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Bioscience Research

Print ISSN: 1811-9506 Online ISSN: 2218-3973

Journal by Innovative Scientific Information & Services Network

RESEARCH ARTICLE BIOSCIENCE RESEARCH, 2019 16(4):3610-3628 OPEN ACCESS

Physiochemical and microalgal investigation of Nile River water and a comparison between seed extract of *Moringa oleifera* and aluminum sulfate in removing microalgae and turbidity from water

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Egypt has the Nile River, which is the main resource of drinking water. Nile water was examined in Bahr Shebin branch (in Shebin El-kom city). The physiochemical parameters determination and algal examination were performed on raw and treated Nile water in Shebin El-kom surface water plant. The results showed various phytoplankton structures belonging to five groups, namely, Bacillariophyta, Chlorophyta, Cyanophycta, Pyrrophyta and Euglenophyta. Bacillariophyta represent the most abundant group during the period of investigation as it accounted 64.9 % of total annual crop. Chlorophyta ranked as the 2nd group with 24.3 % of the total annual crop then followed by Cyanophyta with 10.1% of total annual crop. Pyrrophyta and Euglenophyta are the remaining groups they were 0.42 % and 0.11 % of total annual stock, respectively. Coagulation of raw Nile water for algal and turbidity removal was performed with two different coagulants, chemical coagulant (aluminum sulfate) and natural coagulant *(Moringa oleifera* seeds) with and without chlorination. Coagulation with *M. oleifera* seeds extract was very effective than aluminum sulfate, as it reduced turbidity of raw water from 13.8 NTU to 2.2 NTU and the algal removal was 98.7% without chlorination, while with chlorination, it reduced turbidity of raw water from 5.5 NTU to 1.5 NTU and the algal removal was 99.1%. Aluminum sulfate reduced turbidity of raw water from 13.8 NTU to 2.0 NTU and the algal removal was 85.8 % without chlorination, while with chlorination, it reduced turbidity 5.5 NTU to 1.2 NTU and the algal removal was 96.8%.

Keywords: Nile River, Phytoplankton, Algal Count, Coagulants, Aluminum sulfate, *Moringa oleifera.*

INTRODUCTION

The Nile River is the artery of life in Egypt as it considered as the main resource of drinking water. Unfortunately, Nile ecosystem is currently suffering from the discharge of contaminated agricultural wastewater, oil discharge and untreated domestic wastewater (Ali and El Shehawy, 2017). The phytoplankton plays a central role in the structure and function of river ecosystems. Changes in phytoplankton abundance, species diversity or community composition constitute a potential bio-indicator of water quality and changes in response to local pollution or disturbance (El-Otify and Iskaros, 2015). The phytoplankton (microscopic algae) has been used as indicators of water quality, as some species result in noxious blooms; sometimes develop offensive tastes and odors or toxic conditions that may lead to in animal death or human illness. Although many species of freshwater algae proliferate quite intensively in water, they do not accumulate to form dense surface blooms of extremely high cell density, as do some cyanobacteria. The toxins that freshwater algae may contain are therefore not accumulated to concentrations likely to become hazardous to human health (Chorus and Fastner, 2001).

Conventional treatment of Nile water (coagulation and filtration) can remove enough amounts of algal toxins by removing the intact algal cell (Loper, 1989). These toxins are secondary metabolites which are largely contained in the algal cell and transport to water during lyses or damage of the cell. The coagulation process is the removing of colloidal suspensions, organic (humic compounds) and both inorganic clays and silts which could be a good support for pathogens development and represent a great problem in drinking water aspect (Kargi and Pamukoglu, 2004). Aluminum sulfate is a well known coagulant, being used in water and wastewater treatment due to its low cost and high efficiency. Although aluminum sulfate is the most commonly coagulant that used in the developing countries, there are many studies result in its linkage with developing neurological diseases (e.g. pre-senile dementia or Alzheimer's disease) due to the presence of aluminum ions in the drinking water (Alo et al., 2012).

Some studies on natural coagulants have been carried out with using various natural coagulants from microorganisms, animals or plant such *Moringa oleifera* seeds (Ganjidoustet al., 1997). *Moringa oleifera* is the most widely cultivated species of the family *Moringaceae*, and it is native in Pakistan, India, Bangladesh and Afghanistan. It is considered as an important crop in India, Ethiopia, Philippine and Sudan, and also grown in West, East and South Africa, tropical Asia, Latin America, the Caribbean islands, Florida and the Pacific Islands (Jed, 2005). It is used as a primary coagulant in drinking water clarification and wastewater treatment due to the presence of a water-soluble cationic coagulant protein, that able to reduce turbidity of the raw surface water. Seeds are powdered and extracted with water (Ndabigengesere and Narasiah, 1998). Therefore, the aim of this work was to monitor the algal community and the physiochemical parameters of River Nile water before and after treatment in Shebin El-kom surface water plant, Menoufia Governorate, Egypt and to evaluate an effective process of water treatment and compare between two different coagulants in removing the algae and turbidity of surface.

MATERIALS AND METHODS

Sampling procedure

The sampling cruise was done every two months during the period from May, 2017 to March, 2018 from Nile River water of Shebin El-kom surface water plant as shown in figure (1).

All water samples were collected according to (APHA, 2010).For Algal examination, samples were collected in one liter clean glass containers and fixed with standard Lugol's solution. For chemical analysis, samples were preserved immediately after collection by acidifying with concentrated HNO_3 to pH < 2 by adding 5 ml nitric acid to 1 liter water sample in refrigerator.

Figure (1): Location map of River Nile branch showing sampling site (Shebin El-kom water plant).

2 Phytoplankton examination

The phytoplanktonic samples were concentrated using membrane filtration using Sartorius SM 16828 membrane filter and centrifugation technique at 1000 g for 20 min using MPW – 350e centrifuge (APHA, 2010). The phytoplanktonic algae were counted using standard microscope through Sedgwick Rafter cell. 1ml of concentrated sample was pipetted on Rafter cell and examined under standard microscope. Sedgwick Rafter cell is a slide with 1 mm, of 1,000 mm^2 area and volume of 1.0 ml (Mcnabb, 1960).

2.2. Physicochemical parameters

Physicochemical parameters were measured using the methods described according to (APHA, 2010). The pH value was measured directly by using a digital pH meter (MW 102). Turbidity was measured directly by using HACH 2100 digital turbidimeter. Conductivity and TDS (total dissolved salts) were measured directly by using WTW Inolab 720 digital meter. Alkalinity was determined by titration method against 0.2 N H_2SO_4 (APHA, 2010)). Total and calcium hardness were measured by EDTA titrimetric method (Schwarzenbach and Flaschka, 1969). Chlorides were measured by titration method against $AgNO_3$ (Paustian, 1987). Heavy metals and inorganic elements were measured by spectrophotometer (cecil CE7400). Iron ions were measured by phenanthroline method (Caldwell and Adams, 1946). Manganese ions were measured by the persulfate method (Nydahl, 1949). Ammonia was measured by Nessler method (APHA, 2005). Nitrate was measured by UV spectrophotometric screening method (Armstrong, 1963). Phosphate was measured by stannous chloride method (Sletten, 1961). Sulfate was measured by the turbidimetric method (Rossum and Villarrus, 1961).

2.3. Water Treatment for Algal Removal

2.3.1 Collection of *M. oleifera* seeds

Seeds of *M. oleifera* were collected from National Research Center; Dokki, Cairo, Egypt. The *Moringa* seeds were de-shelled and dried. The white kernels were milled into a fine powder with the aid of porcelain mortar.

2.3.2 Preparation of *M. oleifera* seeds water extract

Five grams of the seeds powder was dissolved in1 L sterilized distilled water and stored in sterile bottle with cap in the refrigerator at 3 ^{0}C for seven days.

2.3.3 Treatment of water by *M. oleifera* seeds extract

The solution was shaken for 1 minute to extract and activate the coagulant proteins in the seed powder. Then different concentrations of *Moringa* seed solution (350 – 400- 450 -500- 550-600) mg/l were made by adding (70- 80- 90- 100-110-120) ml of *moringa* extraction respectively to 6 beakers containing 6 liters of raw water. Then the jars were fast stirred for 60 seconds and then slowly for 20 munities using VELP flocculator (Bulusu and Sharma, 1967). The treated water was then allowed to stand 30 minutes for settling. Then treated samples were collected from the top of the water and subjected to post-treatment analysis. The jar test was repeated with adding suitable concentration of chlorine (5 mg\L) was used and determined iodometrically before running each experiment (Ali et al., 2009; Amagloh and Benang, 2009; Alo et al., 2012; Martin et al., 2012).

2.3.4 Treatment of water by aluminum sulfate solution

Different concentrations of aluminum sulfate solution (10, 15 0, 20, 25, 30 and 35) mg\l were added to 6 beakers containing 6 liters of raw water. The jar test procedure was performed like *M. oleifera* (Shehataet al., 2008) as shown in figure (2).

Figure 2: Jar test for raw water and coagulated samples

2.4. Statistical analysis

Data collected throughout laboratory investigations and outcome measures coded, entered and analyzed using Microsoft Excel software.The data collected were tabulated and analyzed by SPSS (statistical package for social science) version 25 on IBM compatible computer.Two types of statistics were done:

2.4.1 Descriptive statistics:

According to the type of data qualitative represent as number and percentage, quantitative continues group represent by mean ± SD

2.4.2 Analytic statistics:

1- Chi-square test ($\chi 2$): was used to study comparison and association between two qualitative variables.
2- Student t-test: is a test of significance used for comparison between two groups having quantitative variables with normal distribution
3- Mann-Whitney U Test: is a test of significance used for comparison between two groups having quantitative variables without normal distribution
4- ANOVA (f) test: is a test of significance used for comparison between three or more groups having quantitative variables.
5- Kruskal-Wallis test (nonparametric test): is a test of significance used for comparison between three or more groups not normally distributed having quantitative variables.
6- Correlation by Pearson's correlation or Spearman's.
7- A P-value of < 0.05 was considered statistically significant &<0.001 for high significant result. Data were collected and submitted to statistical analysis. The following statistical tests and parameters were used.

RESULTS

Spatial and seasonal distribution of phytoplankton

Raw water

As shown in table (1) and represented in figure (3), the total number of phytoplankton populations during the period of investigation in Shebin El-kom water plant was (1694×10^3 organism\l). The highest yield was (407×10^3 organism\l) in January. On the other hand, the minimum yield was (191×10^3 organism\l) in September. The counts in March and November showed moderate values with seasonal average of (252×10^3 organism\l).

As shown in table (2) and in figures (4, 5 and 6), the phytoplankton populations encountered in Shebin El-kom water plant are included in the groups Bacillariophyta, Chlorophyta, Cyanophyta, Pyrrophyta and Euglenophyta. Bacillariophyta dominated the whole populations, as it accounted for 64.9 % of total annual crop. Chlorophyta ranked as the 2nd group with 24.3 % of total annual crop. Then the 3rd group was Cyanophyta with 10.1% of total annual crop. Pyrrophyta and Euglenophyta represented 0.42 % and 0.11 % and of total annual stock, respectively. The range, average and seasonal variation of the recorded groups can be summarized as the following:-

1- Bacillariophyta

Members of Bacillariophyta attained the maximum accumulation (257×10^3 organisms\l) in March. The minimum occurrence was (112×10^3 organisms\l) in September. The most common species of family Bacillariophyta was *Cyclotella comta* with (323×10^3 organisms\l) total number per year with high rank of occurrence. The rare occurrence of species of family Bacillariophyta was *Navicula cryptocephala*, *Cymblla lanceolata* and *Rhopalodia gibba* with (1×10^3 organisms\l) total number per year.

2-Chlorophyta

Chlorophyta attained the maximum accumulation (109×10^3 organisms\l) in January. The minimum occurrence was (34×10^3 organisms\l) in May. The most common species was *Tetraedron minimum* with (69×10^3 organisms/l) total number per year with high rank of occurrence. The rare occurrence of chlorophyta was *Spirogyra Mirabilis*, *Mougeotia calospora* and *Tetraedron trigonum* with (1×10^3 organisms/l) total number per year.

3- Cyanophyta

Cyanophyta attained the maximum accumulation (44×10^3 organisms\l) in January. The minimum occurrence was (12×10^3 organisms\l) in September. The most common species of cyanophyta was *Merismopdia elegans* with (61×10^3 organisms\l) total number per year with high rank of occurrence. The rare occurrence was *Spirolina meneghiniana* with (1×10^3 organisms\l) total number per year.

4- Pyrrophyta and Euglenophyta

Pyrrophyta attained the maximum occurrence (5×10^3 organisms\l) in January, while the minimum accumulation was (1×10^3 organisms\l) in September. The most common species was *Ceratium hirundinella* with (5 × 10^3 organisms\l) total number per year. The species *Peridinium cinctum* showed rare occurrence (1 × 10^3 organisms\l) total number per year. Euglenophyta was represented by only two species *Euglena sanguine* and *Euglena acus* with (1 × 10^3 organisms\l) total number per year in January.

Table (1): Distribution of algal groups in Nile water in Shebin El-kom surface water plant, during the period of investigation (May, 2017- March, 2018)

Month / Algal Groups	May	July	September	November	January	March	Total No. per year	Relative density of total (%)	No. of isolation cases	Rank of occurrence
Bacillariophyta										
Cyclotell acomta	63	30	27	23	75	105	323	19.07	6	H
Cyclotella kutzingiana	36	41	40	28	53	60	258	15.23	6	H
Stephanodiscus asteraea	11	4	0	4	2	0	21	1.24	4	M
Stephanodiscus hantzschii	4	2	0	1	0	0	7	0.41	3	M
Diatoma elongatum	19	41	4	20	13	29	126	7.44	6	H
Diatoma vulgare	14	9	0	11	16	0	50	2.95	4	M
Synedra ulna	3	9	9	3	12	19	55	3.25	6	H
Synedra acus	5	4	11	2	2	10	34	2.01	6	H
Synedra vaucheriae	1	2	0	2	14	0	19	1.12	4	M
Fragillaria capucina	1	8	2	5	19	22	57	3.36	6	H
Fragillaria crotonensis	0	3	0	2	5	0	10	0.59	3	M
Navicula radiosa	1	1	1	3	1	1	8	0.47	6	H
Navicula theinamanni	0	2	0	0	1	0	3	0.18	2	L
Navicula cryptocephala	0	0	1	0	0	0	1	0.06	1	R
Nitzschia aclcularis	1	1	1	3	4	4	14	0.83	6	H
Nitzschia amphibia	0	1	1	1	8	0	11	0.65	5	H
Nitzschia angustata	0	0	4	2	4	0	10	0.59	3	M
Melosira granulata	4	4	9	18	14	5	54	3.19	6	H
Melosira varians	3	5	0	8	3	2	21	1.24	3	M
Asterionella formosa	7	3	0	2	0	0	12	0.71	3	M
Gyrosigma attenuatum	0	0	1	0	2	0	3	0.18	2	L
Cymblla lanceolata	0	1	0	0	0	0	1	0.06	1	R
Rhopalodia gibba	0	0	1	0	0	0	1	0.06	1	R
Chlorophyta										
Pediastrum simplex	2	1	0	0	0	0	3	0.18	2	L
Pediastrum clathratum	5	3	0	2	1	2	13	0.77	5	H
Pediastrum boryanum	2	1	0	0	0	1	4	0.24	3	M
Pediastrum gracillimum	0	2	6	2	0	2	12	0.71	4	M
Pediastrum duplex	0	1	1	0	1	2	5	0.30	4	M
Pediastrum Sturmii	0	0	3	0	1	4	8	0.47	3	M
Scenedesmus armatus	3	2	1	2	3	1	12	0.71	6	H
Scenedesmus quadricauda	3	4	0	0	5	1	13	0.77	4	M
Scenedesmus opoliensis	0	2	0	0	2	1	5	0.30	3	M
Scenedesmus acutus	0	1	2	0	1	0	4	0.24	3	M
Scenedesmus bijugatus	0	3	1	5	5	2	16	0.94	5	H
Scenedesmus acuminatus	0	2	2	2	6	4	16	0.94	5	H
Staurastrum paradoxum	2	2	1	0	0	1	6	0.35	4	M
Staurastrum gracile	1	1	0	0	0	0	2	0.12	2	L
Staurastrum tetracerum	0	0	2	0	1	0	3	0.18	2	L
Staurastrum polymorphum	0	0	2	0	0	3	5	0.30	2	L
Staurastrum vestitum	0	1	3	3	3	6	16	0.94	5	H

Coelastrum microporum	0	5	15	6	16	0	42	2.48	4	M
Coelastrum sphaericum	0	2	0	3	0	0	5	0.30	2	L
Treubaria triappendiculata	3	3	0	0	0	0	6	0.35	2	L
Ankistrodesmus falcatus	4	1	4	12	1	2	24	1.42	6	H
Ankistrodesmus Acicularis	0	0	0	11	1	0	12	0.71	2	L
Botryococcus braunii	2	2	1	1	0	1	7	0.41	5	H
Chlorella vulgaris	0	1	5	6	2	2	16	0.94	5	H
Spirogyra Mirabilis	0	1	0	0	0	0	1	0.06	1	R
Ulothrix zonata	2	0	1	0	0	1	4	0.24	3	M
Mougeotia calospora	0	1	0	0	0	0	1	0.06	1	R
Cosmarium praemorsum	0	0	1	3	0	0	4	0.24	2	L
Tetraedron minimum	2	0	5	13	31	18	69	4.07	5	H
Tetraedron incus	0	0	3	0	1	1	5	0.30	3	M
Tetraedron trigonum	0	0	1	0	0	0	1	0.06	1	R
Tetraedron muticum	0	0	2	1	3	0	6	0.35	3	M
Tetraedron schmidlei	0	0	1	1	1	0	3	0.18	3	M
Kirchneriella lunaris	0	0	0	1	2	0	3	0.18	2	L
Kirchneriella obesa	0	0	0	2	1	0	3	0.18	2	L
Nephrocytium agradhianum	0	0	2	4	0	1	7	0.41	3	M
Eudorina elegans	0	0	0	0	1	5	6	0.35	2	L
Selenastrum gracile	0	0	1	1	0	0	2	0.12	2	L
Closterium pronum	0	0	0	1	2	0	3	0.18	2	L
Closterium kutzingii	0	0	0	2	3	0	5	0.30	2	L
Actinastrum hantzschii	3	0	0	3	15	7	28	1.65	4	M
Cyanophyta										
Merismopdia elegans	4	2	6	13	10	26	61	3.60	6	H
Merismopdia glauca	7	12	0	2	5	0	26	1.53	4	M
Chrococcus turgidus	1	11	1	5	12	4	34	2.01	6	H
Chrococcus limneticus	4	8	3	2	1	6	24	1.42	6	H
Microcys taeruginosa	0	3	0	1	4	7	15	0.89	4	M
Microcyst wesnbergii	0	0	1	0	1	0	2	0.12	2	L
Spirolina meneghiniana	0	0	0	0	1	0	1	0.06	1	R
Oscillatoria agardhii	0	0	0	0	3	0	3	0.18	1	R
Oscillatoria formosa	0	0	0	2	5	0	7	0.41	2	L
Gomphospheria lacustris	0	0	1	2	2	1	6	0.35	3	M
Pyrrophyta										
Peridinium cinctum	0	0	0	0	1	0	1	0.06	1	R
Peridinium umbonatum	0	0	1	0	2	0	3	0.18	2	L
Ceratium hirundinella	0	0	0	2	2	0	4	0.24	2	L
Euglenophyta										
Euglena sanguinea	0	1	0	0	0	0	1	0.06	1	R
Euglena acus	0	0	0	0	1	0	1	0.06	1	R
Total No. of individuals	**223**	**250**	**191**	**254**	**407**	**369**	**1694**			

N.B: Filamentous and colonial organisms were counted as one organism **Total counts × 10^3= organisms / liter**

H= high occurrence: - (from 5 to 6 cases of isolation) **M= moderate occurrence: - (**from 3 to 4 cases of isolation)
L= low occurrence: - (2 cases of isolation) **R= rare occurrence: -** (one case of isolation)

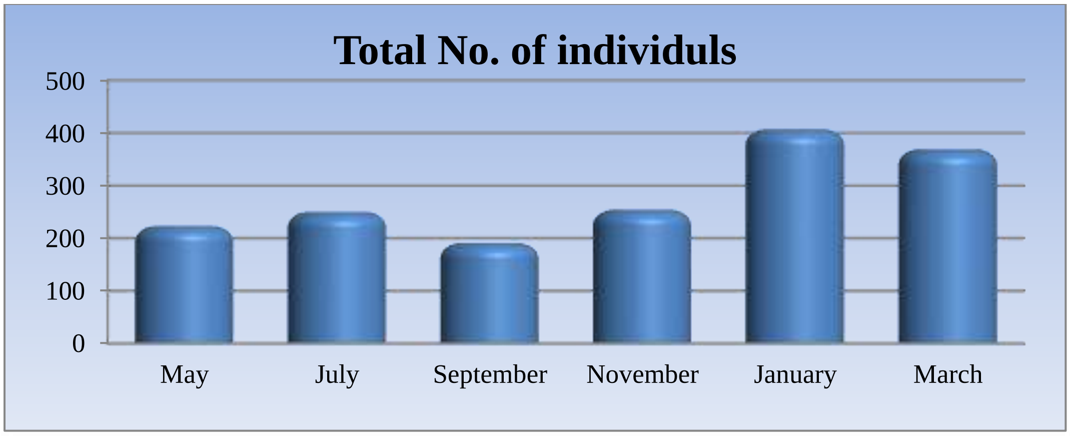


Figure 3: The total No. of algal groups of Nile water at Shebin El-kom surface water plant, during the period of investigation (May, 2017- March, 2018)

Table 2: Percentage of algal group's distribution of Nile water at Shebin El-kom surface water plant, during the period of investigation (May, 2017- March, 2018)

Algal groups		May	July	September	November	January	March	Annual average
Bacillariophyta	Species No.	15	19	14	18	18	10	15.6
	% of total	46.9	40.4	31.8	36.7	31.6	27	35.7
	Individual No.	173	171	112	138	248	257	183.1
	% of total	77.6	68.4	58.6	54.3	60.9	69.6	64.9
Chorophyta	Species No.	13	22	24	23	25	22	21.5
	% of total	40.6	46.8	54.5	46.9	43.9	59.5	48.7
	IndividualNo.	34	42	66	87	109	68	67.6
	% of total	15.2	16.8	34.6	34.3	26.8	18.4	24.3
Cyanophyta	Species No.	4	5	5	7	10	5	6
	% of total	12.5	10.6	11.4	14.3	17.5	13.5	13.3
	Individual No.	16	36	12	27	44	44	29.8
	% of total	7.1	14.4	6.3	10.6	10.8	11.9	10.1
Pyrrophyta	Species No.	0	0	1	1	3	0	0.83
	% of total	0	0	2.3	2	5.3	0	1.6
	Individual No.	0	0	1	2	5	0	1.3
	% of total	0	0	0.52	0.79	1.23	0	0.42
Euglenophyta	Species No.	0	1	0	0	1	0	0.33
	% of total	0	2.1	0	0	1.8	0	0.65
	Individual No.	0	1	0	0	1	0	0.33
	% of total	0	0.45	0	0	0.25	0	0.11

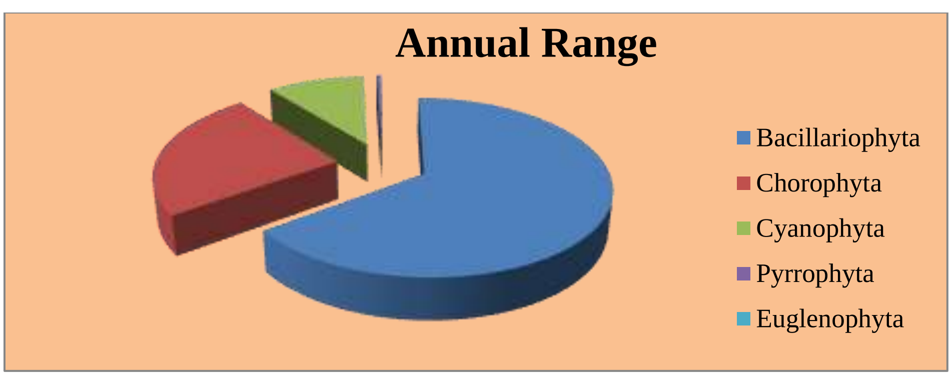


Figure 4: The annual average of algal groups of Nile water at Shebin El-kom surface water plant, during the period of investigation (May, 2017- March, 2018)

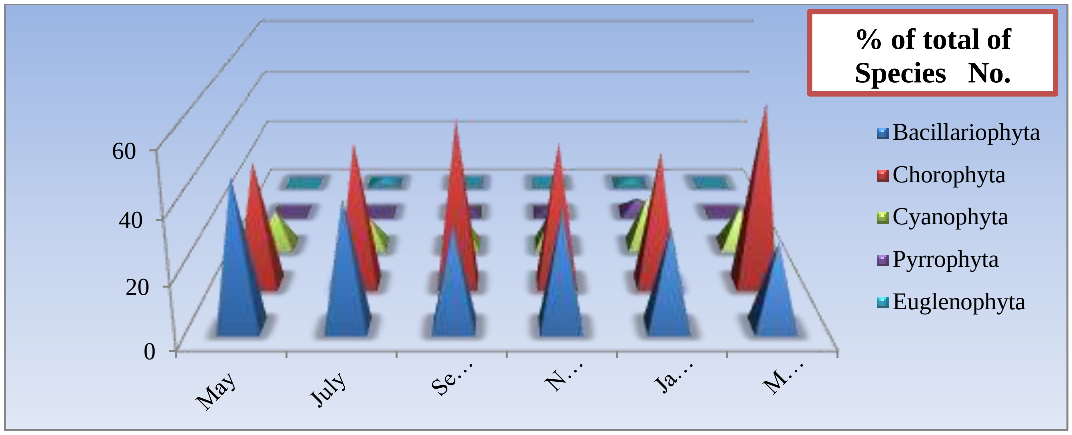


Figure 5: Percent of total Species number of algal groups of Nile water at Shebin El-kom surface water plant, during the period of investigation (May, 2017- March, 2018)

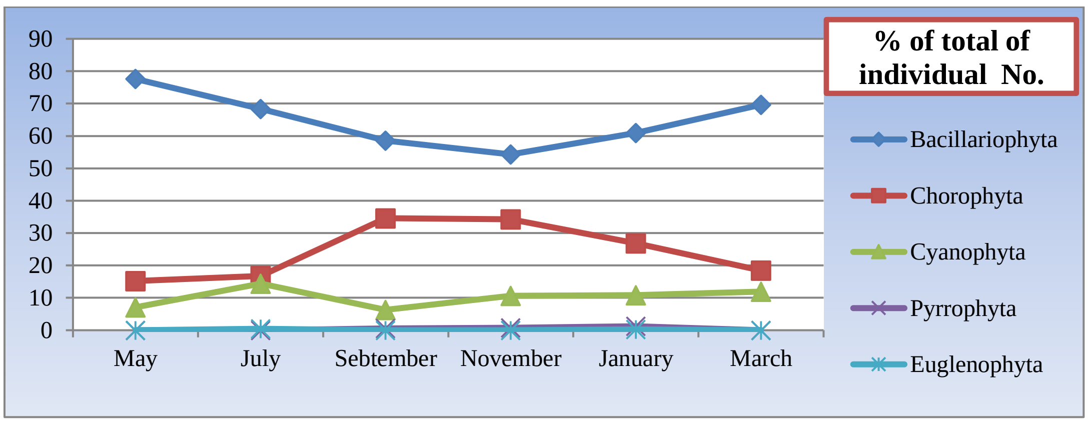


Figure 6: Percent of total individual number of algal groups of Nile water at Shebin El-kom surface water plant, during the period of investigation (May, 2017- March, 2018)

Treated water

As shown in tables (3, 4), the total number of phytoplankton populations per year in Shebin El-kom treated water was (83× 10^3 organisms\l). The efficiency of treatment according to the total number of phytoplankton populations per year in raw and treated water was (95.1%) and this represented (7). The highest count was (23× 10^3 organisms\l) in November followed by March with yield of (16×10^3 organisms/l). On the other hand, the minimum yield was (8× 10^3 organisms\l) in July followed by January with yield of (9×10^3 organisms\l). May and September showed moderate values (14, 13) ×10^3 organisms\l, respectively. As shown in table (6), the phytoplankton populations encountered in Shebin El-kom treated water are included in the divisions of Chlorophyta, Bacillariophyta and Cyanophyta. Bacillariophyta dominated the whole populations, as it accounted for 41.3 % of total annual crop. Chlorophyta ranked as the 2nd division with 38.0 % of total annual crop, followed by Cyanophyta with 20.6% of total annual crop. Euglenophyta and Pyrrophyta were not detected in treated water.

The chemical and physical parameters

As shown in table (5), water temperature was ranged from 19.5°C to 30.1°C. Turbidity was ranged from 7.3 to 10.8 NTU. Total dissolved salts (TDS) and conductivity were ranged from 215 to 362 ppm, 332 to 581µS/cm, respectively. The range of pH of surface water was from 7.8 to 8.2. The range of total hardness was from 150 to 172 ppm. Total alkalinity was ranged from 150 to 190 ppm. The range of chlorides of surface water was from 20 to 46 ppm. Iron was ranged from <0.01 to 0.30 ppm while Manganese, was ranged from <0.01 to 0.21 ppm. The range of Sulfate was from 25 to 50 ppm while Phosphate, was from <0.01 to 0.12 ppm. Nitrate was ranged from 0.07 to 0.55

ppm. Ammonia was ranged from 0.15 to 0.41 ppm.

Algal removal (Without chlorination)

As shown figure (8), the total number of phytoplankton populations in Nile water was (544× 10^3 organisms/l). Algal removal without chlorination from raw Nile water using *M. oleifera* was very high and reached 98.7% removal, on other hand aluminum sulfate removed algae by 85.8 % removal without chlorination. Different concentrations of *M. oleifera* and aluminum sulfate were used for treatment. The efficiency of treatment of different concentrations of *M. oleifera* (350 – 400 – 450 – 500 - 550 – 600) mg\l were (60.4 -92.8 - 95.6 - 96.9 - 98.7 - 98.7) %, respectively. The most effective concentration was 550 mg\l and the result was constant in concentration 600 mg\l. while the efficiency of treatment of different concentrations of aluminum sulfate (10 – 15 – 20 – 25 – 30 – 35) mg\l were (69.7 - 75.1 - 80.1 – 80 - 85.8 - 87.5) %, respectively.

With chlorination

As shown in figure (9), the total number of phytoplankton populations in Nile water was (575× 10^3 organisms/l). Algal removal with chlorination from raw Nile water using *M. oleifera* was very high and reached 99.1% removal, on other hand aluminum sulfate removed algae by 96.8 % removal with chlorination. Different concentrations of *M. oleifera* and aluminum sulfate were used for treatment. The efficiency of treatment of different concentrations of *M. oleifera* (350 – 400 – 450 – 500 - 550 – 600) mg\l were (96 – 98.4 - 98.7 - 98.9 - 99.1 - 99.1) %, respectively. The most effective concentration was 550 mg\l and the result was constant in concentration 600 mg\l. while the efficiency of treatment of different concentrations of aluminum sulfate (10 – 15 – 20 – 25 – 30 – 35) mg\l were (85.5 - 87 - 91.6 – 92 – 96.5 - 96.8) %, respectively. The most effective concentration was 35 mg\l.

The chemical and physical parameters (without chlorination)

As shown in figures (10) the chemical parameters weren't affected negatively with using *M. oleifera* seeds extraction or aluminum sulfateas coagulants for water treatment. Some parameters were decreased such turbidity, total dissolved solids (TDS), alkalinity, phosphates and ammonia. Others were increased such nitrates in using *M. oleifera* and Aluminum sulfate, sulfate in using Aluminum sulfate only. The remaining parameters had slightly changes with using both of *M. oleifera* seeds extraction or Aluminum sulfateas coagulants. Turbidity of raw water was 13.8 NTU by using different concentrations of *M. oleifera* (350 – 400 – 450 – 500 - 550 – 600) mg\l it was decreased to (5 – 2.8 – 2.6 – 2.3 – 2.2 - 2.2) NTU, respectively. While with using different concentrations of aluminum sulfate (10 – 15 – 20 – 25 – 30 – 35) mg\l, it was decreased to (4.5 – 3.8 - 2.2 – 2.1 - 2.1 - 2.1) NTU, respectively. TDS of raw water was 267 mg\l by using different concentrations of *M. oleifera* (350 – 400 – 450 – 500 - 550 – 600) mg\l it was slightly decreased to (257 – 256 – 253 – 254 – 251 – 250) mg\l, respectively. While with using different concentrations of aluminum sulfate (10 – 15 – 20 – 25 – 30 – 35) mg\l, it was decreased to (266 – 258– 256 – 256 – 252 – 252) mg\l, respectively. Total alkalinity of raw water was 160 mg\l by using different concentrations of *M. oleifera* (350 – 400 – 450 – 500 - 550 – 600) mg\l it was slightly decreased to (150 – 140 – 140 – 140 – 130 – 130) mg\l, respectively. While with using different concentrations of aluminum sulfate (10 – 15 – 20 – 25 – 30 – 35) mg\l, it was decreased to (140 – 144– 138 – 130 – 130 – 126) mg\l, respectively. Phosphate of raw water was 0.44 mg\l by using different concentrations of *M. oleifera* (350 – 400 – 450 – 500 - 550 – 600) mg\l it was slightly decreased to (0.32 – 0.22 – 0.24 – 0.15 – 0.13 – 0.13) mg\l, respectively. While with using different concentrations of aluminum sulfate (10 – 15 – 20 – 25 – 30 – 35) mg\l, it was decreased to (0.35 – 0.33 – 0.29 – 0.27 – 0.26– 0.21) mg\l, respectively. Ammonia of raw water was 0.53 mg\l by using different concentrations of *M. oleifera* (350 – 400 – 450 – 500 - 550 – 600) mg\l it was decreased to (0.27 – 0.24 – 0.19 – 0.19 – 0.11 – 0.09) mg\l, respectively. While with using different concentrations of aluminum sulfate (10 – 15 – 20 – 25 – 30 – 35) mg\l, it was decreased to (0.43 – 0.41 – 0.33 – 0.26 – 0.24– 0.19) mg\l, respectively. Nitrate of raw water was 0.1 mg\l by using different concentrations of *M. oleifera* (350 – 400 – 450 – 500 - 550 – 600) mg\l it was increased to (0.91 – 1.1 – 1.83 – 1.82 – 1.91 – 1.91) mg\l, respectively. While with using different concentrations of aluminum sulfate (10 – 15 – 20 – 25 – 30 – 35) mg\l, it was increased to (1.0 -1.2 – 1.53 – 1.64 – 1.83 – 1.87) mg\l, respectively.

Table 3: Distribution of algal groups in treated water in Shebin El-kom surface water plant, during the period of investigation (May, 2017- March, 2018)

Month / Algal Groups	May	July	September	November	January	March	Total No. per year	Relative density of total (%)	No. of cases of isolation	Rank of occurrence
Bacillariophyta										
Cyclotella comta	2	5	1	3	0	3	14	16.87	5	H
Cyclotella kutzingiana	3	0	0	0	2	0	5	6.02	2	L
Synedra ulna	1	0	0	0	0	0	1	1.20	1	R
Synedra acus	2	0	1	0	0	0	3	3.61	2	L
Navicula radiosa	0	0	0	0	0	1	1	1.20	1	R
Nitzschia aclcularis	0	0	0	3	0	0	3	3.61	1	R
Nitzschia amphibia	0	0	0	2	0	0	2	2.41	1	R
Melosira granulata	0	0	3	0	0	0	3	3.61	1	R
Melosira varians	0	0	1	0	0	0	1	1.20	1	R
Chlorophyta										
Pediastrum clathratum	1	1	0	0	0	0	2	2.41	2	L
Pediastrum boryanum	1	0	0	0	0	0	1	1.20	1	R
Pediastrum gracillimum	0	0	1	0	0	0	1	1.20	1	R
Pediastrum duplex	0	2	0	0	0	0	2	2.41	1	R
Pediastrum sturmii	0	0	2	0	0	1	3	3.61	2	L
Scenedesmus armatus	0	0	0	0	1	0	1	1.20	1	R
Scenedesmus quadricauda	0	0	0	0	1	0	1	1.20	1	R
Scenedesmus bijugatus	0	0	0	2	0	0	2	2.41	1	R
Coelastrum microporum	0	0	1	1	0	0	2	2.41	2	L
Botryococcus braunii	0	0	0	1	0	0	1	1.20	1	R
Chlorella vulgaris	0	0	0	0	0	1	1	1.20	1	R
Tetraedron minimum	0	0	1	5	2	4	12	14.46	4	M
Nephrocytium agradhianum	0	0	0	1	0	1	2	2.41	2	L
Eudorin aelegans	0	0	0	0	0	1	1	1.20	1	R
Cyanophyta										
Merismopdia elegans	1	0	1	2	2	1	7	8.43	5	H
Merismopdi aglauca	3	0	0	2	0	0	5	6.02	2	L
Chrococcus turgidus	0	0	0	1	1	2	4	4.82	3	M
Chrococcus limneticus	0	0	1	0	0	0	1	1.20	1	R
Gomphospheria lacustris	0	0	0	0	0	1	1	1.20	1	R
Total No. of individuals	14	8	13	23	9	16	83			

N.B: Filamentous and colonial organisms were counted as one organism **Total counts × 10^3= organisms / liter**

H= high occurrence: - (from 5 to 6 cases of isolation) **M= moderate occurrence: - (**from 3 to 4 cases of isolation)
L= low occurrence: - (2 cases of isolation) **R= rare occurrence: -** (one case of isolation)

Table 4: Percentage of algal group's distribution of treated water at Shebin El-kom surface water plant, during the period of investigation (May, 2017- March, 2018)

Algal groups		May	July	September	November	January	March	Annual average
Bacillariophyta	Species No.	4	1	4	3	1	2	2.5
	% of total	50	33.3	40	27.3	16.7	18.2	30.9
	Individual No.	8	5	6	8	2	4	5.5
	% of total	57.1	62.5	46.2	34.8	22.2	25	41.3
Chorophyta	Species No.	2	2	4	5	3	5	3.5
	% of total	25	66.7	40	45.5	50	45.5	45.4
	Individual No.	2	3	5	10	4	8	5.3
	% of total	14.3	37.5	38.5	43.5	44.4	50	38.0
Cyanophyta	Species No.	2	0	2	3	2	3	2
	% of total	25	0	20	27.3	33.3	27.3	22.1
	Individual No.	4	0	2	5	3	4	3
	% of total	28.6	0	15.4	21.7	33.3	25	20.6

Table 5: Statistical analysis of algal group's distribution in raw and treated water at Shebin El-kom surface water plant, during the period of investigation (May, 2017- March, 2018)

Algal groups			Mean	Standard Deviation	t TEST	P-value
Bacillariophyta	Species No.	Raw water	15.6667	3.09121	9.376	0.000
		Treated water	2.5000	1.25831		
	Individual No.	Raw water	183.1667	53.24602	8.570	0.000
		Treated water	5.5000	2.14087		
Charophyta	Species No.	Raw water	21.5000	3.94757	13.561	0.000
		Treated water	3.5000	1.25831		
	Individual No.	Raw water	67.6667	25.42090	6.822	0.000
		Treated water	5.3286	2.80874		
Cyanophyta	Species No.	Raw water	6.0000	2.00000	5.084	0.002
		Treated water	2.0000	1.00000		
	Individual No.	Raw water	29.8333	12.62823	5.541	0.001
		Treated water	3.0000	1.63299		
Pyrrophyta	Species No.	Raw water	0.833	1.169	-----------	
		Treated water	0	0		
	Individual No.	Raw water	1.333	1.966	-----------	
		Treated water	0	0		
Euglenophyta	Species No.	Raw water	0.333	0.516	-----------	
		Treated water	0	0		
	Individual No.	Raw water	0.333	0.516	-----------	
		Treated water	0	0		

Table 6: the chemical and physical parameters of Shebin El Kom raw water during the period of investigation (May, 2017- March, 2018)

Month Parameters	May	July	Sept.	Nov.	Jan.	March	Min.	Max.	Mean	Standard deviation
Temperature °C	22.6	30.1	25.5	23	19.5	22.1	19.50	30.10	23.80	3.63
Turbidity (NTU)	10.8	9	10.5	10.6	7.8	7.3	7.30	10.80	9.33	1.53
Ph	8.2	8	7.9	7.8	7.8	7.8	7.80	8.20	7.92	0.16
TDS (ppm)	258	215	266	311	362	260	215.00	362.00	278.67	50.95
Conductivity (µS/Cm)	406	332	455	494	581	414	332.00	581.00	447.00	85.12
Iron (ppm)	<0.01	<0.01	0.22	0.21	0.07	0.3	0.01	0.30	0.14	0.12
Manganese (ppm)	0.21	<0.01	<0.01	0.03	0.11	0.07	0.01	0.21	0.07	0.08
Total hardness (ppm)	170	156	150	150	172	150	150.00	172.00	158.00	10.35
Calcium hardness (ppm)	70	86	100	80	90	80	70.00	100.00	84.33	10.23
Magnesium hardness (ppm)	100	70	50	70	82	70	50.00	100.00	73.67	16.51
Ca^{2+}(ppm)	28	34	40	32	36	32	28.00	40.00	33.67	4.08
Mg^{2+} (ppm)	24	17	12	16	19	17	12.00	24.00	17.50	3.94
Total Alkalinity (ppm)	164	160	160	190	180	150	150.00	190.00	167.33	14.79
Chlorides (ppm)	43	20	30	32	46	36	20.00	46.00	34.50	9.42
Sulfate (ppm)	38	30	25	43	43	50	25.00	50.00	38.17	9.24
Phosphate (ppm)	0.12	0.07	<0.01	<0.01	0.01	0.05	0.01	0.12	0.05	0.04
Nitrate (ppm)	0.07	0.55	0.32	0.38	0.42	0.44	0.07	0.55	0.36	0.16
Ammonia (ppm)	0.38	0.41	0.28	0.32	0.15	0.41	0.15	0.41	0.33	0.10

Table 7: Comparison between effect of *Moringa oleifera* seeds extraction and aluminum sulfate on total algal count of Nile raw water without chlorination

Algal groups		Raw water	*Moringa oleifera* extraction mg\l						Aluminum sulfate mg\l					
			350	400	450	500	550	600	10	15	20	25	30	35
Chlorophyta	***Actinastrum***	107	49	29	16	7	2	0	13	6	5	8	13	2
	Scenedesmus	13	7	1	1	4	1	0	11	23	12	9	3	7
	Ankistrodesmus	6	0	0	0	0	0	0	3	0	1	1	2	0
	Pediastrum	5	2	1	0	0	0	0	1	2	2	1	1	0
	Tetraedron	7	2	1	1	1	0	0	9	9	5	2	4	1
	Staurastrum	6	3	0	1	0	0	0	0	2	0	2	1	1
	Coelastrum	2	0	0	0	0	0	0	1	1	0	1	0	1
	Closterium	2	0	0	0	0	0	0	3	0	1	0	0	1
	Chodetella	1	0	0	0	0	0	0	0	0	0	0	0	0
	Cosmarium	1	0	0	0	0	0	0	1	0	0	0	0	0
	Nephrocytium	2	0	0	0	0	0	0	1	0	0	1	0	0
	Chlorella	1	0	0	0	0	0	0	1	0	0	0	0	0
Bacillariophyta	***Melosira***	55	14	1	2	0	2	1	32	15	30	20	9	15
	Cyclotella	262	99	4	3	4	2	5	69	59	37	46	30	28
	Fragillaria	18	13	0	0	0	0	0	2	2	4	5	0	2
	Synedra	9	9	0	0	0	0	0	5	5	2	3	2	3
	Diatoma	9	12	1	0	1	0	1	0	3	0	3	1	3
	Navicula	2	0	0	0	0	0	0	0	0	0	0	1	0
	Nitzschia	9	4	0	0	0	0	0	9	2	2	0	2	3
	Stephanodiscus	3	0	0	0	0	0	0	0	1	0	0	1	1
Cyanophyta	***Merismopdia***	5	1	1	0	0	0	0	1	2	2	1	2	0
	Chrococcus	13	0	0	0	0	0	0	2	2	2	2	5	0
	Oscillatoria	2	0	0	0	0	0	0	0	0	1	0	0	0
	Microcyst	2	0	0	0	0	0	0	0	1	2	0	0	0
	Gomphospheria	1	0	0	0	0	0	0	1	0	0	0	0	0
Pyrophyta	***Ceratium***	1	0	0	0	0	0	0	0	0	0	0	0	0
Total algal count		544	215	39	24	17	7	7	165	135	108	105	77	68
Efficiency of treatment %			60.4	92.8	95.6	96.9	98.7	98.7	69.7	75.1	80.1	80	85.8	87.5

N.B: Filamentous and colonial organisms were counted as one organism

Total counts × 10^3 = organisms / liter

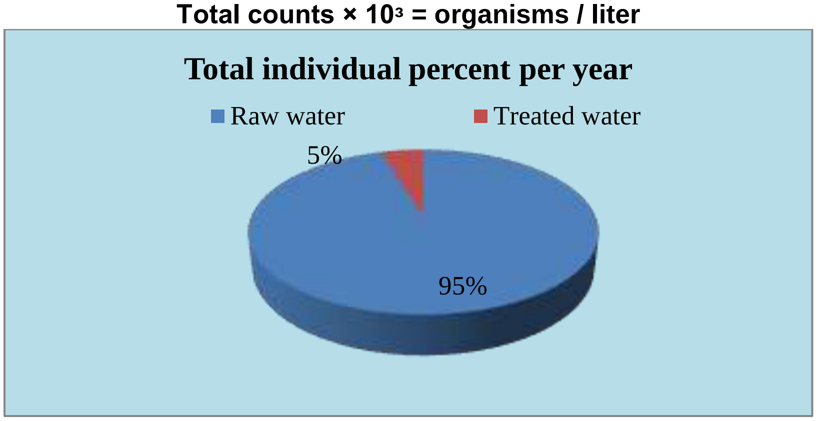


Figure 7: Total individual percent per year at Shebin El Kom raw and treated surface water, during the period of investigation (May, 2017- March, 2018)

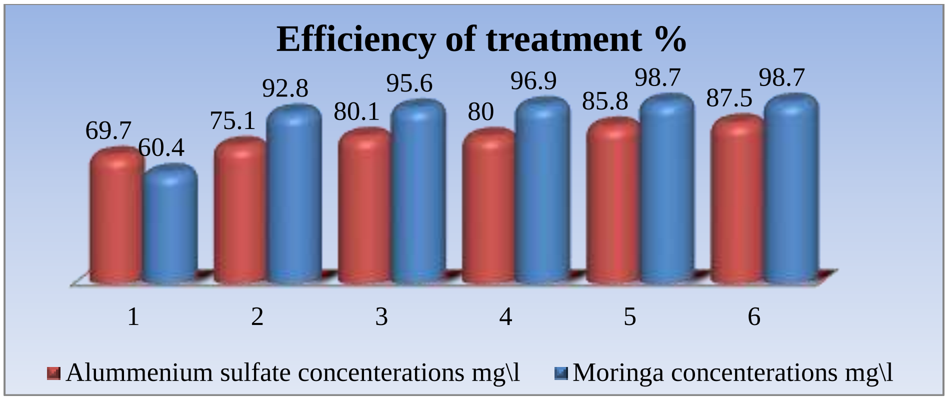


Figure 8: Comparison between the efficiency of treatment of *Moringa oleifera* seeds extraction and aluminum sulfate on algal count of Nile raw water without chlorination

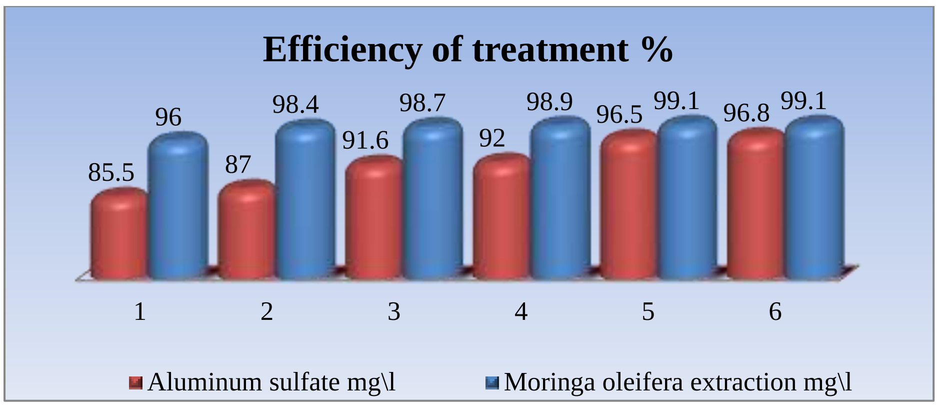


Figure 9: Comparison between the efficiency of treatment of *Moringa oleifera* seeds extraction and aluminum sulfate on algal count of Nile raw water with chlorination

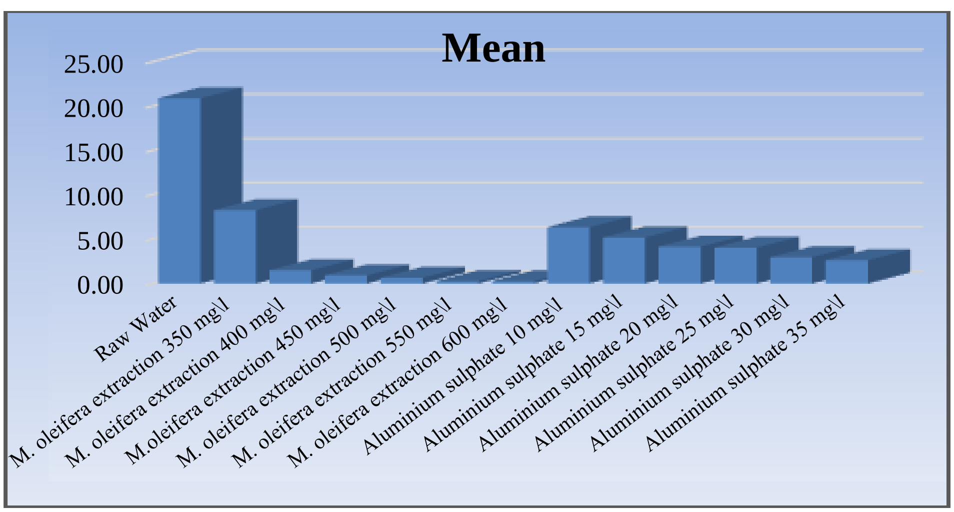
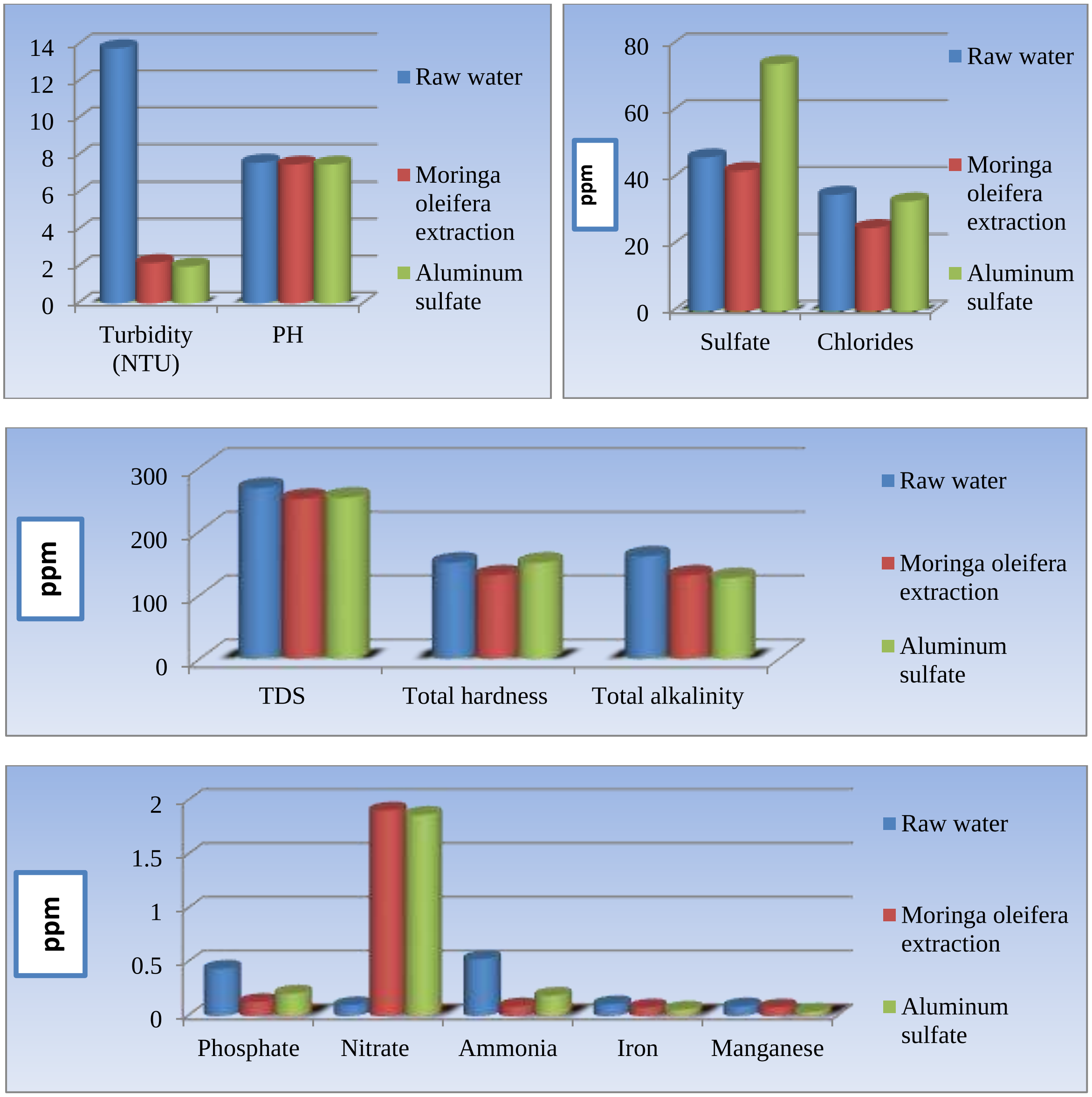


Figure 10: Statistical analysis of the effect of *Moringa oleifera* seeds extraction and aluminum sulfate on total algal count of Nile raw water without chlorination



Figures 11: Comparison between the effect of *Moringa oleifera* seeds extraction and aluminum sulfate on the physiochemical parameters of raw water without chlorination

Sulfate of raw water was 46 mg\l by using different concentrations of *M. oleifera* (350 – 400 – 450 – 500 – 550 – 600) mg\l it was decreased to (44 – 45 – 43 – 43 – 42 – 42) mg\l, respectively. While with using different concentrations of aluminum sulfate (10 – 15 – 20 – 25 – 30 – 35) mg\l, it was increased to (55 – 62 – 68 – 70 – 71 – 74) mg\l, respectively.

With chlorination

Most chemical parameters weren't affected by addition of chlorine except chlorides that increased with both *Moringa oleifera* and aluminum sulfate as it was in raw water 30 mg\l by using different concentrations of *Moringa oleifera* (350 – 400 – 450 – 500 - 550 – 600) mg\l it was increased to (35 – 35 – 36– 35 – 36 – 36) mg\l, respectively, and with using different concentrations of aluminum sulfate (10 – 15 – 20 – 25 – 30 – 35) mg\l, it was increased to (35 – 36 – 36 – 35 – 35 – 36) mg\l, respectively.

DISCUSSION

In this study, physicochemical parameters and algal distribution were investigated in Nile water in Shebin El Kom surface water plant.

Water temperature was ranged from 19.5°C to 30.1°C. The highest was in July in January. The temperature values of water were affected by the climatic conditions, sampling time and sun shine hours. These results were agreed with (Elewa and Mandi, 1988; Kobbia et al., 1991; Abdo, 2005; Daboor, 2008; Hazaa et al., 2015; Hisham et al., 2015; Galal et al., 2017). Turbidity of water is caused by suspended particles, primarily of clay, silt, organic matter, and microorganisms (APHA, 2010). Water turbidity was ranged from 7.3 NTU to 10.8 NTU. The highest and the lowest values were during May and March, respectively. These results were agreed with (Hazaa et al., 2015; Hisham et al., 2015; Galal *et al.*, 2017). TDS in water vary owing to different mineral solubility in different geological regions.It ranged from 215 ppm to 362 ppm and the highest and the lowest values were during January and July, respectively. The maximum TDS was observed during the winter season rather than in summer, as a large amount of sediment load was transported from the watershed during the rainy season. Conductivity was ranged from 332µS/cm to 581µS/cm and the highest and the lowest values were during January and July, respectively. The lowest value in summer might be due to the dilution with the Nile flood season. The increase in conductivity may be due to the disposal of domestic and industrial effluents in the water.The value ofpH value was nearby constant in all tested water samples of the River Nile, as they were alkaline and ranged from (7.8 to 8.2). The highest pH value was during May. The relatively low pH can be attributed to the discharge of effluents which are loaded with a large amount of organic acids, and also may be due to many input of waste from different types of industries. And these results were agreed with (Allam and El-Gemaizy, 2015, Hazaa et al., 2015; Hisham et al., 2015; Galal et al., 2017). The principal natural sources of hardness in water are dissolved polyvalent metallic ions from sedimentary rocks, seepage, and run-off from soils. Calcium and magnesium, the two principal ions, are present in many sedimentary rocks, the most common being limestone and chalk (Anderson et al., 1975). The range of total hardness was from 150 ppm to 172 ppm. The highest value was during January. Total hardness depends on the value of TDS, as if the value of total dissolved salts (that contain calcium and magnesium salts) is high, the water hardness increases. These results were agreed with (Narendra and Kapil, 2007; Mostafa et al., 2013; Allam and El-Gemaizy, 2015; Hazaa et al., 2015; Hisham et al., 2015; Galal et al., 2017). Total alkalinity was ranged from 150 ppm to 190 ppm the highest value was during March and the lowest value was during September. Alkalinity usually enters the water as salts, such as calcium carbonate (also known as limestone). Carbonate and bicarbonate can also be formed when carbon dioxide from the air is dissolved in the water (APHA, 2010), so if TDS increase, the alkalinity of water also increases.

The range of chlorides was from 20 ppm to 46 ppm, the highest value was at in January and the lowest value was during July. The lowest content in summer could be due to the decomposition of chemical compounds. The occurrence of heavy metals in water bodies can be of natural origin (i.e., eroded minerals within sediments, leaching of ore deposits) or for anthropogenic one (i.e., solid waste disposal, industrial or domestic effluents, harbors channels dredging) (Donia et al., 2015). Iron was ranged from <0.01 ppm to 0.30 ppm. The highest value was during March.Manganese was ranged from <0.01 ppm to 0.21 ppm and the highest value was during May. The range of Sulfate was from 25 ppm to 50 ppm the lowest value was during March and the highest was in September. Phosphates were ranged from <0.01 ppm to 0.12 ppm and the highest value was during May. The high concentrations of phosphates may be due to the effect of drainage water that enriched with phosphorous compounds.The range of nitrate was from 0.07 ppm to 0.55 ppm. The highest value was in July and the lowest value was during May. The increasing in nitrate might be due to agricultural discharges in the tested sites near the residential blocks and also may be due to containing very high protein residues, Also indicated the existence of an agricultural discharge in these tested areas. Ammonia was ranged from 0.15 ppm to 0.41 ppm the highest value was during March. While the lowest, was during January. This is probably due to the utilization of ammonia by phytoplankton and bacteria, sewage disposal or discharges of industries that use ammonia liquor or gas for their production processes. All of these results were agreed with (Allam and El-Gemaizy 2015; Hazaa et al., 2015; Hisham et al., 2015; Galal et al., 2017).

Enumeration of algae in surface water samples is often a necessary part of water quality monitoring and algal research. The results obtained from this study showed various phytoplankton structures belonging to five groups, namely, Bacillariophyta, Chlorophyta, Cyanophyta, Pyrrophyta and Euglenophyta. They varied in their numbers during the period of investigation. Bacillariophyta represent the most abundant group and Chlorophyta ranked as the 2nd group in their occurrence during the period of investigation. Cyanophyta were present during the period of investigation with low species number and ranked as the 3rd group in their occurrence. Pyrrophyta and Euglenophyta showed rare occurrence. These results were agreed with (Shehata et al., 2008; Allam and El-Gemaizy, 2015; Dango et al., 2015; Khairy et al., 2015; Onyema, 2017).

Phytoplankton abundance is controlled by physicochemical conditions, water level fluctuation, sunlight and nutrient supply (Hussian et al., 2015). Temperature is an important factor that affects the distribution, health and survival of aquatic organisms. Algal distribution was affected by temperature as the highest numbers were indicated in warmer seasons, so the highest algal count was recorded in autumn and spring while the lowest counts were recorded during the summer. This agreed with (Allam and El-Gemaizy, 2015; Hussian et al., 2015; Khairy et al., 2015)except special case in as the highest algal count was in January then March and this was due to the winter closure period in Egypt (Galal et al., 2015). In this period water level was highly decreased in the river and this affected the rate of water flow in the river as it highly decreased and this in turn resulted in high phytoplankton population as algal population is inversely proportional to water level (APHA 2010). Bacillariophyta represent the most abundant group with 64.9 % of total annual with 16 species number. The maximum accumulation was (257 × 10^3 organism \l) in March. The minimum occurrence was (112 × 10^3 organism\l) in September. The increase in Bacillariophyta can be seen as an ecological advantage, supplying energy for the planktonic web and they have been used to investigate the natural and the anthropogenic influences on biodiversity (Calliaria et al., 2005 and Hussian et al., 2015). The most common Bacillariophyta species was *Cyclotella comta* with (323 × 10^3 organism \l) per year with high rank of occurrence and these results agreed with (Morsi, 2012; Allam and El-Gemaizy, 2015; Dango et al., 2015; Hussian et al., 2015; Khairy et al., 2015 and Onyema, 2017). Chlorophyta was ranked as the 2nd division with 24.3 % of total annual with 22 species. Maximum density was recorded during winter season (January) and low density during autumn season (September) and these results agreed with (Sharmaet al., 2016). The most common Chlorophyta species was *Tetraedron minimum* with (69 × 10^3 organism \l) total number per year. The presence of high density of Cyanophyta indicates high pollution load and nutrient rich condition (Muhammad et al., 2005; Tas and Gonulol, 2007 and Sharma et al., 2016). Cyanophyta was ranked as the 3rd group. Their maximum accumulation was (44 × 10^3 organism \l) in January. The minimum occurrence was in September and these results agreed with (Morsi, 2012 and Sharma et al., 2016). The most common Cyanophyta species was *Merismopdia elegans* with (61 × 10^3 organism \l) per year. Euglenophyta and Pyrrophyta showed rare occurrence in both Shebin El-kom and Menof water plants. They occurred as 0.11 % and 0.42 % of total annual stock in Shebin El-kom and in Menof they occurred with 0.12 % and 0.47 % of total annual stock, respectively and these results agreed with (Morsi, 2012; Hussian et al., 2015; Khairy et al., 2015 and Sharma et al., 2016).Surface water was treated and coagulated with two different coagulants, chemical coagulant (aluminum sulfate) and Natural coagulant *(Moringa oleifera* seeds). Coagulation with *M. oleifera* seeds extraction was very effective than aluminum sulfate, as it reduced turbidity of raw Nile water from 13.8 to 2.2 NTU with algal removal 98.7% without chlorination, and with chlorination reduced turbidity of raw Nile water from 5.5 to 1.5 NTU with algal removal 99.1%. On other hand aluminum sulfate reduced turbidity of raw Nile water from 13.8 to 2.0 NTU with algal removal 85.8 % without chlorination, and with chlorination reduced turbidity of raw Nile water from 5.5 to 1.2 NTU with algal removal 96.8%. This agreed with (Shehata et al., 2008; Ali et al., 2009; Amagloh and Benang, 2009; Alo et al., 2012 and Martin et al., 2012). The seeds of *M. oleifera* contain a coagulant protein which can replace conventional coagulant such as aluminum sulfate, in both domestic and larger scale water treatment (Shehataet al., 2008). Ndabigengesere and Narasiah, (1998) suggested that *M. oleifera* seeds used as a coagulant in water and wastewater treatment after a suitable purification of the cationic active proteins (Ndabigengesere et al., 1995). The seed of *M. oleifera* contain lower molecular weight water-soluble proteins which carry a positive charge. When the seeds are crashed and added to water, the protein produces positive charges acting like magnets and attracting predominately negatively charged particles such as clay, silk, alga and other toxic particles. These bound particles then grow in size to form the flocculates which are left to settle by gravity (Amagloh and Benang, 2009).

CONCLUSION

It can be concluded that *Moringa oleifera* seeds extraction is an effective and safe natural coagulant in drinking water clarification and wastewater treatment due to the presence of a water-soluble cationic coagulant protein that able to reduce turbidity and remove algae instead of aluminum sulfate that has many side effects as it has various health problems in numerous studies, from gastrointestinal damage and phosphate deficiency to dialysis encephalopathy, renal oestrodistrophy and Alzheimer's disease.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

ACKNOWLEGEMENT

The authors are very grateful to the Botany and Microbiology Department, Faculty of Science, Menoufia University for supporting this research.

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