RESULTS

Part (I)

This chapter describes the results of a laboratory scale (jar test) unit to determine the extraction condition, optimum dose and the optimal conditions of three types of natural seeds as natural coagulant or coagulant aid as well as oxidizing agent. In addition, the effect of different plant extract on the physico -chemical characteristics of drinking water in comparing to aluminum sulphates, which used in water treatment plants as a coagulant material.

1. Optimum conditions for plant extraction

1.1. The Extraction Condition

The results in figures (27a, b-29) show that the water extraction of each plant material of *M.oleifera, M.indica* and *Prunus armeniaca* give high efficiency in turbidity removal over than that obtained in other extraction form.

1.2. Optimum Dose

The water extracted of each plant material would used to obtain the optimum dose for high efficiency removal of turbidity. The water extract of *M.oleifera* would be tested at doses of 100,150,200,250,300 and 350 mg/l, while water extract doses of *M.indica* and *Prunus armeniaca* are 10, 20,30,40,50 and 60 mg/l .The results in fig (27a, b-29) indicate the optimum dose for high turbidity removal of each plant water extract are 150, 30 and 30 mg/l of *M.oleifera*, *M.indica* and *Prunus armeniaca* respectively.

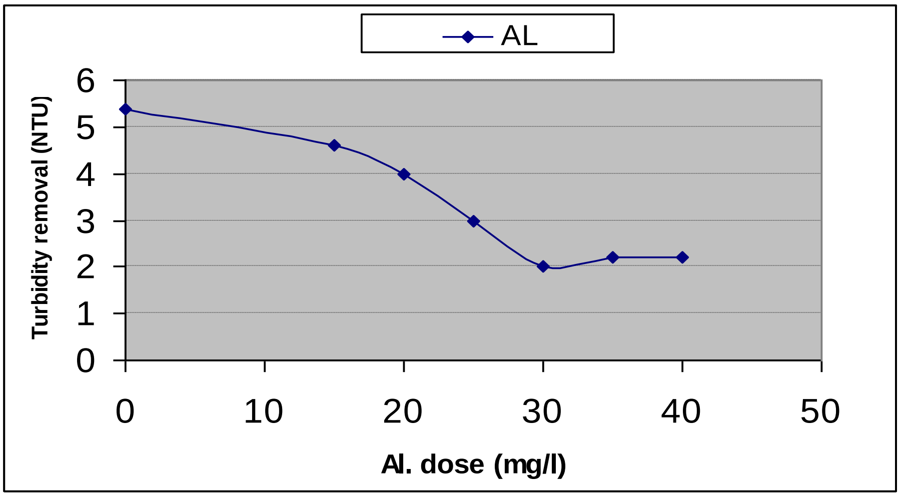


Figure (26) Turbidity removal by Aluminum sulphates

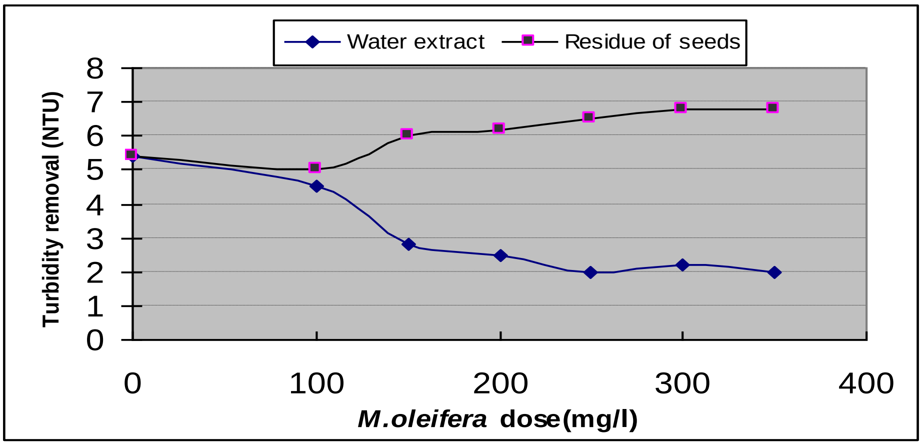


Figure (27a) Turbidity removal by (water, residue of seeds) extracts of *M.oleifera*

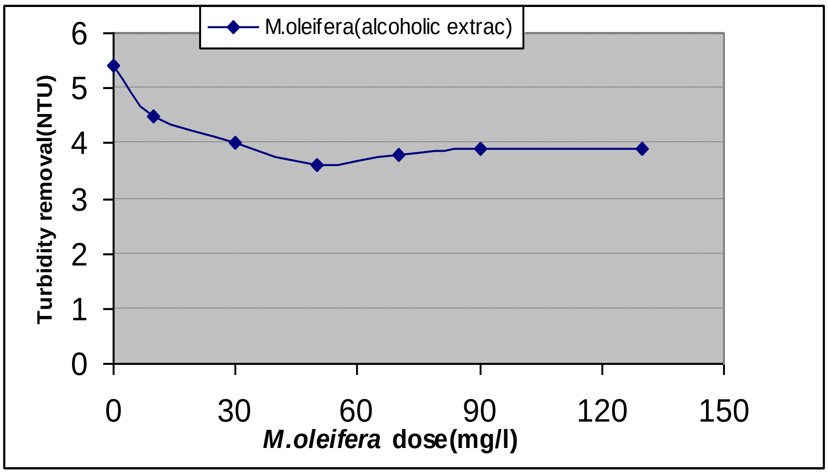


Figure (27 b) Turbidity removal by alcoholic extracts of *Moringa oleifera*

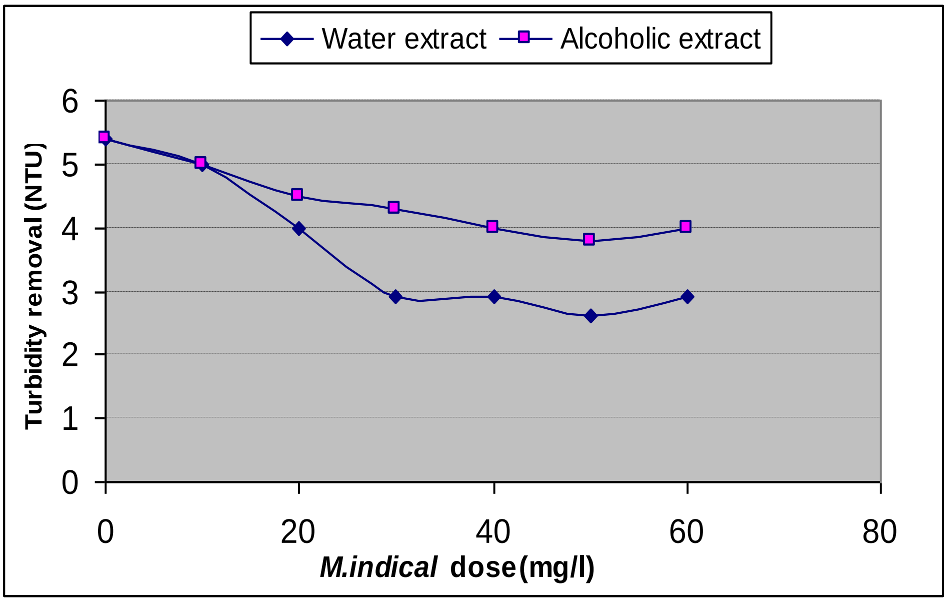


Figure (28) Turbidity removal by different plant seeds extracts of *Mangifera indica*

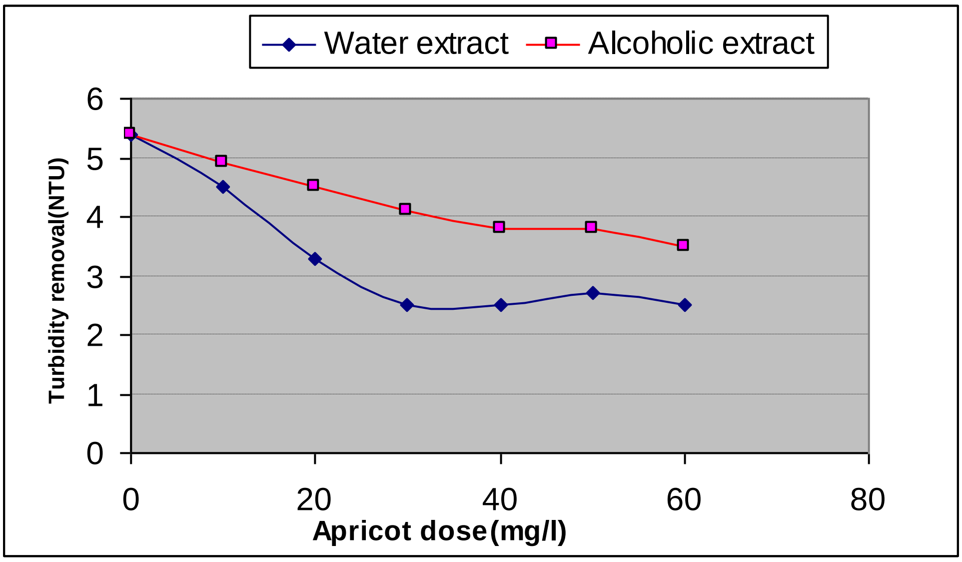


Figure (29) Turbidity removal by different plant seeds extracts of *Prunus armeniaca*

1.3. Settling time

For successful high efficiency of turbidity removal, different settling time mainly: 0.5 hr, 1 hr, 1.5 hr, 2 hr and 2.5 hr were carried out using the optimum dose of each plant extract, as (*M.oleifera* 150 mg/l, *M.indical* 30 mg/l and *Prunus armeniaca* 30 mg/l*)*.High removal in turbidity was detected after 1 hr for *M.indica* and *Prunus armeniaca* while it reached to 2 hrs with *M.oleifera*.Fig (30).

2. The use of plant extract as a coagulant aid

Two doses below the optimum dose of each plant extract were tested in combination with different dose of aluminum sulphates. For *Moringa oleifera* two doses of 50 and 100 mg/l were tested with (10, 15, 20, 25, 30, and 35 mg/l) doses of alum. While for *M.indica* and *Prunus armeniaca* doses of 10 and 20 mg/l were tested in combination with the same doses of aluminum sulphates.The results of turbidity removal indicated that, the combination of (alum + *Moringa*) and (alum + *Prunus armeniaca)* gives best turbidity removal than the combination of (alum + *M.indical*).In addition, the combination of (*Moringa* + *Prunus armeniaca*) doses raise the turbidity removal of low alum concentration Fig (31-33).

So, it can be concluded that the three plant water extract have economic value when used as coagulant aid where it enhance the efficiency of low alum dose.

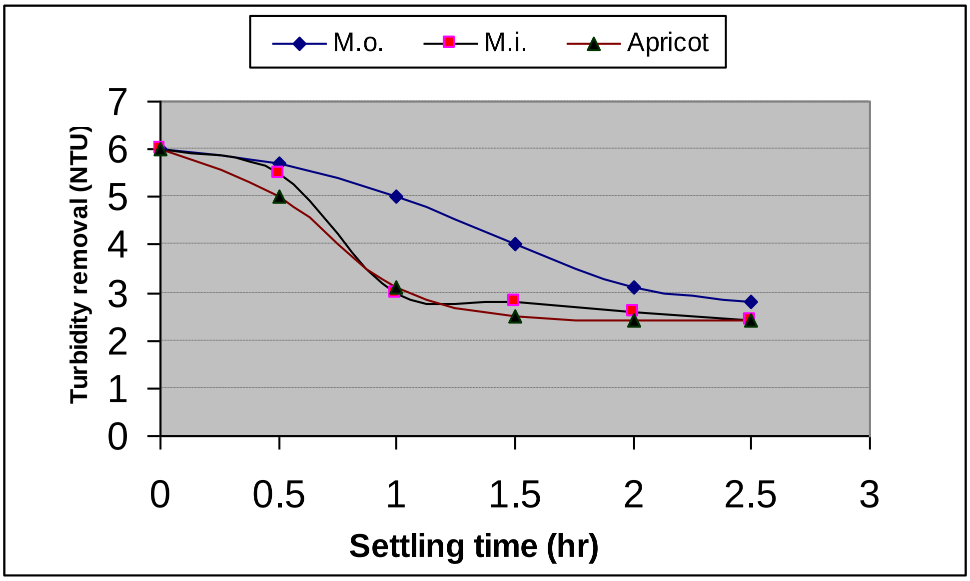


Figure (30) Turbidity removal due to change in settling time using different plant seeds extracts.

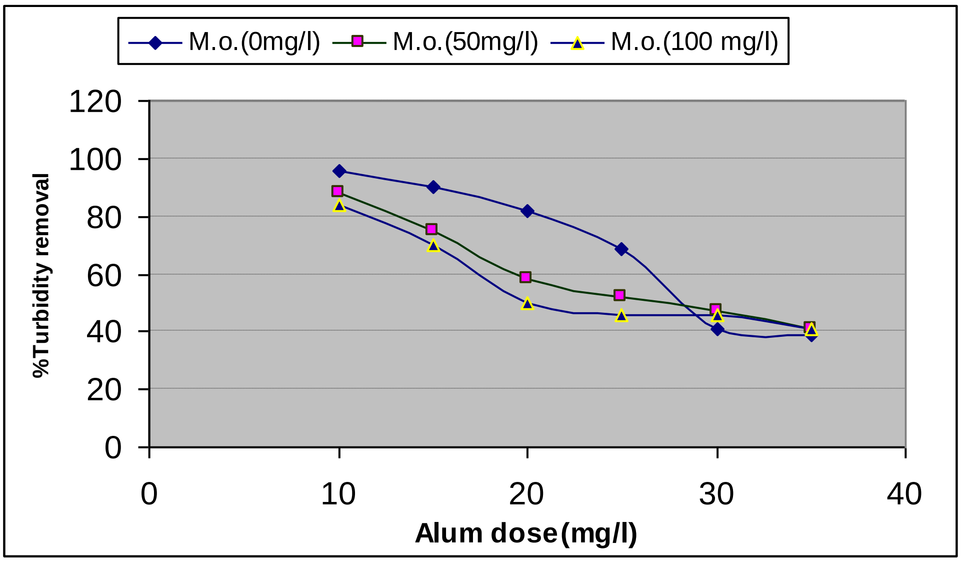


Figure (31) Percent turbidity removal by different doses of *Moringa oleifera* as a coagulant aid with alum

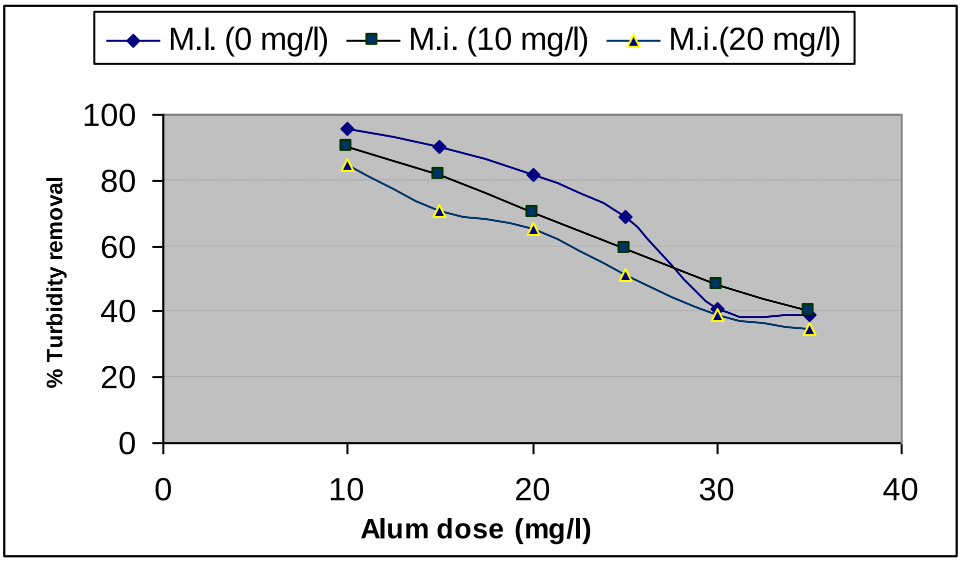


Figure (32) Percent turbidity removal by different doses of *Mangifera indica* as a coagulant aid with alum

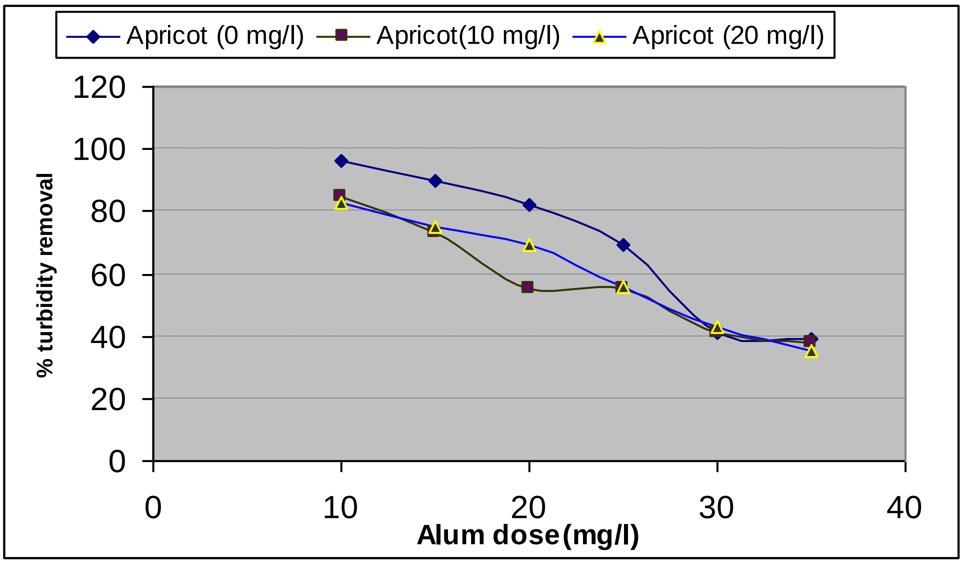


Figure (33) Percent turbidity removal by different doses of *Prunus armeniaca* as a coagulant aid with alum

3. Natural plant extract as oxidizing agent

It may be worth to note that some plant extract have a powerful oxidizing efficiency. So different plant extract (water extract, alcoholic extract and fixed oil) of plants used through this investigation were tested to improve its efficiency as oxidizing agent.

It is important to note that, the preliminary experiments for testing the efficiency of different plants seed extracts as oxidizing agent showed that, *Moringa oleifera* seed extracts have a cytotoxicity and antimicrobial activity. While, *Mangifera indica* and *Prunus armenaica* seed extracts have not been indicated a cytotoxicity or antimicrobial activity.

3.1. *Moringa oleifera*

Three types of plant extract (water extract, alcoholic extract and fixed oil) were tested against three types of microorganisms (algae, bacteria and viruses).

3.1.1. Cytotoxicity effect of different *Moringa oleifera* extract

Green algae species and *Scenedesmus obliquus* were used to investigate the inhibitory efficiency of *Moringa oleifera* extract. Figure (34) showed that, all concentrations of fixed oil lead to a pronounced promoting in algal growth with percentage growth over than that of control reached to 49%. While alcoholic, extract concentrations (50-300 mg/l) especially (300 mg/l) different *Moringa oleifera* seed extracts showed inhibitory effect on algal growth with percentage inhibitory 75%. Moreover, *Moringa oleifera* water extract concentrations (50-300 mg/l) improve varying effect on algal growth. Low water extract concentrations (50- 100 mg/l) revealed on enhancement to the algal growth, while higher concentrations (300 mg/l) manifest an inhibitory effect to the algal growth with percentage inhibition was 44% .Figure (35).

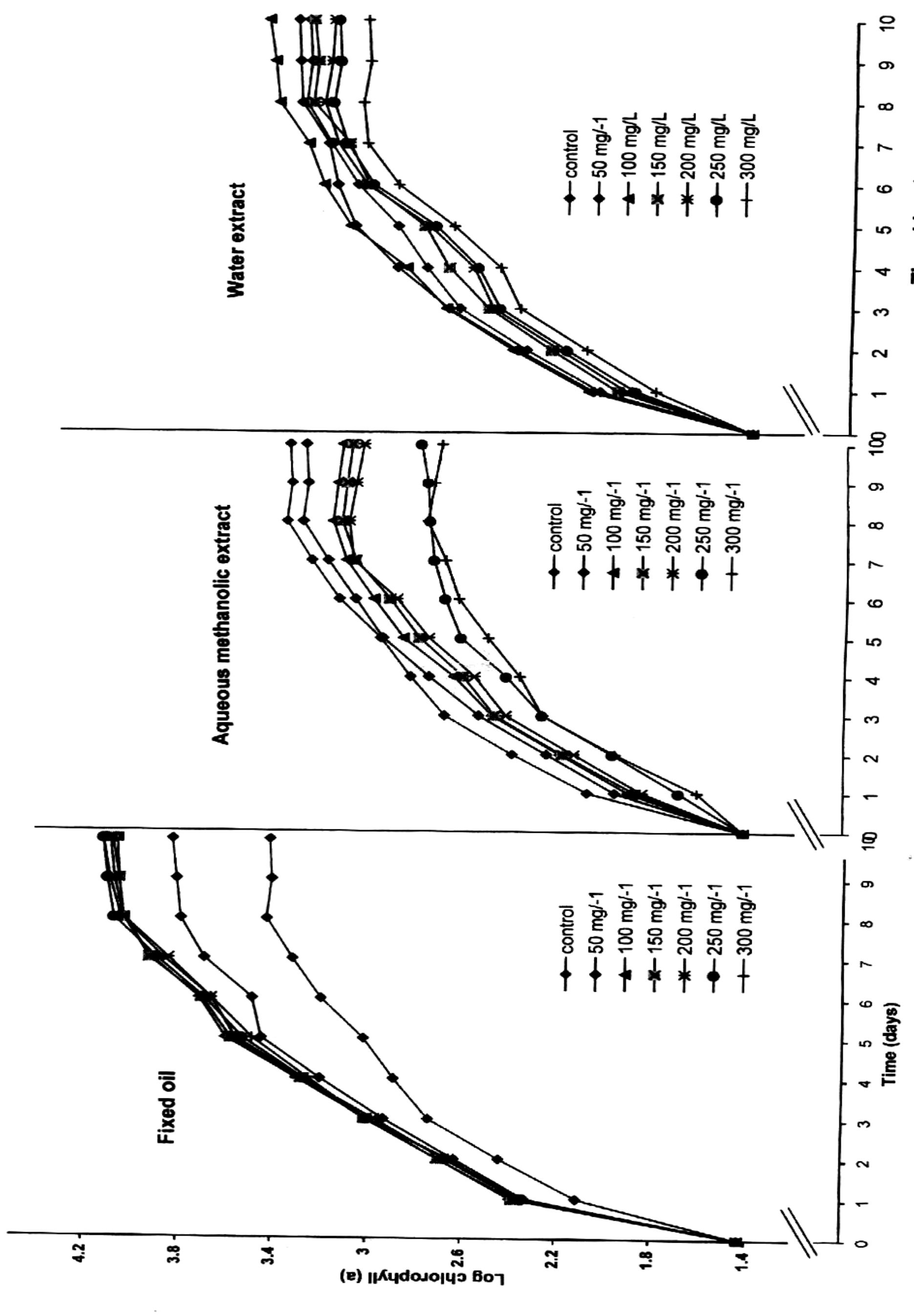


Figure (34) Growth response of *Scenedesmus obliquus* treated with different extracts of *Moringa oleifera*.

3.1.2. Antibacterial Activity

The results of antibacterial activity of different *Moringa oleifera* seed extracts are shown in Tables (3-5) .Table (3) represents the data of antibacterial activity for different fixed oil concentrations. The results revealed that all fixed oil concentrations have no antibacterial effect against *Ps.aeruginosa* and *E. coli,* while *Staph.aureus* growth was encouraged by concentrations from 100 to 700 mgl^{-1}. The other concentrations (of crude and its dilution) inhibited the growth of the *Staph. aureus* strain. On the other hand, the antibacterial effects of fixed oil concentrations against *B. sterothermophilus* were found to be 300-900 mg/L while other concentrations had no effect on the same strain (Tab. 3) So, it can be concluded that *E. coli* and *Ps. aeruginosa* were more resistant to the fixed oil extracted from *Moringa oleifera* seeds. The oil extracts from *Moringa* seeds were completely inactive against all the micro-organisms tested. *Moringa* seeds contain isothiocyanate with bactericidal properties and families who treat the water with plant materials seem to have a lower incidence of gastrointestinal disturbances. Information on the fate of this active agent in treated water is presently not available and research is being carried out to find the fate of this agent in treated water.

The results of antibacterial effects of aqueous methanol extract from *Moringa oleifera* seeds are recorded in Table 4. All aqueous methanol extract concentrations wore not as effective as antibacterial for *Ps. aeruginosa,* except that the crude extract leads to a reduction in the growth of the organism with a poor inhibition zone (0.7 mm). With regard to the *Staph aureus* strain, the extract was encouraging organism growth in concentrations of 50-250 mg/ L, while the crude extract and 300 mg/L inhibits the strain. In addition, concentrations (1/10 and 1/100 of crude) have no effect on the *Staph aureus.* For *E. coli* strain, it was sensitive to 1/10 and 1/100 of crude aqueous methanol extracts, while other concentrations had no effect. All concentrations of aqueous methanolic extract would inhibit the growth of *B. sterothermo-philus* by different inhibition zones, except that the crude extract was not effective (Tab 4).

704 GAMILA H. ALI

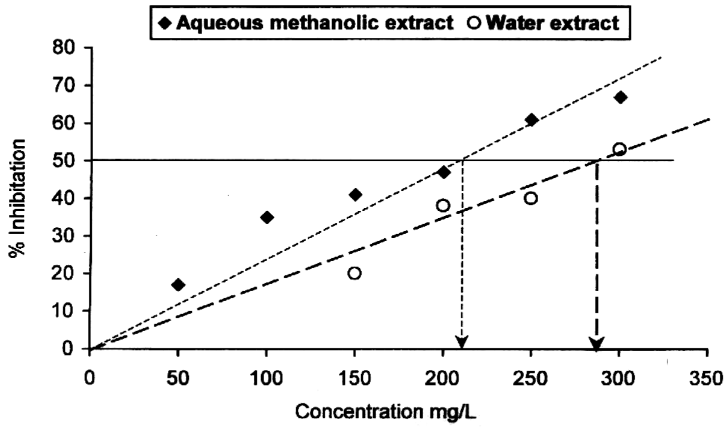


Fig (35) percentage inhabitation and EC50 of *Scenedesmus obliquus* treated with *Moringa oleifera* extracts

Table (3) Antibacterial activity of fixed oil extracted from *Moringa oleifera*.

Moringa concentration	Organisms			
	Ps.aeruginosa	*Staph.aurues*	*E.coli*	*B.sterother*
100 mg^{-1}	±	_	±	±
300 mg^{-1}	±	_	±	+
500 mg^{-1}	±	_	±	+
700 mg^{-1}	±	_	±	+
900 mg^{-1}	±	++	±	++
1000 mg^{-1}	±	+	±	±
Crude	±	++	±	±
1:10	±	+	±	±
1:100	±	++	±	±
1:1000	±	++	±	±

The results are the average of three replicates

(±): not effective (-) encourage

(+): inhibition zone 0.7-0.9mm (++): inhibition zone 0.9-1.1mm

(+++): inhibition zone 1.1-1.3mm (++++): inhibition zone 1.3-1.6mm

From the effect of water extract on selected bacterial strains, it was clear that the water extract had no effect as an antibacterial against Ps. aeruginosa at different concentrations used (Tab.5). Although, all water extract concentrations (50-300 mg/L and 1/10, 1/100, 1/1000 of crude) showed an encouragement for the *Staph. aureus* strain used, the crude water extract (without dilution) showed strong inhibition activity against the strain. For *E. coli* strain the results showed fluctuation in its effects by the water extract, where the concentrations from 100-200 mg/L have an inhibition effect. The other concentrations revealed no effect on *E.coli*. Regarding *B. slerothermophilus* strain used in this study, it is clear that this strain was found sensitive to all the concentrations of the water extract used, except for two concentrations (200 and 250 mg/L) had no effect on this strain.

Hence, it may be concluded that this organism was more sensitive than the other organisms to water extract of *Moringa* seed i.e. it is not pathogenic and there is no massive amount of antibiotics used against it in the treatment. It was found that the sensitivity of the tested micro-organisms to the aqueous seed extracts of *M. oleifera* showed that Gram - negative bacteria (*E.coli* and *Ps. aeruginosa*) were more resistant than Gram - positive bacteria (*Staph. aureus)*. They added that the oil extracts from the seeds were completely inactive against all the micro-organisms used.

3.1.3. Cytotoxicity and Antiviral activity

One of the remarkable scientific achievements of the past quarter of a century has been the growth of the search for antiviral drugs from natural materials. This study is one of these efforts to search for the bioactivity of *Moringa oleifera* against model viruses. Accordingly, three types of *Moringa oleifera* extracts (fixed oil, aqueous methanolic extract and water extract) were analysed for both cytotoxicity and antiviral activity. Cytotoxicity assay results, as shown in Figure 3, revealed that no toxic effect was observed for all extracts at dilutions (1:4). This may be an indicator for the safe use of the plant seeds for human consumption. Aqueous methanolic extract was the highest active extract against HSV1 where the percentage of HSV1 reduction was 34.3% and 52.55% for doses 20 ug and 50 ug, respectively. The fixed oil extract was slightly similar in its activity as aqueous extracts where the percentages of virus reduction were 37.9%and 45.2% for doses 20 ug and 50 ug. No antipolio virus activity was observed for all extracts. Generally, the bioactivity of *Moringa oleifera* was noticed foe HSV type 1 (DNA virus) as shown in figure (36). Activity against EBV was also observed but for three fractions of the *Moringa oleifera.* They found that 10 ug/ml showed at 40.4% inhibition and the aximum inhibition was shown at 100 ug/ml (72.9%) in comparison of our results where 52% was observed for 50 ug aqueous extract, this may be slightly similar

3.2. *Mangifera indicia* and *Prunus armeniaca*

The results of cytotoxicity and antibacterial activity of both *Mangifera indicial* and *Prunus armeniaca explain that all plant extract (*water extract, alcoholic extract and fixed oil) have no effect on all microorganisms used through the investigation.

So, it can be concluded that the *Moringa oleifera* water seeds extract can be used as an oxidizing agent for microorganisms living in water.

Table (4) Antibacterial activity of aqueous methanol extracted from *Moringa oleifera*.

Moringa concentration	Organisms			
	Ps.aeruginosa	*Staph.aurues*	*E.coli*	*B.sterother*
50 mg^{-1}	±	_	±	+
100 mg^{-1}	±	_	±	+
150 mg^{-1}	±	_	±	+
200 mg^{-1}	±	_	±	++
250 mg^{-1}	±	_	±	++
300 mg^{-1}	±	++	±	+++
Crude	+	+++	±	±
1:10	±	±	+	+++
1:100	±	±	+	+
1:1000	±	_	±	+

The results are the average of three replicates

(±): not effective (-) encourage

(+): inhibition zone 0.7-0.9mm (++): inhibition zone 0.9-1.1mm

(+++): inhibition zone 1.1-1.3mm (++++): inhibition zone 1.3-1.6mm

Table (5) Antibacterial activity of water extracted from *Moringa oleifera*.

Moringa concentration	Organisms			
	Ps.aeruginosa	*Staph.aurues*	*E.coli*	*B.sterother*
50 mg^{-1}	±	_	±	+
100 mg^{-1}	±	_	++	+
150 mg^{-1}	±	_	++	++
200 mg^{-1}	±	_	++	±
250 mg^{-1}	±	_	±	±
300 mg^{-1}	±	_	±	++
Crude	+	+++	±	++++
1:10	±	_	+	+++
1:100	±	_	+	+++
1:1000	±	_	±	+

The results are the average of three replicates

(±): not effective (-) encourage

(+): inhibition zone 0.7-0.9mm (++): inhibition zone 0.9-1.1mm

(+++): inhibition zone 1.1-1.3mm (++++): inhibition zone 1.3-1.6mm

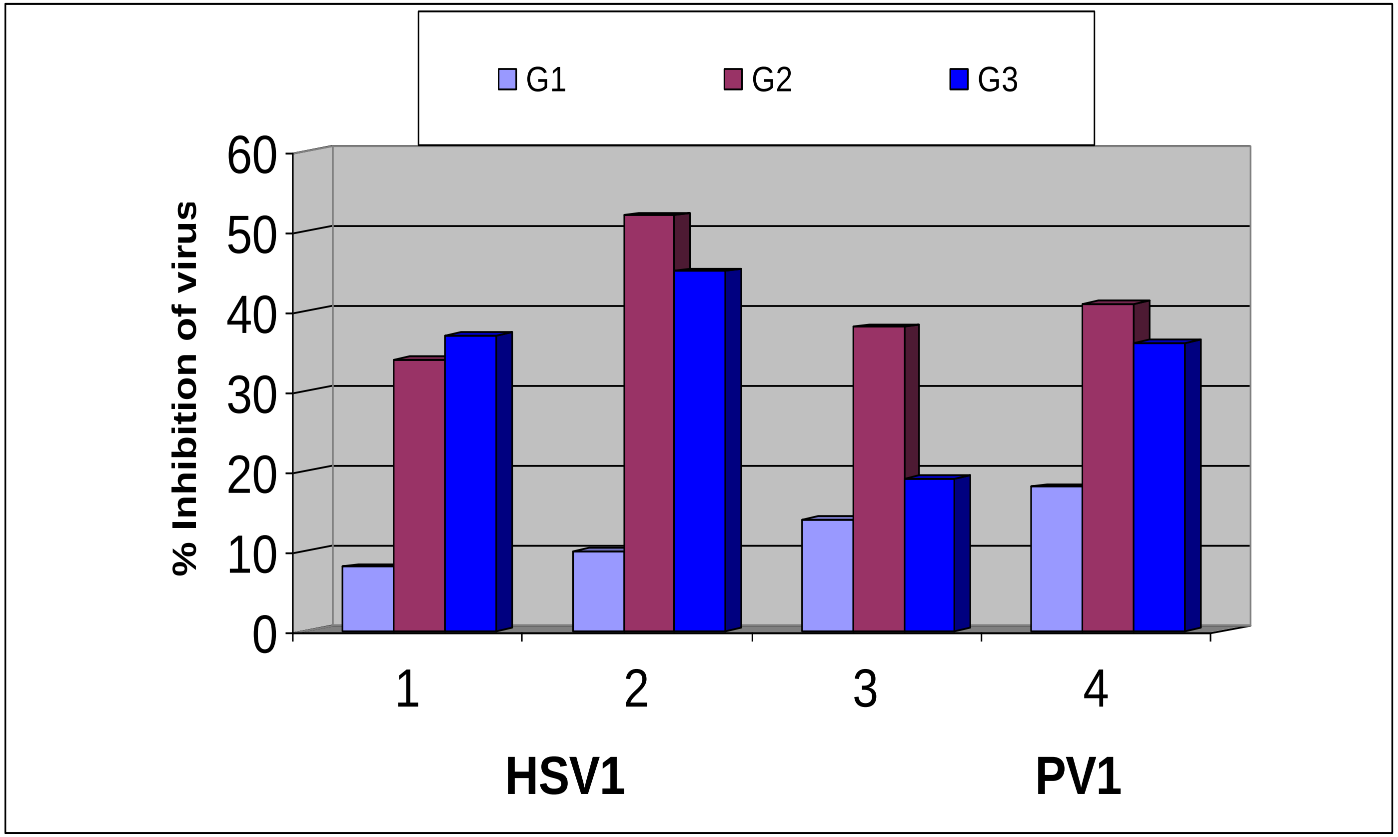


Figure (36) Antiviral bioassay of *Moringa oleifera* (G1 water extract, G2 aqueous methanolic extract and G3 is the fixed oil).extracts were all expressed as ug/10^5 cell for each virus.

4. Effect of different plant extract on phsico-chemical characteristics of water

The phsico-chemical characteristics of water after treatment with plant extract where studied in comparison with water treated by aluminum sulphates. Results shown on table (3) indicated that plant extract of *Moringa oleifera* led to a pronounced change in the odor of water although it is acceptable odor. In addition, it raises the concentration of phosphate and nitrates over than that it presents in raw Nile water. Simultaneously, *Mangifera indicia* water extract give a greenish color to water after treatment.

Table (6) Phsico-chemical characteristics of water after treatment with different coagulant material.

Parameters	Raw Nile water	Plant outlet	*M.o.*	*M.i*	*Prunus armeniaca*
pH	7.7	7.5	7.5	7.4	7.4
Turbidity (NTU)	6	2	2.4	2.6	2.6
Total Dissolved Solids (mg/l)	237	240	237	239	237
Color C o. pt unit	<5	<5	<5	20	<5
Odure	odorless	odorless	aromatic odor	odorless	odorless
Taste	Tasteless	Tasteless	Tasteless	Tasteless	Tasteless
Total alkalinity(as $CaCo_3$) (mg/l)	146	134	140	136	136
Total hardness(as CaCo3) (mg/l)	142	140	140	140	140
Calcium hardness(as CaCo3) (mg/l)	90	88	88	88	88
Magnesium hardness(as CaCo3) (mg/l)	52	52	52	52	52
Chloride (mg CL/l)	20	20	20	20	20
Sulphate (mg So_4/l)	22	38	22	22	22
Silica (mg So_4/l)	0.3	0.3	0.3	0.3	0.3
Ammonia (mg N/l)	0	0	0	0	0
Nitrite (mg N/l)	0	0	0	0	0
Nitrate (mg N/l)	0.1	0.1	0.25	0.1	0.1
Total Phosphorus (mg P/l)	0.05	0.05	0.17	0.05	0.05
Iron (mg/l)	0.15	0.13	0.15	0.15	0.15
Manganese (mg/l)	0	0	0	0	0

Part (II)

In this part of work, the optimum doses of each plants extract (*M.oleifera* 150 mg/l, *M.indical* 30 mg/l and *Prunus armeniaca* 30 mg/l) were used in a semi – pilot system constructed in El – Giza water works plant. Moreover, two constant flow rates through the pilot system (0.15 L/sec and 0.1 L/sec) were assumed for each optimum dose of plant extract. Percentage removal of turbidity, phosphate, nitrate algal count, bacterial count and change in pH were measured to specify the efficiency of each plant extract to remove pollutant from water. In addition, it had been planned to carry out a full scale over a 2-week period; however, due to shortage of seeds, only a single 6 hr run (for each trial) was possible.

II.A. *Moringa oleifera* water seed extracts

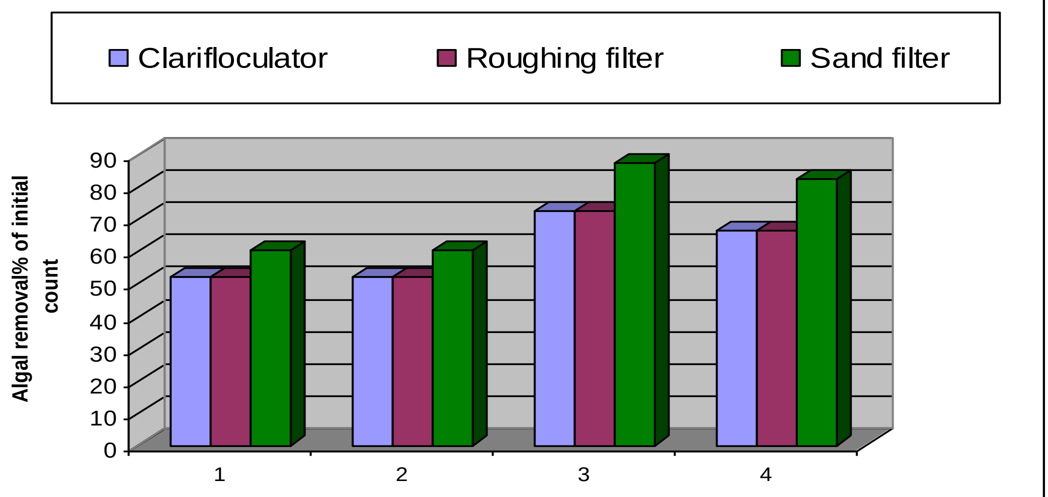
II.A.1. Semi –pilot scale runs at rate 0.15 L/sec.

II.A.1.a. Efficiency of *Moringa oleifera* in removing algae

Figure (37) shows the results of the runs carried out using 150 mg/1 *M. oleifera* seeds extract. It can be seen that, removal of different algal groups following flocculation, sedimentation and filtration increased stepwise. Diatom removal was higher than blue-green and green algal groups. The percentage removal of diatoms group was 72%, 72% and 87% at the successive treatment steps. Blue-green and green algae were removed at 52%, 52%, 60% and 40%, 45% and 75%, respectively, which lead to a total percentage removal of 66%, 66%, 82% after sand filtration step.

II.A.1.b. Efficiency of *M. oleifera* seeds extract in removing bacterial indicators.

Table (7) represents the data of bacteriological parameters determined in the outlet of water works plant and in the experimental semi-pilot system conducted at 0.15 l/sec flow rate. This table shows that the water plant could remove the classical bacterial indicators (total bacterial counts at 22 and 37°C, total and faecal coliforms as well as faecal streptococci) at the end of treatment and that the produced water was acceptable for drinking from the bacteriological point of view. The semi-pilot system only reduced these bacterial parameters by one and two logs. The percentage removal after flocculation, sedimentation and filtration



Fig(38) Percentage rmoval of different algal groubs after treatment with M.oleifera seeds at flow rate 0.15 L/sec

Where 1: Green Algae 2: Blue – Green Algal 3: Diatoms 4: Total Algal count

Table (7) Bacterial indicators in water from El-Giza water treatment and from the pilot system after treatment with *M.oleifera* at flow rate (0.15l/sec)

Sampling site	Total bacterial counts/ml at		MPN index/100 ml		
	22^0C	37^0C	T.C.	F.C.	F.S.
Raw water	$8.3X10^3$	$5.0X\ 10^3$	$1.6X\ 10^4$	$3.4X\ 10^2$	$5.0X\ 10^2$
Plant flocculator	45	52	Nil	Nil	Nil
% Removal	99.9	99	100	100	100
Plant outlet	49	44	Nil	Nil	Nil
% Removal	99.4	99	100	100	100
Pilot flocculator	$8.8X10^2$	$8.0X10^2$	160	34	21
% Removal	89.4	84	99	90	95.8
Pilot roughing filter	$6.6X10^2$	$6.3X10^2$	240	17	50
% Removal	92	87.4	98.5	95	90
Pilot sand filter	$8.9X10^2$	$8.0X10^2$	300	34	53
% Removal	89.3	84	98	90	89.4

T.C. = Total coliforms F.C. = feacal coliforms F.S. = Faecal streptococci

were up to 89% and 84% for total bacterial counts at 22 and 37°C, respectively. Faecal bacterial indicators (total and faecal coliforms as well as faecal streptococci), showed percentage removals up to 98%, 90% and 89%, respectively.

From the obtained results, it is clear that, the semi-pilot plant after treatment with M. oleifera at flow rate (0.15 l/sec.) produced water not acceptable for drinking according to the Egyptian Standard (Egyptian Standards, 1995). This may be due to the operating time was not sufficient to improve water quality, also the lack time between operating times.

II.A.2. Semi –pilot scale runs at rate 0.1 L/sec.

II.A.2.a. Efficiency of *Moringa oleifera* in removing algae

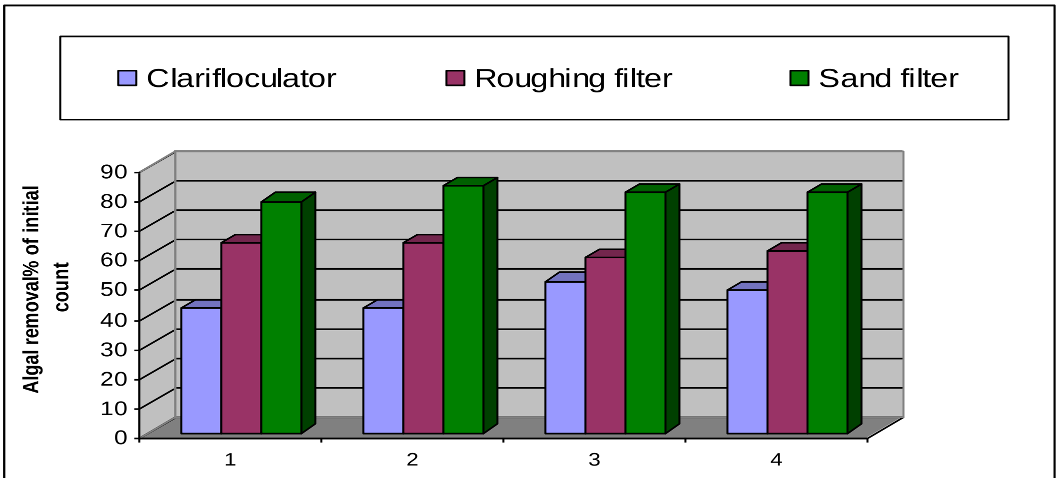
The results obtained from the semi-pilot system operated at 0.1 sec for 6 hr with the test material added at 150 mg/1 are given in Fig. (38). Removal rates of algae within after clarification were approximately 42%, 42% and 51 % for green, blue-green and diatoms, respectively. The use of roughing filter and sand filter following the clarifloculator led to a substantial increase in algal removing rate (Fig. 39). Consequently, total algal count removing rate showed clear reduction due to the treatment with M. *oleifera* dose.

From the results obtained at both flow rates, it can be concluded that the change in flow rate had a pronounced effect on the removing rate of total algal count especially in clarifloculator treatment step. However, there was no clear difference between the removal rates due to the other treatment steps (roughing filter and sand filter) at the applied flow rates.

II.A.2.b. Efficiency of *M. oleifera* seeds extract in removing bacterial indicators and some pathogenic bacteria

Tables 8 and 9 represent the data of classical bacterial indicators determined in the outlet of water treatment plant and in the pilot experiment conducted at 0.1 1/sec flow rate. From the results it was found, that flocculation by alum at the plant had higher percentage removal than flocculation by *M. oleifera* for total and faecal coliforms and faecal streptococci. However, total bacterial counts at 22 and 37°C increased after flocculation in the pilot system. After roughing and sand filters, the same observation was recorded for total bacterial counts. Total coliforms, faecal coliforms and faecal streptococci were removed by the percentages 78%. 66% and 73%, respectively. In general, both the plant and pilot system produced water not acceptable for drinking, where the total and faecal coliform and streptococci in the water works were found 23, 23 and 9 MPN/100 ml. This might be due to failure in the operation process.

With regard to new indicators of pollution (*total yeast, Candida albicans and total staphylococcus)* and selected pathogenic bacteria (salmonellae, total vibrio and *Listeria* group), it is clear that both systems (plant and pilot) failed to remove these parameters from raw water, except C. *albicans* and Salmonellae which were removed from water at the outlet of the pilot system only. In addition, the results in Table (9) showed that total yeast were more resistant to treatment by *M. oleifera,* where the percentage removal was 25% only. Generally, the semi-pilot system using *M. oleifera* had better reduction of tested parameters than the plant system using alum.



Fig(39) Percentage rmoval of different algal groups after treatment with *M.oleifera* seeds at flow rate 0.1 L/sec

Where 1: Green Algae 2: Blue – Green Algal 3: Diatoms 4: Total Algal count

Table (8) Bacterial indicators in water from El-Giza water treatment and from thepilot system after treatment with *M.oleifera* at flow rate (0.10l/sec)

Sampling site	Total bacterial counts/ml at		MPN index/100 ml		
	22^0C	37^0C	T.C.	F.C.	F.S.
Raw water	$1.2X10^3$	$6X\ 10^2$	$1.1X\ 10^3$	$2.7X\ 10^2$	$1.3X\ 10^2$
Plant flocculator	$1.2X\ 10^2$	87	Nil	Nil	Nil
% Removal	90	85.5	100	100	100
Plant outlet	32	24	23	23	9
% Removal	97.3	96	97.9	91.5	93
Pilot flocculator	$1.6X10^4$	$9.3X10^3$	360	90	60
% Removal			78.2	66.7	53.6
Pilot roughing filter	$1.2X10^3$	$1.3X10^3$	240	90	26
% Removal	0		78.2	66.7	80
Pilot sand filter	$1.3X10^3$	$1.6X10^3$	160	34	35
% Removal			85.5	87.4	73

T.C. = Total coliforms F.C. = feacal coliforms F.S. = Faecal streptococci

Table (9) New indicators of pollution and pathogenic bacteria in water from El-Giza water treatment and from the pilot system after treatment with *M.oleifera* at flow rate (0.10L/sec)

Sampling site	New indicators of pollution/100ml			Pathogenic bacteria/100 ml		
	T.Yeast	*C.albicans*	T.Staph	Salmonellae	T.vibrio	*Listeria*
Raw water	$1.6X10^2$	12	$2.4X\ 10^3$	$6.4X\ 10^2$	$4X\ 10^2$	$3.6X\ 10^3$
Plant flocculator	35	30	54	Nil	$4\ X10^2$	$3\ X10^2$
% Removal	78		97.8	100	96	91.7
Plant outlet	64	43	15	4	16	42
% Removal	60		99.4	99.4	96	98.8
Pilot flocculator	$2.2\ X10^2$	18	66	24	60	80
% Removal			72.5	96.3	85	97.8
Pilot roughing filter	$1.3X10^2$	14	32	13	40	45
% Removal	18.8		98.7	98	90	98.8
Pilot sand filter	$1.2X10^2$	Nil	12	Nil	18	15
% Removal	25	100	99.5	100	95.5	99.6

II.A.3. Effect of *Moringa oleifera* dose on some physico –chemical characteristics of water

As a result obtained previously in (chapter 4), the addition of *Moringa oleifera* dose lead to slight increase in the concentration of both nitrate and phosphate, while it has a pronounced effect on the reduction of turbidity . The percentage reduction in turbidity of both flow rates used through the study are 56% and60 % (table10).

Table (10) Changes in some physico- chemical characters of water after treatment in semi- pilot system

Water physico-chemical characters	Raw water	Plant outlet	System outlet (0.1L/sec)	System outlet (0.15L/sec)
pH	7.8	7.3	7.3	7.35
Turbidity NTU	4.5	1.0	2.0	1.8
Turbidity percent removal		77.8	56	60
Phosphate mg P/l	0.1	0.1	0.14	0.14
Nitrate mg N/l	0.2	0.2	0.23	0.25

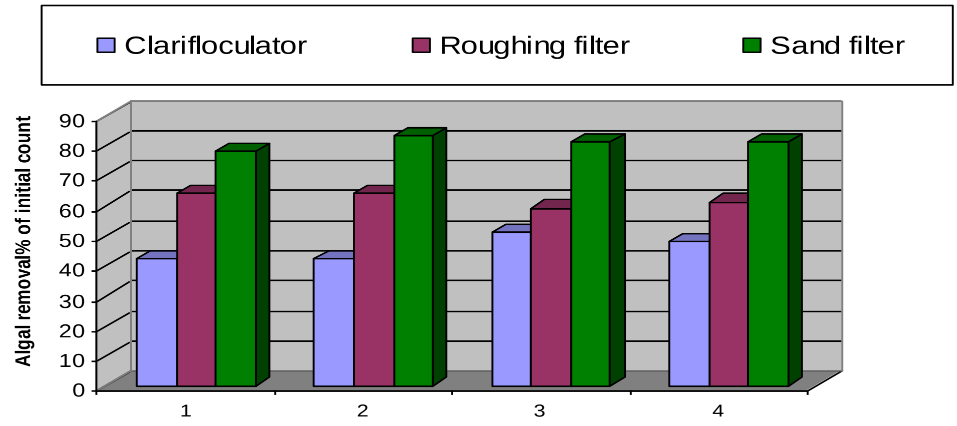
II.A.4. Chlorination

At the flow rate, 0.1L/sec the semi pilot system was conducted with prechlorination and postchlorination (disinfectant) treatment step. Figure (39) removing rate of different algal group revealed that percentage removal of total algal was 62%, 76% and 90% at the different treatment step, successively.

From the data obtained from the semi pilot system (table11), it is clear that the semi – pilot system could reduce the initial count of total bacterial count by 41% while 93% in the flocculated water in the water plant. The feacal bacteria were reduced in the water plant with higher rate than in the semi- pilot system.

The addition of chlorine as postchlorination (disinfectant) was conducted at two different contact times (30 and 60 min) and at two chlorine doses (0.5 & 1.0 mg/I Cl^-). Figure (40) shows the results of post-chlorination which indicated that the removing rate of green and blue-green algae was highly affected by the contact time and chlorine dose. On contrary, postchlorination had no effect on the removing rate of diatoms group. So, there is no clear variation in the removing rate of total algal count due to the change in contact time and chlorine dose.

Regarding to the effect of chlorine addition by using different doses and different contact time on classical, new indicators and selected pathogenic bacteria (Tables 12 and 13). The data in Table 12 shows that 0.5 mg/1 chlorine at 30 min more effective for removal of classical bacterial indicators than 0.5 mg/1 chlorine at 1 hr. On the other hand, the same percentage of removals occurred by using 1 mg/1 chlorine at both times. To remove the residual bacteria in water at the semi-pilot system, other chlorine doses and contact time must be tested. Table 13 represents the data of new indicators of pollution (total yeast, C. *albicuns* and total staphylococcus*)* and selected pathogenic bacteria (salmonellae, total vibrio and *Listeria* group).



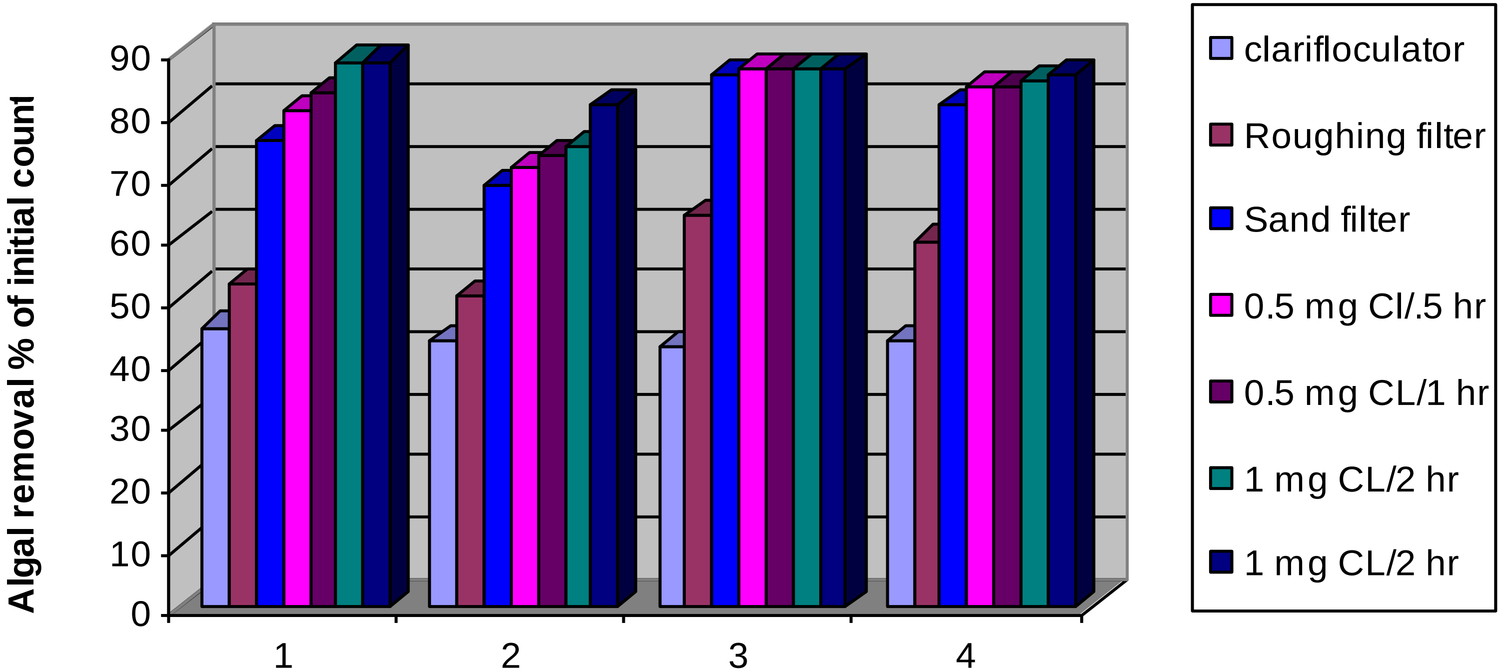
Fig(40) Percentage rmoval of different algal groups after treatment with *M.oleifera* seeds at flow rate 0.1 L/sec and prechlorination

Where 1: Green Algae 2: Blue – Green Algal 3: Diatoms 4: Total Algal count

Table (11) Bacterial indicators in water from El-Giza water treatment and from the pilot system after treatment with *M.oleifera* at flow rate (0.10L/sec) with prechlorination

Sampling site	Total bacterial counts/ml at		MPN index/100 ml		
	22^0C	37^0C	T.C.	F.C.	F.S.
Raw water	$6.4X10^3$	$5.6X\ 10^3$	200	90	200
Plant flocculator	$3.9X\ 10^2$	$3.3X10^2$	Nil	Nil	Nil
% Removal	93.9	94.1	100	100	100
Plant outlet	67	67	Nil	Nil	Nil
% Removal	99	98.8	100	100	100
Pilot flocculator	$1.3X10^3$	$3.3X10^3$	260	90	40
% Removal	79.7	41.1		0	80
Pilot roughing filter	$1.4X10^3$	$1.8X10^3$	110	90	40
% Removal	78.1	67.9	45	0	80
Pilot sand filter	$2.2X10^3$	$2.1X10^3$	100	60	2
% Removal	65.6	62.5	50	33.3	99

T.C. = Total coliforms F.C. = feacal coliforms F.S. = Faecal streptococci



Fig(41)Percentage removal of different algal group after treatment with Moringa oleifera seeds at flow rate 0.1 l/sec and postchlorination

Where 1: Green Algae 2: Blue – Green Algal 3: Diatoms 4: Total Algal count

Table (12) Bacterial indicators in water from El-Giza water treatment and from the pilot system after treatment with *M.oleifera* at flow rate (0.10L/sec) with postchlorination

Sampling site	Total bacterial counts/ml at		MPN index/100 ml		
	22^0C	37^0C	T.C.	F.C.	F.S.
Raw water	$1.4X10^4$	$1.2X\ 10^4$	$1.1X\ 10^3$	$3.0X\ 10^2$	$3.0X\ 10^2$
Plant flocculator	$1.8X\ 10^4$	$2.8X10^4$	$2.1X10^2$	80	80
% Removal			80.9	73.3	73.3
Plant roughing filter	$5.2X\ 10^4$	$5.1X10^4$	$2.6X10^2$	80	30
% Removal			76.4	73.3	90
Pilot sand filter	$6.1X10^4$	$5.5X10^4$	$2.8X10^2$	80	30
% Removal			74.5	73	90
0.5 mg CL,30 min	$2.9X10^3$	$2.9X10^3$	23	23	23
% Removal	79.3	75.8	97.9	92.3	92.3
0.5 mg CL, 1 hr	$1.1X10^4$	$4.2X10^3$	23	12	23
% Removal	21.4	65	97.9	96	92.3
1 mg CL,30 min	$1.3X10^3$	$1.2X10^3$	23	12	23
% Removal	90.7	90	97.9	96	92.3
1 mg CL, 1 hr	$1.4X10^3$	$1.1X10^3$	23	12	23
% Removal	90	90.8	97.9	96	92.3

T.C. = Total coliforms F.C. = feacal coliforms F.S. = Faecal streptococci

Table (13) Effect of postchlorination on new indicators of pollution and pathogenic bacteria in water from El-Giza water treatment and from the pilot system after treatment with *M.oleifera* at flow rate (0.10L/sec)

Sampling site	New indicators of pollution/100ml			Pathogenic bacteria/100 ml		
	T.Yeast	*C.albicans*	T.Staph	Salmonellae	T.vibrio	*Listeria*
Raw water	$1.6X10^2$	12	$2.4X\ 10^3$	$6.4X\ 10^2$	$4X\ 10^2$	$3.6X\ 10^3$
Plant flocculator	$2.6X10^3$	30	$2.6X\ 10^3$	$5.0X\ 10^2$	$2.8\ X10^2$	$3.8\ X10^3$
% Removal				21.9	30	
Plant roughing filter	$4.1X10^3$	66	$2.8X\ 10^3$	$4.0X\ 10^2$	$3.1X\ 10^2$	$4.0X\ 10^3$
% Removal				37.5	22.5	
Pilot sand filter	$2.2\ X10^3$	36	$1.4X\ 10^3$	$2.2X\ 10^2$	$1.1X\ 10^2$	$2.3X\ 10^2$
% Removal			41.7	65.6	72.5	93.6
0.5 mg CL,30 min	43	17	22	13	34	52
% Removal	73.1		99.1	98	91.5	98.6
0.5 mg CL, 1 hr	76	28	41	Nil	42	35
% Removal	52.5		98.3	100	89.5	99
1 mg CL,30 min	58	32	56	12	36	22
% Removal	63.8		97.7	98.1	91	99.4
1 mg CL, 1 hr	63	25	17	15	28	14
% Removal	60.6		99.3	99.8	93	99.6

From the obtained results, it can be concluded that C. *albicans* more resistant parameter for chlorine doses and total staphylococcus, salmonellae and *Listeria* group more sensitive than others. Data from this experiment reported in Tables 12 and 13 show that the pilot system and chlorine doses reduce only the initial count for each parameter without complete removing.

II.A.5. *Moringa* crushed seeds on top of the sand filter

The use of *Moringa oleifera* crushed seed beds as disinfectant agent. The present part was carried out to evaluate *Moringa oleifera* crushed seed beds as disinfectant agent , crushed *Moringa* seeds were used as abed layer on the top or below the sand layers in the sand filter , at the flow rate $120m^3/ m^2$/day.

II.A.5.a. Percentage Algae Removal

The microscopical examination and the algal count for River Nile water showed that it characterized by the presence of main three groups are: diatoms, green and blue-green algae. The results showed that diatoms are the most dominant algal group (62 %) followed by the green group (23%), while the blue-green group is the lowest group (15%). The percentage removal of those algal groups is ranged from 52-72%, 48-59% for diatoms, green and blue-green algae respectively, after treating the River Nile water with alum inside the clariflocculator of the water treated plant. Fig (41).

The results showed that placement of crushed seeds of *M. oleifera* layer on the top of sand filter showed height efficiency in the removal of different algal group more than that obtain in sand filter without crushed *M. oleifera* seeds (control). In addition, the percentage removals of different algal group after 1 hr are 97%, 93% and 81%. For green, diatoms and blue-green algae group, respectively. Moreover the results declare that, estimating the operating time led to the height efficiency of the filter system which containing the *M. oleifera* seeds layer. The percentage removal of blue-green algae group after 6 and 24 hrs reached to 81%, 95% and 95%, respectively. Also, the percentage removals of the diatoms group along the operating time are 93, 96 and 96% respectively. So the total percentage removal of the algal group along the operating time are 92%,96% and 96%, while the total percentage removal in the control filter are 85%,89% and 85% for operating time 1 hr, 6 hrs and 24 hrs , respectively. Fig (42).

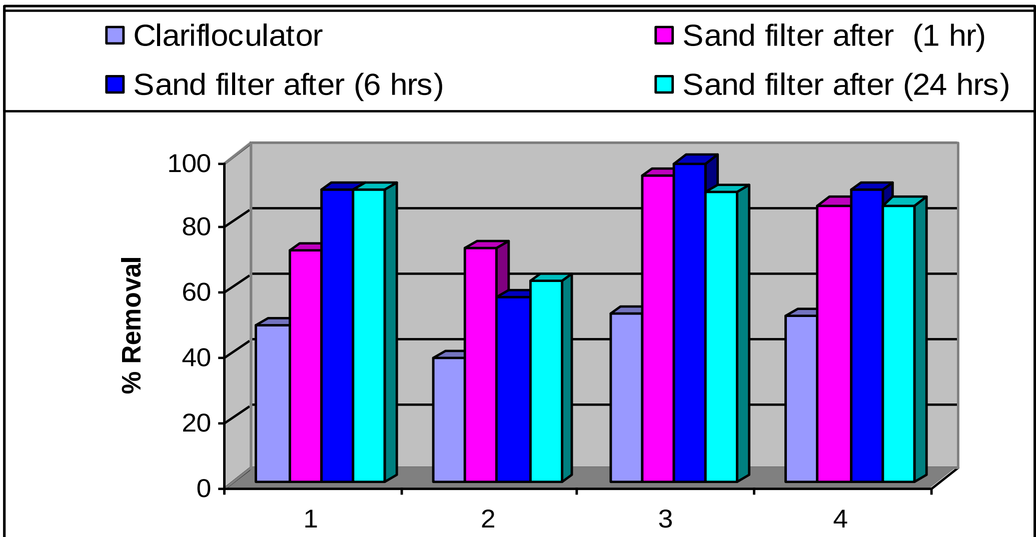


Fig (42) Percentage removal of different algal groubs after passing through clarifloculator and sand filter(without *M.oleifera)*

Where 1: Green Algae 2: Blue – Green Algal 3: Diatoms 4: Total Algal

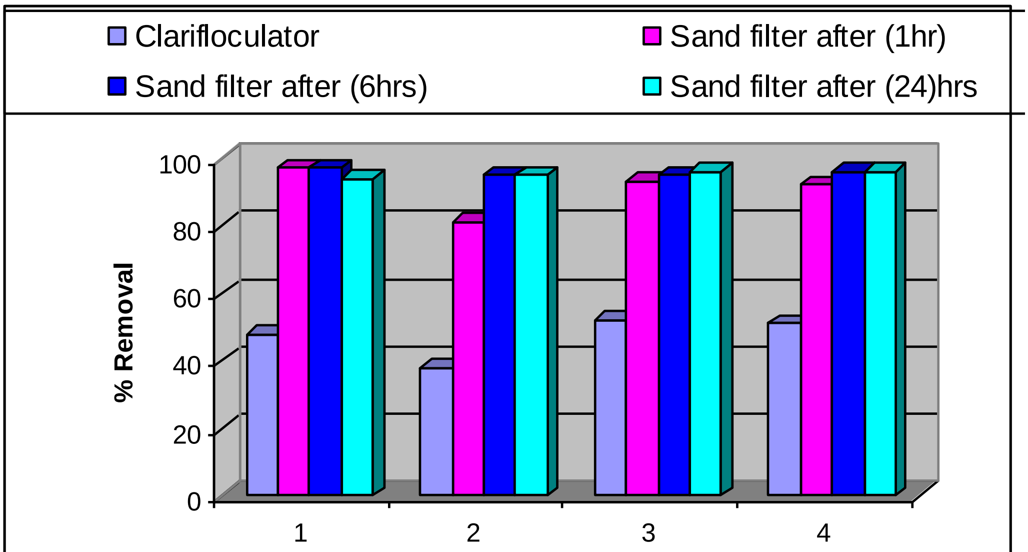


Fig (43) Percentage removal of different algal groubs after passing through clarifloculator and sand filter(with *M.oleifera* as upper layer)

Where 1: Green Algae 2: Blue – Green Algal 3: Diatoms 4: Total Algal

II.A.5.b. Percentage Bacterial Removal

Classical bacterial indicators

Table (14), represents the efficiency of sand filter without *Moringa* as a control for removal of classical bacterial indicators. Results of classical bacterial indicators indicated that the density of total bacterial counts from raw Nile water were 1.6×10^4 and 7.5×10^4 CFU/1 ml at 22º C and 37º C , respectively. Where, the density of faecal bacterial indicators (total coliforms, faecal coliforms and faecal streptococci) were 1.1×10^4, 2.1×10^2 and 4.6 ×103 MPN/100ml respectively. After coagulation and sedimentation step faecal bacterial indicators were completely removed but the residual density of total bacterial counts were 2.0×10^2 and 5.0×10^3 CFU/ 1 ml at 22 and 37º C , respectively. On the other hand, after sand filter the water is free from faecal bacterial indicators after operation time 1, 6 and 24 hours, while, the densities of total bacterial counts at 22 and 37º C were reduced to less than 100 CFU / 1 ml.

To achieve the goals of this study, another experimental work is conducted by using the bed of crushed *Moringa seeds* up sand layer (Table 15) Results indicated that, water samples were free from faecal bacterial indicators after sand filter at different times, while total bacterial counts were slightly reduced with the same power after different time intervals. This may be due that, when *Moringa oleifera* added with sand filter help to encourage some bacterial strain.

Table (14) Counts of classical bacterial indicators for raw water, after clarification and after sand filter without *Moringa* (control).

Sampling site	Total bacterial counts/ml at		MPN index/100 ml		
	22^0C	37^0C	T.C.	F.C.	F.S.
Raw water	$1.6X10^4$	$7.5X\ 10^4$	$1.1X\ 10^4$	$2.1X\ 10^2$	$4.6X\ 10^3$
After clarification	$2.0X10^2$	$5.0X10^2$	ND	ND	ND
% Removal	99.7	96.9			
After sand filter (1 hr)	$2.8X10^4$	9.0X10	ND	ND	ND
% Removal	86	82			
After sand filter (6 hrs)	2.3X10	6.2X10	ND	ND	ND
% Removal	88.5	87.6			
After sand filter (24hrs)	1.6X10	1.6X10	ND	ND	ND
% Removal	92	96.8			

T.C. = Total coliforms F.C. = feacal coliforms F.S. = Faecal streptococci

Table (15) Counts of classical bacterial indicators for raw water, after clarification and after sand filter with *Moringa*.

Sampling site	Total bacterial counts/ml at		MPN index/100 ml		
	22^0C	37^0C	T.C.	F.C.	F.S.
Raw water	$1.6X10^4$	$7.5X\ 10^4$	$1.1X\ 10^4$	$2.1X\ 10^2$	$4.6X\ 10^3$
After clarification	$6.0X10^2$	$5.0X10^2$	ND	ND	ND
% Removal	99.7	96.9			
After sand filter (1 hr)	$4.9X10^2$	$4.0X10^2$	ND	ND	ND
% Removal	18	20			
After sand filter (6 hrs)	$4.0X10^2$	$3.3X10^2$	ND	ND	ND
% Removal	33.3	34			
After sand filter (24hrs)	$2.8X10^2$	$2.5X10^2$	ND	ND	ND
% Removal	53.3	50			

T.C. = Total coliforms   F.C. = feacal coliforms   F.S. = Faecal streptococci

New indicators of pollution and some pathogenic bacteria

Results of control filter in Table (16) showed that counts of new indicators of pollution (total yeast, *Candida albicans*, *Aeromonas hydrophila* and total staphylococci) for raw water were 9.4×10^3, 1.4×10^2, 5.8×10^3 and 1.6×10^3 CFU/100 ml respectively .On the other hand, counts after clarification step were 18, 38 and 4 CFU/100 ml for total yeast, *Aeromonas hydrophila* and total staphylococci respectively, were *C.albicans* was not detected. When sand filter without *Moringa* were operated for one hour counts of previous parameters were reduce to 9, 19 and 2 CFU/100 ml respectively. After 6 hours, counts of total yeast, *Aeromonas hydrophila* and total staphylococci were removed by 75, 71 and 100% respectively. After operating sand filter for 24 hours the removal values reached 88.9 and 81.6% for total yeast and *Aeromonas hydrophila* respectively, where the other pollution indicators were completely removed (Table 16).

With regard to pathogenic bacteria, results indicated that, the density of salmonellae, total vibrios and *Listeria* group in raw Nile water were 3.8×10^2, 35 and 4.8×10^2 CFU/100 ml respectively. After clarification step removal value reached 77.6, 91.4 and 98.3% for pathogenic bacteria respectively. The efficiency of sand filter for removing these parameters, after operation for one, sex and 24 hours showed different effects. Where total vibrios and *Listeria* group were removed after sex hours, salmonellae were removed after 24 hours (Table 16).

Results of sand filter using the bed of crushed *Moringa* seeds up sand filter, showed that addition of *Moringa* seeds help to encourage some bacterial strain for multiplication. So, the reduction values for new indicators after clarification step were reduced after operating sand filter for one hour. Where, after sex hours the reduction values were slightly increased for total yeast, *Candida albicans*, *Aeromonas hydrophila* and pathogenic bacteria, but total staphylococci were completely removed after sex and 24 hours continuously (Table 17).

Table (16) Counts of new indicators and pathogenic bacteria for raw water, after clarification and after sand filter without *Moringa oleifera*

Sampling site	New indicators of pollution/100ml				Pathogenic bacteria/100 ml		
	T.Yeast	*C.albicans*	*A.hydrophila*	T.Staph	Salmonellae	T.vibrio	*Listeria*
Raw water	$9.4X10^3$	$1.4X10^2$	$5.8X10^3$	$1.6X\ 10^3$	$3.8X\ 10^2$	35	$4.8X\ 10^2$
After clarification	18	ND	38	4	85	3	8
% Removal	99.8	100	99.3	99.7	77.6	91.4	98.3
After sand filter (1 hr)	9	ND	19	2	23	1	2
% Removal	50	100	50	50	72	66.7	75
After sand filter (6 hrs)	6	ND	11	ND	6	ND	ND
% Removal	75	100	71	100	92.9	100	100
After sand filter (24 hrs)	2	ND	7	ND	ND	ND	ND
% Removal	88.9	100	81.6	100	100	100	100

Table (17) Counts of new indicators and pathogenic bacteria for raw water, after clarification and after sand filter with *Moringa oleifera*

Sampling site	New indicators of pollution/100ml				Pathogenic bacteria/100 ml		
	T.Yeast	*C.albicans*	*A.hydrophila*	T.Staph	Salmonellae	T.vibrio	*Listeria*
Raw water	$9.4X10^3$	$1.4X10^2$	$5.8X10^3$	$1.6X\ 10^3$	$3.8X\ 10^2$	35	$4.8X\ 10^2$
After clarification	18	ND	38	4	85	3	8
% Removal	99.8	100	99.3	99.7	77.6	91.4	98.3
After sand filter (1 hr)	12	ND	29	4	58	1	6
% Removal	33.3	100	23.7	zero	31.8	66.7	25
After sand filter (6 hrs)	1	ND	16	ND	37	ND	3
% Removal	41.7	100	57.9	100	56.4	100	62.5
After sand filter (24 hrs)	5	ND	12	ND	12	ND	1
% Removal	72.2	100	68.4	100	85.9	100	87.5

II.A.6. *Moringa* crushed seeds as a layer below the sand filter

II.A.6. a. Percentage Algal Removal

The results of this run showed that the presence of *Moringa* crushed seeds layer below the sand layer led to increase the operating time. Since in case of *Moringa* crushed seeds on the top of sand filter, the filter calking after 24 hr had been done , while in case of *Moringa* crushed seeds as down layer, the filter continue to run in highest efficiency for more than 48 hr. The percentage removal of different algal group (fig 43 & 44) at 1 hr, 6 hr, 24hr and 48hr operating time are 93%, 93% , 96% and 96% for green algal group 69%, 96%, 87% and 94% for blue-green algal group while it reached to 92%, 94%, 97% and 97% for diatoms group respectively .From the above mentioned data. It can be concluded that the position of *Moringa* layer inside the filter have very important role in the efficiency of the system increasing. Crushed *Moringa* seeds as down filter are better than when present as upper layer on the sand filter.

II.A. 6. b. Percentage Bacterial Removal

Classical bacterial indicators

Results in Table (18) indicated that, coagulation and sedimentation step resulted complete removal of faecal bacterial indicators, but the reduction values of total bacterial counts were 97.2 and 96.3% at 22 and 37º C , respectively. While the percentage removal after filtration with sand filter after operation time one, sex , 24 and 48 hours were 54 , 44.4 ; 60 , 71.1; 83.9 , 92.8 and 94.5 , 94.4% for total bacterial counts at 22 and 37º C , respectively. And, water which produced after 48 hours filtration was acceptable for drinking according to the Egyptian standard **(Egyptian standard 1995).**

Result of sand filter using the bed of crushed *Moringa* seeds below sand filter (lower layer) table (19), showed that reduction values of total bacterial counts were reduced compared to control filter after one, sex 24 and 48 hours, where reached to 68.9 and 66.7% at 22 and 37º C , after 48 hours respectively. Water after treatment with crushed *Moringa* seeds was not acceptable for drinking, where the density of total bacterial counts exceed the standards.

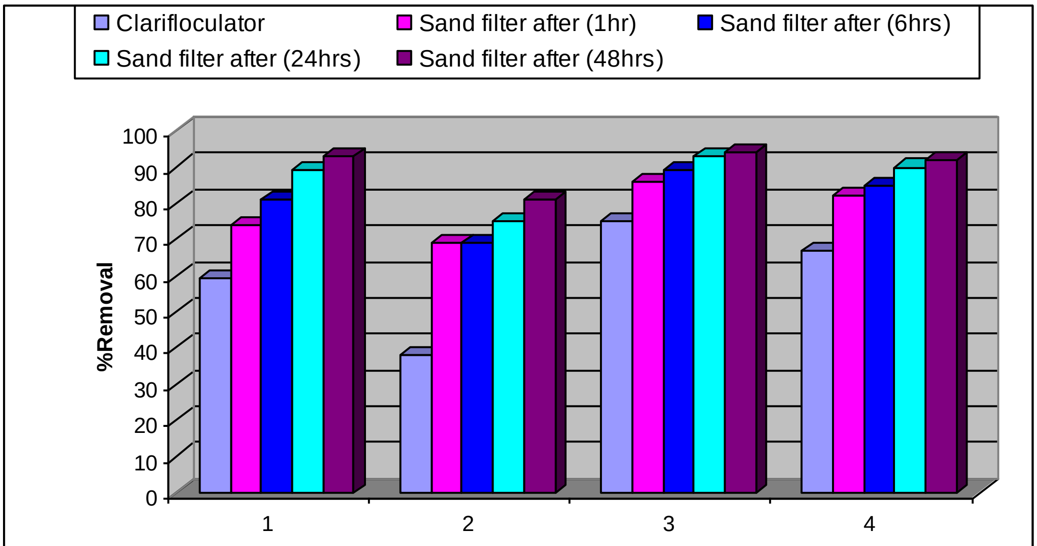


Fig (44) Percent removal of different algal group after passing through sand filter without *M.oleifera* crushed seeds

Where 1: Green Algae 2: Blue – Green Algal 3: Diatoms 4: Total Algal

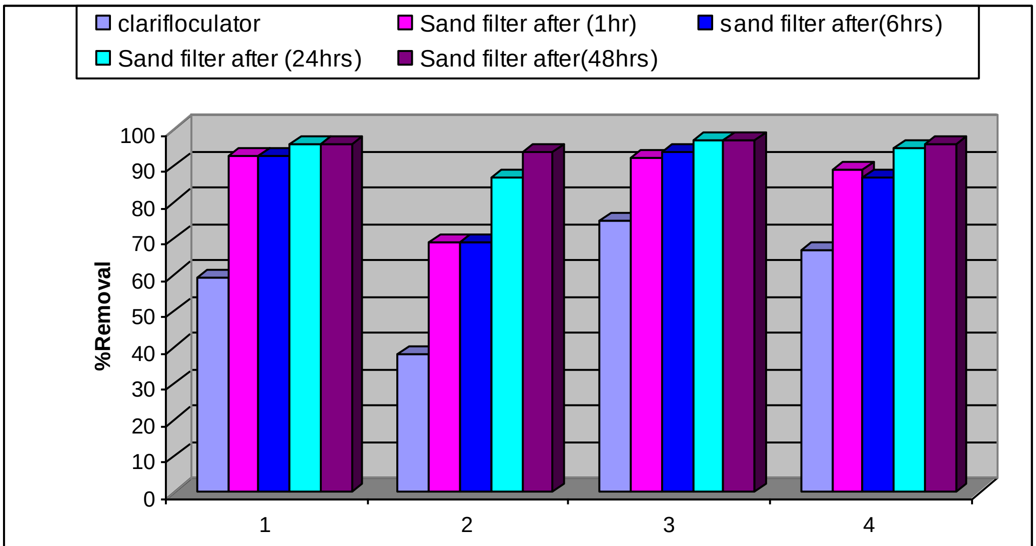


Fig (45) Percent removal of different algal group after passing through sand filter with *M.oleifera* as down layer

Where 1: Green Algae 2: Blue – Green Algal 3: Diatoms 4: Total Algal

Table (18) Counts of bacterial indicators for raw water, after clarification and after sand filter without *Moringa* (control).

Sampling site	Total bacterial counts/ml at		MPN index/100 ml		
	22^0C	37^0C	T.C.	F.C.	F.S.
Raw water	$2.2X10^4$	$1.2X\ 10^4$	$1.1X\ 10^4$	$2.3X\ 10^2$	9.0X 10
After clarification	$6.1X10^2$	$4.5X10^2$	ND	ND	ND
% Removal	97.2	96.3			
After sand filter (1 hr)	$2.8X10^2$	$2.5X10^2$	ND	ND	ND
% Removal	54	44.4			
After sand filter (6 hrs)	$2.4X10^2$	$1.3X10^2$	ND	ND	ND
% Removal	60.7	71.1			
After sand filter (24hrs)	9.8X10	3.2X10	ND	ND	ND
% Removal	83.9	92.8			
After sand filter (48hrs)	3.3X10	2.5X10	ND	ND	ND
% Removal	94.5	94.4			

Table (19) Counts of classical bacterial indicators for raw water, after clarification and after sand filter with *Moringa*.

Sampling site	Total bacterial counts/ml at		MPN index/100 ml		
	22^0C	37^0C	T.C.	F.C.	F.S.
Raw water	$2.2X10^4$	$1.2X\ 10^4$	$1.1X\ 10^4$	$2.3X\ 10^2$	9.0X 10
After clarification	$6.1X10^2$	$4.5X10^2$	ND	ND	ND
% Removal	97.2	96.3			
After sand filter (1 hr)	$4.4X10^2$	$3.5X10^2$	ND	ND	ND
% Removal	27.9	22.2			
After sand filter (6 hrs)	$3.9X10^2$	$2.8X10^2$	ND	ND	ND
% Removal	36	37.8			
After sand filter (24hrs)	$3.0X10^2$	$2.2X10^2$	ND	ND	ND
% Removal	50.8	51			
After sand filter (48hrs)	$1.9X10^2$	$1.5X10^2$	ND	ND	ND
% Removal	68.9	66.7			

New indicators of pollution and some pathogenic bacteria

This experiment was carried out with sand filter without *Moringa* as a control. Results indicated that *Candida albicans* was completely remover after clarification step, when sand filter operated for one hour the percent of new indicators removal was 18.3, 27.3 and 30.4% for total yeast, *Aeromonas hydrophila* and total staphylococci, respectively. After operation for sex hours, counts of previous parameter were decreased by 33.8, 45.5 and 55.4% respectively. On operating sand filter for 24 hours the removal rate reached 67.6 and 56.4 and 85.7% for the previous parameter respectively. While after 48 hours total yeast and total staphylococci were completely eliminated, but the reduction of *Aeromonas hydrophila* reached 89.1%, table (20).

After the operation of sand filter with *Moringa*, for 48 hours total yeast and *Aeromonas hydrophila* will still present where total staphylococci were removed completely. Pathogenic bacteria were determined through this experiment results indicated that sand filter without *Moringa* reduce the density of salmonellae, total vibrios and *Listeria* group to 43.7,100 and 51.8% after one hour, respectively. While after 24 hours, salmonellae and total vibrios were completely removed, *Listeria* groups were removed after 48 hours, On the other hand, sand filter with *Moringa* (lower layer) reduce the density of pathogenic bacteria to 31.3,100 and 23.5% after one hour while total vibrios completely removed, *Listeria* groups were removed after 24 and 48 hours respectively ,Table (21).

Although, the reduction value of the previous parameters were reduced with *Moringa* if compared with control sand filter. This may be due to, the time need for sand filter maturation to retain these microorganisms or may be due to the inhibitory effects of materials in crushed *Morgina* seeds, or due to the inhibitory efforts presents in down filter case, but it was loosed through sand filter in up case.

From the obtained results it is clear that, the semi- pilot plant after treatment with crushed seeds of *M.oleifera* on top or below sand filter (at flow rate (0.15 L/Sec.) help to encourage some bacteria strains and produced water not acceptable for drinking according to the Egyptian standard **(Egyptian standard 1995) .**

In order to over come this problem *M.oleifera* seeds may be used in conjunction with small dose of chlorine, or changing operating parameters like rate and time .May be the change in flow rate and contact time will produce better water .

Table (20) Counts of new indicators and pathogenic bacteria for raw water, after clarification and after sand filter without *Moringa*

Sampling site	New indicators of pollution/100ml				Pathogenic bacteria/100 ml		
	T.Yeast	*C.albicans*	*A.hydrophila*	T.Staph	Salmonellae	T.vibrio	*Listeria*
Raw water	$8.2X10^{2}$	$6.1X10^{2}$	$5.4X10^{3}$	$4.5X\ 10^{2}$	$1.5\ X\ 10^{2}$	$2.9\ X\ 10^{2}$	$4.8X\ 10^{2}$
After clarification	96	ND	$3.2\ X10^{2}$	$1.0\ X10^{2}$	16	2	$1.7X\ 10^{2}$
% Removal	88.3	100	94.1	77.8	89.3	99.3	64.6
After sand filter (1 hr)	72	ND	$2.6\ X10^{2}$	78	11	ND	$1.3X\ 10^{2}$
% Removal	25	100	18.8	22	31.3	100	23.5
After sand filter (6 hrs)	65	ND	$1.4\ X10^{2}$	58	6	ND	94
% Removal	32.3	100	56.3	42	62.5	100	44.7
After sand filter (24 hrs)	41	ND	87	25	ND	ND	45
% Removal	57.3	100	72.8	75	100	100	73.5
After sand filter (48hrs)	10	ND	13	ND	ND	ND	ND
% Removal	89.6	100	95.9	100	100	100	100

Table (21) Counts of new indicators and pathogenic bacteria for raw water, after clarification and after sand filter with *Moringa*

Sampling site	New indicators of pollution/100ml				Pathogenic bacteria/100 ml		
	T.Yeast	*C.albicans*	*A.hydrophila*	T.Staph	Salmonellae	T.vibrio	*Listeria*
Raw water	$8.2X10^{2}$	$6.1X10^{2}$	$5.4X10^{3}$	$4.5X\ 10^{2}$	$1.5\ X\ 10^{2}$	$2.9\ X\ 10^{2}$	$4.8X\ 10^{2}$
After clarification	71	ND	$1.1\ X10^{2}$	56	16	2	$1.7X\ 10^{2}$
% Removal	91.1	100	97.9	87.5	89.3	99.3	64.6
After sand filter (1 hr)	58	ND	80	39	9	ND	$1.1X\ 10^{2}$
% Removal	18.3	100	27.3	30.4	43.7	100	35.3
After sand filter (6 hrs)	47	ND	60	25	4	ND	82
% Removal	33.8	100	45.5	55.4	75	100	51.8
After sand filter (24 hrs)	23	ND	48	8	ND	ND	38
% Removal	67.6	100	56.4	85.7	100	100	77.6
After sand filter (48hrs)	ND	ND	12	ND	ND	ND	ND
% Removal	100	100	89.1	100	100	100	100

II.B. *Mangifera indica* seeds water extract

The following part of results cover the information obtained from using the optimum dose of *Mangifera indica* for testing its efficiency in removing pollutants from water in a continuous flow system. Hence, the optimum dose 30mg/l water seed extract of *Mangifera indica* was conducted in the semi –pilot system at continuous flow rate of 0.15 and 0.1 l/sec.

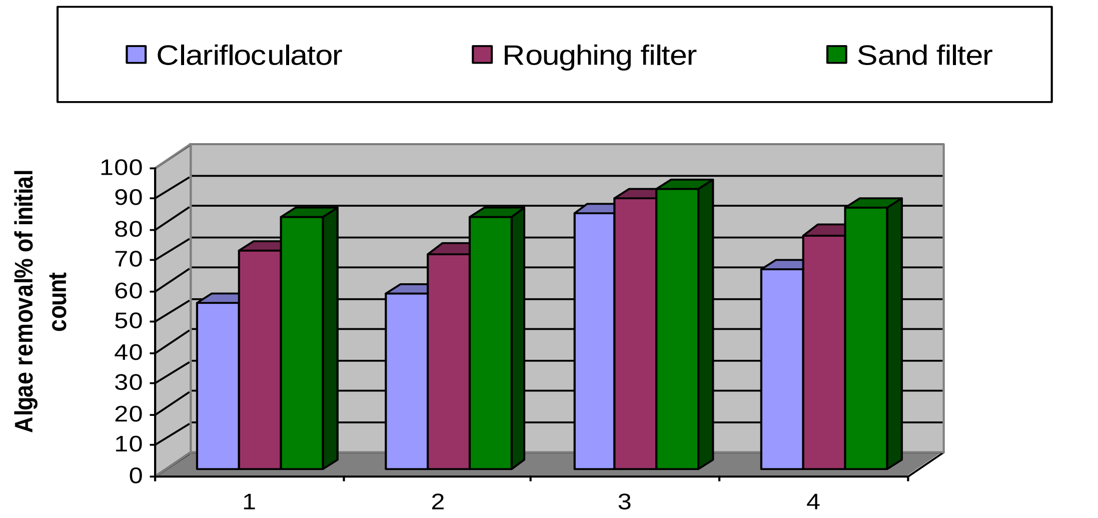
II.B.1. Semi –pilot scale runs at rate 0.15 L/sec.

II.B.1. a. Efficiency of *M. indica* seed extract in removing algae

Fig. (45) showed the results obtained from Nile water algal treatment using the optimal dose of *Mangifera indica* water seed extract (30 mg/l) and 2hrs sedimentation time at flow rate 0.15l/sec. The removal rate of different algal groups as well as total algal count are 54%, 57%, 83% and 65% for green, blue green, diatoms and total algal count respectively. The removal rate increased in the different treatment steps, where it reached to 71%, 70%, 88% and 76% after roughing filter and 82%, 82%, 91% and 85% after sand filter for the same algal group. It is very important to note that the produced water have a greenish color, although the high rate of percentage removal of different algal group.

II.B.1. b. Efficiency of *M. Indica* seeds extract in removing bacterial indicators.

Table (22) shows that the data of coagulation using *Mangifera indica* (30 mg/l) increase the density of total bacterial counts and bacterial indicators. This may be due to the nutrient material in the plant extract, where we use the crude water extract in the coagulation. From the same table after roughing filter, a small reduction in the counts of tested parameters were recorded and ranged from 60.46 to 95.61%. By application of sand filter in this system, the outlet of roughing filter goes to the sand filter. From the data and results recorded in table (22) one can observe that sand filter step is the best in remove the bacterial parameters. Where, the removal percentage reaches about 96%.



Fig(3) Percentage removal of different algae groups after treatment with *M.indca* seeds at flow rate 0.15 l/sec

Where 1: Green Algae 2: Blue – Green Algal 3: Diatoms 4: Total Algal count

Table (22) Bacterial indicators in water from El-Giza water treatment and the pilot system after treatment with *M.indica.*

Sampling site	Total bacterial counts/ml at		MPN index/100 ml		
	22^0C	37^0C	T.C.	F.C.	F.S.
Raw water	$2.4X10^5$	$2.1X\ 10^5$	$5.0X\ 10^3$	ND	$1.3X10^2$
Plant outlet	$2.3X10^2$	$2.2X10^2$	20	ND	ND
% Removal	99.9	98.89	99.6		100
Pilot flocculator	$4.0X10^5$	$4.2X10^5$	$8.6X10^3$	ND	$1.3X10^3$
% Removal	—	—	—		—
Pilot roughing filter	$1.0X10^5$	$9.8X10^4$	$3.4X10^3$	ND	57
% Removal	75	76.66	60.46		95.61
Pilot sand filter	$6.5X10^3$	$9.1X10^3$	1.2X102	ND	57
% Removal	93.5	94.57	96.47		—

T.C. = Total coliforms F.C. = feacal coliforms F.S. = Faecal streptococci

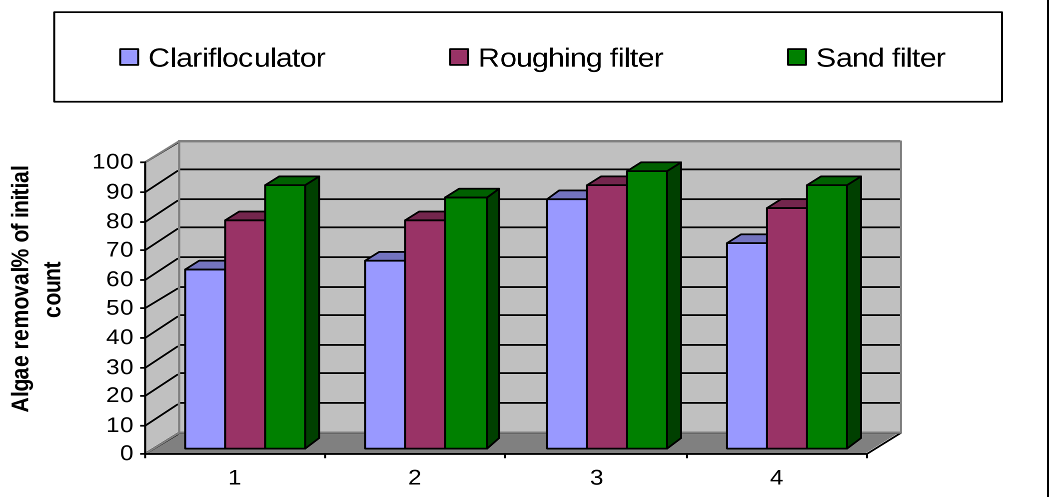
II.B. 2. Semi –pilot scale runs at flow rate 0.1 l/sec.

II. B. 2. a. Efficiency of *Mangifera indica* in removing algae

As the pilot system operated at flow rate 0.1 l/sec, the obtained results revealed that the removal rate of different algal groups are more efficient than at the flow rate 0.15 l / sec. Figure (46) indicated the percentage removal of different algal groups as well as total algal count at different treatment steps of the pilot (clariflocculator, roughing filter and sand filter). Although that, the produced water have a greenish color**.**

II. B. 2. b. Efficiency of *M. Indica* seeds extract in removing bacterial indicators

Table (23) represents the data of 0.1l/sec flow rate and 30 mg/l coagulation dose of *Mangifera indica*. From this table it is clear that raw water has low count for the tested parameter, in addition to, the coagulations step reduce the counts by (13-27%) of the initial count. This may be due to reduction in the flow rate and the characteristics of raw water inlet. By using gravel roughing filter after coagulation the data shows decrease in count and removal percentage ranged from 42.30 to 69.47%. After sand filter step, it was obvious that the highest reductions were recorded for the tested parameters, where reached 86% for total bacterial count and ranged between 31 to 68% for bacterial indicators.



Fig(6) Percentage removal of different algae groups after treatment with *M.indica* seeds at flow rate 0.1 l/sec

Where 1: Green Algae 2: Blue – Green Algal 3: Diatoms 4: Total Algal count

Table (23) Bacterial indicators in water from El-Giza water treatment and from the pilot system after treatment with *M.indica.*

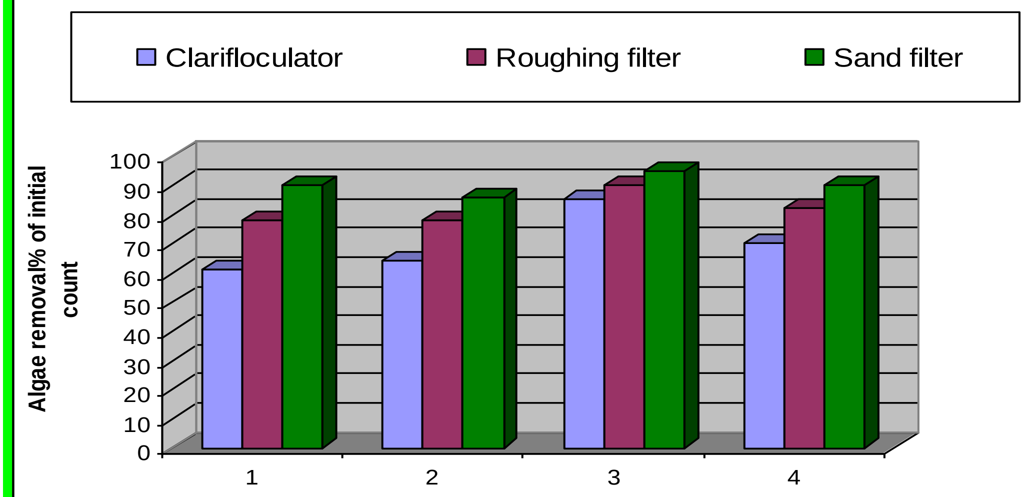
Sampling site	Total bacterial counts/ml at		MPN index/100 ml		
	22^0C	37^0C	T.C.	F.C.	F.S.
Raw water	$2.5X10^3$	$2.3X\ 10^3$	$2.2X\ 10^2$	$1.0X\ 10^2$	$2.3X\ 10^2$
Plant outlet	3	2	ND	ND	ND
% Removal	99.85	98.9	100	100	100
Pilot flocculator	$2.1X10^3$	$2.0X10^3$	$1.6X10^2$	78	$1.9X10^2$
% Removal	16	13	27	22	17
Pilot roughing filter	$1.1X10^3$	$1.0X10^3$	80	45	58
% Removal	47.61	50	50	42.3	69.47
Pilot sand filter	$1.5X10^2$	$1.6X10^2$	55	14	26
% Removal	86.36	84	31.25	68.88	55.17

T.C. = Total coliforms F.C. = feacal coliforms F.S. = Faecal streptococci

II.B.3. Efficiency of activated carbon in removing the color of *Mangifera indica*

The obtained results in this part of work indicated that, although *Mangifera indica* seeds water extract have a pronounced efficiency in removing pollutants from water but the produced water have a greenish color. Hence, granular activated carbon was used as a bed in the sand filter as a trail to improve the quality of the finished water.

Fig (47) and table (24) revealed that the presence of activated carbon bed improve the efficiency of sand filter in removing different algal groups as well as classical bacterial indicator more than that obtained in *Mangifera indica* at flow rate 0.1l/sec. In addition, unfortunately the produced water still has a greenish color but less than that without activated carbon bed. So, this problem needs extensive effort to find the best position and the best concentration of activated carbon to solve the problem of color due to the use of *Mangifera indica* water seeds extract in water treatment.



Fig(6) Percentage removal of different algae groups after treatment with *M.indica* seeds at flow rate 0.1 l/sec

Where 1: Green Algae 2: Blue – Green Algal 3: Diatoms 4: Total Algal count

Table (23) Bacterial indicators in water from El-Giza water treatment and from the pilot system after treatment with *Mangifera indica* and activated carbon at flow rate 0.1l/sec

Sampling site	Total bacterial counts/ml at		MPN index/100 ml		
	22^0C	37^0C	T.C.	F.C.	F.S.
Raw water	$1.5X10^4$	$1.6X\ 10^4$	$9X\ 10^4$	$2.2X\ 10^2$	$1.2X\ 10^2$
Plant outlet	$6.1X10^2$	$4.5X10^2$	ND	ND	ND
% Removal	97.2	96.3	100	100	100
Pilot flocculator	$2.3X10^3$	$2.7X10^3$	$1.5X10^4$	$1.2X10^2$	65
% Removal	84.66	83.1	83.33	45.45	45.83
Pilot roughing filter	28	9.0X10	$1.9X10^2$	41	28
% Removal	86	85	87.33	80.57	65
Pilot sand filter	16	16	16	15	11
% Removal	92	96.8	91.57	83.41	60.71

T.C. = Total coliforms F.C. = feacal coliforms F.S. = Faecal streptococci

II.C. *Prunus armeniaca* seeds water extract

The third part plant used through this investigation was the *Prunus armeniaca* (apricot) for evaluate its efficiency in removing pollutants from water. Also, the optimum dose 30mg/l water seed extract of *Prunus armeniaca* was conducted in the semi –pilot system at continuous flow rate of 0.15 and 0.1 l/sec.

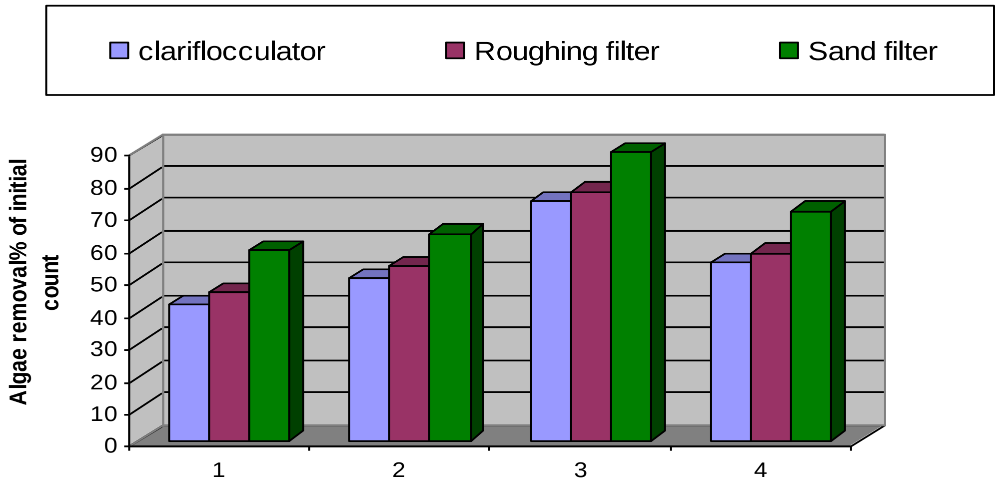
II.C.1. Semi –pilot scale runs at rate 0.15 L/sec.

II.C.1. a. Efficiency of *Prunus armeniaca* in removing algae

The optimal dose of Prunus armeniaca seed water extract (30 mg/l) was applied at flow rate 0.15 l/sec to test its efficiency for algal removal. Average results of different treatment steps in the pilot system showed a percentage algal removal increased as the treatment steps preceded. In addition, total algal count percentage removal were 55%, 59% and 71% for different treatment steps (clariflocculartor, roughing filter and sand filter, respectively (Fig. 48).

II.C.1. b. Efficiency of Prunus armeniaca seeds extract in removing bacterial indicators

Table (24) represents the results of water analysis for bacterial parameters in case of use *Prunus armeniaca* water extract at dose (30 mg/l) and flow rate (0.15 l/sec), from this table it was obvious that the coagulation step by the *Prunus armeniaca* was satisfactory, where the reduction reached percentage range from (31 to 90%) for all bacterial parameters. While, the roughing filter was less efficient in removal of bacteria. However, the removal percentage less than 75% from the initial count for bacterial parameters, expect in cases of total coliform reached 87.33%. In the last step (sand filter), the results in table (24) shows that total bacterial reduction reached 91% and faecal bacterial reduction reached 63%.



Fig(4) Percentage removal of different algal groups after treatment with Apricot seeds at flow rate 0.15 l/sec

Where 1: Green Algae   2: Blue – Green Algal   3: Diatoms   4: Total Algal count

Table (24) Bacterial indicators in water from El-Giza water treatment and the pilot system after treatment with *Prunus armeniaca*.

Sampling site	Total bacterial counts/ml at		MPN index/100 ml		
	22^0C	37^0C	T.C.	F.C.	F.S.
Raw water	$3.2X10^4$	$3.7X\ 10^4$	$8.2X\ 10^3$	$1.0X\ 10^2$	$8.0X\ 10^2$
Plant outlet	46	44	13	8	13
% Removal	99.85	99.88	99.83	92	98.37
Pilot flocculator	$1.1X10^4$	$1.1X10^4$	$1.5X10^3$	69	80
% Removal	65.62	70.27	81.25	31	90
Pilot roughing filter	$2.8X10^3$	$3.1X10^3$	$1.9X10^2$	41	28
% Removal	74.54	71.81	87.33	40.57	65
Pilot sand filter	$2.5X10^2$	$3X10^2$	16	15	11
% Removal	91.07	90.32	91.57	63.41	60.71

T.C. = Total coliforms   F.C. = feacal coliforms   F.S. = Faecal streptococci

II.C.2. Semi –pilot scale runs at rate 0.10 L/sec.

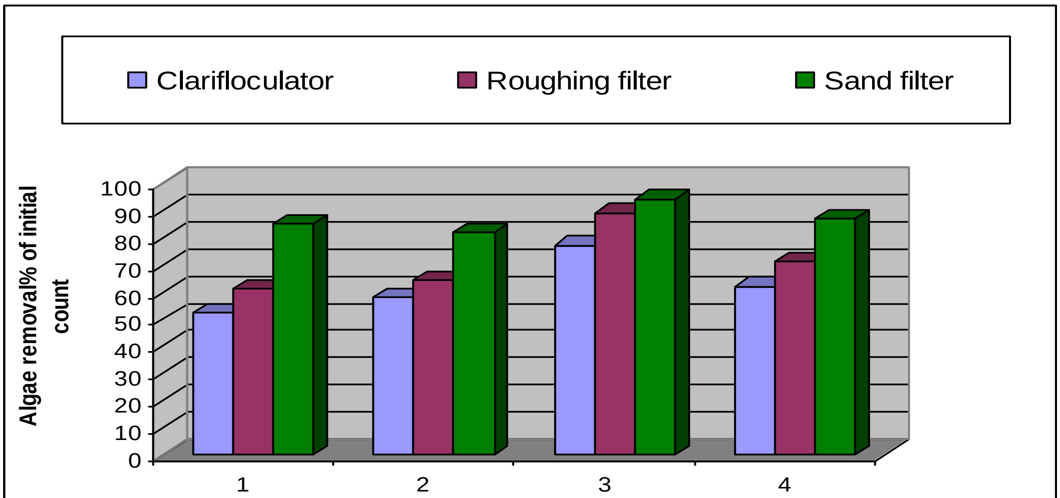
II.C.2. a. Efficiency of *Prunus armeniaca* seed extract in removing algae

The optimal dose of *Prunus armeniaca* seed water extract (30 mg/l) secured percentage removal to algal groups increase as different treatment steps proceed. Moreover, 30 mg /l *Prunus armeniaca* seed extract at flow rate 0.1l/sec showed efficiency removal to different algal species over than that obtained at flow rate 0.15 l/sec. In spite of the finished water (sand filter) contains high numbers of algal species from the three major algal groups, the percentage algal removal appear to be high which was 85%, 82% and 94% for green, blue- green algae and diatoms, respectively, (Fig .49).

II.C.2. b. Efficiency of *Prunus armeniaca* seeds extract in removing bacterial indicators

In case of using *Prunus armeniaca* seed water extract (30 mg/l and flow rate (0.1 l/sec), the results were recorded in table (25). From this table the coagulation step showed a reduction rate percentage reach 45.83, 53.33, 24.28, 33.75 and 93.84% for total bacterial count at 22 and 37^{o}C, total cofiom, faecal coliform and faecal strestococci respectively. While, the roughing filter step remove only about 25% for total bacterial count and remove about 75% for total and faecal colfiore as well as faecal streptococci. At the end of the experiment with sand filter, it was the best reduction recorded; wheare reached 52.38% for total bacterial count at 37^{o}C, 99.05% for total coliform and 93.57% for faecal coliform.

Moreover many authors confirmed the coagulation activity of several plants seeds extract which could be used as an alternative to chemicals for drinking water clarification. (Grunaratna *et al.*, 2008) found that red beans, sugar maize and red maize have coagulation activity. (Marina *et al.*, 2005) the seed extracts of some leguminiouses can be used as natural coagulants with previous determination of their optimum dose for successful clarification.



Fig(7) Percentage removal of different algal groups after treatment with Apricot seeds at flow rate 0.1 l/sec

Where 1: Green Algae 2: Blue – Green Algal 3: Diatoms 4: Total Algal count

Table (25) Bacterial indicators in water from El-Giza water treatment and from the pilot system after treatment with *Prunus armeniaca.*

Sampling site	Total bacterial counts/ml at		MPN index/100 ml		
	22^{0}C	37^{0}C	T.C.	F.C.	F.S.
Raw water	4.8X10^{4}	6.0X 10^{4}	7.0X 10^{3}	8.0X 10^{2}	2.6X 10^{3}
Plant outlet	90	80	23	4	2
% Removal	99.81	99.86	99.67	99.5	99.92
Pilot flocculator	2.6X10^{4}	2.8X10^{4}	5.3X10^{3}	5.3X10^{2}	1.6X10^{2}
% Removal	45.83	53.33	24.28	33.75	93.84
Pilot roughing filter	2.1X10^{4}	2.0X10^{4}	1.8X103	1.4X102	22
% Removal	19.23	25	66.03	73.58	86.25
Pilot sand filter	1.2X104	1.6X104	17	9	11
% Removal	42.85	52.38	99.05	93.57	50

T.C. = Total coliforms F.C. = feacal coliforms F.S. = Faecal streptococci

II.D.The use of *Prunus armeniaca* (apricot) as a coagulant aid

By using aluminum sulphates as a coagulant (25mg/l) and *Prunus armeniaca* water seeds extract (30mg/l) as a coagulant aid in the pilot system at both flow rates 0.15l/sec and 0.1l/sec.

The data recorded in Fig (50) and in table (26) revealed that the percentage removal of bacterial parameters and algal groups ranged between 73% up to 98.8% and 65% to 90% respectively, when the pilot system processed at flow rate 0.15l/sec. while after roughing filter the removal rate reached to 21-57.5%for bacterial parameters and 70 to 91% for different algal groups. The sand filter still to be the best step to remove the bacterial parameters. Where the bacterial count removal reached 91.66% and faecal bacterial indicators reached 100% of the out let of the roughing filter. Fig (50).