University of Thi-Qar Journal of Science (UTJsci)
E-ISSN: 2709-0256, P-ISSN: 1991-8690, Vol. 12 , No. 1 , Jun. 2025

Evaluation the efficiency of paper and clay filters loaded with nano-silver in removing water pollutants

Sabah Ali Khaduir*[1a]

[1] *Ministry of Education\General Directorate of Education\Diyala.*

[a] E-mail: sciphydr222307@uodiyala.edu.iq

[a*]Corresponding author: Sabah Ali Khaduir

Received:2024-10-06 , Revised:2024-11-03,Accepted: 2025-01-27, Published:2025-06-15

***Abstract*— To obtain pure water free from pollutants that are harmful to humans, Nano silver was placed on circular paper filters and clay filters to filter polluted water through these filters. Clay filters are manufactured by drying the clay filter at a temperature of 200 ^{0}C and then burning it at a temperature of 1000 ^{0}C. Also, another clay filter was taken and burned at a temperature of 1000 ^{0}C. This filter was broken breaks after filtration due to the sudden rise in temperature. If the drying and thermal gradation of the clay filter is completed, the filter becomes better and stronger than the plasticized filter. Also, a circular membrane paper was taken and a layer was removed from it, and we also took filter paper, all in a circular shape. Filtration is done by a filtration device. We noticed that the removal rate of paper filters ranges between (45% to 87%) due to the speed of emptying the polluted water and allowing some pollutants to pass through them. As for clay filters, the removal efficiency are not less than 95% and the water passage is slow and did not allow pollutants to pass through them.**

***Keywords*—paper filter, red mud, filters, purification, nano silver, TDS, PPM .**

I. INTRODUCTION

Given the special importance of water in our life., imposed by the necessary human need and the water being free of chemicals and microorganisms in quantities that lead to riskpublic health, therefore, the water prepared for drinking must be free of all substances that cause these risks, and this water must be palatable by being free of turbidity, color, odor and unacceptable taste. Based on the multiplicity and diversity of water sources in the country and the impact that has on the quality of water prepared in each region, these specifications were established to determine the proportions and quantities of permitted materials in addition to methods of examining and analyzing this water to determine these materials to determine the extent to which the prepared water conforms to the limited requirements [1] . Nanotechnology is a word used to represent a wide range of topics that involve the management of matter and its new properties at the atomic and molecular level, and in the coming decades, nanotechnology has the potential to transform every aspect of existence. Nanotechnology has become when the dimensions of matter are reduced to in the nanoscale, it develops new physical and chemical properties that differ significantly from those of the same material in larger (bulk) quantities. This is what distinguishes nanoparticles and makes them a new scientific marvel in constant improvement. Nanomaterial's are unique in their small size and suitability for medical applications in delivering drugs to specific tissues, and nanoparticles of cell walls [2]. Silver nanoparticles (AgNPs) are among the metals that have been widely studied due to their unique physical and chemical properties. They have found application in areas such as water and air purification devices, imaging, textiles, sensors, energy sector, antibacterial products, and anticancer agents. AgNPs have strong optical absorption attributed to the in-band quantum excitation of conduction electrons which makes them good candidates for technological applications. For example, in surface enhanced resonance and Raman scattering for optical biosensors and photocatalysis. AgNPs can be synthesized and silver nanoparticles loaded onto MMA/HEMA copolymer to demonstrate the effectiveness of nanoparticles in supporting the properties of paper. Cellulose acetate membrane (CAM) was used as a support for silver nanoparticles (AgNPs) in mineralization of pesticides in water. Silver nanoparticles were used on a highly porous cellulose acetate fibrous membrane for treating dye wastewater [3]. Clay is one of the oldest materials were used by humans. Clay is formed naturally and is spread across three continents of the world. The most important countries are the United States of America in the Montana region, in four continents of Asia specifically, in China. The third country is in Africa in the state of Niger in the Tahoe region and Algeria in many five regions such as the state of Constantine, the Mila region in the Neogene basin, and the state of El Oued, the Wadi Righ region in Sidi Amran, the two regions of Bri Nuba and Sidi Rashid in the municipality of Sidi Amran, the university district. Clay is characterized by its distinctive structure and contains many different minerals, which give them many properties and make them as a raw material in many different industries and is used in many other fields such as water purification and pottery formation [4].

Ceramics industry is one of the arts that have accompanied man throughout his life. This research aims to obtain a solid

https://doi.org/10.32792/utq/utjsci/v12i1.1307

ceramic body with porosity by adding organic materials. The ceramic surface is concentrated with porous treatments and sets fibrous boundaries to obtain a texture for the ceramic surface, by adding materials to improve the ceramic's porosity for water filtration [5] .

Water is the only substance that is used in industry in such large quantities that its consumption exceeds the consumption of all other substances by weight and volume.

We need tons of water to make one ton of steel, and tons to make one ton of paper. Turbidity, color, taste, odor, manganese, iron and bacteria content are very obvious in water. Hardness to the degree of ppm = 70 and bicarbonate is unacceptable in this case. It is preferable that the hardness of bicarbonate in water is less than 70 ppm. If water is used for several purposes according to the type of treatment [6].

Pollution is one of the major problems facing humans and the environment, especially after the technological development accompanying modern life. Pollution occurs in its various forms, whether it is air, water or soil pollution, as a result of the presence of some harmful organic and inorganic materials, or due to an increase or decrease in the proportions of some basic components in the environment from their natural proportions . This occurs as a result of human interventions or as a result of some natural phenomena. Water pollution is considered one of the most important pollution problems, given the major role water plays in daily life [7] .

To identify the different types of pollutants of industrial wastewater resulting from pollution of production units of industrial waste and petrochemicals, methods, techniques, levels, and traditional treatment techniques, successful models and studies based on industrial wastewater treatment processes The techniques of complete water recycling has recently become common with the developments obtained environmental and economic pollution. The importance of treating and reusing industrial wastewater Therefore, the obtained information and data will help those interested in Arab countries to preserve the available water resources and preserve the environment [8].

II. Experimental part

The nano silver was purchased from Bab Al-Moatham, Iraq – Baghdad. After verifying and examining it with necessary tests , they were added to the filters paper and take another type of paper, The membrane paper was cut into a circular shape, with removing a layer of membrane from the membrane paper . We took it all and add some additions to it. Red clay with low pores , diyala - Al-Bawia factories, was shaped into a circular shape , nano silver was added to the clay filters, burned and dried at a temperature of 200 ^{0}C - 1000 ^{0}C . The first filter is manufactured and burned at a temperature of 200 ^{0}C , then gradually burned to 1000 ^{0}C in the oven . The second filter was formed and burned directly at a temperature of 1000 ^{0}C . Then, we compared the results between them, then put the filters in the filtration device (Fakhner) and filtered them. Before that , pollute the water with fecal coliform bacteria and filter the water in the filtration device to compare the results.

Fig. (1) **:** A picture of the free clay from which we formed the clay filters .

Fig. (2) : A picture of paper and clay filters used to filter water contaminated with E. coli bacteria .

Fig. (3) **:** The filter device (Fakhner) used to filter polluted water.

III. Results and Discussion

A- X-ray diffraction results (XRD)

Figure (4), shows the results of the appearance of four main picots of nano silver at angles (37, 45, 65 and 77) and the appearance of intensity significantly. The figure confirms that nano silver at this intensity at four angles [9].

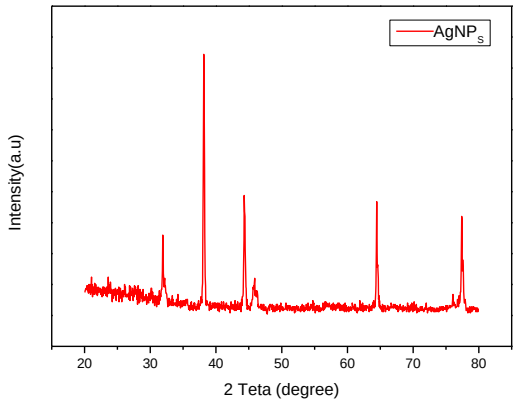

Fig. (4) **:** X-ray diffraction pattern of silver nanoparticles and the clear appearance of silver picates for purchased ready-made silver .

B- Infrared spectrum results

Figure (5**),** shows the presence of four distinct bands in the infrared spectrum of the prepared sample, where a strong absorption peak was detected at (3209 cm^{-1}--- 3600 cm^{-1}) due to the vibrations of the hydroxyl group (O-H) [10]. silver nanoparticles are present in bonds less than 1cm-0001. The spectra shows absorption bands that clearly indicate that the silver particles have oxidation on the surface, i.e. the strong hydroxyl group (O-H) [11].

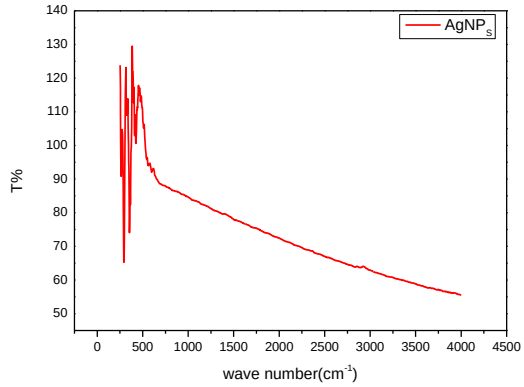

Fig. (5): FTIR spectra of the prepared silver nanoparticles.

C-UV-Visible Results

- Optical Properties Results
- Absorption

Nanoparticles Figure (6), shows the location surface Plasmon peak (SPR) of the of silver particles at about (520 nm) and the absorption (0.386) produced by the nanoparticles which can be attributed to the absorption due to the transition between the bands in the silver particles. Interbank absorption can occur at shorter wavelengths in noble metals due to the transition of the electron in the conduction band above the Fermi level [12]. It has been shown that the peak intensity increases in solutions containing nanoparticles with surfactants compared to deionized water, and this indicates an increase in the efficiency of producing silver nano particles [13] . However, in other solutions we see a decrease in the peak intensity due to the aggregation and clumping of the nanoparticles , which increases their weight and leads to their sinking towards the bottom of the solution, where the peak surface plasmon peak (SPR) eventually disappears [14,15] .

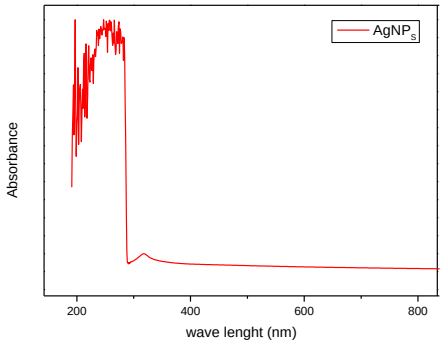

Fig. (6) **:** UV and visible absorption spectra of silver nanoparticles.

The absorption spectrum of silver nanoparticles solution shows a surface plasmon peak at (400 nm), indicating that the prepared nanoparticles are almost spherical in shape [16].

D- Biological application for inhibition of E. coli (E coli ATCC 25922) bacteria in contaminated water before filtration

N anoparticle's are highly sensitive to cells in biofilms and are highly sensitive to bacteria due to their small sizes, which complicates the treatment of bacterial diseases. Therefore, inhibiting the morphological change and development of biofilms can reduce the virulence of these microbes and promote the elimination of infection. Silver nanoparticles have shown their antimicrobial effects through membrane damage, resulting from the adhesion of silver nanoparticles to the cell surface, causing structural and functional changes in the membrane (pore formation and cytoplasmic leakage). This activity is associated with the release of Ag^{+2} ions from the surface of the nanoparticles, which stimulates the formation of reactive oxygen species (ROS) that causes significant damage to essential molecules (proteins, (DNA) DEOXYRIBONUCLEIC ACID, and structural lipids), in addition to the Ag^{+2} ions attached to the external microbial surfaces, preventing the adhesion of microbial cells to the host cells, or the Ag^{+2} ions disrupt the microenvironment of these pathogens, causing the collapse of the cell and cell wall, and preventing the activity of enzymes important for colonization. [17].

E- Study the effect of Nano silver added to different paper filters and clay filters on the vitality of bacteria (E. coli ATCC 25922)

Plate casting method was followed to study the effect of prepared silver nanoparticles loaded on filter papers with different manufacturing specifications to study their effects on the viability of the E. coli ATCC 25922 isolate, through the steps shown below:

- Activate bacterial cells by culturing them in brain infusion broth medium for 24 hours at 37 °C with continuous shaking.

- Adjust the number of cells in the bacterial suspension to ($1x10^8$) cells/ml.

- Pass the water containing the bacterial cells through filter papers with different manufacturing specifications.

- Take one milliliter of treated water (filter) and mix it with 25 ml of the liquid medium and leave it to solidify at room temperature, then put it in the incubator for 24 h at 37 ^{0}C and then.

- After 24 hours, we removed the dishes containing the bacterial growth from the incubator and count the bacterial colonies.

- Calculate the inhibition percentage based on the following equation:

Inhibition percentage = number of test colonies / number of control colonies 100%

The filter paper filters quickly while clay filters filter slowly, so filtration and purification were better than other filters.

The filters that were prepared with a graduated temperature are more efficient. The filter is strong and similar to clay filter and does not break and highly efficient, while the clay filter that raises the temperature from zero ^{0}C to 1000 ^{0}C is effective but breaks [18]. Different types of manufactured filters are as shown in table (1).

TABLE (1): FILTER PAPERS USED IN FILTERING WATER CONTAMINATED WITH E. COLI BACTERIA.

#	Description of Filters Filtration
1	Factory filter paper without any additives
2	Factory filter paper containing silver particles
3	Laboratory filter paper without any additives
4	Laboratory filter paper containing silver particles
5	Pottery clay without additives fired at 1000°C
6	Pottery clay fired at 1000°C + silver
7	Filter paper without layer
8	Filter paper without middle layer + silver particles

The filtration process was done in pure water first, then putting the pollutants in the water second and purifying it from them. We noted that the rate of removing the bacteria placed is (99.99 %) in the clay filters due to the low porosity. the lack of rapid water penetration, the retention of bacteria, with long filtration period that reaches 8 hours, and thus the resulting water is pure, clear, and free of pathogenic bacteria. As for paper filters, the removal rate is (34%) and the removal rate is (45%) and this rate is due to the speed of filtration through the filters. The best filter in paper filters is the filter from which the membrane paper layer was removed, and the removal rate in this filter is high, although the filtration speed also reaches (99.99 %) and the water is free of pathogenic pollutants [19] . As shown in table (2).

TABLE (2): SHOWS THE RESULTS OF THE FILTRATION FILTERS AND SHOWS THE NUMBER OF BACTERIA AND THEIR REMOVAL RATE.

Removal rate (%)	*Number of bacteria*	*Types of filters*
0.0	$1x10^8$	0.0
45	$55x10^6$	1
69	$31x10^6$	2
34	$6.6x10^7$	3
87	$1.3x10^7$	4
99.92	$8x10^4$	5
99.9976	$24x10^2$	6
99.9	$1x10^6$	7
95	$5x10^6$	8

TABLE (3): SHOWS THE RESULTS OF THE WATER PRODUCED FROM THE FILTER PAPERS MEASURED BY A DISSOLVED SOLIDS METER.

Water output number	*ppm*	*EC MS\Cm*	*^{0}C*	*^{0}F*
0	2	4	35.3	96.8
1	227	451	34.4	94.2
2	370	336	34.0	93.5
3	812	606	36.2	97.3
4	583	168	35.8	96.8
5	35	65	35.4	96.0
6	25	48	33.5	92.8
7	168	185	35.2	95.3
8	40	77	35.0	95.1

The ppm salts are low in clay filters only, while in the other filters the ppm salts passing through are greater than others, and this is what we conclude from table (3).

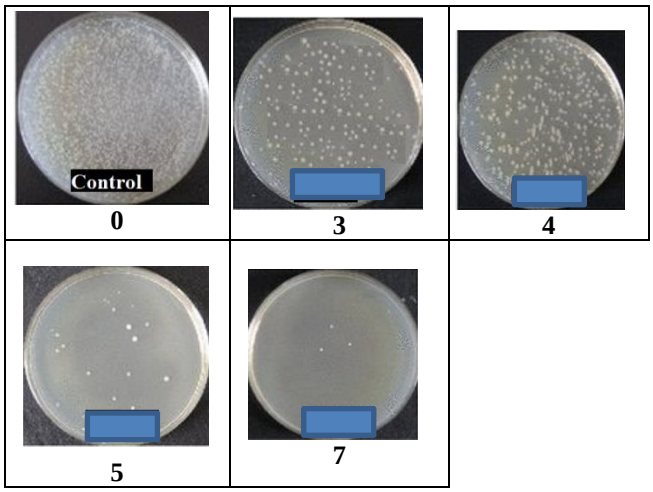

Fig. (7) **:** Number of Escherichia coli ATCC 25922 colonies exposed to different filters and different filtration conditions for some filters from the table.

Different sizes of silver,different preparation methods and silver nitrate were uses. More, the amount of reducing materials increases, and thus the rapid decrease in the rate of Ag^+ to Ag^- leads to the phenomenon of agglomeration between the particles, The smaller the size of silver, the less it agglomerates and its effectiveness is greater on the filters, especially on E. coli bacteria, the presence of which means the presence of other pollutants [20]. Figure (7) picture shows the number of bacteria removed by some filters.

IV. CONCLUSION

The Paper filters removed less bacteria as more water passes through them, the less efficient they are. Clay filters removed bacteria more but the less water passes through, and this is considered a defect in the clay filter. Clay filters

are better in filtration and purification with the presence of silver because it increases the salts necessary for the body and acts as an antibacterial for the bacteria in the water. Also, the defect of clay filters is the longer filtration period that makes the passing water pure and clear and free of bacterial pollutants, including E. coli. Therefore, we will place the filter layers on top of each other to increase the filtration period and increase their efficiencies.

ACKNOWLEDGMENT

I thank the Ministry of Science and Technology for giving me the opportunity to conduct the necessary tests for the research and I extend my thanks to the University of Technology, Nano Department, for conducting biological tests on the purification filters to remove bacteria.

CONFLICT OF INTEREST

Author declares that he has no conflict of interest.

REFERENCES

[1] M . Pal , Y. Ayele , A. Hadush , S. Panigrahi and V. Jadhav " Public Health Hazards Due to Unsafe Drinking " Water " *Air & Water Borne Diseases " DOI: 10.4172/2167-7719.1000138* , 2018 .

[2] Z. Abadi , M Sajjadi , S . Sajjadi, M . Nasrallahzadeh, " Chapter1-Introduction to Nanotechnology"*Interface Science and Technology*, Volume 28, , Pages 1-27 Elsevier https ://doi.org/10.1016/B978-0-12-813586-0.00001-8 , 2019 .

[3] M. Nkosi , J. Sackey, A. Fell, J.B. Ngilirabanga, L. ahandry , S. Ntwampe, "Antibacterial effect of silver nanoparticle synthesis on polycarbonate membrane" *Materials Today: Proceedings ,36, 336-342* , 2021.

[4] S. Abdullah "Preparation of nanoparticles (Au, Ag, Ti and Cu) by pulsed laser ablation in liquid (PLAL) technology for medical applications " *PhD thesis, Physics* , 2022 .

[5]R . Srinivasan "Advances in Application of Natural Clay and Its Composites in Removal of Biological, Organic, and Inorganic Contaminants from Drinking Water " *Hindawi Publishing Corporation Advances in Materials Science and Engineering Volume 2011, Article ID 872531, 17 pages doi:10.1155/2011/872531*, 2011.

[6] M . Awaleh , Y . Soubaneh "Waste Water Treatment in Chemical Industries " The Concept and Current Technologies " *Awaleh and Soubaneh, Hydrol Current Res,http://dx.doi.org/10.4172/2157-7587.1000164*,2014

[7] D . Briggs " Environmental pollution and the global burden of disease " *David Briggs BMJ, Volume 68, Issue 1, Pages 1-24, https://doi.org/10.1093/bmb/ldg019* , 2003 .

[8] S. Kato, Y. Kansha " A comprehensive review of industrial wastewater treatment technologies" *Environment al Science and Pollution Research* , Vol. 31, pp . 51064–51097, https://doi.org/10.1007/s11356-024-34584-0 , 2024 .

[9] I. Hassan , "Characterizations of Metals and Metal Oxides Nanoparticles using Laser Ablation for Biological Applications" *Msc. Thesis, University Wasit, Iraq* , 2018 .

[10] D. Dorranian , E. Solati and L. Dejam " Photo lumine scence of ZnO Nanoparticles Generated by Laser Ablation in Deionized Water " *Applied Physics A, Materiales Science and Processing, Vol. 109 , pp. 307-314* , 2012.

[11] M. Tajdidzadeh, B. Azmi, W. Yunus, Z.. Talib, A. Sadrolhosseini, K. Karimzadeh, S. Gene and M. Dorraj, " Synthesis of Silver Nanoparticles Dispersed in Various Aqueous Media Using Laser Ablation" *The Scientific World Journal, Vol.10, , pp. 1-11*, 2014 .

[12]G. Messina, " In Liquid Laser Processes for Nanoparticles Synthesis and Manipulation*" Università degli Studi di Catania, Dottorato di Ricerca, in Scienza dei Materiali ,XXV Ciclo*, 2012 .

[13] T. Tsuji, D. Thang, Y. Okazaki, M. Nakanishi, Y. Tsuboi and M. Tsuji, " Preparation of Silver Nanoparticles by Laser Ablation in Polyvinylpyrrolidone Solution " *Applied Surface Science, Vol. 254 , pp. 5224-5230 , https://doi.org/10.1016/j.apsusc.2008.02.048*, 2008.

[14] J. Xiao, P. Liu, C. X. Wang and G. W. Yang, " External FieldAssisted Laser Ablation in Liquid: An Efficient Strategy for Nanocrystal Synthesis and Nanostructure Assembly " *Progress in Materials Science, Vol. 87, pp. 140-220 , https: //doi .org/ 10.1016/j. pmat sci. 2017 .02.004*, 2017 .

[15]S. Barcikowski, A .Manjon and B. Chichkov, " Generation of nanoparticle colloids by picosecond and femtosecond laser ablations in liquid flow " *Applied Physics Letters, Volume 91, Issue 8, 20 August* , 2007.

[16] X. Zheng , W. Xu, , ,S. Xu , J. An, Bing Zhao and J. Lombardi " Laser-Induced Growth of Mon disperse Silver Nanoparticles with Tunable Surface Plasmon Resonance Properties and a Wavelength Self-Limiting Effect *" J. Phys. Chem. C - 111, 14962-14967, https :// doi. Org /10. 1063 /1. 2773 937* , 2007.

[17] A. Dantas , K. Lee, I. Raziunaite, K. Schaefer, J. Wagener, B. Ya dav and A. Gow, " *Cell Biology of Candida Albicans – Host Interactions", Current Opinion in Microbiology " Vol. 34 , pp.111-118 , DOI: 10. 101 6/j. mib . 2016.08.006* , 2016.

[18] M. . El-Ghandour " Study of the formation of a ceramic filter from Egyptian clays for purifying drinking water "*Article15,Volume,DOI: 10.21608/mbse.2016.139292, Issue 43, July, Page 349-386* , 2016 .

[19] N . Jabr Al-Fatlawi " Isolation and diagnosis of some types of bacteria causing respiratory tract infections and evaluation of their inhibition efficiency using nano-prepared antibiotics Azithromycin and Ciprofloxacin *" College of Science / Department of Life Sciences - University of Karbala, Thesis submitted* , 2021.

[20] S. Hassoun , M. Awadhi, A ,Hamdani , I. Azzawi , A. Ali " *Enhancement of the antimicrobial activity of imipenem in combination with silver nanoparticles against S " fonticola and Pantoea sp. 11(2): pp-200-214* , 2019