blood, fluoride readily distributes throughout the body, with approximately 99% of body burden of fluoride retained in calcium rich areas such as bone and teeth. In infants, 80-90% of absorbed fluoride is retained, but in adults this level falls to about 60% [1]. Fluoride crosses the placenta and is found in mother's milk at low levels essentially equal to those in blood. Levels of fluoride that are found in bone vary with the part of bone examined with the age and sex of the individual. Bone fluoride is considered to be a reflection of long-term exposure to fluoride (IPCS2002). Fluoride is excreted primarily via urine. Urinary fluoride clearance increases with urine pH due to a decrease in concentration of HF.

B. Flurosis in India

Yama et al. 1999 and FRRDF1999 noted a total of 17 out of 32 States in India are reported to have endemic fluorosis in India. In 1987, it estimated that 25 million people were suffering from fluorosis. The prevalence of dental fluorosis has been investigated in Rajasthan [15]. On an average fluoride concentration of 1.4 and 6 mg/l, dental fluorosis was seen in 25.6% and 84.4% of school children and 23.9% and 96.9% of adults. Dental mottling was reported in 76% of children in 5-10 years age group and 84% of children in 10-15 years age group in Kodabakshupally, Armpit and Sivanagiren [16]. The prevalence of dental fluorosis was examined in Haryana, and over 50% children were examined to be affected by dental fluorosis [17]. Mean-while, in Andhra Pradesh, dental fluorosis levels were reported as 43%, whereas drink-ing water fluoride concentration ranges from 1.2 to 2.1 mg/l [18]. Endemic skeletal fluorosis was reported in India and was first observed in Andhra Pradesh bullocks that were used for plowing [3].

C. Defluoridation Technique

Fluoride at excess level in drinking water in developing country is an emerging problem. Several methods are available for defluoridation of water to prevent fluorosis.

Few methods include; Bone charcoal, Contact precipitation, Algona, activated alumina, Ion-exchange technique, Membrane filtration and Nanofiltration. Advanced treatment technologies are Reverse osmosis (RO), Electrodialysis and Distillation.

1) Bone Charcoal

Since 1940's bone charcoal is the oldest known defluoridation technique used and successfully removes arsenic from water. This method of fluoride removal is still followed in the USA mainly because of its large scale use in sugar industry. The first domestic defluoridators were developed in 1960's and in 1988 the ICOH filter type was launched by WHO. Bone charcoal is produced by calcification of animal bones or carbonizing bone at a temperature of 1100-1600 degree [4]. Bone charcoal consists of calcium phosphate and carbonates. Using bone charcoal defluoridation technique has become simple and regenerated without significant loss of binding capacity for fluoride. Today bone charcoal is replaced by ion-exchange resins and activated alumina but at domestic level bone charcoal seems to work well as defluoridation.

2) Contact Precipitation

Contact precipitation is a method for defluoridation which requires addition of calcium and phosphate compound and bringing water in contact along with bone charcoal medium. In a solution containing calcium, phosphate, and fluoride, the precipitation of calcium fluoride is easily catalyzed in contact bed that acts as a filter for precipitation. From bed, the fluoridation water follows continuously by gravity to shallow clean water tank. The flow from the raw water tank to clean water tank is constrained by a narrow tube or valve to allow sufficient contact time in bed. The constant time of 20-30 minutes is reported to show excellent operation [7]. The filter resistance is compared with flow resistance through tube and valve by Dahi in 1998. It was reported that this method allows high removal efficiency, has low operating cost, no overdose or any health risk and low daily working load.

There are several other methods used in Defluoridation of water and in the present study we are using corn cobs powder for the defluoridation, which is ***efficient, low-cost, environment friendly and sustainable.***

D. Methods to Estimate Fluoride Concntration in Water

Several methods were reported for analyzing the total fluoride in water, but preference was given only to International or National Standard methods. The analytical methods of determining were as follows:

- Ion chromatography(IC). To analyze samples using IC, the calcium carbonate must be dissolved in a strong acid, such as hydrochloric acid. The carbonate is con-verted to carbonic acid, and then to carbon dioxide gas [5]. As a result, the carbonate ion concentration is only slightly higher than the amount normally found in aqueous solutions, due to dissolved carbon dioxide from the atmosphere. The resulting solu-tion will contain calcium ions, carbonate, chloride (from the acid), and any other ions that were incorporated into the calcium carbonate structure.
- Fluoride ion-selective electrodes. It is used to measure a wide variety of matrices however, they are not ideal for studying fluoride in a calcium carbonate matrix. After the dissolution of the shell with a strong acid, the solution would have a pH ~1 [6]. Determination of fluoride at this pH using an electrode will be inaccurate because most of the fluoride is in the form of HF, $HF2-$ and [HF]n and will not be detected by the electrode, which only measures fluoride. This problem can be overcome by adding a total ionic strength adjustment buffer, which serves to buffer the solution at an optimal pH, releasing fluoride from complexes with captions such as iron and aluminum, and it ensures that all measurements are done at the same ionic strength. Unfortunately, this technique does not allow for the identification of other ions present in the matrix.
- The colorimetric method. The sodium 2-(para sulfophenylazo)-l, 8-dihydroxy-3, 6 naphthalene disulfonate method, is based on the reaction between fluoride and a dark red zirconium dye lake, forming a colorless complex anion (American Public Health Association [APHA], American Water Works Association [AWWA], and Water Pollution Control Federation [WPCF] 1985). This method results in a bleaching of the red color in an amount proportional to the fluoride concentration [20]. As the amount of fluoride increases, the resulting color becomes lighter. Color then is determined photometrically using a filter photometer or spectrophotometer. The colorimetric and fluoride ion-specific electrode methods are currently the most common methods employed (APHA, AWWA, and WPCF 1985).

There are many other methods are available to estimate fluoride concentrations, but in the present investigation Ion chromatography method is adopted.

II. Materials and Methodology

In this section, the usage of corn cob powder is used as an adsorbing agent and its methodology in adopting for the filtration unit is discussed

A. Corn Cob:

Corn is a major crop plant, every part of which is utilized except cob. A corn cob is the central core of an ear of maize. It is the part of the ear on which kernels grow. The ear is also considered as a “cob” or “pole” but it is not fully a “pole” until the ear is shucked, or removed from the plant material around the year [7]. The inner most part of the cob is white and has a consistency similar to foam plastic. In this study an attempt is made to utilize this less- utilized plant part to clean one of the most precious natural resource - Water. The corn cobs powder are micronized to a required size of 75 micron. The corn cobs powder so formed is taken into the Filteration Unit as shown in Fig.1.

Uses of corn cobs. Most of this agricultural waste product is used as a,

- Industrial source of the chemical furfural.
- Fiber in fodder for ruminant livestock.
- Bedding for animals- cobs absorbs moisture and provide a compliant surface.
- Raw material for bowls of corn cob pipes.

Advantages of Corn cobs:

- Simple and Efficient
- Cost effective and Feasible
- Eco – friendly and locally available
- Porous and reusable
- A stainless steel household filter was procured and fabricated as per requirements
- IS sieves of appropriate sizes are provided
- IS sieve of size 63micron is provided at the primary course of filter media, in which micronized corn cobs powder is placed.

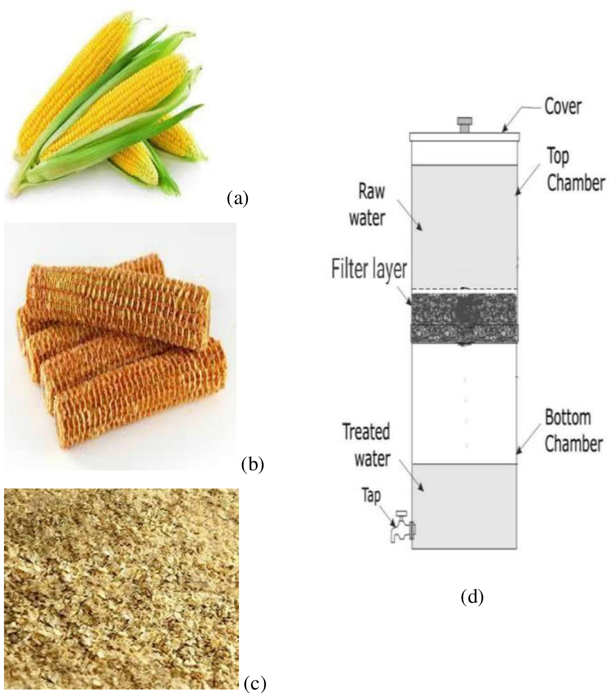

Fig 1: Corn Cobs and Powder along with the Prototype Filtration Unit. (a) Corn, (b) Corn cobs, (c) Corn cobs powder and (d) Prototype model.

*1) **Sand:***

Sand is the loose granular material which is formed due to the disintegration of rocks. The composition of sand varies, depending on the local rock sources and conditions, but the most common constituent of sand in inland continental settings and non-tropical coastal settings is silica, usually in the form of quartz. The second most common type of sand is calcium carbonate [8].

Sand filters are mainly used along with corn cob powder for water purification in order to increase porosity and rate of filtration. While using sand as a filter media, grain size and depth of layer are predominant factors to be considered.

B. Methodology

Water sampling and analysis involves the collection of water samples and measurement for chemical, physical and biological characteristics to determine its quality. According to the information given by the local people, samples from borewells of Arsikere Taluk of Hassan district were taken for the analysis. First sampling of about six liters of water was collected from Uppinahally (Sample 1), Doddagatta (Sample 2) and Yadapura (Sample 3) villages of Arsikere Taluk. Second sampling of about four liters of water was collected from each place mentioned above. The flowchart shown in Fig. 2 shows the methodology adopted during the process.

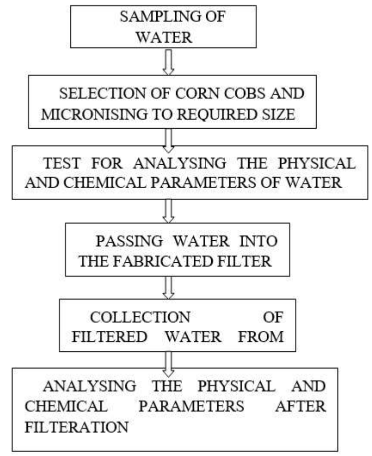

Fig. 2. Flow Chart of methodology adopted

Fabricated filter:. The filter is fabricated as per requirement using locally available materials viz., Corn cob powder, sand and a mesh layer. IS sieve of size 63micron mesh is provided at the primary course of filter media, in which 75 microns corn cobs powder and sand mixture in the ratio of 1:0.3 is thoroughly mixed and placed to form the Filteration Unit.

The Raw water is to be inlet from the above as shown in the Fig 2(d).Water is passed through the mesh carrying micronized corn cobs powder. The corn cobs powder present in this stage adsorbs the fluoride present in the water. The corn cobs powder is reused several times.

The water that comes through the filter material is taken out and the tests are conducted to check the fluoride limits. Along with the Fluoride tests, other tests like Acidity, Alkalinity, Turbidity, TDS, pH, Hardness, Conductivity are also carried out. These tests were conducted to ensure that the parameters are within the limits of WHO guidelines.

III. Results and Discussion

The experiment were conducted with an aim to find the optimum removal of fluoride concentrations using corn cobs powder and the results are compared with Bureau of Indian Standards: 10500-2012 [9]. The physical and chemical parameters are tested before and after filtration. Comparative results are presented for the samples collected from Uppinahally (Sample 1), Doddagatta (Sample 2) and Yadapura(Sample 3) villages.

The acidic content in water is found to increase by 36.25%, 10.29% and 6% in Sample 1, Sample 2 and Sample 3 respectively as shown in Fig.3. Though incremental is observed, the values are found to be well within the permissible limits and hence treatment is not required. High acidity in water may results in foul-tasting in water.

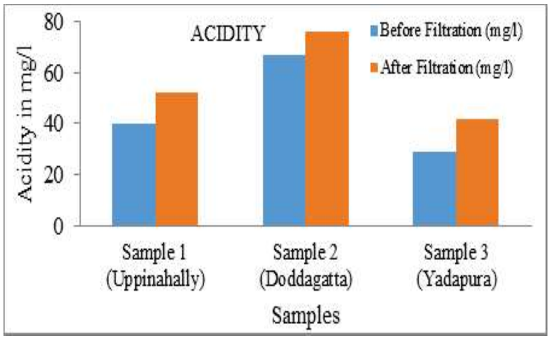

Fig. 1. Variation in *ACIDITY* using corn cobs powder.

The pH content in water is found to increase by 4.20%, 2.9% and 3.6% in Sample 1, 2 and 3 respectively as shown in Fig.4. Though pH increases, the values are preferably less than 8 and are well within the permissible limits. These values of pH generally don't have any health hazards and hence further treatment may not be required.

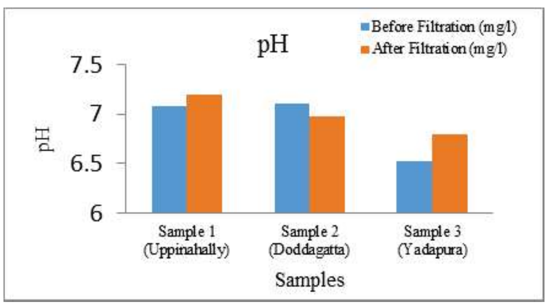

Fig. 2. Variation in *pH* using corn cobs powder.

The Alkalinity content in water is found to increase by 9.0%, 0% and 16% in Sample 1, 2 and 3 respectively as shown in Fig.5. The permissible limits for alkalinity in drinking water is 200mg/l. Hence, it is well within the limits of WHO guidelines.

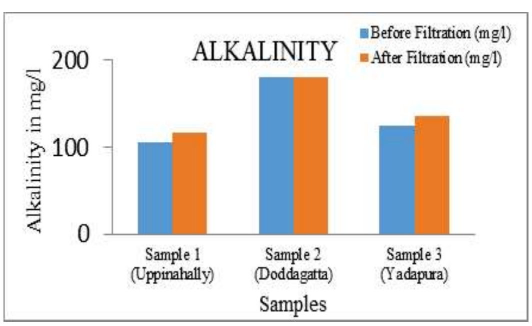

Fig. 3. Variation in *ALKALINITY* using corn cobs powder.

The Turbidity and Chloride content in water are found to increase in Sample 1, Sample 2 and Sample 3 respectively and are shown in Fig.6 and Fig. 7 respectively. The levels are found to increase, which may results in foul-tasting in water. This can be reduces upon further filtration.

The water is found to be hard water in the selected regions and upon filteration the increase in the levels was observed as shown in Fig. 8. It is found to increase by 2.5%, 20.7% and 36.9% in sample 1, sample 2 and sample 3 respectively.

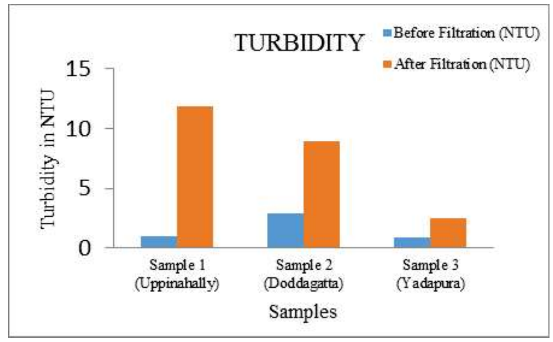

Fig. 4. Variation in Turbidity using corn cobs powder

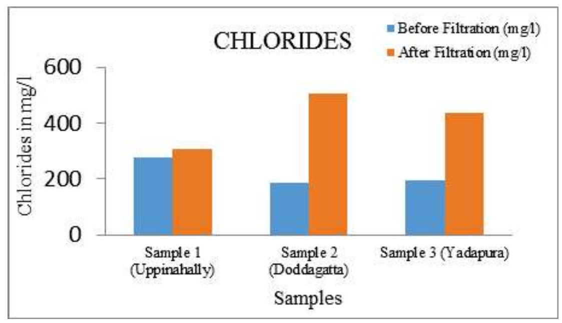

Fig. 5. Variation in Chloride using corn cobs powder

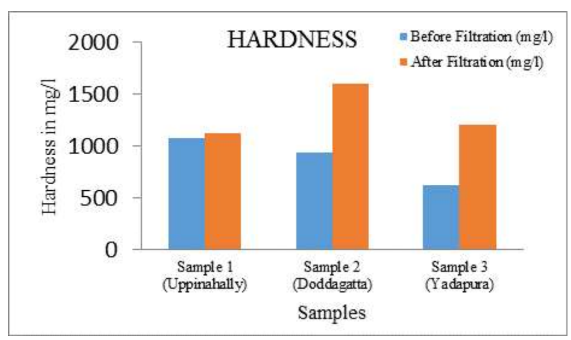

Fig. 6. Variation in Hardness using corn cobs powder

According to BIS Specifications, the fluoride levels should be in the range of 1-1.5 mg/l. It is observed that, higher levels of fluorides are found in the places selected for the present study. After passing the water through the filtration unit, the fluoride levels reduced by 60%, 38.4% and 28.5% respectively in samples 1, 2 and 3 respectively. It is to be noted that, fluoride concentration also reached the acceptable limits.

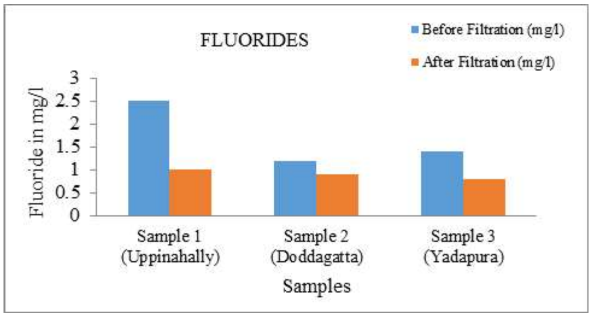

Fig. 7. Variation in Fluoride using corn cobs powder

From the comparative results presented, it is observed that the samples collected from Uppinahally (sample 1), Doddagatta (sample 2) and Yadapura (sample 3) village are found to have excess concentrations of fluoride content and after filtration using Corn Cob powder it was found to be safe for drinking.

IV. CONCLUSIONS

The samples collected from Uppinahally (Sample 1), Doddagatta (Sample 2) and Yadapur (Sample 3) villages have fluoride content more than the desirable limits and is therefore processed under filtration to reduce fluoride content. Usage of corn cob powder with sand during filteration has efficiently reduced the fluoride content. Acidity and Alkalinity were found to be in the permissible limits. Hence, this naturally available low cost adsorbent can be used fruitfully for the removal of fluoride over wide range of concentration. The parameters like pH, chlorides, hardness, and TDS has increased than the desirable limit which requires further treatments like distillation, softening, reverse osmosis etc. for their further use as safe drinking purposes.

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