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A STUDY ON IODINATED RESIN SORBENT AS DISINFECTOR FOR RURAL DRINKING WATER SUPPLY

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ABSTRACT

Provision of safe and adequate drinking water to rural community is a Herculian task since majority of the population live in rural areas in India. Realising the need for providing adequate water supply, Govt. of India has set a target to cover hundred percent population both rural and urban, by the year 2010. With the limited financial resources and other constraints, it is of vital importance to develop new appropriate technologies, which are economically viable, scientifically sound, technologically feasible and socially acceptable.

Key words: Iodinated resin, Sorbent, Disinfector, Rural water supply.

INTRODUCTION

It is a process in which pathogenic (disease producing) organisms[1] are destroyed or otherwise inactivated, and that is how it differs from sterilization which involves complete destruction of all micro-organism's including bacteria, amoebic cysts, algae, spores and viruses. In disinfection, all microorganisms are not destroyed, indeed not even all pathogenic microorganisms. As reviewed by Bernarde et al.[2] Madsen, Nyman and Chick proposed mathematical model for the disinfection. As reported by White[3], disinfection of domestic water on a continuous basis using chlorine was first adopted at Middlekerke, Belgium in 1902.

The most significant aspect of this present study is the possibility of developing compact fixed bed disinfector comprising of iodinated resin, which can be low cost, simple and self regulatory device requiring no skilled maintenance and supervision for disinfecting small quantities of water in isolated locations in rural areas. In villages, hand pumps are popular sources of water supply. This water can be disinfected by installing a cartridge of

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iodinated resin in a by-pass incorporated on the delivery side of the hand pump. The available water in the railway compartment is becteriologically not safe. The cartridge may be introduced in the plumbing system in this case.

Iodine as a disinefectant

Among halogens, iodine has the highest atomic weight, the lowest oxidation potential, the lowest water solubility and hydrolyses to the least extent. One of the greatest advantage of iodine as a disinfectant is that it does not react with ammonia or similar nitrogenous compounds making it relatively stable in ordinary water[4]. As against this, it has been found that during chlorination of water some low molecular weight chlorinated hydrocarbons like chloroform, dichloromethane and bromoform were produced. These low molecular weight chlorinated hydrocarbons has been proved to be carcinogenic. Also Black et al.[5,6] have shown that effect of iodinated water on prison inmates that long term use of iodinated water supply is not deleterious to health. In fact, iodine is required as nutrient and in iodine deficiency areas, people take supplementary iodine in the form of iodised salt containing 10 to 15 ppm of iodine[7].

Besides the above advantages, iodination of water is specially suitable in remote rural areas or in developing countries where little or inadequate supervision and expertise are available[8]. It may further be noted that as iodine does not react with organic compounds, it is available for a much longer time as compared to chlorine for protection, against pathogens and does not leave offensive taste and odour as is often the case with chlorine. Kinman and Layton[9] have recommended that the free chlorine present in chlorinated water should be converted first to chloramines and then allowed to react with KI converting the later to I_2, just before water enters the distribution system. Venkobechar[10] suggested that free residual chlorine should be made to react directly with KI than through chloramines to reduce the cost of addition of ammonium sulphate. Unlike chlorine, iodine does not combine with ammonia to form iodamines, rather it oxidises ammonia. Iodine also oxidises phenols rather than combining with them. Thus, less iodine is usually required to obtain a free residual. Another advantage with iodine is that both I_2 and its hydrolysis product, HIO, are equally good disinfectant.

EXPERIMENTAL

Fixed bed disinfectors

A water disinfection process using fixed bed disinfector that releases antibacterial chemical on demand and leaves little or very small detectable concentration in the water is desirable.

Not much work appears to have been done to develop a fixed bed resin charged with chlorine or iodine to disinfect water. The work of Wayman et al.[11], Dewar and Wayman[12] and Taylor et al.[13] can be cited in this connection. The conventional methods of this was agitation in a wrist shaker and then placing it in incubator for incubation maintaining the temperature at 35 ± 2°C.

Preparation of test water

A known volume of water free from disinfectant was taken and required volume of bacterial culture suspensions prepared was added to it. This gave the desired *E. Coli* concentration in the test water. It was then stirred by using high speed stirrer to disperse the bacterial culture homogeneously.

Solid supporting bases used (Sorbent)

The following solid bases were investigated in this study. Resin A (Indian 810) and Resin B (Indian 850) supplied by Ion Exchange India Ltd., Bombay. Resin "A" was a strong base anion exchange resin containing quaternary ammonium group while "B" was a weak base anion exchange resin containing tertiary amine and quaternary ammonium groups.

Determination of strength of stock iodine solution and iodine residuals

The strength of stock iodine solution being more concentrated was determined by using starch iodide mathod[14], while iodine residuals in the treated water was measured by diethyl-p-phenylene diamine sulphate (DPD) ferrous titrimetric method[15].

Disinfection studies using columns containing sorbents loaded with iodine

Different columns having different sorbents (Resin A or B etc.) with different depths loaded with iodine were prepared for disinfection studies. Test water containing bacteria with or without turbidity was passed through the columns. Samples of influent and effluent were collected in sterilized glass bottles each containing 1 mL of 0.1N sodium thiosulphate to neutralize residual iodine in effluents. Enumeration of survivors was done using eosin methylene blue agar according to standard methods (1976). Rate of flow was manually regulated and maintained constant residual iodine measurements were made regularly.

RESULTS AND DISCUSSION

The results are summarized below:

Table 1

Disinfectant	Depth of disinfector (cm.)	Contact time (sec.)	Iodine sorbed per g of sorbent (g)	Total iodine sorbed (g)	Vol. of becteria free water (1 Litres)
Resin A	7.5	25	0.9872	4.9360	79.5
Resin B	7.5	25	0.9330	4.6680	87.0
Methylated Resin A	10.5	35	1.0291	5.1456	150.0
Selected ratio of resin A and B	6.5	21	0.8315	4.1156	67.5

In the present study, the total number of contacts that are possible between the bacterial cell and resin grains were calculated from the equation:

$$N_0 = 1.5\,(n_D + n_I)\,AV_0 n \left(\frac{1-F}{dc}\right) L \qquad \ldots(1)$$

Where,

n_D = $0.9\,(KI/\mu dpdc\ V_0)^{2/3}$, $n_I = 1.5\,(dp/dc)^2$

where, dc = Geometrical mean diameter of resin grain,

V_o = Superficial velocity of flow,

Dp = Equivalent diameter of E. coli,

n = Bacterial number,

L = Depth of resin bed,

k = Boltzmann’s constant,

A = Area of disinfector,

F = Porosity of the resin bed,

n_D and n_I = Dimensionless single collector efficiency due to diffusion and Interception, respectively and

μ = Absolute velocity

The efficiency of diffusion and interception transport mechanism calculated are 8.978 x 10^6 and 2.28 x 10^6 are extremely low. This is because the bacterial diameter is approaching the critical size of 1 According to Yao[14] for this size, none of the transport mechanism is dominant as such the contacts would be minimum. The total number of contacts, N_o, obtained is 17/sec. The low value is due to small size of bacteria (1 g.m) and high loading ratio (1 5 m^3/m^2/hr) on the disinfector. The effective contacts are expected to be still less as the run progresses. However, it is not known, what is the critial minimum number of effective contacts required to inactivate the microorganism. It is felt that the number of contacts itself is low and hence, the contribution of direct contact of *E. coli* cells with the iodinated resin grains towards their inactivation appears to be not very significant. The experimental data show that large volume of water can be disinfected by the disinfector without increasing the contact time. Thus, it is apparent that the major contribution towards becterial inactivation is by the contact of released iodine with microorganism within disinfector. According to Hsu[15] at pH above 8, as is the case in the present investigation, the fraction of hypoiodous acid is much larger than that of elemental iodine, I_2 and the redox potential of HIO being higher that of I_2, it would interact with the vital function of the cell membrane of *E. coli*.

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