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BACTERIA AND TURBIDITY REMOVAL FROM WATER BY BITUMINOUS COAL PRETREATED WITH ALUM AND SILVER

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ABSTRACT

The present work is part of a study to develop low-cost filtration/adsorption media for removal of bacteria, viruses and turbidity from water, using locally available materials. Method of preparation of alum and silver pretreated bituminous coal was standardised. High removal of total coliforms (>90%) and heterotrophic plate count bacteria (>88%) was observed in a downflow column test (10 cm bed depth in 30 cm x 2.5 cm ID column; 10 minutes bed contact time) from a dug well water (pH 9.0; turbidity 9.5 NTU; total coliforms 21-57 CFU/mL; and heterotrophic plate count 69-98 CFU/mL). Effluent characteristics (turbidity 1.2-3.0 NTU; faecal coliforms 0-3/100 mL; and heterotrophic plate count 7-44 CFU/mL) of 4-8 days duration column tests, using the river Ganga water (turbidity 12.0-23.5 NTU; faecal coliforms 14-130/100 mL; and heterotrophic plate count 60-190 CFU/mL), demonstrated the potential of the medium for water filters for village or small community households in the developing countries.

KEYWORDS

Bacteria and turbidity removal; alum and silver pretreated bituminous coal; coliforms; heterotrophic plate count; water filter; developing countries.

INTRODUCTION

General lack of sufficient quantities of safe drinking water in the developing world continues to be a serious problem; this is particularly true for the rural and small suburban communities. Although concerted efforts are underway to correct the situation through the International Drinking Water Supply and Sanitation Decade, unabated increase in the population is making it difficult to meet the Decade's initial objective of providing coverage for 85% of the rural population of the developing world (WHO, 1986). Even if resources are made available, introduction of conventional methods of drinking water treatment in villages and small communities in the developing world would not be a feasible approach. There is, therefore, a pressing need for introduction of inexpensive methods of making safe drinking water. As a result, there is a renewed interest in development and testing of simple low-cost devices or systems of drinking water treatment which show promise for application in village or small community households in the developing world. To this end, studies were undertaken at the Indian Institute of Technology, Kanpur to develop low-cost filtration/adsorption media for removal of bacteria, viruses and turbidity from water, using locally available materials. Among a number of coal/lignite-based media tested, alum pretreated Giridih bituminous coal was

found effective in removing bacteria and turbidity (Prasad and Chaudhuri, 1989) as well as polio (Chaudhuri and Sattar, 1986) and rotavirus (Chaudhuri and Sattar, 1989) from water. Jayadev and Chaudhuri (1990) demonstrated the usefulness of incorporating silver into alum pretreated Giridih bituminous coal in improving its performance. In the present work, method of preparation of alum and silver pretreated Giridih bituminous coal was standardised and the medium was subjected to downflow column test for removal of bacteria (coliform and heterotrophic plate count) and turbidity from dug well and river water.

EXPERIMENTAL

To standardise the alum pretreatment procedure, Giridih bituminous coal (GBC), obtained through the National Environmental Engineering Research Institute, Nagpur, India, was subjected to batch aluminium sorption test. Sorption kinetic tests (5 grams GBC of 0.388 mm geometric mean size in 100 mL alum ($Al_2(SO_4)_3.16H_2O$) solution (0.025,0.05 and 0.075 M) agitated at 20 rpm in an end-over-end shaker) showed that bulk of the sorption occurred in one hour and saturation was reached in 6 hours. Equilibrium sorption tests (6 hours contact time; 0.025, 0.05, 0.075 and 0.1 M alum solutions) indicated maximum aluminium sorption for 0.075 M alum solution and 5% GBC. Silver pretreatment was carried out by two methods, viz., agitating 5 grams alum pretreated GBC (prepared by agitating 5 grams GBC in 100 mL 0.075 M alum solution at 20 rpm for 6 hours, separating the alum pretreated medium and washing with distilled water followed by drying at 103°C) in 100 mL silver nitrate solution (0.5 mg Ag/L) or 5 grams raw GBC in 100 mL mixed solution of silver nitrate (0.5 mg Ag/L) and alum (0.075 M), at 20 rpm for 1, 6 and 24 hours, separating the alum and silver pretreated medium and washing with distilled water followed by drying at 103°C. The two media were designated as Alum-GBC-Ag and Alum/Ag-GBC, respectively. To estimate the amount of silver incorporation, 2 grams Alum-GBC-Ag or Alum/Ag-GBC were refluxed in 40 mL 0.1 N nitric acid for 20 minutes and following cooling, the membrane (0.45 μm) filtered solution was analysed for silver, using a silver ion electrode. The data presented in Table 1 show that 6 hours

TABLE 1 Silver Incorporation in Alum and Silver Pretreated GBC

	Agitation Time (h)	Silver in Refluxing Solution (μg Ag/g medium)			
		Test 1	Test 2	Test 3	Mean
Alum-GBC-Ag	1	4.13	3.71	6.56	4.80
	6	7.19	5.77	7.72	6.89
	24	6.75	4.14	6.32	5.74
Alum/Ag-GBC	1	5.17	3.48	5.00	4.55
	6	6.45	4.18	7.02	5.88
	24	5.18	3.36	4.03	4.19

agitation accomplished maximum silver incorporation. Subsequently, 6 hours agitation was employed for preparation of both Alum-GBC-Ag and Alum/Ag-GBC.

Downflow column tests, employing dug well or the river Ganga water, were conducted with 10 cm bed depth of Alum-GBC-Ag or Alum/Ag-GBC in 30 cm x 2.5 cm ID perspex columns at 132.5 mL/h (0.27 $m^3/m^2/h$) which corresponded to a bed contact time of 10 minutes. Column effluents were monitored for pH, turbidity and bacteria (faecal coliform - membrane filter (MF) method - 44 ± 0.5°C/24 h - MFC broth (WHO, 1985) or total coliform - pour plate method - 37 ± 0.5°C/48 ± 3 h - MacConkey agar (McCambridge and McMeekin, 1979) and heterotrophic plate count - pour plate method - 35 ± 0.5°C/48 ± 3 h - plate count agar (APHA, 1985)) at selected time intervals. All bacterial enumerations were made in duplicate and the mean values are reported.

RESULTS AND DISCUSSION

Performance of the two media, viz., Alum-GBC-Ag and Alum/Ag-GBC in removing

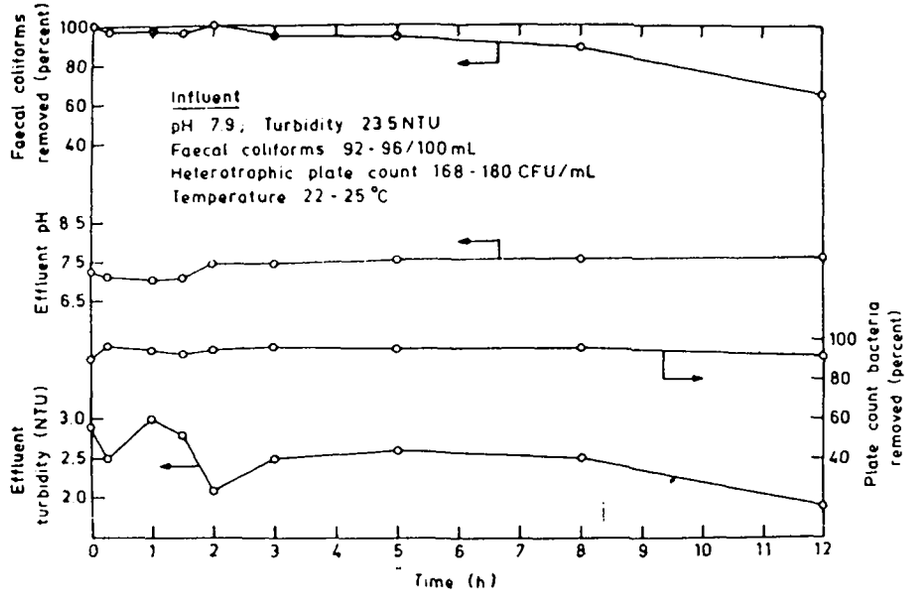

Fig. 1. Alum-GBC-Ag - Ganga water column test

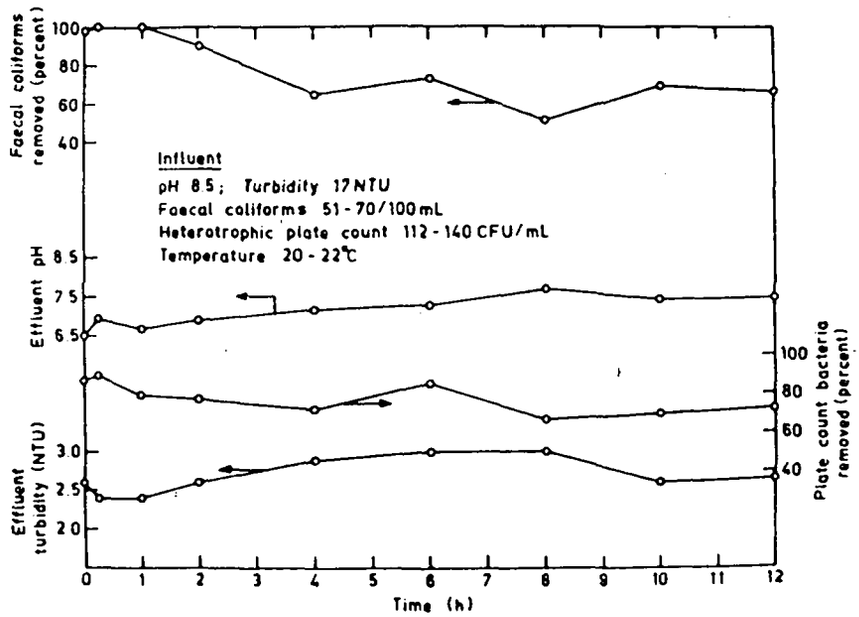

Fig. 2. Alum/Ag-GBC - Ganga water column test

bacteria and turbidity from the river Ganga water is shown in Fig. 1 and 2. Alum-GBC-Ag performed better than Alum/Ag-GBC both in terms of faecal coliform and heterotrophic plate count bacteria removal, presumably because of higher amount of incorporated silver (Table 1). Consequently, Alum-GBC-Ag was employed in further column tests.

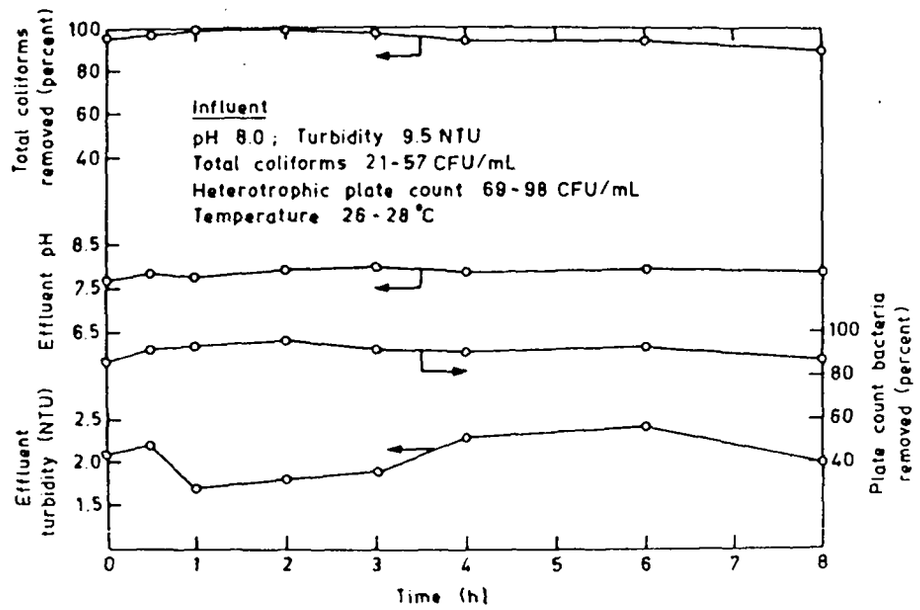

Fig. 3. Alum-GBC-Ag - well water column test

The Alum-GBC-Ag - well water column test was conducted to assess the performance of the medium in removing bacteria and turbidity from a dug well water. High removal of total coliforms (>90%) and heterotrophic plate count bacteria (>88%) was observed in a eight-hour column test (Fig. 3).

Figure 4 shows the effluent characteristics of Alum-GBC-Ag - Ganga water long duration (4-8 days) column tests. Leakage of faecal coliforms observed during the first day in both runs cannot be readily explained. Nevertheless, low faecal coliform levels (0-3/100 mL) were observed in the effluent of both runs following 1½ days which continued up to 4-8 days; however, effluent heterotrophic plate count increased after 4 days in Run 2. The effluent turbidity range was 1.2-3.0 NTU.

CONCLUDING REMARKS

Performance of alum and silver pretreated Giridih bituminous coal in column tests, employing dug well or river water, demonstrated the potential of the medium for water filters for village or small community households in the developing countries. The medium showed high removal of faecal coliforms, total coliforms and heterotrophic plate count bacteria. Effluent turbidity levels were always below 3.0 NTU. It is not usually possible to achieve a zero faecal coliform standard in a water supply which is not chlorinated and any device that can reduce substantial number of coliforms will be a step in the direction of achieving the ultimate goal of "no faecal coliform" in the drinking water.

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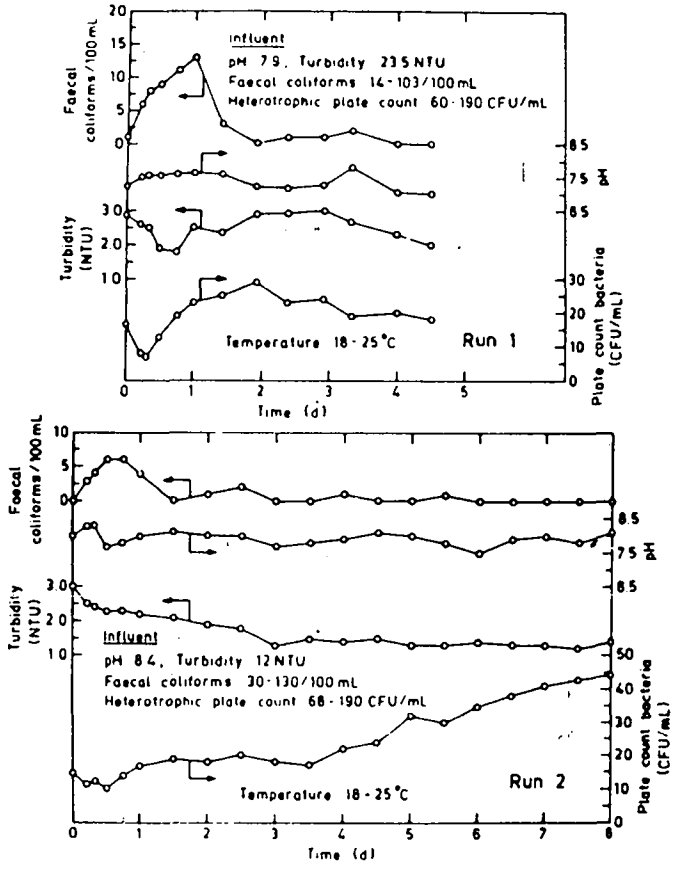

Fig. 4. Effluent characteristics of Alum-GBC-Ag - Ganga water long duration column tests

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