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Cost-Effective with Silver Alloys in Water

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The aim of this study is to determine the effect of Silver and electrical current in preventing the growth of bacteria in drinking water to keep water safe. Silver in the form of thin discs was immersed in drinking water samples at various intervals; 2, 4 and 8 days at room temperature (20 ±2 ° C). The total number of bacteria isolates in water samples were significantly reduced with time. Furthermore, no bacteria were isolated when we used electrical current with silver, however, the result of Plasma atomic emission spectrometer(PAES) analysis showed that the concentration of Ag^+ ions which may be released with treatment is between 0.001- 0.0001 μg/ml. Thus, the treatment of drinking water with silver discs is confirmed to be effective in realizing both its antibacterial and bioactive properties.

Keywords: Alloys, Drinking water, Bacteria, Silver, plasma Atomic emission spectroscopy.

Water is a transparent liquid and it is the main component of liquid substances in all living organisms. Chemically, water molecule consists of three atoms: two atoms of hydrogen and one oxygen atom (H_2O) linked together with a covalent force. Obtaining a pure source of drinking water has been a very important craving since the emergence of civilization and throughout history. In recent decades, cases of the scarcity of fresh water were recorded in many parts of the world. According to a recent United Nations report, an estimated one billion people on Earth still lack the means to access a safe source of drinking water, and about 2.5 billion people lack access to adequate means of water purification. There are several methods used to purify water, include physical processes such as filtration, sedimentation, and distillation; biological processes such as slow sand filters or biologically active carbon; chemical processes such as flocculation and chlorination and the use of electromagnetic radiation such as ultraviolet light. However, these methods are effective for getting rid of some strains of bacteria and organisms like algae. The use of chlorine in water purification has been one of the most widely used methods until it was found to have a certain health effect, thereby reducing the use of chlorine in the purification of water.

Sewage and industrial waste are one of the most common sources of polluted water, however, to purify such heavily polluted water, it is important to consider an alternative method of purification, And one of such method is the use of silver, silver has the most effective antibacterial action and the least toxic to animal cells [1]. Silver became commonly used in medical treatments. There are different forms of silver which proved to be effective in microbial inhibition; silver salt, silver zeolite and silver nanoparticles.

The wide acceptance of silver as antimicrobial agents is as a result of the physiochemical properties silver[2], confirmed this in their studies when they used Silver nanoparticle-coated substrates as an antibacterial agent in their water purification system and at the end of the setup, no bacterium was detected in the water. On another side[3], reported a reduction in pathogenic

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bacteria such as *E. coli* and *Staphylococcus aureus* when they used electric current on the composite membranes in water purification.

In this study, it is intended to find the extent to which silver alloys could remove bacteria present in contaminated water by simply immersing them at various time.

MATERIALS AND METHODS

Water samples were collected from different location of drinking water sources and kept in sterile plastic flasks at 4°C until use. An electrical source consisting of 1.5 volts power supply, silver alloys with a small hole punctured at the top edge and copper wire fitted into the holes in order to hang the alloys partially in the water except the part of holes and cooper wire .

Isolation

1ml from the sample was added to 99ml of sterile distilled water and stirred gently for two mins then we get 10-1 distilled and serially diluted until 10-6 was obtained and finally spread on nutrient agar medium, inoculated at (28-37)°C for 24-48hr.

Bacterial colonies with morphological characteristics were isolated and sub cultured for further purification. Finally, uncontaminated cultures were sub cultured on nutrient agar starts and reserved at 4°C for further analysis [4].

Oligodynamic activity of silver

One of silver metal disc form having a thickness of 0.5mm and diameter 3mm of 99.5% pure silver was put into a conical flask having 100ml of sample of water and left for specific time intervals of 2,4,8 days at room temperature ($20\pm$ 1°C).And the mesurment of metal in water by Plasma atomic emission spectrometer(PAES) .

Electrical Source

Direct current (DC) electrical stimulation was provided by a 9 v power supply for specific time intervals of 5,15 and 30 min.

RESULTS

(Table1) shows the count of bacteria study before and after use of the silver alloys in water test. Results showed a decrease in count of bacteria among 8 samples of tested water except for sample No: 4, which did not have any isolator. The decrease in bacterial count reached a zero point after 8 days in the samples when the silver was used with sample No: 2,3,4,5,6, and 7, whereas samples 1 and 8 still had isolates of bacteria decrease from 24,105.33,55 and 10 after the use of silver within 2,4 and 8 days for sample No: 1 and from 230 to 108,23 and 3 for sample No:8. The table showed that the stimulation with electric and silver reduced the mean of bacteria isolates after a short period of 15 min. In all samples except 3 samples: 6,7 and 8, no bacteria were found for any isolators after 30 min, whereas 7 isolators of bacteria were found in sample No:8.

DISCUSSION

The study showed that the presence of silver alloy in water has the ability to inhibit bacterial growth. It also showed that to conduct 9 volts electrical current through silver also prevented the growth of bacteria in water. The antimicrobial properties of silver have been known to cultures all around the world for many centuries. Silver has the most effective antibacterial action and the least toxicity to animal cells [1]. The effect of silver in this experiment may be due to the ionized form [5].

Silver in its non-ionized form is inert, but contact with moisture leads to the release of silver ions [6]. Thus, silver ions (Ag^+) come from ionizing the surface of a solid piece of silver as with silver nanoparticles. [7], Proposed that Ag^+ enters the cell and intercalates between the purine and pyrimidine base pairs disrupting the hydrogen bonding between the two anti-parallels and denaturing the DNA molecule. While In Switzerland, [8], found that copper/silver ionization was not effective at reducing Legionella in their hospital hot water system (90% of water samples were positive for Legionella).

Before treatment, water samples were 93% positive to bacterial isolates. After the introduction of ionization, when the silver alloys conduct with electrical current through the water samples, the number of isolated bacteria became zero after 15, 30 mins, and thus, due to the role of electrical current in releasing silver ions Ag^+ into the water . However, the Plasma atomic emission spectrometer report showed little or traces of Ag^+ in water sample, it was ranged between

Table 1. The count and kind of Bacteria in water samples befor and after treatment with Silver and Electric and incubation .

No. of Samples	No. of bacteria isolates	Number of Bacteria isolates after use Silver 2 Dayes	4 Dayes	8 Dayes	No. of Bacteria isolates with Silver and electric 5 min.	15 min.	30 min.	No. of bacteria after incubation for 1 day
1	*204 Sphingomonas paucimobilis*	*105.33 Sphingomonas paucimobilis*	*55 Sphingomonas paucimobilis*	*10 Sphingomonas paucimobilis*	*7.67 Sphingomonas paucimobilis*	0.00	0.00	0.00
2	*2.33 Ochrobactrum anthropi*	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	*0.33 Acinetobacter lwoffii*	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	*126 Sphingomonas paucimobilis 32 Ochrobactrum anthropi*	*151 Sphingomonas paucimobilis*	*9 Sphingomonas paucimobilis*	*0.00*	*6.67 Sphingomonas paucimobilis*	0.00	0.00	0.00
6	*72 Acinetobacter lwoffii*	*32 Acinetobacter lwoffii*	*0.00*	*0.00*	*26.33 Acinetobacter lwoffii*	*6 Acinetobacter lwoffii*	*0.00*	*Delftia acidovorans*
7	*203 Sphingomonas paucimobilis*	*139 Sphingomonas paucimobilis*	*35 Sphingomonas paucimobilis*	*0.00*	*8.33 Sphingomonas paucimobilis*	*1 Sphingomonas paucimobilis*	*0.00*	*Sphingomonas paucimobilis*
8	*76.67 Rhodococcus sp 94.67 Acinetobacter lwoffii 58.33 Sphingomonas paucimobilis*	*67.67 Sphingomonas paucimobilis 38.33 Acinetobacter lwoffii*	*23 Sphingomonas paucimobilis*	*3 Sphingomonas paucimobilis*	*79.67 Sphingomonas paucimobilis*	*13 Sphingomonas paucimobilis*	*7 Sphingomonas paucimobilis*	0.00

Table 2. Statistic analytic for samples of water after and before treatment with Silver and Electric and incubation

Samples of water	Before treatment	Silver only			Silver and electric			After incubation for one day
		2 days	4 days	8 days	5 min	15 min	30 min	
1	204 ± 2.6	105.33 ± 5.81	55 ± 3.53	10 ± 0.33	7.67 ± 2.028	0 ± 0	0 ± 0	0 ± 0
2	2.33 ± 0.333	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0
3	0.33 ± 0.33	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0
4	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0
5	212 ± 0.33	151 ± 14.29	9 ± 0.88	0 ± 0	6.67 ± 1.2	0 ± 0	0 ± 0	0 ± 0
6	72 ± 4.62	32 ± 3.61	0 ± 0	0 ± 0	26.33 ± 4.91	6 ± 0.33	0 ± 0	0 ± 0
7	203 ± 25.44	139 ± 5.2	35 ± 7.86	0 ± 0	8.33 ± 0.33	1 ± 0.33	0 ± 0	0 ± 0
8	230 ± 5.84	108 ± 0.33	23 ± 4.04	3 ± 1.45	79.67 ± 7.26	13 ± 1.5	7 ± 1	0 ± 0
sig *	1.81	1.014	1	4.02	0	0	0	0

mean ± standard error significant at 0.05*

0.001- 0.0001 μg/ml of silver in water (table 3), which does not exceed the limit of silver in the Human body (0.1 mg/L) [EPA (United States Environmental Protection Agency), secondary standards 2017]. While that Ag^+ ions in the blood below 54.6 ppb could be considered as non-toxic in humans, this allows us to use silver alloys in water as an antibacterial agent and to reduce the cost of chemical use in water purification [9]. And that silver ions were generated electrolytically was seen after 20 minutes at a relatively low silver concentration (20ìg/l) [10]. also at the effectiveness of silver disinfection as part of rainwater harvesting treatment the ionizers reduced the level of total coliforms and *E. coli* by approximately 0.4 log and resulted in a silver concentration of approximately 0.01mg/l in the final water [11].(Table 2)showed the significant results and authors suggested the use of alloys in water to prevent growth of microorganisms.

Research on drinking water disinfection systems has shown that silver can be used successfully to control bacterial growth. It has also been found that the addition of copper and silver to water systems may allow the concentration of free chlorine to be reduced while still providing comparable sanitary quality of the water

CONCLUSION

Recent studies have revealed that the antimicrobial properties of silver are due to its ionized form, Ag^+, and its ability to cause damage to cells by interacting with thiol-containing proteins and DNA. With the ever increasing number of

Table 3. Detection of metal ions in Drinking water(μg/ml)

Samples	Concentration of Some minerals in drinking water				
	Si	S	Hf	Cu	Ag
1	4.32	10.87	3.931	1.755	0.0001
2	3.815	12.17	4.38	2.001	0.0001
3	7.249	-	-	2.038	0.0001
4	4.508	12.189	-	1.799	0.0001
5	8.66	-	-	13.33	-
6	7.44	-	-	2.363	0.0001
7	4.265	10.64	4.33	1.51	0.001
8	7.23	-	-	2.02	-

antibiotic-resistant strains of bacteria and silver's low toxicity to humans, the use of silver as an antimicrobial agent is an exciting topic with a great deal of relevance to many fields of study , industry and household filter.

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