Journal of Al Azhar University-Gaza *(Natural Sciences)*, **2021, 23** : **17-38**

Post Treatment of Secondary Wastewater Effluent by Magnesium Oxide Nanoparticles

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Received 24/3/2021 *Accepted* 30/9/2021

Background: Wastewater is one of the world's most serious issues today. Not only does it have an impact on the environment and human health, but it also has an impact on economic and societal expenses. Nanostructured materials have the potential to be used in wastewater treatment.

Objective: Application of nanostructured materials such as the Magnesium Oxide (MgO) nanoparticles to treat wastewater effluent.

Materials and Methods: The MgO nanoparticles were synthesized via co-precipitation methods. Microbiological quality for both raw and treated secondary wastewater effluent was estimated by a viable cell count. Bacteria were isolated from secondary wastewater samples by conventional methods to determine the minimum inhibitory concentration (MIC). Moreover, some of the chemical and physical parameters for raw and filtrated secondary wastewater samples were measured according to standard methods.

Results: The MgO nanoparticles have antimicrobial activity against: Gram-positive bacteria *Staphylococcus aureus* at 7 mg/ml, Gram-negative bacteria *Escherichia coli* at 6 mg/ml, *Klebsiella* sp. at 9

mg/ml, *Salmonella* sp. at 10 mg/ml, and *Shigella* sp. at 8 mg/ml. The chemical and physical parameters such as (COD, BOD, NH_4^+ and Mg^{+2}) were decreased significantly during the filtration process of MgO nanostructured powder compared with raw wastewater,
P-value = 0.044.

Conclusion: Magnesium oxide nanoparticles have a tangible bactericidal effect on wastewater bacteria.

Keywords: wastewater treatment, MgO nanoparticles, antimicrobial, minimum inhibitory concentration (MIC).

1. Introduction

Water is one of the most abundant natural resources on the planet, yet only approximately 1% of it is available for human use. **(Adeleye et al., 2016)**. The contaminants of wastewater are released with the rapid industrialization of social activities, including heavy metal ions, organics, bacteria, viruses, etc. These are seriously harmful to human health and the environment **(Wang et al., 2012)**. Nanostructure materials are the smallest structures between one to less than 100 nm **(Sulekha, 2016)**. Nanoparticles have very high absorbing, interacting, and reacting capabilities due to their small size with a high proportion of atoms at the surface **(Pranjali et al., 2013)**. Nanotechnology has a large potential in improving water and wastewater treatment as it offers potential advantages like low cost, reuse, and high quality in removing and recovering pollutants **(Dave & Sharma, 2015)**. Magnesium oxide (MgO) has a salt/sodium chloride (NaCl) type cubic structure, and MgO is being used in catalysis, antibacterial materials, industrial paints, and superconductor products **(Singh et al., 2016)**. The MgO nanostructure is a functional material with a good bactericidal effects in aqueous environments due to the formation of superoxide (O^{-2}) anions on its surface**.** Also, the high pH in this thin surface water layer could damage cell membrane, resulting in cell death **(Sawai et al., 1997)(Yamamoto et al., 2010)**. This study investigates the effectiveness of nanostructured material such as MgO nanoparticles in the treatment of wastewater effluent.

2. Material and methods

2.1 Sample collection: Secondary-treated wastewater was collected from the North Gaza emergency sewage treatment (NGEST) plant, Gaza Strip, Palestine, using sterile bottles. The samples were transported to the microbiology laboratory at the Biology department, Faculty of Science, Al Azhar University- Gaza.

2.2 Synthesis of MgO nanoparticles

A typical synthesis of MgO nanoparticles, wherein 20 mmol. of magnesium acetate tetrahydrate, $Mg(CH_3COO)_2·4H_2O$ was dissolved into 25 mL deionized water. 20 mmol. of oxalic acid was dissolved in an equal volume of deionized water and added drop_wise to magnesium acetate solution under magnetic stirring for 60 min. A white precipitate of magnesium oxalate was isolated, washed with water several times, and dried at 100 ˚C for 24 h. The dried material was grounded using mortar and pestle to produce a fine powder precursor. Subsequently, the precursor, magnesium oxalate, was annealed in a muffle furnace under air at 600 ˚C for four hours to form MgO nanoparticles.

2.3 Characterization of MgO nanoparticles

The X-ray diffraction (XRD) patterns of the dried as-prepared and classified samples were obtained using an X-ray diffract meter with Cu Ka radiation (0.154 nm wavelength) under 40 kV and 200 mA. The TEM analysis was done with AG-EVO 60 Carl Zeiss scanning microscopy. The EDX spectrum was done by the energy dispersive X-ray spectrometer (National Research Center, Egypt).

2.4 Microbiological analyses

The total numbers of bacteria and fungi in the secondary treated wastewater sample were estimated by a viable cell count method **(Tomasiewicz et al., 1980)**. Whereas nutrient agar (for detection of bacteria), Salmonella Shigella agar (HiMedia,India) (for detection of *salmonella & Shigella* spp.), MacConkey agar (HiMedia,India) (for detection of *E. coli, Klebsiella* sp.), Mannitol salt agar (HiMedia,India) (for *S. aureus*), M-endo agar (HiMedia,India) (for detection of total coliform) and Potato dextrose agar (HiMedia,India) (for detection of fungi). All plates were incubated at 37°C for 24 hours, while fungi at 25°C for 3-5 days.

2.5 Bacterial isolation and identification from a secondary treated wastewater sample

According to the conventional microbiological methods, the bacteria were isolated from secondary treated wastewater samples **(APHA, 1998)**. The bacteria were also identified according to a standard microbiological method, including morphological (gram staining), culture via selective media of bacteria, and physiological characteristics via biochemical tests such as catalase, coagulase, and triple sugar iron agar test (TSIA), and citrate utilization test.

2.6 Determination of the minimum inhibitory concentration (MIC) of the MgO nanoparticles against different isolated bacteria

Ten microliters of bacteria suspension of *S. aureus*, *E. coli*, *Klebsiella* sp., *Salmonella* sp. and *Shigella* sp. were compared with McFarland standard no. 0.5 and inoculated into eight test tubes contain 500 μL of nutrient broth media in the presence of different amounts of MgO nanoparticles (3mg, 4mg, 5mg, 6mg, 7mg, 8mg, 9mg, 10mg). All test tubes were incubated at 37°C for 16-24 hours **(Wiegand et al., 2008)**. After that, the number of bacteria was estimated by a viable cell count method **(Tomasiewicz et al., 1980).**

2.7 Using Magnesium oxide (MgO) nanoparticles as a filter

Every 50 ml and 100 ml of secondary treated wastewater were filtered by Buchner funnel through different amounts of (MgO) nanoparticles (10 mg, 20 mg, 30 mg, 40 mg, 50 mg, 60 mg, 70 mg, and 80 mg) between two filter paper. The contact time and the total number of bacteria were estimated for filtered samples by stopwatch and a viable cell count method. After that, the optimum conditions about contact time and the total number of bacteria were used to determine microbial, chemical, and physical parameters of treated (filtrated) wastewater **(Ullmann et al.,2019)**.

2.8 Determination of the microbial, chemical, and physical parameters

The microbial analyses of secondary treated wastewater through 50 mg of (MgO) nanoparticles samples were estimated via a viable cell count **(Tomasiewicz et al., 1980)**. In addition, chemical oxygen demand (COD) and BOD parameters were analyzed by using standard methods. The pH of samples was measured by pH meter (Hanna Instruments Company, USA). The electric conductivity (EC) of the sample was measured by the EC meter (Hanna Instruments Company, USA). The total dissolved solids (TDS) of the sample was measured by evaporation 105°C. The SO_4 of the sample was measured by turbidity meter. The Cl^-, Ca^{+2}, Mg^{+2}, and hardness of the sample were measured by the titration method. The nitrate (NO_3^-), phosphate (PO_4^{-3}), and ammonia (NH_4^+) of the sample were measured by UV/Visible spectrophotometer. The sodium (Na) and potassium (K) of the sample were measured by a flame photometer. Average values of three replicates were taken for each determination **(Iram et al., 2013)**.

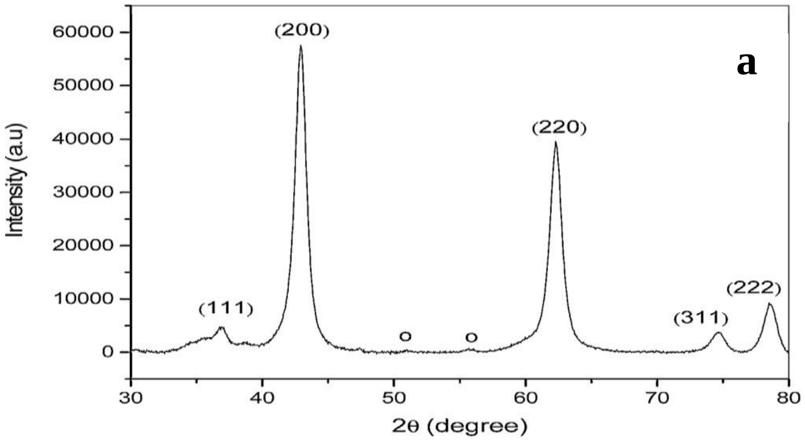
2.9 Using Magnesium oxide (MgO) nanoparticles as a filter by different diameters to measure COD test

Each 3 ml of secondary wastewater was filtered through filters have different area diameters (syringes 3ml, 5ml, 10ml) that contains 3mg of MgO nanoparticles between two micro filter papers to measure the COD test. After that, the optimum contact time and optimum diameters were selected according two conditions, the first condition is pressure onto syringes, while second condition without the pressure onto syringes during the filtration process.

3. Results

3.1 Synthesis and characterization of MgO nanoparticles

The synthesis of MgO nanoparticles was synthesized as fine powder precursor, the precursor; Magnesium oxalate was annealed in a muffle furnace under air at 600 ◦C for four h to form MgO nanoparticles. Besides, the characterization of MgO nanoparticles was evaluated by XRD analysis, Transmission electron microscopy (TEM image), and Energy-dispersive X-ray spectroscopy (EDX spectra**)**



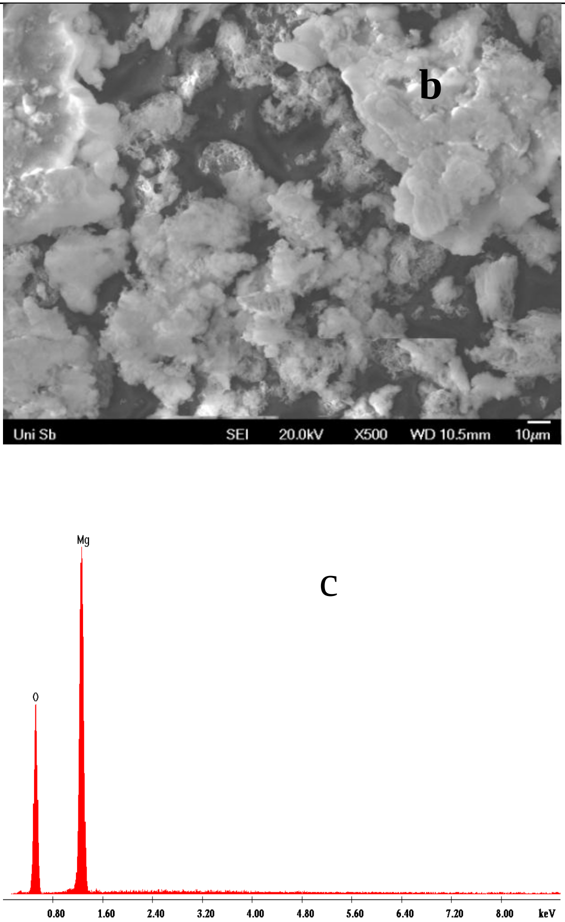


Fig. (1) :Structural characterization of MgO nanoparticles: (a) XRD pattern, (b) TEM image and (c) EDX spectra.

The XRD pattern of the synthesized MgO is shown in (Fig. 1a). The diffraction pattern matched with the face-centered cubic structure of periclase MgO (JCPDS No. 87-0653). The major peaks at 2Θ values of 36.8◦, 42.9◦, 62.2◦, 74.6◦, and 78.6◦ can be indexed to the lattice planes of (1 1 1), (2 0 0), (2 2 0), (3 1 1), and (2 2 2) respectively. From the XRD pattern, the small peaks at $2\Theta = 56$◦ and 50.5◦ (designated by o) correspond to the peaks of $Mg(OH)_2$. It means only a negligible fraction of smaller $Mg(OH)_2$ particles present on the surface of MgO nanocrystallite, which does not significantly contribute to MgO particles' solubility in water. The crystallite size is determined using Scherrer's formula. The calculated crystallite size of MgO is 8.2 nm. The morphology of MgO nanoparticles was studied by TEM analysis. The MgO nanocrystals are porous, as shown in (Fig. 1 b). Here, nanocrystals are closely seen as grouping together and forming layers. The EDX spectrum (Fig. 1c) indicated that the nanoparticles were composed of elemental Mg and O, and it was found that the nanoparticles contain 54.6% magnesium and 45.4% oxygen. The Mg/O atomic ratio, approximated from these data, is in good agreement with the bulk ratio. A slightly lower oxygen atomic ratio than magnesium is probably high oxygen vacancies in the MgO nanoparticles.

3.2 Microbiological analyses

Available cell count estimated the microbial count of secondary treated wastewater. Moreover, the bacterial number 16×10^6 (CFU/ml), fungi 14×10^3(CFU/ml), total coliform 86×10^4(CFU/ml), lactose fermenter on MacConkey 70×10^4(CFU/ml) and non-lactose fermenter on MacConkey60×10^4(CFU/ml). In addition, detection of *Shigella* spp. and *Salmonella* spp. .

3.3 Bacterial isolation and identification from a secondary treated wastewater sample

The bacteria of secondary treated wastewater samples were isolated according to conventional microbiological methods. The bacteria were also identified according to the standard microbiological techniques, including morphological, cultural, and physiological characteristics**.** The results were investigated five strains of bacteria, including *(E. coli, Klebsiella* sp.*, S. aureus, Salmonella* sp.*,* and *Shigella* sp.).

3.4 Determination of the minimum inhibitory concentration (MIC) of MgO nanoparticles against different isolated bacteria

The MIC of MgO nanoparticles against *E. coli* was 6 mg/ml of MgO nanoparticles. The statistical test showed a statistically significant between the amount of MgO nanoparticles and the number of *E.coli*

(*P*-value =0.007). It indicated a linear relationship at low concentrations and a strong negative association, R = - 0.822.

The MIC of MgO nanoparticles against *Klebsiella* sp. was 9 mg/ml of MgO nanostructured powder. The statistical test showed statistically significant between the amount of MgO nanoparticles and the number of *Klebsiella* sp. (*P*-value =0.005). It indicated a linear relationship at low concentrations and a strong negative association, R = -0.832.

The MIC of MgO nanoparticles against S. *aureus* was found to be 7 mg/ml of MgO nanoparticles. The statistical test showed statistically significant between the amount of MgO nanostructured powder and the number of S. *aureus* (*P*-value =0.003). It indicated a linear relationship at low concentrations and a strong negative association, R = - 0.866.

The MIC of MgO nanoparticles against *Salmonella* sp. was found to be 10 mg/ml of MgO nanoparticles. The statistical test showed a statistically significant between the amount of MgO nanoparticles and the number of *Salmonella* sp. (*P*-value =0.027). It indicated a linear relationship at low concentrations and a strong negative association, R= -0.725.

The MIC of MgO nanoparticles against *Shigella* sp. was 8 mg of MgO nanoparticles. The statistical test showed a statistically significant between the amount of MgO nanoparticles and the number of *Shigella* sp. (*P*-value =0.037). It indicated a linear relationship at low concentrations and a strong negative association, R= -0.598.

3.5 Using Magnesium oxide (MgO) nanoparticles as a filter

Table 3.1 showed that concentration 50 mg of MgO nanoparticles and the time during 20 sec. was found to be the optimum condition to decrease the number of bacteria to zero.

Table 3.1: Determination of the optimum amount, contact time, and total number of bacteria of MgO nanoparticles for post-treatment of 50 ml secondary treated wastewater

Volume of WW (ml)	Amount of MgO (mg)	Time (Sec.)	Total number of bacteria (CFU/ml)

50	10	12	30×10^3
	20	14	29×10^3
	30	16	27×10^3
	40	17	24×10^2
	50	20	0
	60	25	0
	70	32	0
	80	37	0

* Statistical test: Pearson correlation, multiple linear regression

The statistical test (Table 3.2) shows the correlation coefficient R =0.926 and R-Square = 0.857. This means 89.7% of the variation in the total number of bacteria in 50 ml of secondary wastewater is explained by the optimum amount of MgO nanoparticles and contact time. Besides, the analysis of variance for the regression model. F=21.695, *P*-value = 0.003, so there is a significant relationship between the dependent variable (total number of bacteria in 50 ml of secondary wastewater) and the independent variable (optimum amount MgO nanoparticles and contact time) .There is a significant negative relationship between the (total number of bacteria in 50 ml of secondary wastewater) and the optimum amount of MgO nanoparticles. Besides, a meaningful negative correlation between the (total number of bacteria in 50 ml of secondary wastewater) and contact time.

Table 3.2: Multiple Linear Regression Model

Variable.	B	T	Sig	R	R Square	F	Sig
Constant	21362.619	3.464	.018	0.926	0.857	21.695	0.003
Amount MgO	-1242.751	-4.286	.008				
Contact time.	-2154.274	-2.717	.042				

Total number of bacteria in 50 ml =

21362.6-1242.7× (optimum amount MgO nanoparticles) + 2154.2× (contact time)

The estimated regression equation predicts the value of the total number of bacteria in 50 ml of secondary wastewater for any give value responses to the independent variable optimum amount of MgO nanoparticles and contact time.

Table 3.3 showed that 100 mg of MgO nanoparticles during 24 sec. was found the optimum condition to decrease the number of bacteria.

Table 3.3: Determination of the optimum amount, contact time, and total number of bacteria of MgO nanoparticles for post-treatment of 100 ml secondary treated wastewater

Volume of WW (ml)	Amount of MgO (mg)	Time (Sec.)	Total number of bacteria (CFU/ml)
100	10	12	30×10^3
	20	14	29×10^3
	30	16	27×10^3
	40	17	24×10^2
	50	24	0
	60	26	0
	70	34	0
	80	38	0

*Statistical test: Pearson correlation, multiple linear regression

The statistical test Table 3.4 shows the analysis of variance for the regression model. F=14.090, *P*-value = 0.006, so there is a significant relationship between the dependent variable total number of bacteria in 100 ml of secondary wastewater and the independent variable optimum amount MgO and contact time.

There is a significant negative relationship between the total number of bacteria in 100 ml of secondary wastewater and the optimum amount of MgO and a meaningful negative correlation between the total number of bacteria in 100 ml of secondary wastewater and contact time.

Table 3.4: Multiple Linear Regression Model

Variable	B	T	Sig	R	R Square	F	Sig
Constant	23635.989	2.990	0.030	0.926	0.857	14.090	0.006
Amount MgO	-1269.649	-2.980	0.031				
Contact time.	-1968.983	-2.806	0.033				

Total number of bacteria in 100 ml = 23635.9-1269.6× (optimum amount MgO nanoparticles) + 1968.9×(contact time)

The estimated regression equation predicts the value of the total number of bacteria in 100 ml of secondary wastewater for any give value responses to the independent variable optimum amount MgO nanoparticles and contact time.

3.6 Determination of the chemical and physical parameters

Table 3.5 shows the differences in secondary treated wastewater's chemical and physical parameters before and after filtering by MgO nanoparticles.

Z test = -2.017 and *P*-value = 0.044 < 0.05, chemical and physical parameters of Secondary treated wastewater after filtering by MgO nanoparticles smaller than chemical and physical parameters of Secondary treated wastewater before filtering by MgO are significant.

Table 3.5: Chemical and physical parameters of secondary treated wastewater filtrated through 50 mg of MgO nanoparticles

Item	Unit	Sample 1	Sample 2	Z test	*P*-value
pH		7.5	9.46		
EC	Mc/cm3	3100	3080		
TDS	Mg/l	1922	1910		

Cl^-	Mg/l	594	675	-2.017	0.044
Ca^{+2}	Mg/l	142	68		
Mg^{+2}	Mg/l	101	133		
Hardness	Mg/caco3	770	716		
Alkalinity	Mg/caco3	445	411		
NO_3^-	Mg/l	30.2	22.8		
Na	Mg/l	362	344		
K	Mg/l	27.3	25.3		
SO_4	Mg/l	163.6	138.9		
COD	Mg/l	110	32		
BOD	Mg/l	33	10		
PO_4-P	Mg/l	7.72	3.74		
NH_4^+	Mg/l	1.21	0.58		

Sample 1: Secondary treated wastewater

Sample 2: Secondary treated wastewater filtered by 50 mg of MgO nanoparticles

* Statistical test: Wilcoxon test

3.7 Microbial analyses of secondary treated wastewater filtrated by 50 mg of MgO nanoparticles

Table 3.6 shows the total number of bacteria, coliform, *Shigella* spp., *Salmonella* spp., lactose fermenter , non-lactose fermenter, , and fungi after filtrated by 50 mg of MgO nanoparticles is decreased compared with before filtrated. The statistical test showed statistically significantly between the total number of bacteria, coliform, and fungi of secondary treated wastewater after filtering by MgO nanoparticles is substantially smaller than the total number of bacteria, coliform, lactose fermenter, non-lactose fermenter and fungi of Secondary treated wastewater before filtering by MgO nanoparticles. In addition, the showed decrease number of *Shigella* spp., *Salmonella* spp., after filtration process.

Table 3.6: Microbial analyses of secondary treated wastewater filtrated by 50 mg of MgO nanoparticles

Type of microorganisms	Sample 1 (CFU/ml)	Sample 2 (CFU/ml)	Z test	*P*-value
Total bacteria	16×10^6	22×10^2	-2.366	0.016
Total coliform	86×10^4	13×10^2		
Lactose +ve on MacConkey	70×10^4	19×10^2		
Lactose -ve on MacConkey	60×10^4	15×10^2		
Fungi	14×10^3	24×10^2		

Sample 1: Secondary treated wastewater

Sample 2: Secondary treated wastewater filtered by 50 mg of MgO nanoparticles

* Statistical test: Wilcoxon test

3.8 Using Magnesium oxide (MgO) nanoparticles as a filter by different diameters to measure COD test

Table 3.7 describes the experiment results for determining the optimum COD, contact time, and syringe under pressure and without pressure. Also, the COD was decreased at syringe 5ml during short contact time under pressure and without pressure.

Table 3.7: Comparison between filtration of secondary wastewater by using MgO nanoparticles under pressure and without pressure through different diameters

Parameter	Filtration without pressure		Filtration with pressure	
	Control	Sample	Control	Sample
Syringe 3ml				
COD (mg/l)	120	32	100	20
Contact time	72	155	21	27

(Sec.)				
Syringe 5ml				
COD (mg/l)	120	13	100	2
Contact time (Sec.)	43	145	20	25
Syringe 10ml				
COD (mg/l)	120	33	100	23
Contact time (Sec.)	16	20	12	15

Control: Secondary treated wastewater

Sample: Secondary treated wastewater filtered by MgO nanoparticles

Table 3.8 shows the correlation between control and sample in the COD test, correlation coefficient, and significant negative association infiltration without pressure and filtration with pressure.

Table 3.8: Correlation between control and sample in the COD test (syringes 3ml, 5ml, and 10ml)

	R correlation	***P*-value**
Filtration without pressure	-0.694	0.035
Filtration with pressure	-0.961	0.007

* Statistical test: Pearson correlation, simple linear regression

Table 3.9 shows the correlation between control and sample in contact time, correlation coefficient, and a significant positive association between filtration without pressure and filtration with pressure.

Table 3.9: Correlation between control and sample in time (sec.) (syringe 3ml, 5ml, and 10ml)

	R correlation	***P*-value**
Filtration without pressure	0.893	0.017
Filtration with pressure	0.998	0.001

* Statistical test: Pearson correlation, simple linear regression

Table 3.10 represents the analysis of results applying the Wilcoxon test and showed differences between filtration without pressure and filtration with pressure sample, Z test = -2.214, and p-value = 0.027 < 0.05, filtering with pressure sample smaller than filtering without pressure.

Table 3.10: Statistical test between filtration without pressure and filtration with pressure sample

Z test	***P*-value**
-2.214	0.027

* Statistical test: Wilcoxon test

4. Discussion

4.1 The MIC of MgO nanoparticles against different isolated bacteria

Our result showed the MIC of MgO nanoparticles against *E. coli* at 6 mg/ml; this result was in disagreement with study performed by **He et al., 2016**which showed that the MIC of MgO nanoparticles against *E. coli* was at least 8 mg/ml. Besides, **(Tabassum et al., 2014)** showed the MIC of MgO nanoparticles against *E. coli* at a 100 mg/ml concentration.

The current study showed that the MIC of MgO nanoparticles against *Klebsiella* sp. at 9 mg/ml, this result was in disagreement with **(Ravikumar et al., 2011)** showed the MIC of MgO nanoparticles against *Klebsiella* sp. at 30 mg/ml.

The result revealed the MIC of MgO nanoparticles against *S. aureus* at 7 mg/ml; this result was in disagreement with **(Sundrarajan et al., 2012)**, which showed the MIC of MgO nanoparticles against *S. aureus* at 19 mm of zone inhibition. In addition, **(Sharma, Soni, & Jasuja, 2017)** showed the MIC of MgO nanoparticles against *S. aureus* at 40 mm of zone inhibition.

The result demonstrated the MIC of MgO nanoparticles against *Salmonella* sp. at 10 mg/ml; this result was in disagreement with **(He et al., 2016)** which showed the MIC of MgO nanoparticles against *Salmonella Enteritidis* at 8 mg/ml. Furthermore, The result illustrate**s** the MIC of MgO nanoparticles against *Shigella* sp**.** at 8 mg/ml; this result was in disagreement with **(EL-Moslamy, 2018),** which showed the MIC of MgO nanoparticles against *Shigella* 0.025 mg/ml.

MgO nanoparticles. Sawai *et al*. (1997) proposed that the possible antibacterial mechanism was the adsorption of water moisture on the MgO nanoparticle surfaces, forming a thin water layer around the particles. The local pH of this thin water layer formed around the nanoparticles might be much higher than its equilibrium value in the solution. When the nanoparticles are in contact with the bacteria, the high pH in this thin surface water layer could damage the membrane, resulting in cell death **(Sawai et al., 1997)**. Our results in the MIC of MgO nanoparticles against different isolated bacteria were in disagreement with previous studies because of the difference in wastewater and environmental condition of Gaza Stripe, strains of bacterial isolated from sewage. In addition, the size and shape of MgO nanoparticles were synthesized by co-precipitation.

4.2 Magnesium oxide (MgO) nanoparticles as a filter

This study **(Table 3.1) (Table 3.3)** showed that the number of bacteria was completed inhibited when higher concentration at 50 mg of MgO nanoparticles through filtration 50 ml and 100 ml of secondary treated wastewater during 20 sec. and 24 sec., respectively. Whereas **(Tabassum et al., 2014)** showed that bacteria's growth is completely inhibited when a higher concentration at 0.1 g/ml of MgO nanoparticles was added into 100 ml of the water sample. In addition, the antibacterial activity increased with dose and contacted time for nearly all treatments, the higher value up to (12.000 mg. min/l) of contact time value **(Al-Issai et al., 2019)**.

4.3 The chemical and physical parameters

This study **(Table 3.5**) showed that some chemical and physical parameters were decreased when filtered 50 ml of secondary treated wastewater at 50 mg of MgO nanoparticles. The statistical test showed statistically significant (P-value =0.044) between chemical and physical parameters before and after the secondary treated wastewater filtration process by MgO nanoparticles. Still, the pH, Cl^- and Mg^{+2} were increased. Whereas the variation in tested water samples' chemical characteristics appeared to cause noticeable differences in the antibacterial efficacies of MgO nanoparticles **(Al-Issai et al., 2019)**. Besides, 0.25 g/100ml of MgO nanoparticles is considered the optimum dosage for treating some chemical and physical parameters. However, there is increasing in the pH, Cl^- and Mg^{+2} after treatment by MgO nanoparticles, and this increase is due to the partial dissolution of MgO and formation of $MgCo_3^-$.Also, MgO has salt/sodium chloride (NaCl) **(Singh et al., 2016)**.

4.4 Microbial analyses of secondary treated wastewater filtrated by 50 mg of MgO nanoparticles

Table 3.6 showed that the total number of microbes such as bacteria, coliform, *Shigella* spp., *Salmonella* spp., +ve lactose, - ve lactose, and fungi were decreased during filtration of secondary treated wastewater by MgO nanoparticles at 50 mg. Also, **(Sharma et al., 2017)** showed that the MgO nanoparticles were found effective against both Gram-positive bacteria and Gram-negative bacteria. Moreover, the MgO nanoparticles treatments distort and damage the cell membrane, resulting in a leaking of intercellular contents and, eventually, the death of the bacterial cell **(Jin & He, 2011)**.

4.5 Comparison between filtration of secondary wastewater by using MgO nanoparticles under pressure and without pressure through different diameters

As shown in tables **(Table 3.7) (Table 3.8) (Table 3.9) (Table 3.10),** we found that the COD was decreased during filtration of secondary treated wastewater by MgO nanoparticles as a filter through different diameter (3 ml, 5 ml, and 10 ml) under pressure and without pressure. The contact time was increased during the filtration process under pressure and without pressure. Whereas, **(T. Singh & Jain, 2014)** showed the over 98% influent COD reduction removal of metal ions. Also, the COD reduction percentage remained almost constant when the adsorbent dosage was higher than 35 mg. Interestingly, 55 mg MgO nanoparticles are required to achieve COD reduction > 90%. The breakpoint time increased with increasing bed height (2–8 cm), resulting in increased COD reduction from 1500 mg/L to 286 mg/L. The influence of flow rate(4–12 mL/min) in a column packed with MgO−NPs was examined at pH 7 and an organic load of 1500 mg/L **(Oladipo et al., 2017)**.

5. Conclusion

Magnesium oxide nanoparticles have a tangible impact on the tertiary treatment of secondary treated wastewater.

Magnesium oxide nanoparticles have antibacterial activity against different isolated bacteria.

Magnesium oxide nanoparticles have a tangible impact on the reduction of chemical and physical parameters.

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