Application of Silver Nanoparticles in Drinking Water Purification

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Abstract

The use of nanotechnology for drinking water purification becomes the emerging field around the world. Usually the nanoparticles are synthesized by variety of chemicals which are quite toxic, flammable in nature and their modes of working are unethical for mankind. The extensive application of the AgNP results in their inevitable release into the environment. Silver nanoparticle is known as excellent antimicrobial agents and therefore they could be used as alternative disinfectant agents. It was found that the aggregation of AgNPs depends on the properties of the background ions, such as Na^+ and Ca^{2+} at different water chemistry conditions. The antimicrobial properties of AgNPs when coated with different organic compounds using natural water conditions. The results obtained showed that silver nanoparticles in surface water and ground water are stable.

The composition of AgNPs - impregnated RO-filters and silver- impregnated RO-filters. This study was performed using different water chemistry condition and different manufacturing materials. The results showed that AgNPs- impregnated RO Water filters are more appropriate for this application due to the lesser amount of silver nitrate treated filters.

The bacterial removal performance of the AgNPs-treated RO- Water filters and concentration of viable bacteria in the filters are dose-dependent on the amount of silver applied.

Keywords: Nanoparticles, ground water, antimicrobial

Introduction

Recently the use of microorganisms to synthesized functional nanoparticles drastically increases. A silver nanoparticles (AgNPs) is known for their excellent antimicrobial agents and thus can be used as alternative disinfectant agents, in water treatment systems.

Nearly one billion people worldwide do not have potable water according to the WHO. In current days, considerable interest has arisen in the use of nano-biotechnology for water purification. Particularly the nanoparticles can be used for small scale or point of use systems for water purification such systems should be eco-friendly, cheap, nontoxic, easy to use & distribute and require low energy input.

Our approach uses silver nanoparticles incorporated with RO- membranes to purify drinking water contaminated with pathogenic bacteria. Silver nanoparticles have been incorporated into a range of different concentration. With fine particle sizes silver and some other materials like gold, copper, etc. have been used for centuries to store potable water and their antibacterial properties are well known & explore.

The AgNPs surface area is much finer and greater than the complex metal and is more active biologically as a result. Previously, the applications of silver nanoparticles have been used for water purification, generally to prevent bio-fouling of RO-membrane. We use silver nanoparticles produced by bacillus bacteria in-situ reduction of silver salt solution in NB- media at room temperature.

In our case, we use two types of RO-membrane water filters. i.e. one which is without AgNPs incorporated RO- water filter (Control) and another is with AgNPs incorporated RO- water filter (Test). The primary water purification procedure is not the removal of pathogenic bacteria from the effluent but the deactivation of pathogens through the incorporated AgNPs into the RO- membrane.

Even though a number of experimental studies have been done on microbial removal with silver nanoparticles impregnated with RO-membrane filters. Therefore, this study concentrated on the development of modified water filter with silver nanoparticles and compared their effectiveness in removing microbes from polluted water sources and their physicochemical quality improvement.

Our main intention was to find the alternative technology through the best concentration of silver nanoparticles impregnated with RO-membrane filters, which could completely remove microbes from test water and produce safe potable water for the needy peoples.

Materials & Method

2.1. Silver Nanoparticles

: Currently there is a growing need to develop environmentally benign nanoparticle synthesis process that do not use toxic chemical in the synthesis protocol. Presently, biology provides a rich field for application of nanoparticles synthesis and assembly; with the ultimate aim of improving quality of human life such nanoparticles have a wide range of application, as in drug delivery, bio-pharmaceuticals, food science, fabrics, and in water purification. With this end view, the present research has sought to explore the local biodiversity of the state of Bihar to isolate microbial life form and has successfully exhausted AgNPs and used as antimicrobial agent in the purification of water. This study deals, with more convenient and environment friendly method for the synthesis of AgNPs from silver nitrate with the help of Bacteria.

2.2. R.O- membranes.

The manufacture of high quality RO- membranes filter material will remain important in achieving high performing filters. Silver application improves filter effectiveness, however AgNPs application at lower concentration do not appear to have lasting effectiveness and therefore is not cost effective.

This study was performed using the comparison of AgNPs- impregnated RO membrane filter and silver nitrate impregnated RO membrane filter. The results showed that AgNPs- impregnated RO membrane water filters are more appropriate for this application due to the lesser amount of silver desorbed with silver nitrate treated RO membrane water filter.

2.3. Installation of AgNPs impregnated RO-Water filter systems- Schematic diag.

Installation of RO membrane water filter. Materials required- Movable Iron stand having two column and two rows, Sample container-2 (one for control and one for test), effluent container -2 (one for control and one for test).

Methodology – A movable iron stand of 50 Kg having 2 column and 2 rows was prepared to keep 4-plastic drum of 10 litre capacity. (2- for sample water and 2-for effluent water).

On the upper row of iron stand sample container was placed for keeping waste water connected with RO- membrane then, in lower row, a plastic container was placed. This container is connected with a tap for collecting effluent water. Finally, the installation of RO membrane water filter was set up.

Fig.-The complete setup Design mounted on four columned Movable Iron stand.

2.4. Collection and Analysis of the quality of CONTROL & TEST water samples.

The collection of water samples from river Ganga where the sewage water discharge form the dumping sites situated at Patna.

Materials – Sampling Bottles, P^H- Paper, and measuring cylinder.

Methodology – Water samples were collected from the sites of River Ganga. These samples were mainly collected from the dumping sites. Samples were collected in sampling bottles after one month interval.

The sampling containers of RO membrane filter were placed at upper row filled with sewage water. Analysis of the quality i.e physicochemical and microbiological characteristics has been discussed in results and discussion portion.

Results & Discussion

3.1. Microbiological Quality of CONTROL & TEST water samples.

Table 1. Microbiological Quality-

Water sources	**Targeted microbes**		
	E. coli	S. typhi	V. cholerae
Control	3.20×10^3	1.10×10^3	2.00×10^3
Test	3.00×10^3	1.02×10^3	1.80×10^3

3.2. Physico-chemical & Microbiological Quality of CONTROL & TEST Water samples.

Table 2. Physico-chemical Quality-

Parameters	**Units**	**CONTROL**	**TEST**	**SANS 291**
P^H	_	7.22+-0.12	7.0+-0.12	5-9.5
Turbidity	NTU	1.55+-0.11	0.9+-0.11	< 1
Fluorides	Mg/L	0.45+-0.18	0.4+-0.18	< 1
Nitrates	Mg/L	1.56+-0.02	1.60+-0.02	< 10
Calcium	Mg/L	98.00+-1.10	99.00+-1.10	< 150
Magnesium	Mg/L	25.26+-7.18	26.36+-7.18	< 70
E. Coli	Cfu/100ml	2.50×10^3	1.40×10^3	0

Table 1 shows the initial concentration of E. coli i.e. CONTROL which was 3.20×10^3 Cfu/100ml & the final concentration of E .coli i.e. TEST which was 3.00×10^3 Cfu/ml.

Consequently these water samples also contain S. typhi and V. Cholerae in CONTROL was 1.10×10^3 and 2.00×10^3 Cfu/100ml respectively, and in TEST was 1.02×10^3 & 1.80×10^3 Cfu/100ml respectively.

The **table 2**. Shows the average physic-chemical values of CONTROL water samples were 7.22 for pH, 1.55 NTU for turbidity, 0.45 mg/L for fluorides, 1.56 mg/L for nitrates, 98mg/L for calcium & 25.26 mg/L as Mg respectively. On the other hand, the micro biological quality i.e. the presumptive E. coli (av.cont 2.50×10^3 Cfu/100ml) was present in CONTROL water samples.

Therefore, the TEST water samples were 7 for pH, 0.9 NTU for turbidity, 0.4 mg/L for fluorides, 1.60 mg/L for nitrates, 99 mg/L for calcium & 2.36 mg/L as Mg respectively & the microbes i.e. E.coli amount was 1.40×10^3 Cfu/100ml in TEST water samples. This study illustrated the use of Silver Nanoparticles (AgNPs) impregnated with RO- membrane for possible use in drinking water purification. Using eco-friendly, cost-effective, low energy consumption method.

The physicochemical analysis of the TEST water samples were within the recommended limits. of no risk for drinking i.e. SANS 241[13]. The turbidity level was also within the limit. Turbidity can also protect microbes from the effects of disinfection, stimulate the growth of microbes & increases a

significant disinfection demand. The aim of this study was to determine the concentration of AgNps which would have the most effective antimicrobial property against the E.coli. The results showed that the TEST water filter impregnated with AgNps were able to deactivate E.coli from CONTROL water filter when compared with it. The overall results illustrated a significant higher microbial efficiency with 0.1 mm AgNPs compared to other silver nanoparticles concentration. The particle sizes of silver ranging from 1-100 nm have been reported more effective on the antibacterial properties. The performance of AgNPs filter system namely removing 100% E.coli was also reported by other researchers 15.

A similar filter system i.e. Ag/fibreglass nanoparticles filter system which achieved in the first 10 min. of the filter operation for the purification of drinking water for the removal of E.coli also reported by some researchers 16.

Conclusion:

The collected sample water (Control Unit) was slightly reddish color with foul smell in other hand the AgNPs treated water (Test Unit) was colourless & had no smell i.e. Odourless. The total Hardness was 80 mg/L (Test Unit) in comparison to 230 mg/L (Control Unit).TDS may be high during initial rinsing then lowers, then rises slightly. These all findings indicate that AgNPs are suitable for the application in the filtration of water as well as working as an antimicrobial agent for water quality.

After successful completion of Physico-chemical & Microbial analysis, the findings are shown. During the first few hours of operation, the concentration of AgNPs increases at the surface of the membrane. Concurrently, bacteria in the feed water are detaching to the membrane. It appears that only certain bacteria can attach at this stage & that there are a limited number of attachment sites, about 15% of the membrane. While the concentration of AgNPs increases in the RO membrane the bacterial colony decreases drastically. But the exact mechanism is not known, the reduction in water flux & increase in bacterial colony throughout the life of the membrane element is well known.

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