Bacteria Removal from Water by using Al_2O_3 and FeO Nanoparticles

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ABSTRACT

The world is facing formidable challenges in meeting rising demands of clean water, as the available supplies of fresh water depend on the population and the demands of the users. It is essential for human to have a supply of clean water which is free from toxic chemicals and pathogens. Al_2O_3 and FeO nanoparticles have wide range of applications in electronics, engineering, chemistry, industry and in the biomedical applications. In the present work, Al_2O_3 and FeO nanoparticles are used to check their antibacterial activities in water. It is observed that bacteria can be proficiently killed or removed from water through Nano Al_2O_3 as compared to nano FeO. Moreover, alumina nanoparticles with smaller diameter i.e. 30nm play critical role in bacteria removal from water.

1. INTRODUCTION

Nanotechnology is rapidly being used in various environmental applications. The supply of water may come from lakes, rivers or wells (Subramani et al. 2011). Dealing waste water involves elimination of contaminants so that water can be reused. Internationally the majority of water (70%) is used for agriculture (Pechan et al.2013). This is followed by 20% for industrial use and 10% for domestic use. A number of dynamics increase the demand for water growing populations, urbanization and economic growth. Usage of water has a close relationship to population growth. The availability of clean water has come into view as one of the most serious problems facing by international society in the twenty first century (Schmidt et al. 2007). The biggest invention in water purification industry is to discover reverse osmosis membrane process. The pollution crisis is a major problem around the world that might lead to deaths (Gibbon et al. 2005). At least one billion people worldwide do not have access to clean water according to the World Health Organization (WHO).

Nanotechnology plays a vital role in the water purification by removing contamination from water using several methods and materials at nanoscale (Gleick et al. 1993). Contaminations in water are sand, bacteria, algae, viruses, fungi which are dangerous for health. Some of the metals i.e. arsenic, copper, chromium, lead and nitrates are also very harmful to the human body due to water soluble property (Diallo et al. 2008). The pollution is caused by pathogens usually a natural thing. Most

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microbiological organisms are not harmful but some of them are not good for health and may cause serious health issues like bacteria -, viruses-, protozoa-based diseases (Csuros et al. 1999). Water can be purified by boiling, sunlight exposure, chlorination, flocculation and filtration–straining, Three-Pot treatment, distillation, Ion exchange, carbon adsorption, Micro porous basic filtration, reverse osmosis and ultraviolet radiation etc. (Thornton et al. 2002).

Nano sized iron oxide due to its natural magnetic properties, microstructure, surface area, surface charge and low toxicity make its biologically compatible. Nano sized iron oxide can be used in many applications like it is used as catalytic material, water treatment material, pigments, gas sensors, ion exchangers, magnetic data storage devices, toners and inks and in biomedical applications. Iron oxide black pigment is widely used in construction materials, paints, coatings, magnetic recording materials and other fields.

Alumina is one of the most extensive elements in earth (Teo et al. 2014). Nano alumina is white in colour and it can be prepared with different methods like sol gel etc. It is present in two phases α-Al_2O_3 and γ-Al_2O_3. Nano sized Al_2O_3 can be used in many applications i.e. as catalytic, water treatment, jewel, analytical reagents, reinforcing agent, ceramics and in artificial rubber production (Hosseini et al. 2012). Nano sized alumina containing materials are also used in industrial, medical products and in energetic systems to replace lead primers in artillery, etc. For example, alumina nanoparticles are used in explosive combinations (Dankovich et al. 2014).

In the present study FeO and Al_2O_3 nanoparticles have been used to remove bacteria from water. FeO and Al_2O_3 nanoparticles were synthesized using sol-gel method. Anti-bacterial study of these nanoparticles for different water samples has been correlated with shape and size of nanoparticles.

2. EXPERIMENTAL DETAILS

Pre-synthesized FeO and Al_2O_3 nanoparticles, using sol-gel method, were used to study antibacterial study of water. Detailed synthesis of nanoparticles has been reported earlier (Kayani et al. 2014, Riaz et al. 2014a, Riaz et al. 2014b, Riaz et al. 2014c). Water samples for bacteria detection were taken from different places in Lahore, Pakistan. Water samples were stored at 5^oC to control the bacterial growth. Initial pH was measured by the pH meter and bacteria were detected by staining method. For antibacterial activities, water samples were taken in petri dish and cultured on blood and mac Conkey agar (Figs. 1 and 2). Samples were placed in incubator for one night at 37^oC.

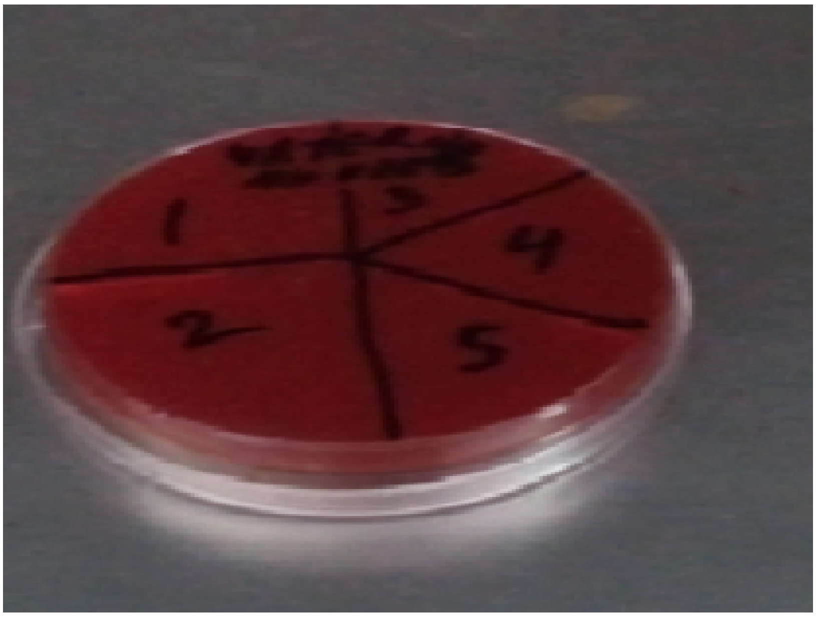

Fig. 1 Different water samples cultured on Blood agar

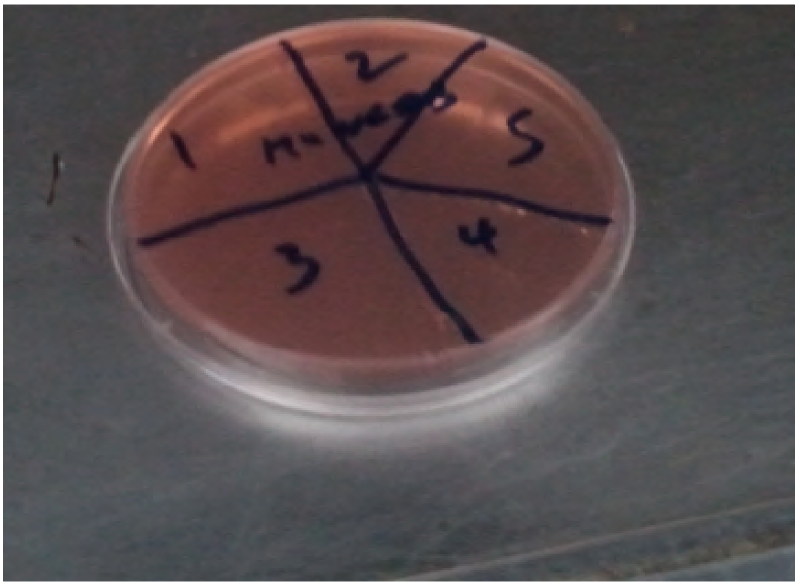

Fig. 2 Different water samples cultured on mac conkey agar

5 portion in Figs. 1 and 2 represent 5 water samples taken from different areas.

3. RESULTS AND DISCUSSION

It was seen, after taking the samples out of incubator that there was a visible growth of bacterial colonies as shown in Figs. 3 and 4. However, there was no indication of any bacteria in sample number 5 that was taken from a department that is actively involved in water treatment.

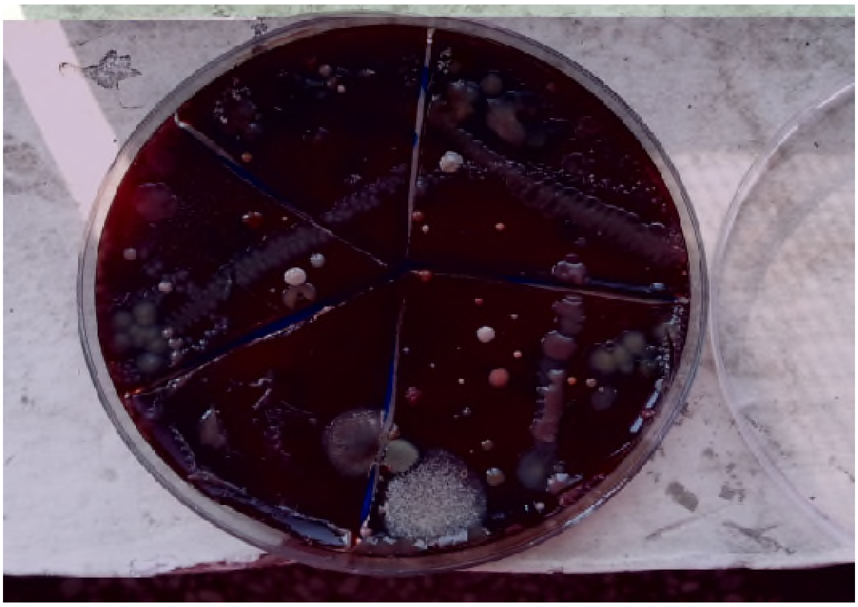

Fig. 3 Colonies of bacteria on blood agar

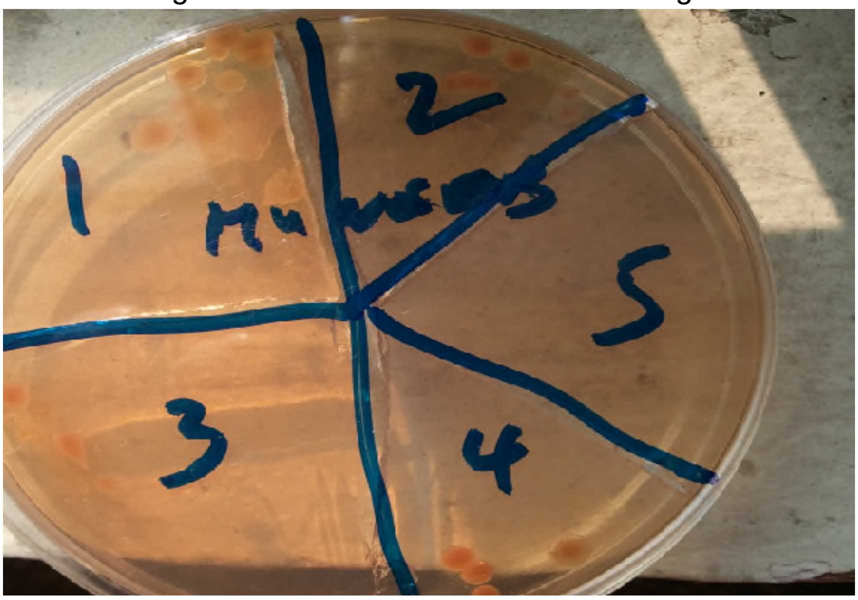

Fig. 4 Colonies of bacteria on mac conkey agar

Results of these samples of water without treatment are shown in Table 1. First 4 water samples were selected for nanoparticles based treatment since there was no indication of bacteria in the last sample.

Table 1: Conditions of different water samples chosen for this study and their bacteria type

No of samples	Kind of water	pH	Bacteria type
1	Canal	6	Gram negative, pseudomonas
2	Well	8	Gram negative, enterobacter
3	Fountain	9	Gram negative, pseudomonas
4	Centre of Excellence in Solid State Physics (CSSP), PU	8	Gram negative, enterobacter
5	MMG Dept., PU	7	No microorganisms

Cultured water samples, in the presence of nano alumina (50nm diameter), on blood and mac conkey agar are shown in Figs. 5 and 6. These cultured samples show the presence of gram negative bacteria, pseudomonas, in the canal water only (Sample 1A) whereas rest of the samples showed no bacterial growth at all.

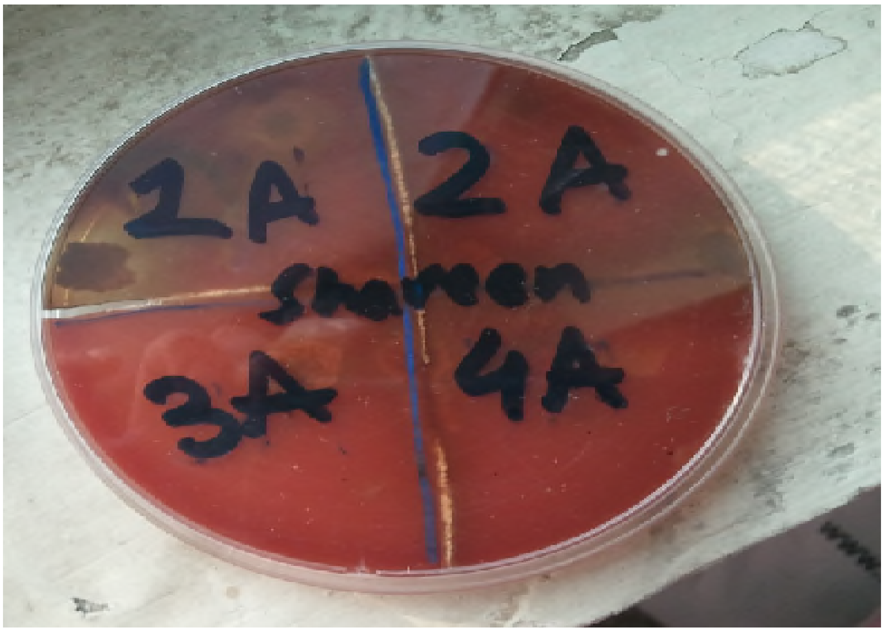

Fig. 5 Bacterial colonies on blood agar treated with 50 nm diameter nano alumina

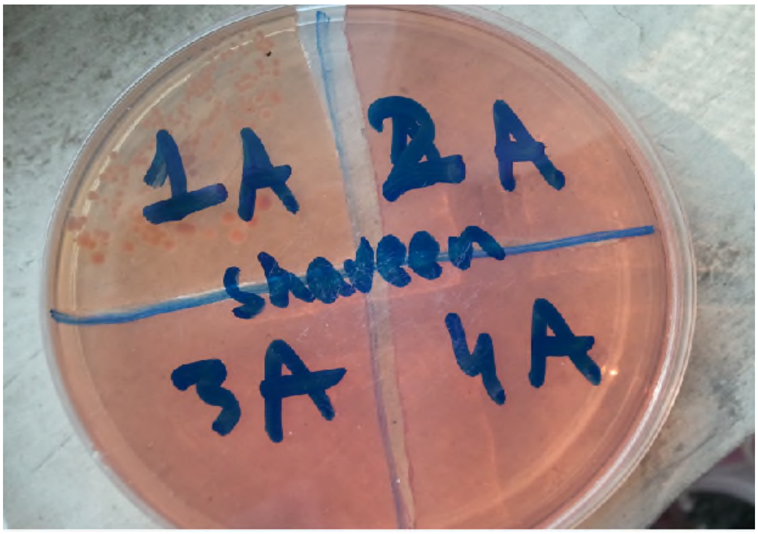

Fig. 6 Bacterial colonies on mac conkey agar treated with 50nm diameter nano alumina

Results of different samples of water after treatment with alumina nanoparticles are shown in table 2.

Table 2: Growth condition of bacteria in water after nano Al_2O_3 treatment

No of samples	**Kind of water**	**pH**	**Bacteria Type**	**Treatment Results**
1	Canal	6	Gram negative, pseudomonas	Moderate growth
2	Well	8	Gram negative, enterobacter	No growth
3	Fountain	9	Gram negative, pseudomonas	No growth
4	CSSP	8	Gram negative, enterobacter	No growth

Water samples were also treated using alumina nanoparticles of smaller diameter i.e. 30nm and results are shown in Figs. 7 & 8.

Fig. 7 Growth of bacterial colonies on blood agar cultured samples treated with 30nm diameter alumina nanoparticles

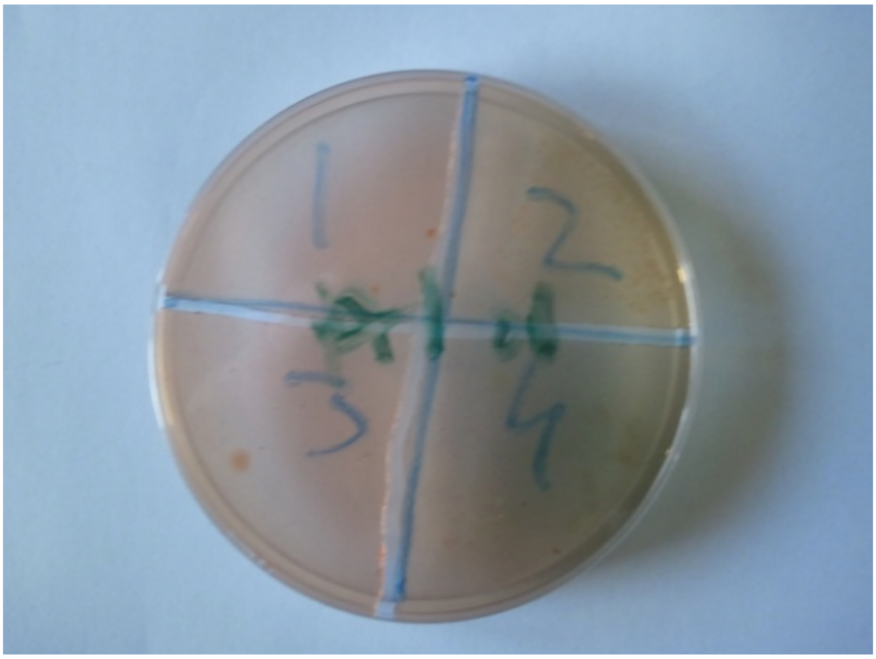

Fig. 8 Growth of bacterial colonies on mac conkey cultured samples treated with 30nm diameter alumina nanoparticles

These results after treatment with 30nm alumina nanoparticles are summarized in Table 3.

Table 3: Growth of bacteria in water after 30nm Al_2O_3 nanoparticles

No of samples	Kind of water	pH	Bacteria Type	Treatment Results
1	Canal	6	Gram negative, pseudomonas	Perfused growth
2	Well	8	Gram negative, enterobacter	No growth
3	Fountain	9	Gram negative, pseudomonas	No growth
4	CSSP	8	Gram negative, enterobacter	No growth

Cultured water samples, in the presence of nano iron oxide (50nm diameter) on blood and mac conkey agar are shown in Figs. 9 and 10.

Fig. 9 Bacterial colonies on blood agar treated with 50 nm diameter nano iron oxide

Fig. 10 Bacterial colonies on mac conkey agar treated with 50 nm diameter nano iron oxide

The results of different samples of water after treatment with 50nm diameter iron oxide nanoparticles are shown in Table 4.

Table 4: Growth condition of bacteria in water after nano FeO (50nm) treatment

No of samples	**Kind of water**	**pH**	**Bacteria Type**	**Treatment Results**
1	Canal	6	Gram negative, pseudomonas	Moderate growth
2	Well	8	Gram negative, enterobacter	Moderate growth
3	Fountain	9	Gram negative, pseudomonas	Moderate growth
4	CSSP	8	Gram negative, enterobacter	Moderate growth

These cultured samples showed the presence of gram negative bacterias, pseudomonas and Enterobacter in all cases.

Water samples were also treated using iron oxide nanoparticles with smaller diameter i.e. 30nm and the results are shown in Figs. 11 and 12.

Fig. 11 Bacterial colonies on blood agar treated with 30 nm diameter nano iron oxide

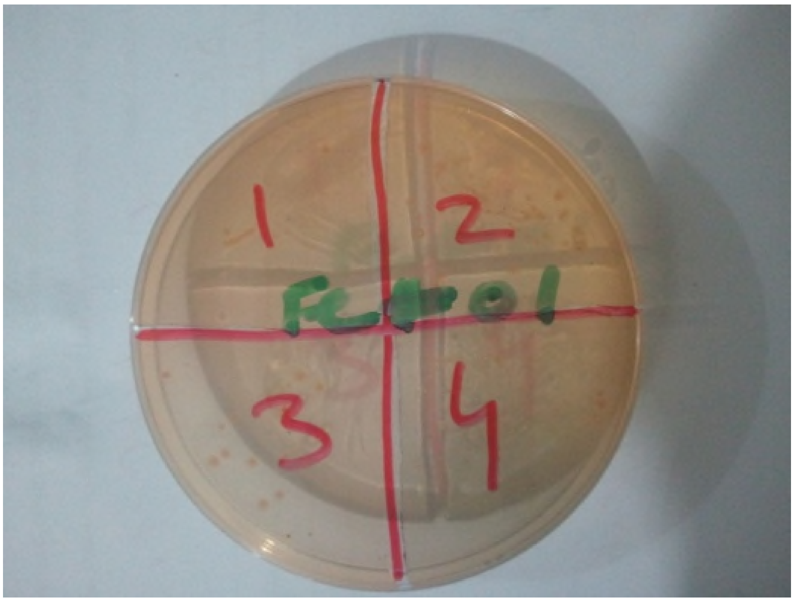

Fig. 12 Bacterial colonies on mac conkey agar treated with 30 nm diameter nano iron oxide

Once again, all results of water treatment with 30nm iron oxide nanoparticles are given in Table 5.

Table 5: Growth condition of bacteria in water after 30nm nano FeO treatment

No of samples	**Kind of water**	**pH**	**Bacteria Type**	**Treatment Results**
1	Canal	6	Gram negative, pseudomonas	Moderate growth
2	Well	8	Gram negative, enterobacter	Moderate growth
3	Fountain	9	Gram negative, pseudomonas	Moderate growth
4	CSSP, PU	8	Gram negative, enterobacter	Perfused growth

Moderate growth of bacteria was observed for all water samples. However, perfused bacterial growth was observed for the water sample took from CSSP, PU.

4. CONCLUSIONS

Various nanoparticles of alumina and iron oxide were used for antibacterial studies of water from around the COE in SSP. Nanoparticles of 30nm and 50nm diameter were used for this study. It was observed that alumina nanoparticles with 30nm diameter killed more gram negative bacteria as compared to iron oxide nanoparticles. Alumina nanoparticles were observed to have more effect on pseudomonas and Enterobacter bacteria. Such cleaning method is inexpensive as compared to the other methods which have been used previously.

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