Dynamic case study of phytoplankton as a result of the non-biological characteristics of water at Embaba Drinking Water Station, Giza

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Abstract:

The results showed that water treatment negatively affected the concentration of turbidity, hydrogen ion concentration, total hardness and magnesium hardness, while concentrations were not changed or were close due to the processes of water treatment for both electrical conductivity and total dissolved salts and calcium hardness in comparison of the Nile samples and expulsion for these parameters. The result of water treatment has been fruitful in reducing concentrations or clearing concentrations of ammonia, nitrite and nitrates. The results confirmed that water treatments did not affect the various cations such as sodium, potassium, calcium, magnesium, aluminum, iron and manganese.

Aluminum cation may have increased as a result of the use of aluminum sulphate in water treatment.

Phytoplankton count in row and treated water from Embaba Drinking Water Treatment Plant was recorded in both Nile water and treated ones where the highest count was 2396000 and the lowest was 1818999 Unit/L in the case of row water while the highest results were195334 Unit/L and the lowest results were 30000 Unit/L in the case of treated water, respectively. Phytoplankton composition was belonged to Bacillariophyceae, Cyanophyceae and Chlorophyceae groups. The dominant diatoms were *Cyclotella* spp. and *Melosira* spp., while blue-greens were dominated by *Gomphosphaeria aponina* and *Merismopedia tenuissima*. Green algae were dominated by *Ankistrodesmus falcatus* and *Coelastrum microporum*.

Keywords: Phytoplankton, Water Treatment Plant, River Nile, Chlorophyceae, Cyanophyceae, diatoms, Nile samples, treated samples.

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Introduction

The main water resource in Egypt is the River Nile, which originates in Lake Tanganyika at latitude 3°S, passing northward through several African countries to the shore of the Mediterranean Sea in Egypt at latitude 31°15 N (**Zahran, and Willis, 2003**).

The global trend toward eutrophication of drinking water supplies has increased especially on the negative effects of algae on water treatment processes. In particular, the addition of oxidants such as chlorine, ozone, or permanganate to untreated water prior to coagulation has been shown to increase the removal of algae (**Plummer and Edzwald, 2002; Chen and Yeh, 2005**). These oxidants alter the surface charge of algae and thus improving their removal during coagulation (**Daly *et al.*, 2007).**Generally, chlorine disinfection effectively depends on the applied dose and contact time (**Casey *et al*., 2012**).

A typical drinking water treatment system in Egypt comprises stages of pre-chlorination, flocculation/coagulation with alum, filtration, post-chlorination, and settling in distribution tanks (**Donia, 2007**). In this set-up, pre-chlorination is regarded as the most important stage for the control of algal growth (**Donia, 2007; Badawy *et al*., 2012**).

After the completion of the Aswan High Dam in 1966, stream-flow regulation has caused significant changes to the Nile aquatic ecosystem and waterway environment (**El-Shinnawy *et al*., 2000; Talling *et al*., 2009**). This change in flow led to the retention of water masses in reservoirs behind dams and barrages in some regions within the Nile system, which provided favorable conditions and ample time for phytoplankton development. Subsequently, this altered the aquatic vegetation which is a source of nutrients for phytoplankton and algae utilization.

Shehata *et al.* (2008) reported that with regards to the total algal counts before and after High Dam construction, it may be shown that the total algal counts in the river Nile water increased one tenfold after construction impoundment.

Regardless of the damage caused by algae in the Nile River, but by controlled them and follow their growth can be used to convert atmospheric carbon dioxide into biomass, fatty acid and lipids (**Spolaore *et al.*, 2006**). Microalgae are easy to culture, characterized by rapid growth and are able to grow in waters, unsuitable in some cases, for human consumption. Moreover, they can grow anywhere, their rate of growth depends on sunlight and simple nutrients, as well as to certain specific compounds and appropriate aeration (**Aslan and Kapdan, 2006; Frac *et al.*, 2010; Verma *et al.*, 2010**).The current study is a follow - up of Embaba Water Treatment Plant for drinking water and comparison of water produced before and after treatment in terms of physical and chemical properties and phytoplankton count.

Materials and Methods

Samples collection

Samples were taken from Embaba water treatment plant (WTP), from one of each of the following: (Nile intake), and taps (out take). Samples were monthly collected from November, 2013 to November, 2014.

Physical and Chemical properties:

Turbidity, Electrical conductivity (EC) and Total Dissolved Salts (T.D.S.), Free Residual Cl_2(FR Cl_2), pH Value, Total Hardness (T.H.):as mg $CaCO_3$ /L, Calcium Hardness (Ca H.), Magnesium Hardness (Mg H.), Alkalinity, Chloride, Ammonia, Nitrite, Nitrate, Sulfate and Heavy Metals by Inductively Coupled Plasma/Optical Emission Spectrometry (ICP-OES) were measured using (**APHA *et al.*, 2005**).

The phytoplankton was preserved in Lugol's solution according to the method describe by (**APHA *et al.*, 2005**), and was calculated using Sedgwick-Rafter cell.

Identification of algal taxa was carried out according to **Prescott** (**1982**) and **Patrick and Reimer, (1966 and 1975); Jensen, (1985); Krammer and Lang-Bertalot, (1986, 1988); Round *et al.* (1990).**

Statistics Analyses:

Correlation and regression using SPSS (statistical package for the social sciences) to link the relationships between all physical and chemical properties of water (**Nie *et al*., 1975**).

The matrix of phytoplankton and physical, chemical properties were subjected to canonical corresponding analysis using PC-ORD 5 program.

Results and Discussion

Physical and Chemical properties of Nile water from Embaba (WTP):

Turbidity of a natural body of water is an important determinant of its condition and productivity. Where, turbidity in water body known as all suspended particles being present in water. As water becomes more turbid, less sunlight is able to penetrate its surface, therefore the amount of photosynthesis that can occurs decreases. The present results (Table 1) shows that turbidity values ranged between (2.97 and 30.70 NTU) in Nile sample with average of (9.11 NTU), while in treated water the turbidity was between (0.3 and 1.18 NTU) with average of (0.63 NTU). Also, it varied from month to month with maximum peak (30.7 NTU) in May and the lowest value (2.97 NTU) in February. Turbidity is the measure of total suspended matter in water, mostly dependent on many factors as temperature and the water conditions such as waste disposal or flooding. Turbidity may be as a result to clay, silt, organic matter, inorganic matter, microscopic organisms and similar materials contribute to turbidity level (**Abd El-Shakour*et al*., 2012**).The present data revealed that the highest water turbidity was observed in spring period whilst the lowest value was in winter season.

The lower values of turbidity were always associated with are remarkable drop in total standing crop and increase in turbidity parallel to conspicuous increases in phytoplankton populations(**El-Attar, 2000**).

El-Dars *et al*. (**2015**) reported that the highest water turbidity was observed during the winter period while the lowest was during the summer season, this may be related to the water closure period. High turbidity of the Nile stream was attributed to the increase in water nutrient content (**Emara *et al*., 2012**).The turbidity was dramatically reduced due to drinking water treatment and was average between 0.3-1.18 NTU. Also, **Mahmoud *et al.*** (**2016**) reported that the turbidity values of treated water sampled was 1 NTU.

The results of current electrical conductivity in either Nile or treated water samples were not significantly affected. The measurement of EC were different between Nile water and treated water samples as follows, where the results as in table (1) were between 258 - 492 µS/cm and average was 396 µS/cm in Nile water. In treated water the EC ranged from 260 - 510 µS/cm with average was 410µS/cm. The current results were similar with those attained by **El-Otify and Iskaros** (**2015**) who stated that in winter, slightly high EC values were recorded as compared to the other seasons the value between 230.83 and 269.33 µS/cm. **Mahmoud *et al.*** (**2016**) reported that the EC of treated water samples was 410.9 µS /cm in tap water and 424.6 µS/cm in Nile water. Total Dissolved Solids (TDS) is a measure of the inorganic dissolved salts and small amounts of organic matter present in a sample of water. In TDS analysis, the results show in table (1) were slight different between Nile water and treated water samples, where, it was between170 - 325 mg\L with average of 261 mg\Lin Nile water. On the other hand, in treated water the TDS ranged from 172 - 337 mg\L with average of 271 mg\L.

Table (1): Physical and chemical properties of the Embaba WTP.

	Tur.		EC		T.D.S		R.Cl.	pH value		T.H.		Ca. H.		Mg. H.	
	Nile	Treated	Nile	Treated	Nile	Treated	Treated	Nile	Treated	Nile	Treated	Nile	Treated	Nile	Treated
Month	NTU		µS/cm		mg/L		mg/L	-		mg/L		mg/L		mg/L	
November 2013	3.07	0.49	373	394	246	260	2.3	8.47	7.3	139	142	91	90	48	52
December 2013	5.31	0.93	484	504	319	333	1	8.47	7.3	170	162	103	104	67	58
January 2014	4.67	1.18	492	510	325	337	0.4	8.47	7.3	163	164	87	100	77	64
February 2014	2.97	0.57	474	459	313	303	3.3	8.47	7.3	133	138	77	82	55	56
March 2014	6.53	0.5	318	327	210	216	2.5	8.10	7.3	127	138	73	82	55	56
April 2014	9.30	0.5	258	260	170	172	1.5	8.47	7.3	129	128	77	82	52	46
May 2014	30.70	0.99	395	418	260	276	2.5	8.30	7.35	123	132	71	78	52	54
June 2014	11.47	0.52	375	387	248	255	2.7	8.30	7.45	125	130	81	84	44	46
July 2014	10.50	0.5	342	382	226	252	2.5	8.20	7.5	132	130	82	84	50	46
August 2014	8.90	0.52	362	387	239	255	2.8	8.20	7.45	118	120	75	78	43	42
September 2014	14.47	0.4	393	413	259	273	3.5	8.20	7.45	129	134	83	86	47	48
October 2014	7.12	0.3	438	440	289	290	1.8	8.20	7.45	137	138	80	88	57	50
November 2014	3.48	0.8	445	456	294	301	2.3	8.20	7.45	133	140	82	90	51	50
Average	9.11	0.63	396	410	261	271	2.24	8.31	7.38	135	138	82	87	54	51
Minimum	2.97	0.30	258	260	170	172	0.40	8.10	7.30	118	120	71	78	43	42
Maximum	30.70	1.18	492	510	325	337	3.50	8.47	7.50	170	164	103	104	77	64

Where: T.H. = Total Hardness; **Ca. H.** = Calcium Hardness; **Mg. H.** = Magnesium Hardness.

Ali *et al*. (**2014**) showed slight variations throughout the sampling segment of the Nile. An obvious increase in TDS was however, recorded at (El-Nasria) during April (318.0 mg/L) and June (524.0 mg/L) during season 2011. **Amer and Abd El-Gawad** (**2012**) reported that the salinity of Nile water increased going from Aswan High Dam (160mg/L) to Cairo (around 260 mg/L). **Wahaab and Badawy** (**2004**) and **Talling** (**2009**) reported that higher TDS recorded during winter for the Nile waters was attributed to the dam closure period in which the amount of water released from the behind the dam was less than that in summer. Water EC is the direct function of its total dissolved salts (**Harilal *et al*., 2004**) and is used as an index to represent the total concentration of soluble salts in water (**Purandara *et al*., 2003; Gupta *et al*., 2008**).The present TDS values were not affected by significant change either before treatment in raw water or after treatment of drinking water. This means that the soluble salts of the treated water are not disposed of and this requires more domestic measures to use this water. **Mahmoud *et al.*** (**2016**) reported that the TDS value of treated water samples was 243.8 mg/L and 260.5 mg/L in Nile water.

Overall, the efficiency of the pre-chlorination stage is governed by two indicators, namely: the chlorine demand and residual chlorine content. The chlorine demand determines the chlorine dose applied during the pre- chlorination /disinfection process and the residual chlorine signifies that sufficient amount of chlorine has been added to inactivate bacteria and some viruses that may cause diarrheal disease in drinking water (**WHO, 2011**). Residual chlorine was found between 0.4 and 3.5 mg\L with average of 2.24 mg\L table (1). **Mahmoud *et al.*** (**2016**) reported that residual chlorine values of treated water samples were 1.9 mg/L. Technically, a minimum of 0.5 mg/L residual chlorine must be maintained to ensure water protection from recontamination during storage and that residual chlorine levels between 0.2 and 0.5 mg/L at the consumer outlet water given the extremities of the supply network (**WHO, 2011**).

Measurement of pH is one of the most important and frequently used tests in water chemistry. The pH of a water body is very important in determination of water quality since it affects other chemical reactions such as solubility and metal toxicity (**Agbaire and Obi, 2009**). Practically every phase of water supply and wastewater treatment, e.g., acid-base neutralization, water softening, precipitation, coagulation, disinfection, and corrosion control, is pH-dependent.

The pH values were slightly alkaline with a range of 8.31, 7.38 in both raw and treated water, respectively table (1). **Alaa and Werner** (**2010**) reported that results of pH seem to be constant all over the river Nile and all pH values were in alkaline side. **Ali *et al*.** (**2014**) also recorded that with regards to pH, determined pH values showed a tendency towards alkaline side, with no clear seasonal changes during their study period. However, a sudden decrease in pH value (7.44) was recorded at El- Nasria during June 2011.**Mahmoud *et al.*** (**2016**) reported that pH values of water samples ranges from 7.6 in tap water.

Originally, water hardness was understood to be a measure of the capacity of water to precipitate soap. Calcium and magnesium in water cause hardness. Total hardness is defined as the sum of calcium and magnesium concentrations. **Alaa and Werner** (**2010**) recorded that water hardness was slightly increased from Aswan to Rosetta and Damietta reaching the highest value at Rosetta (162.3 ppm). They noticed that Ca and Mg nearly have the same distribution as water hardness. From table (1) Total hardness was measured in Nile sample between 118 and 170 mg\L with average was 135 mg\L while the total hardness was between 120 and 164 mg\L with average was 138 mg\L in treated water. The highest value of calcium and magnesium hardness were 103 and 77 mg\L respectively in the Nile water samples, where, it was 104 and 64 mg\L respectively in treated water samples, while the lowest value was 71 and 43 mg\L in the case of Nile water and78 and 42 mg\L in treated water samples. **Ali *et al.*** (**2014**) also recorded that hardness refers to the concentration of calcium and magnesium in water with hard water possesses high concentrations of these elements. Total hardness in their study at different segments of Nile ranged from 41.15 to 111.18 mg $CaCO_3$ /L. The present results took the same trend i.e. the hardness linked to hardness of calcium and magnesium hardness. **Mahmoud *et al.*** (**2016**) reported that the total hardness values of treated water samples were 127.9

mg\L and Ca hardness values of treated water samples were 85.1 mg\L, but Mg hardness values of treated water samples were 56.3 mg\L.

Alkalinity is a measure of water's ability to neutralize acids. In most types of water, alkalinity is the result of bicarbonates (HCO_3), carbonates (CO_3^{2-}), and hydroxides (OH^-) of the metals calcium, magnesium, and sodium.

Alkalinity as in table (2) revealed that the highest values of alkalinity (177 and 148) were recorded, where the lowest values (115 and 108) were recorded in both Nile and treated water samples, respectively. **Alaa and Werner** (**2010**) described alkalinity as an indication of the concentration of carbonate, bicarbonate and hydroxide content in water. Alkalinity was fluctuated within a very narrow ranges recording highest values at Rosetta (124.3 mg/L) followed by Damietta (115.2 mg/L).) **Ali *et al.*** (**2014**) also recorded that alkalinity is produced by the existence of minerals such as limestone ($CaCO_3$). Total alkalinity showed distinctive variations throughout the sampling period with regards to time. In any case, the current results show variations between results in different months and this is consistent with previous results. The results confirmed that the alkalinity had decreased in the treated samples of drinking water and was between 108-148 mg/L. **Mahmoud *et al.*** (**2016**) reported that the total alkalinity values of treated water samples were 118.7 mg/L.

Chloride, in the form of chloride (Cl^-) ion, is one of the major inorganic anions in water. The salty taste produced by chloride concentrations is variable and dependent on the chemical composition of water. Sulfate ion (SO_4^{2-}) is precipitated in an acetic acid medium with barium chloride ($BaCl_2$) so as to form barium sulfate ($BaSO_4$) crystals of uniform size.

For Chloride and Sulfate ions it was observed that as in table (2) the maximum values (47 and 84 mg\L) were recorded in treated water samples compared to that recorded in (43 and 66 mg\L) in Nile water samples, respectively.

Table (2): Continued of the physical and chemical properties of the Embaba WTP.

Month	Alk.		Cl^-		SO_4		F.		NH_3		NO_2		NO_3	
	Nile	Tap	Nile	Tap	Nile	Tap	Nile	Tap	Nile	Tap	Nile	Tap	Nile	Tap
	mg/L		mg/L		mg/L		mg/L		mg/L		mg/L		mg/L	
November 2013	155	132	28	30	36	53	0.46	0.45	0.28	Nil	0.06	Nil	1.77	1.40
December	177	148	41	45	51	72	0.50	0.4	0.16	Nil	0.01	Nil	1.76	1.39
January 2014	145	134	43	47	66	84	0.59	0.4	0.27	Nil	0.01	Nil	1.81	1.61
February	115	120	39	41	48	58	0.50	0.3	0.26	Nil	0.05	Nil	1.76	1.54
March	149	120	29	30	37	50	0.55	0.38	0.36	Nil	0.05	Nil	2.33	2.10
April	150	120	30	32	37	43	0.50	0.16	0.26	Nil	0.05	Nil	1.76	1.60
May	140	120	27	28	23	37	0.50	0.39	0.19	Nil	0.08	Nil	1.78	1.59
June	127	110	20	26	22	39	0.41	0.4	0.29	Nil	0.02	Nil	1.43	1.30
July	127	108	21	23	18	36	1.09	0.49	0.27	Nil	0.01	Nil	1.36	1.30
August	129	110	19	26	26	39	0.48	0.4	0.41	Nil	0.02	Nil	1.70	1.62
September	135	118	24	29	23	39	0.80	0.41	0.13	Nil	0.01	Nil	1.88	1.71
October	129	114	27	31	25	37	0.67	0.29	0.29	Nil	0.01	Nil	1.45	1.32
November 2014	151	128	31	35	35	50	0.67	0.33	0.40	Nil	0.02	Nil	1.66	1.50
Average	141	122	29	33	34	49	0.60	0.37	0.27	Nil	0.03	Nil	1.73	1.54
Minimum	115	108	19	23	18	36	0.41	0.16	0.13	Nil	0.01	Nil	1.36	1.30
Maximum	177	148	43	47	66	84	1.09	0.49	0.41	Nil	0.08	Nil	2.33	2.10

Alaa and Werner (**2010**) recorded that chloride is the most common inorganic anion found in water and wastewater. The distribution of (Cl) was similar to those of the cations (Ca and Mg) showing a minor increase from Aswan to Damietta and Rosetta.

According to **El-Otify and Iskaros** (**2015**) sulfate did not exhibit wide range of variations among the investigated sites. In winter and spring, levels of sulphate were somewhat lower than those in summer and autumn and the value between 8.56 and 14.06 mg /L. **Ali *et al.*** (**2014**) also recorded that the high levels of sulphate are the result of the excessive use of sulphate-rich fertilizers as well as the domestic wastes (**Emara *et al.*, 2016**). **Mahmoud *et al.*** (**2016**) reported that the Cl values of treated water samples were 25.6 mg/L. also, reported that the SO_4 values of treated water samples were 31.8 mg/L.

Fluoride occurs naturally in public water systems as a result of runoff from weathering of fluoride-containing rocks and soils and leaching from soil into groundwater. Concentrations of fluorides ranged from 0.41 to 1.09 and 0.16-0.49 mg/L in both Nile and water treated samples table (2). According to the present results fluoride did not have a specific tendency to increase or decrease concentrations during study. **Mahmoud *et al.*** (**2016**) reported that the treated water samples have F concentration was 0.26 mg/L.

For the results of concentrations of ammonia and nitrite, the results showed a lack of concentrations of the two parameters as the results confirmed the effectiveness of water treatment methods in the disposal of these concentrations. Nitrate Concentrations ranged from 1.3 to 2.1 in treated water samples table (2).

Alaa and Werner (**2010**) recorded that ammonia is excreted by animals and produced during decomposition of plants and animals, thus returning nitrogen to the aquatic system. Ammonia was recorded in a very low concentration in all sites recording the highest value at Rosetta (0.14 mg\L). Nitrate is often the limiting element restricting biological productivity of Nile water (**Chapman and**

Chapman, 1996). The values of nitrate fluctuated within a wide range and showed low levels during the whole period of investigation. The highest value of nitrate was recorded at Rosetta. Higher concentration of nitrate in water of Rosetta branch can create a large oxygen demand and cause algae to grow in large quantity.

Mahmoud *et al.* (**2016**) reported that the NO_2 values of treated water samples were under detection limits (UDL). Also, reported that the NO_3 values of treated water samples were 1.2 mg/L.

To evaluate the performance of WTPs, all results of treated water were compared to permissible limits of drinking water in Egypt as mentioned in the Egyptian law and decision of the Ministry of Health No. 458/2007; such limits are identical to the international standard of world health organization (**WHO, 2011**). With the increased turbidity, alum sulphate is used in high concentration and this may explain the recorded increase of Al in some month in two WTPs. Al as a harmful neurotoxic metal that may induce Alzheimer's disease must be allowed to precipitate completely as Al hydroxide (**Schutte, 2006**).

Essential and heavy metals were recorded in table (3). Sodium concentration varied in different months of study, ranging from 22.2 - 47.87mg\L with an average of 32.702 mg\L in Nile water samples. In treated water samples, Na concentration ranged from 23 - 47.73 mg\L, with an average of 32.652 mg\L. Potassium concentrations were less than sodium at concentration ranging from 4.92 - 5.82 mg\L with an average of 5.502 mg\L in Nile water samples. In treated water samples, K concentration ranged from 4.97 - 5.84 mg\L, with an average of 5.505 mg\L.

Calcium is the most reactive cations present in water, the decrease in calcium is directly associated with the utilization of CO_2 in photosynthesis process (**Abo El-Lil, 2003**).

Table 3: Na, K, Ca, Mg, Al, Fe and Mn in 13 month Measured of Embaba WTP

	Na		K		Ca		Mg		Al		Fe		Mn	
	Nile	Tap	Nile	Tap	Nile	Tap	Nile	Tap	Nile	Tap	Nile	Tap	Nile	Tap
Month	mg/L		mg/L		mg/L		mg/L		mg/L		mg/L		mg/L	
November 2013	33.350	33.180	5.370	5.420	34.940	36.140	12.270	12.660	0.090	0.200	0.019	0.007	0.037	0.002
December	47.870	45.590	5.800	5.840	38.900	41.020	15.000	15.420	0.060	0.200	0.009	0.012	0.009	0.004
January 2014	43.060	47.730	5.370	5.790	44.940	40.150	14.270	15.410	0.077	0.200	0.009	0.013	0.008	0.011
February	40.970	38.740	5.820	5.760	32.490	33.150	13.720	13.380	0.030	0.200	UDL	UDL	0.002	0.002
March	34.500	36.200	5.820	5.500	32.490	34.670	13.720	12.300	0.030	0.090	UDL	UDL	UDL	UDL
April	33.200	32.710	5.600	5.700	30.920	31.130	11.260	11.500	0.030	0.200	UDL	UDL	0.002	0.003
May	27.440	27.430	5.670	5.800	32.490	31.800	10.770	11.000	0.320	0.170	UDL	UDL	0.002	UDL
June	24.750	23.040	5.690	5.390	32.830	33.420	10.810	10.670	0.060	0.110	0.012	0.016	0.005	0.007
July	22.200	23.000	5.000	5.090	29.880	30.000	10.100	10.300	0.030	0.100	UDL	UDL	0.002	UDL
August	23.300	23.520	4.920	4.970	29.320	31.260	10.180	10.540	0.050	0.090	0.001	UDL	UDL	UDL
September	29.520	28.630	5.450	5.390	33.450	34.500	11.600	11.880	0.030	0.090	UDL	UDL	0.001	UDL
October	32.180	31.660	5.510	5.510	34.180	35.420	12.010	11.910	0.090	0.170	0.010	UDL	0.030	UDL
November 2014	32.780	33.040	5.500	5.400	32.910	37.840	11.990	12.560	0.190	0.200	0.003	0.002	0.031	0.062
Min	22.200	23.000	4.920	4.970	29.320	30.000	10.100	10.300	0.030	0.090	0.001	0.002	0.001	0.002
Max	47.870	47.730	5.820	5.840	44.940	41.020	15.000	15.420	0.320	0.200	0.019	0.016	0.037	0.062
Average	32.702	32.652	5.502	5.505	33.826	34.654	12.131	12.272	0.084	0.200	0.009	0.009	0.012	0.013

Also, **Verma *et al.*** (**2011)** classified water bodies into: (i) poor (ii) medium and (iii) rich water body with regard to calcium content. Calcium concentration varied in different months of study, ranging from 29.32 - 44.94mg\L with an average of 33.82mg\L in Nile water samples. In treated water samples, calcium concentration ranged from 30 - 41.02 mg\L, with an average of 34.654 mg\L.

This harmonized with the discovery of (**Awadallah and Soltan, 1995; Abdel-Satar, 2005**) which they concluded that the lowest values of Ca were recorded in the hot seasons and the highest in the cold seasons. This might be due to the decrease in the solubility of $CaCO_3$ as the temperature increase. This was achieved by a negative correlation existed between calcium and water temperature during autumn and summer.

Magnesium concentrations were less than sodium and calcium at concentration ranging from 10.1 – 15 mg\L with an average of 12.131 mg\Lin Nile water samples. In treated water samples, Mg concentration ranged from 10.3 - 15.42 mg\L, with an average of 12.272 mg\L. In addition, the preferential behavior of dissolved CO_2 may affect the concentration of magnesium in solution, when CO_2 present in appreciable concentration it reacts with calcium salts than with magnesium, thus converting large quantities of calcium into soluble bicarbonates (**Abdel-Satar, 2005**).

For iron and manganese ions, the values were minimal and there were near constant values before and after treatment.

Al Aluminum salts are used in water treatment as coagulants to reduce organic matter, color, turbidity and microorganisms levels (WHO, 2010). The levels of Al is high or low of treated water in Nile water that may be related to low demand period or high aluminum dose in water plants. **Salim** (**2012**) reported that total iron ranged between 0.002 to 0.86 mg\L in raw water at New Mansoura and Bilqlas WTP. He also reported that total manganese concentrations ranged between 0.004 and 0.55 mg\L and the higher values of total iron and total manganese were recorded in colder season of winter.

Mahmoud *et al.* (**2016**) reported that the Al values of treated water samples were 0.3 mg/L, Fe values of treated water samples were 0.1 mg/L and Mn values of treated water samples were 0.1 mg/L.

An over view to the present investigation the elements were record an increased in winter compared to summer at Nile water. Also, comparison of the Nile samples and expulsion for the elements it was clear that the concentration of sodium, calcium, magnesium, iron, manganese and potassium change by increases and decreases according to the season, while the concentration of aluminum it increase with larger proportions in treated water by adding alum (aluminum sulfate) and chlorine practical of coagulation, sedimentation and filtration.

From Table 4, there were statistical relations with positive values at level of 0.01 between turbidity and concentration of hydrogen ion, nitrite and nitrates and positive relationship between electrical conductivity and TDS, TH, Ca H, Mg H, Cl, SO_4, Na, Ca, and Mg.

Also, a positive relation between TDS and TH, Ca H, Mg H, Cl, SO_4, Na, Ca, and Mg. Total turbidity was associated with partial turbidity of Ca H and Mg H as well as alkalinity, SO_4, Na, Ca and Mg. Ammonia was generally associated with nitrite, nitrates, and vice versa in positive relationships. In considering negative relationships R chlorine has been associated with negative relations with turbidity, pH, alkalinity, NH_3, NO_2, NO_3 and F.

Table 4: statistical correlation among physical and chemical parameters of water samples of Embaba plant.

	Tur.	EC	T.D.S	R. Cl	pH	T H	Ca H	M H	CL-	Alk	NH3	NO2	NO3	SO4	F	Na	K	Ca	Mg	Al	Fe	Mn
Tur.	1																					
EC	-0.187	1																				
T.D.S	-0.187	1.000**	1																			
R. Cl	-0.578-**	0.006	0.006	1																		
pH	0.594**	-0.067	-0.067	-0.839**	1																	
T H	-0.305	0.666**	0.666**	-0.112	-0.062	1																
Ca H	-0.437-*	0.569**	0.569**	0.064	-0.265	0.856**	1															
M H	-0.065	0.556**	0.556**	-0.265	.1760	0.832**	0.426*	1														
CL-	-0.342	0.645**	0.645**	0.004	-0.177	0.821**	0.622**	0.771**	1													
Alk	0.299	0.132	0.132	-0.648**	.571**0	0.497**	0.350	0.495*	0.325	1												
NH_3	0.476*	-0.154	-0.154	-0.817**	.871**0	-0.208	-0.395*	0.061	-0.275	0.491*	1											
NO_2	0.644**	-0.266	-0.266	-0.588**	.679**0	-0.299	-0.466*	-0.023	-0.134	0.385	0.601**	1										
NO_3	0.629**	-0.125	-0.125	-0.868**	.954**0	-0.104	-0.335	0.177	-0.174	0.618**	0.908**	0.712**	1									
SO_4	-0.524**	0.544**	0.544**	0.210	-0.423-*	0.775**	0.664**	0.644**	0.902**	0.150	-0.444-*	-0.322	-0.412*	1								
F	0.437*	-0.026	-0.026	-0.538**	.570**0	-0.055	-0.164	0.080	-0.310	0.262	0.560**	0.200	0.585**	-0.433-*	1							
Na	-0.240	0.551**	0.551**	-0.223	.0260	0.846**	0.623**	0.813**	0.931**	0.530**	-0.074	-0.011	0.053	0.805**	-0.195	1						
K	0.022	0.248	0.248	-0.148	-0.027	0.384	0.212	0.445*	0.588**	0.326	-0.099	0.213	0.051	0.400*	-0.339	0.644**	1					
Ca	-0.220	0.679**	0.679**	-0.080	-0.062	0.890**	0.729**	0.776**	0.764**	0.414*	-0.191	-0.244	-0.089	0.748**	-0.142	0.753**	0.322	1				
Mg	-0.287	0.621**	0.621**	-0.169	-0.038	0.848**	0.659**	0.777**	0.913**	0.497**	-0.095	-0.057	0.021	0.822**	-0.174	0.962**	0.621**	0.792**	1			
Al	-0.088	0.434*	0.434*	0.145	-0.532-**	0.429*	0.488*	0.226	0.547**	0.037	-0.466-*	-0.192	-0.489*	0.624**	-0.378	0.410*	0.364	0.437*	0.430*	1		
Fe	-0.148	0.295	0.295	-0.230	.1020	0.483*	0.567**	0.237	0.241	0.339	0.052	-0.045	0.029	0.310	-0.097	0.293	0.157	0.505**	0.342	0.263	1	
Mn	-0.119	0.261	0.261	-0.125	.1260	0.177	0.248	0.044	0.128	0.263	0.145	0.030	0.068	0.052	0.002	0.126	-0.038	0.274	0.133	0.160	0.348	1

**Correlation is significant at the 0.01 level.

*Correlation is significant at the 0.05 level.

Phytoplankton is typically the main primary producer in any ecosystem. Microscopic analysis of algae in collected water sample showed that they belong to three main divisions. Bacillariophyta, Chlorophyta and Cyanophyta as reported by (Shehata *et al.* 2009; Ali, 2010). The current results confirmed the dominance of Bacillariophyceae compared to other divisions where the total Bacillariophyta count in Nile water samples ranged between 745333-1704000unit/L the most numerical common genera were *Cyclotella*, *Melosira* and *Synedra*, while the lowest numerical presence were *Asterionella*, *Fragilaria* and *Navicula* the average of count was 1182590 unit/L. On the other side total Bacillariophyta count ranged from 6667 - 45333 unit/L in treated water samples with average 24103 unit/L. followed by total Chlorophyta count in Nile water samples ranged between 778667 - 328000 unit/L with dominate genera of *Ankistrodesmus falcatus* and *Scenedesmus quadricauda*, the average of count was 572308 unit/L. On the other side, total Chlorophyta count ranged from 11333 - 106667 unit/L in treated water samples with average 37554 unit/L. Finally total Cyanophyta count in Nile water samples ranged between 90667 - 464000 unit/L with dominate genera of *Merismopedia tenuissima* then *Gomphosphaeria aponina*, the average of count was 275231unit/L. On the other side total Cyanophyta count ranged from 3333 - 80667 unit/L in treated water samples with average 31282 unit/L, the finally total count in Nile water samples ranged between 2396000 - 1818999 unit/L with the average was 2030128unit/L. Where, the treated water samples total count ranged from 195334 – 30000unit/L with average 92938unit/L table (5).

The Present results were in consistency of the results found by Shehata *et al.* (2009) who reported that diatoms were the most dominant and diversified group present in good numbers during four seasons especially in fall and winter seasons followed by green algae. Blue-green algae were presented in small number during different seasons. Among the diatoms, *Cyclotella comta* was the most dominant throughout the year, other important centric diatoms was *Melosira granulata*. Pinnate diatoms were dominated by *Diatomae longatum* and *Synedra ulna*.

Table 5: Phytoplankton total count during study period.

	Total Chlorophyta		Total Cyanophyta		Total Bacillariophyta		Total count	
	Nile	Treated	Nile	Treated	Nile	Treated	Nile	Treated
	Average Unit/L							
November 2013	568000	106667	226667	50000	1232000	38667	2026667	195334
December	610667	64667	238667	71333	1182667	28000	2032001	164000
January 2014	698000	31533	358000	15333	1084000	6667	2140000	53533
February	533333	40667	202667	14000	1262667	10667	1998667	65334
March	778667	65333	330667	28667	1001333	17333	2110667	111333
April	555333	29333	145333	62667	1118333	10000	1818999	102000
May	557333	27333	401333	80667	881333	45333	1839999	153333
June	676667	34000	464000	21333	745333	22000	1886000	77333
July	603333	20667	417333	15333	936000	23333	1956666	59333
August	585333	18000	192000	9333	1135333	37333	1912666	64666
September	446667	11333	90667	3333	1585333	32000	2122667	46666
October	498667	12667	146667	6000	1505333	11333	2150667	30000
November 2014	328000	26000	364000	28667	1704000	30667	2396000	85334
Average	572308	37554	275231	31282	1182590	24103	2030128	92938
Min	328000	11333	90667	3333	745333	6667	1818999	30000
Max	778667	106667	464000	80667	1704000	45333	2396000	195334

In general terms, the diatoms found are characteristic of eutrophic water bodies and most are recorded as halophytic which preferring alkaline waters (**Wolf, 1982**),which correspond to the conditions of relative high pH in the river Nile. **El-Dars *et al*.** (**2015**) reported that a higher algal count was obtained during the period from Sept. to Nov. 2012. This increase may be attributed to agricultural wastewater discharge and the accumulation of pollutants and nutrients south of the sampling point. While, **Shehata *et al.* (2009)** showed that clear variability was found in total algal numbers during different investigated seasons. The algal counts ranged from 2246 to 21245 Org. /ml with maximum attained during fall and winter seasons dominated with species belonging to diatoms which favorite low temperature. Current results were consistent with results of **Shehata *et al*. (2009)** who reported that the green algae were dominated by small planktonic

Chlorococcales belonging to the genera; *Scenedesmus*, *Ankistrodesmus*, *Botroyococcus* and *Dictyoshaerium*. Cyanophyta rarely grew to significant concentration except during periods of high temperature in spring and summer seasons. The numbers of genera or species of Nile water algae that are responsible for causing serious problems in water works are relatively high. Some genera of diatoms are significant in this respect and certain green algae and blue-green algae are also important. The present results showed that the percentage reduction in the number of Cyanophyceae was 88.6% and reduction of the number of green algae was 93.4%, while the number of diatoms was reduced to 98%, while the total decrease in the number of phytoplankton was 95.4%. This confirms the important role that water treatment plays in the mechanical or chemical elimination of algae populations. **Swanepoel *et al.* (2017)** showed that when high concentrations of Cyanophyceae (> 100000 cells.mL^{-1}) occur in the raw water, > 2000 cells.mL^{-1} of the same or smaller Cyanophyceae species (e.g. *Cylindrospermopsis raciborskii* and *Merismopedia* sp.) penetrate into the drinking water. This in return, opens the field for the search for modern technological methods for the complete elimination of these algae during the treatment of drinking water. Our results confirmed the presence of numbers of algae found in drinking water after the process of drinking water treatment.

Abdel-hamid *et al.* (2012) reported that under optimum performance of coagulation process, the removal of the rest suspended algae by granular media may reach 99.99%.Where, **Mahmoud *et al.*(2016)** reported that the total alga count in treatment water was 531 organism /L.

In the present investigation, the application of canonical corresponding analysis (CCA) indicated the presence of an ecological relationship between the phytoplankton community (as group) and its surrounding habitats.

CCA between phytoplankton groups and physical and chemical characteristics of water was illustrated in Fig. (1). It illustrates the correlation between abundance of different phytoplankton groups and the environmental variables. It was clear that total count and diatoms count were positive correlated with turbidity, EC and TDS. On the other hand, the Cyanophyta count was positive correlated with R. Cl. but Chlorophyta was positive correlated with hardness, sulphate, alkalinity and chloride and negatively correlated with other parameters. **Khafagy *et al*. (2018)** reported that Chlorophyta and Cyanophyta were positively correlated with ammonia, EC, total alkinilty, chlorides, hardness and sulphate. Also diatoms were positively correlated with turbidity.

Also, the correlation between abundance of different phytoplankton groups and the heavy metal concentrations (CCA) was studied Fig. (2). It revealed that diatoms were positive correlated with Mn. On the other hand, Cyanophyta was positive correlated with K and Al. But Chlorophyta was positive correlated with Ca, Mg, Na and Fe and total count was negatively correlated with all elements.

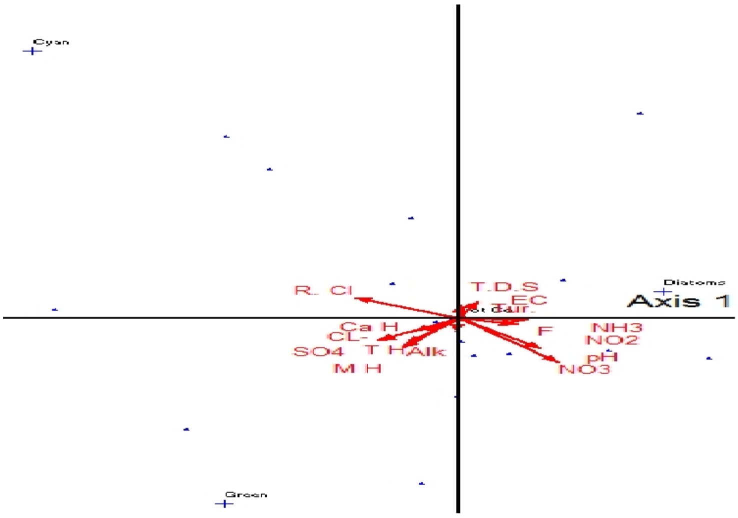

Fig 1: Canonical Corresponding Analysis (CCA) of physical and chemical characteristics and phytoplankton groups.

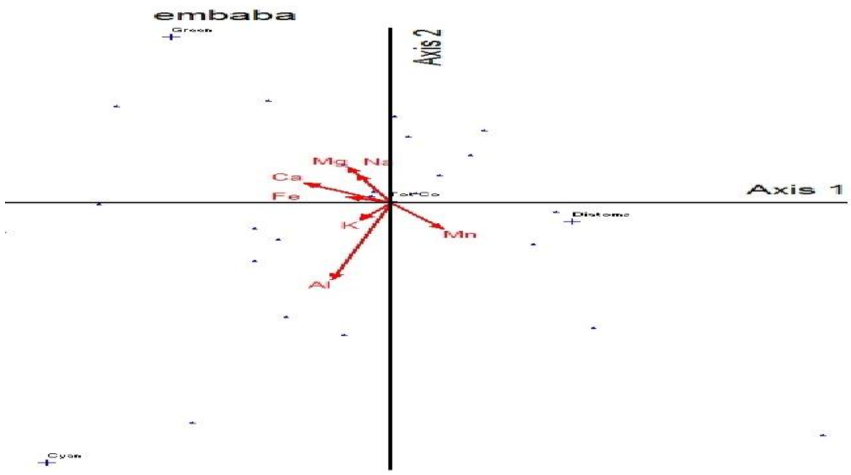

Fig 2: Canonical Corresponding Analysis (CCA) of heavy metal and phytoplankton group.

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دراسة الحالة الديناميكية للهائمات كنتيجة للصفات الغيربيولوجية للمياه في محطة إمبابة لمياه الشرب، جيزة

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أظهرت النتائج أن معالجة مياه الشرب أثرت سلبا على تركيز درجة العكارة ، تركيز أيون الهيدروجين ، الصلادة الكلية للمياه وصلادة المغنيسيوم، بينما لم تتغير التركيزات أو كانت قريبة بسبب عمليات معالجة المياه لكل من التوصيل الكهربائي والأملاح الذائبة الكلية وصلادة الكالسيوم بمقارنة كل من عينات نهر النيل وعينات الطرد للمياه لهذه الخصائص. كانت نتائج معالجة المياه مثمرة في تقليل التركيزات أو انعدام تركيزات الأمونيا والنيتريت والنترات. أكدت النتائج أن معالجات المياه لم تؤثر على الكاتيونات المختلفة مثل الصوديوم والبوتاسيوم والكالسيوم والمغنيسيوم والألومنيوم والحديد والمنجنيز وقد يكون كاتيون الألمونيوم قد زاد تواجده نتيجة لاستخدام كبريتات الألمونيوم في معالجة المياه.

تم تسجيل عدد العوالق النباتية على التوالي في كل مياه النيل والمياه المعالجة في محطة إمبابا لمعالجة مياه الشرب حيث كان أعلى عدد 2396000 وأدنى عدد 1818999 وحدة / لتر في حالة ماء النيل بينما كانت أعلى النتائج 195334 وكانت أقل النتائج 30000 وحدة / لتر في حالة المياه المعالجة ، على التوالي. ينتمي تركيبة العوالق النباتية إلى مجموعات الطحالب العصوية، والطحالب الخضراء والطحالب الخضراء المزرقة. وكانت الدياتومات السائدة .*Cyclotella* spp و*Melosira* spp.، بينما سيطر كل من طحلب *Gomphosphaeria aponina* و *Merismopedia tenuissima* على مجموعة الطحالب الخضراء المزرقه. وكانت مجموعة الطحالب الخضراء يهيمن عليها كل من *Ankistrodesmus falcatus* و *Coelastrum microporum*.