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DEVELOPMENT OF APPROPRIATE TECHNOLOGY IN MEETING DRINKING WATER DEMAND OF RURAL INDIA

S BASU and R N PATRA

INTRODUCTION

More than 99% of the Global Water resources are not accessible for direct human consumption, 97% being confined to seas, and over 2% being fixed up in polar regions as ice-caps.

With much of this available water, which constitutes hardly 1% of the Global water, getting contaminated, due to unrestricted outpouring of domestic and industrial effluents, water supply is fast becoming one of the costliest resources to sustain the industrial growth in most of the developed, and developing countries of the World.

In most of the Third World Countries, there are vast regions of arid lands, where there is no source of surface water (in the form of rivers and lakes), and the underground water is highly brackish having salinity level ranging from 3-10,000 ppm as NaCl, and as such not drinkable.

According to the survey conducted by the Central Ground Water Board, Govt. of India, (Annual Report 1974), underground water sources of large coastal and inland rural areas of India, is brackish, and it has been estimated that nearly 20 million people living in nearly twenty thousand villages in different arid regions of the country, are affected by the salinity problems.

The people in these areas either fetch water from long distances, or they have to survive with the saline water. Consumption of water unfit for drinking, on account of bacteria/viruses, or excess salinity, is the biggest health hazard to millions of rural villagers scattered all over the Third World Countries, where non-availability of drinking quality water is the biggest problem.

The World wide awareness for providing clean drinking water, particularly in the developing countries, has led to the eighties being declared by the United Nations Organizations as the International Drinking Water Supply and Sanitation Decade.

The extremely alarming drinking water situation in Third World Countries, faced by more than half of the World population, has been highlighted recently in a moving documentary "Journey for Survival", produced by the UNO.

The primary requirements of drinking water and health care, needed urgently in rural regions of the developing countries, could be approached if an appropriate and cost-effective desalination technology, and community sewage treatment facility were developed, for implementation in mini units, which could be operated without external power supply, as far as possible.

During the last two decades, extensive exploratory research and engineering studies have been carried out in the field of Membrane techniques-Reverse Osmosis (RO), and Electrodialysis (ED), which has resulted in the commercialization of RO/ED as a cost-effective technique, in the desalination of sea/brackish water for potable water (Ref.1-3), and in different chemical industries as an economically attractive separation operation, for concentration of useful products, along with pollution abatement (Ref.4-7).

Considerable amounts of work have been undertaken during the last decade, on the development of low-cost waste treatment processes based on water hyacinth culturing, which offers promise as an economically attrative, and environmentally sound sewage treatment process for implementation in rural areas, for pollution control, along with generation of water for re-utilization, and production of bio-gas and fertilizers, if applied as an integrated project for the development of rural areas, with respect to improvement of the environmental quality, and sanitation. (Ref.8-13).

In our earlier communications (Ref.8-10), applicability of RO/ED, in treatment of industrial effluents, along with reclamation of water/chemicals have been highlighted. In the present work, an attempt has been made to study the feasibility of developing a mini-RO module, and low-cost sewage treatment process, based on culturing of water hyacinth (Eichhornia cressipes), particularly suited to rural arid regions, where eletrical power may not be available.

EXPERIMENTAL WORK

Brackish water with salinity level ranging from 5-10,000 ppm as NaCl, was used as the feed for studies in RO modules, as per the experimental details reported in earlier communications (Ref.8). Three different RO modules-tubular, plate, and spirally wound have been used, to evaluate best performance, with respect to permeate quality, flux stability and permeate recovery.

To study the development of low-cost stabilization lagoons based on water hyacinth culturing, experimental investigations have been carried out in 100 litre capacity earthen pots with sewage effluents contaminated with some industrial effluents from pulp and paper industries with and without water hyacinth.

Percent reduction of pollutants (bio-degradable as well as non-biogradable constituents) were estimated in terms of BOD_5, and COD/PV at different time intervals (ranging from 1 to 30 day's detention time) under varying conditions of feed pH, SS, BOD load, and degree of coverage with water hyacinth.

RESULTS AND DISCUSSIONS

Since it has been decided to develop a hand-operated mini RO module for desalination of brackish water into drinking quality water, attempts have been made to incorporate a turbulence promotion device inside the tubular RO module for the elimination of concentration polarization effect at the membrane interface.

It has been estimated that maximum power output from human efforts is limited to around 100 Watts, giving output capacity of the hand-operated mini-RO module to one litre product water per minute, at RO operational pressure from 30-40 kg/cm^2.

Due to limitations of human power, two types of turbulence promotor, mentioned as (i) tube with flow modifier-I, and (ii) tube with flow modifier-II, were developed and used in this work.

Improvement of water flux rate, and desalination ratio, by turbulence promotions, at different level of feed velocity (expressed in terms of Reynolds No.), is presented in Figures 1 and 2.

As depicted in Figures 1 and 2, flux improvement with flow modifiers was found to be 50 to 80% as compared with RO operation in a bare tube, without turbulence promotion devices.

Similarly, the desalination ratio was improved to the extent of 2.0 to 2.5 times as compared to bare tube RO operation, under similar conditions of feed pressure, and velocity.

Dependence of turbulence promotion on flux and desalination ratio with a high flux low salt rejection cellulosic membrane, is presented in Figures 3 and 4, which gave similar patterns observed with a low flux high salt rejecting cellulosic membrane in Figures 1 and 2.

Further RO experiments were carried out with plate, and spiral wound modules, and comparative studies indicate that equivalent level of flux rate and desalination ratio could be obtained with a spiral module, as found with tubular RO module, with turbulence modifier-II, under similar operational conditions of feed pressure and velocity.

Apart from improvements in permeate flux rate and desalination ratio, the tubular RO module with turbulence promotions, and the spiral wound RO module gave improved performance (measured in terms of concentration polarization modulus) as compared to tubular RO module (without turbulence promotors) and product water quality was found to be within 500 ppm, with feed salinity around 5-6,000 ppm.

Experimental investigations carried out with water hyacinth culturing, with sewage effluents contaminated with pulp and paper mill effluents, furnished the following results:
(i) pronounced enhancement on the reduction of pollutants, biodegradable as well as non-biodegradable, were found with water hyacinth culturing, (ii) under optimal conditions of surface coverage (60 to 75%) with water hyacinth, 50-55% pollutant reduction was observed in three days, which was increased to 80-85% within 14 days, as compared to pollutant reduction of 50% in 9 days and around 60% even after prolonged detention time of over 28 days when waste stabilization was carried out without water hyacinth, (iii) within the surface depth level of 0.3-1.5m, a significant improvement in pollutant reduction is observed in a shallower container in terms of percent reduction of initial level of pollutants, (iv) pollutant removal capacity of water hyacinth per unit quantity of wet hyacinths initially maintained is independent of effluent depth, and remains more or less constant.

CONCLUSIONS

1. Hand-operated mini RO module with tubular (modified with flow modifier) or spiral module offers great promise as a cost-effective and appropriate rural technology for meeting drinking water demand of millions in isolated arid and rural areas.

2. Development of community sewage/waste treatment plant with water hyacinth culturing in stabilization lagoons, offers great potential in rural areas as a low cost appropriate waste treatment technology for the improvement of environmental quality and sanitary conditions.

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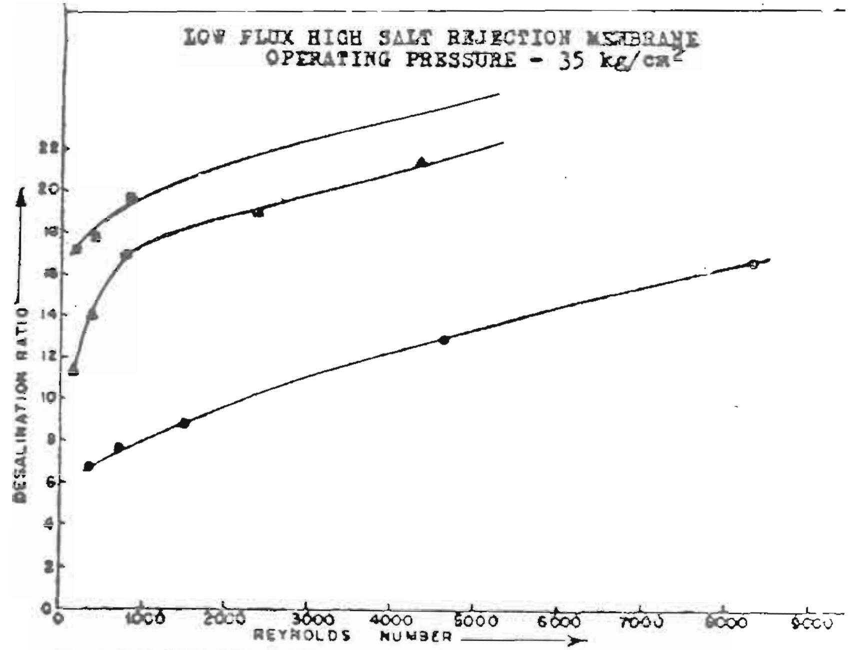

FIG.1 DEPENDENCE OF DESALINATION RATIO ON REYNOLDS NO

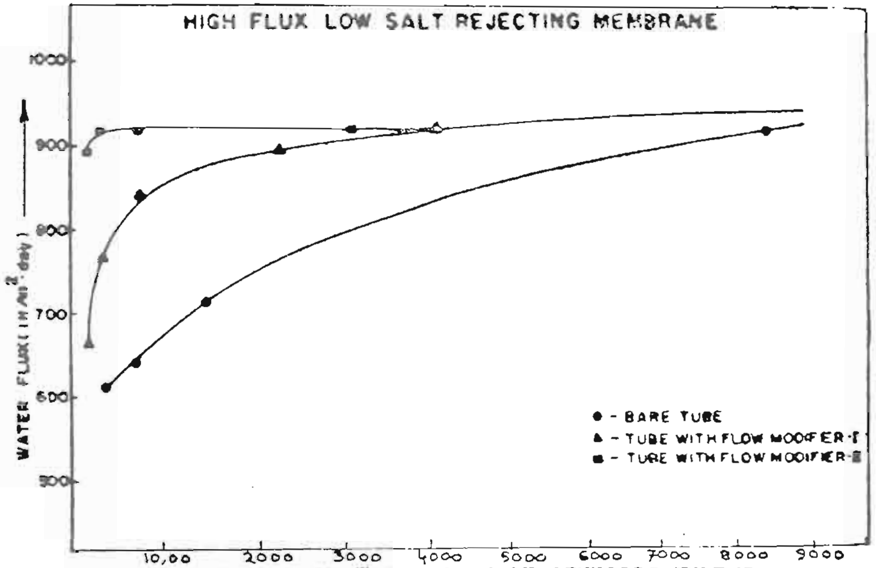

FIG.3 DEPENDENCE OF WATER FLUX ON REYNOLDS NUMBER

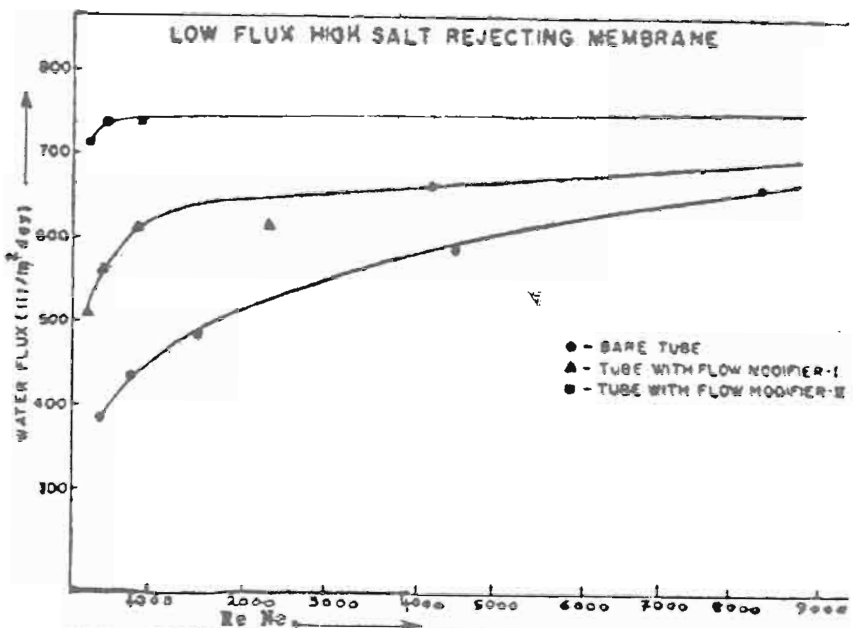

FIG.2 DEPENDENCE OF WATER FLUX ON REYNOLDS NUMBER

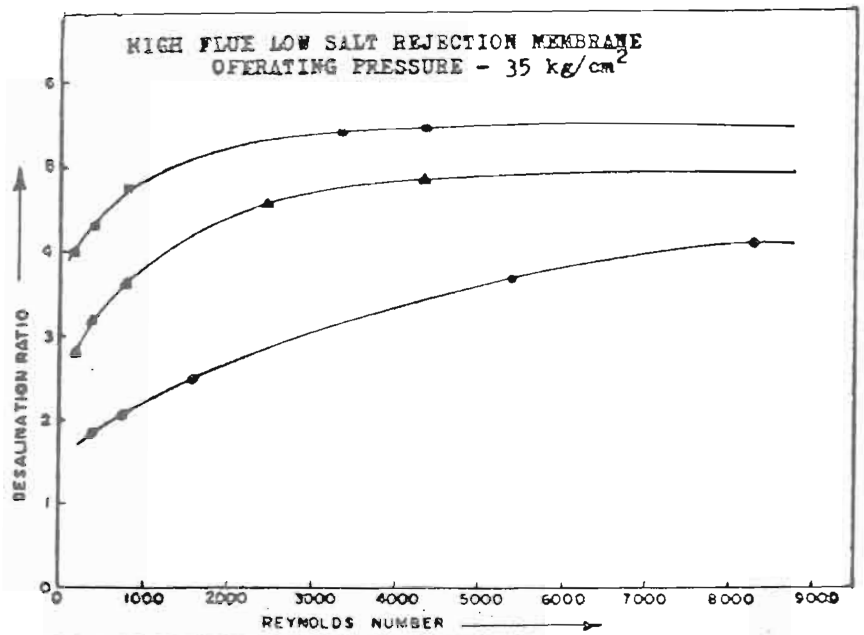

FIG.4 DEPENDENCE OF DESALINATION RATIO ON REYNOLDS NO