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Iron Removal Efficiency of Different Bamboo Charcoals: A Study on Modified Indigenous Water Filtration Technique in Rural Areas of Assam

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ABSTRACT

Iron a common household element which occurs as minor constituent of ground water in all categories of hydro-geological settings in Assam. More than eighty percentages of rural populations of Assam depends on ground water resources for drinking and irrigation purposes so appropriate technologies are needed for purification of groundwater to enable safe use. Conventional methods of iron mitigation are cost effective and difficulty exists in its procurement in developing countries like India. Use of sand, pebbles, charcoal and lime in their common water filtration system by rural people of Assam, known as Sand Filter (SF), is an indigenous technique. A study has carried out in the common indigenous water filtration technique, using four different bamboo charcoals Bambusa balcooa, Bambusa nutans, Bambusa tulda and Bambusa Padilla separately for iron removal. Iron adsorption by different bamboo charcoals in the modified rural SF at bulk volume, revealed that the maximum removal for iron were 74.24%, 59.46%, 64.53% and 56.37% for B balcooa, B nutans, B tulda and B padilla respectively at pH greater than 7.5, when iron concentration ranges (0.3-4) mg/l at room temperature. Efficiency depends on contact time with bamboo charcoals. The study reveals that all the four types of bamboo charcoals were effective in iron removal from water, however charcoals from Bambusa balcooa is more capable of bringing iron levels decreases to desirable limits.

Key words: Ground water, bamboo charcoals, indigenous technique.

INTRODUCTION

Extensive study on indigenous methods and materials for the drinking water treatment is essentially needed, because the methods such as ion exchange, membrane filtration, oxidation–reduction, chemical precipitation, adsorption, reverse osmosis are costly and the difficulty exists in its procurement in developing countries like India [1] [2]. Heavy metals can be removed by a variety of biosorbent, in particular, environment-friendly agro wastes, unconventional raw materials like saw dust, rice husk, wood charcoal, and rice hull have emerged as important adsorbents [3] [4] [5]. Different technologies are developed for iron removal with different limitations. Most of the methods are costly and can't be adopted by the rural peoples.

Purification of groundwater using sand, pebbles and charcoal is an indigenous technique in Assam commonly known as Sand Filter (SF). Sand filtration is a simple technology that has been successfully used for over 200 years in water purification because of its simple and economical construction, operation and maintenance using local materials [6]. Various attempts have already been made to economize and develop activated carbon as adsorbent form unconventional raw materials for the removal of metal ions [7]. A quantitative description of the processes leading to iron removal using household waste bamboo charcoal is lacking and therefore a model filter was developed with some modifications in the indigenous SF techniques of rural areas of Assam. This is a low cost method utilizing the waste product of bamboo firewood which are easily available, eco-friendly and easy to prepare.

Different ethnic diversities of Assam have different Indigenous Technical Knowledge (ITK) in their daily life. These ITK reflects their culture, social status, location, experience and environment of the individuals involved, so it is pertinent to identify the technologies and its scientific values for a better future [8]. Bamboo is an integral part of life for rural peoples of Assam, for fulfilling their basic necessities. India is the second largest producer of bamboo in world next to China and also has the rich diversity of bamboos with almost 130 species. 78 species distributed in the Northeastern region of India and 42 species are found in Assam [9]. An attempt has been made to access the traditional knowledge based system of bamboo charcoals in water purification and its importance as well as future aspects for sustainable development of rural water purification technique. The goal of this work was to find out the iron removal efficiency of locally available bamboo charcoals in indigenous SF at bulk volume of groundwater. The North Eastern state of India, Assam, more than eighty percent of rural populations depend on ground water resources for drinking and irrigation purposes [10]. Iron a common household element which occurs as minor constituent of ground water in all categories of hydro-geological settings in Assam, so appropriate technologies are needed for purification of groundwater to enable safe use.

EXPERIMENTAL SECTION

Reagents: Raw materials that are four different bamboo charcoals viz. *Bambusa balcooa, Bambusa nutans, Bambusa tulda and Bambusa pallida* which are locally known as Bhaluka, Makal, Jati and Bijuli Bah respectively for the preparation of filtration bed of SF are separately collected from rural areas of Assam. A total of 1.5 Kg bamboo charcoals have been collected after the use of bamboos as firewood by villagers, wash with boiling water for several times followed by distilled water to eliminate the water soluble impurities and finally oven dried at 105°C. The river sand was thoroughly washed with of tap water.

Sample Collection and Analysis: The study was carried out from July 2009 to April 2010. Raw waters were collected from the Tube Wells (depth up to 80 fts) and Deep Tube Wells (depth up to 130 fts) from the rural areas of Assam, India. A total of 78 ground water samples were collected and tested for pH, EC, Turbidity, DO, TS, Hardness, Iron and Fluoride before and after filtration through the modified filter. All water samples were collected after 3 minutes of initial pumping in pre-cleaned two polythene containers of five-liter capacity. The water quality parameter estimation and calibration of equipments were done using standard methods of [11] [12]. Iron in the water samples were determined by Phenanthroline Method using UV-spectrophotometer (Hitachi 3210) operating the instrument at 510 nm. All experiments were run in triplicate and arithmetic means of the results were considered for data analysis. A probability level of p (0.05) was used throughout the study and conclusions were drawn only if the results were statistically significant. After pouring raw water to the SF the outlet was stopped for 1 hr, 2 hrs, 6 hrs and 12 hrs and water samples were withdrawn at these time intervals for iron estimation. All statistical analyses were done by using the SPSS Version-13.

Experimental setup of the filter: The experimental setup consists of four concrete chambers of 3.5 feet height with diameter of 2.5 feet with a filter media or filtration bed at the centre. The thickness of the filtration bed changes from 6 inches to 14 inches composed of four layers. The bottom layer is made of bamboo charcoals crushed and sieved with 50-60 mesh size, the second layer is of well mixed river sand and bamboo charcoals crushed and sieved with normal mesh size, the third layer is of normal size bamboo charcoals and the top layer of pebbles to prevent the floating of these charcoals [13] [7]. Four different bamboo charcoals are used separately for each filtration bed. The average rate of filtration through this filtration bed is slightly more than 6 lit/h.

RESULTS AND DISCUSSION

During the study period, average raw groundwater quality range was characterized as pH (6.15-7.92), EC (176.98-648.12) S/cm, TS (121.87-203.54) mg/l , DO (1.90-5.20) mg/l, Fe (0.08-6.15) mg/l, Turbidity (0.87-21.94) NTU and Hardness (36-200) mg/l respectively are presented in **Table 1.**

Table 1: **Statistical summary of physico-chemical parameters of raw water**

Parameters	Max	Min	Range	SD	SE
pH	7.92	6.15	1.77	0.52	0.16
EC (S/cm)	648.12	176.98	471.14	157.23	49.72
TS (mg/l)	203.54	121.87	81.67	23.12	0.78
DO(mg/l)	5.20	1.90	3.30	0.98	0.28
Fe(mg/l)	6.15	0.08	6.07	2.36	0.74
Turbidity (NTU)	21.94	0.87	21.07	7.37	2.12
TH(mg/l)	200	36	164	6.44	1.45

Out of 78 number of water samples 17.94% samples were found iron concentration < 0.3 ppm, 21.79% samples with in <0.3ppm-4ppm> and 60.02% samples found iron concentration >4 ppm. The study shows that percentage removal decreases with the increase in initial concentration of iron (**Table 2** and **Fig.1**). The percentage removal of iron was also recorded maximum at two hour contact time (**Fig. 2**). The extent of removal of iron at room temperature by bamboo charcoal was found highly pH dependent. As pH increases, the extent of removal increases, reaches a maximum value and then decreases further increased up to optimum pH (**Table 3** and **Fig.3**).

***Table 2*: Effect of initial concentration on the extent of removal of Fe**

Concentration	% Removal			
mg/l	*B balcooa*	*B nutans*	*B tulda*	*B pallida*
≤0.3	67.73	57.51	51.16	54.18
<0.3-4>	74.24	59.46	64.57	56.37
>4	62.36	62.23	53.38	52.45

***Table 3*: Effect of initial pH on the extent of removal of Fe at room temperature**

Initial pH	% Removal			
	B balcooa	B nutans	B tulda	B padilla
4.5	15.44	19.21	17.63	13.11
5.3	33.17	29.76	28.33	31.24
6.5	54.81	48.47	39.87	48.78
7.5	71.82	56.05	63.45	56.02
7.8	74.24	59.46	64.57	56.37
8.1	66.45	61.71	59.89	55.13

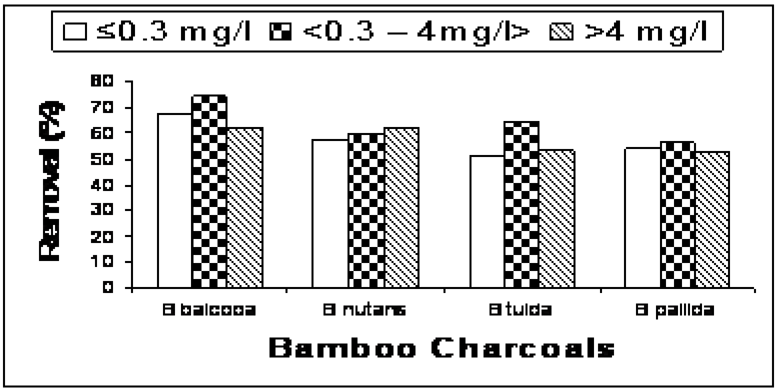

Fig.1: Removal Efficiency Vs Iron Concentration

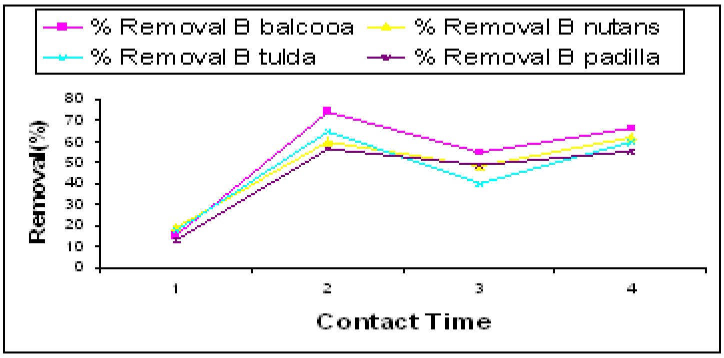

Fig. 2: Removal Efficiency Vs Contact Time

Chemicals, alum and lime are added to and rapidly mixed with the iron contaminated water in various mitigation techniques. High alkalinity and moderate EC are the favourable conditions for effective iron removal by other adsorbents [14] [15] [16]. The present study on iron adsorption by different bamboo charcoals in the modified SF at bulk volume, revealed that the maximum adsorption of iron was 74.24%, 59.46%, 64.53% and 56.37% for *B balcooa*, *B nutans*, *B tulda* and *B padilla* at pH higher than 7.5 respectively, when the concentration of iron with in the range

(0.3-4) mg/l at room temperature. The efficiency of iron removal of the four types of bamboo charcoals depend on the initial concentration of sorbate, contact time and the conditions of sorbents. At the initial stage, the rate of removal of iron was higher, due to the availability of more than required number of active sites on the surface of carbons and became slower at the later stages of contact time, due to the decreased or lesser number of active sites. Same results have been reported in literature for the removal of metal ions by various adsorbents [17] [18] [19] [20]. Charcoals of *Bambusa balcooa* is the best for iron removal among the four types of bamboo sorbents with efficiency 74.24 % in this experiment.

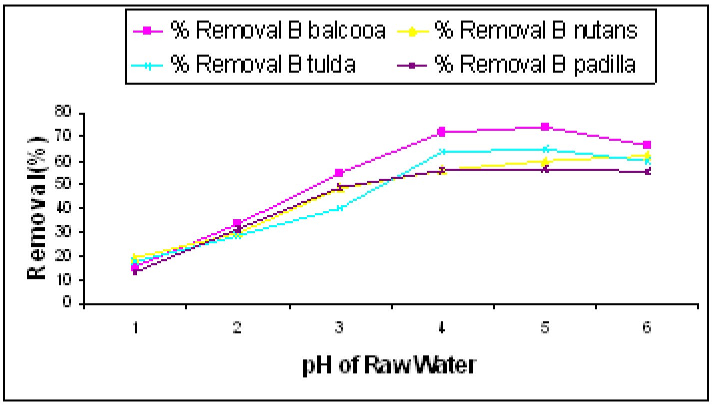

Fig. 3: Removal Efficiency Vs pH of Water

Numerous materials have been tested for their usefulness as iron removal reagent and several methods have been evolved. But most of the methods have some drawbacks as a result could not find practical application. This method has high potentiality due to simple and economical construction, operation and maintenance using local materials. Simultaneous aeration and lime softening is very much essential for better efficiency of iron removal. Efficiency of this Sand Filters depends on raw water quality and filter design. Up to date water filter design and operation mostly rely on experiences gained at laboratory. But, large numbers of variable conditions effect on its performance. But in this method raw water was directly used therefore the role of ambient conditions such as temperature and chemical composition of the raw waters can be nullify. Extensive study on kinetics, thermodynamics and spectroscopy are much needed to develop bamboo charcoals as an effective commercial alternative in near future. This low cost SF method has high potentiality as the waste product of bamboo firewood which is easily available in Assam and easy to prepare.

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