Technical note

Fluoride removal studies in water using natural materials

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Abstract

Excess fluoride in water causes health hazards to the natural environment.

The removal of fluoride was attempted using natural materials such as red soil, charcoal, brick, fly-ash and serpentine. Each material was set up in a column for a known volume and the defluoridation capacities of these materials were studied with respect to time. According to the maximum defluoridation capacity these materials were added proportionately to the vertical column. Ten $mg \cdot \ell^{-1}$ of fluoride was passed through the column and the variation of fluoride removal for a known rate of flow was studied. Correlation analysis of defluoridation capacity with time was done and an attempt has been made to classify them accordingly. The study reveals that red soil has good fluoride removal capacity followed by brick, fly-ash, serpentine and charcoal.

Keywords: fluoride removal, red soil, charcoal, fly-ash, serpentine, brick

Introduction

Fluorine, a fairly common element of the earth's crust, is present in the form of fluorides in a number of minerals and in many rocks. Excess fluoride in drinking-water causes harmful effects such as dental fluorosis and skeletal fluorosis. The permissible limit of fluoride level is generally 1 $mg \cdot \ell^{-1}$. The high fluoride levels in drinking-water and its impact on human health in many parts of India have increased the importance of defluoridation studies. The fluoride -bearing minerals or fluoride-rich minerals in the rocks and soils are the cause of high fluoride content in the groundwater, which is the main source of drinking-water in India. The present study aimed to find a suitable low-cost environmentally friendly method for the removal of fluoride in the groundwater that is used by common man. Therefore, few natural materials such as red soil, untreated charcoal, local powdered brick, fly-ash from Neyveli (thermal power plant) and mineral serpentine were used. The ability of soil to absorb fluorine from solution has been studied by earlier researchers (Bower and Hatcher,1967; Fluker et al., 1982; Gupta et al.,1982). The capacity of fluoride removal by the individual materials was studied and accordingly two columns were set up and studied for their defluoridation capacities. The results obtained may indicate a possible solution for the removal of fluoride from a rural water supply scheme.

Methodology

Fluoride removal was done by passing water through columns, as earlier studies on stirring methods had confirmed that an increase in stirring rate increases the fluoride removal for a given temperature (Killader and Bhargava, 1993) .This study is an attempt to remove fluoride by column methods using local materials. The removal rate of fluoride was tested using 25 g of the material (red soil, charcoal, brick powder, fly-ash and serpentine) collected in different flasks. The fly-ash of Neyveli has oxides of Si, Al, Fe, Ti, Ca, $MgSO_3$ and alkalies along with mixed oxides (Srinivasamorthy, 1996). The red soil used is ferruginous lateritic clay. The composition of the mineral serpentine closely corresponds to $Mg_6Si_4O_{10}(OH)_8$. All the materials used for defluoridation were not pretreated and the size fractions taken were of 2.5ϕ mesh fraction .The surface character of the solid material is not considered here. The standard solution of 10 $mg \cdot \ell^{-1}$ fluoride was prepared by using DDW (pH 7.2; HCO_3 2.2 $mg \cdot \ell^{-1}$; Ca 1.1 $mg \cdot \ell^{-1}$; SO_4 0.46 $mg \cdot \ell^{-1}$). The stopper was adjusted at a standard rate of 1.5 $m\ell$/min. The samples were collected at intervals of 0-15, 15-30, 30-60, 60-90 and 90-120 min. The collected solution was analysed for fluoride using an Orion fluoride ion electrode and TISAB III. According to fluoride removal capacity, two columns were set up in proportion with the adsorption capacity of these five materials and the eluent was collected at a rate of 1.5 $m\ell$/min (discussed later with figures). The removal rate of the collected solution and their fluoride content was determined (Table 1). The flow rate was found to be satisfactory during preliminary trials. Larger flow rates gave high fluoride in the effluent water. Fluctuation in the flow rate was within ±20%. Hence the 1.5 $m\ell$/min flow rate was maintained for this study. The validity of maintaining this flow rate needs further investigation.

TABLE 1
Fluoride removed in time intravels

Time	Red soil	Charcoal	Fly-ash	Brick	Serpentine
15	0.64	9.05	3.4	4.7	3.7
30	0.09	9.05	3.7	4	4.1
60	0.06	9.1	4.7	3.7	4.6
90	0.035	9.05	6	4	4.8
120	0.029	9	7.1	3.9	5.8

Results

Every solid material is a potential adsorbent. It is also reasonable to utilise the naturally occurring fluoride-seeking minerals since the

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