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Water Quality Assessment of Lake Edku using physicochemical and Nutrients Salts, Egypt

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Abstract The present work is aimed to assess the water quality status of Lake Edku using the data at various locations on the lake based on the Water Quality Index (WQI). Water Quality Index was applied in ten water quality parameters (pH, Dissolved Oxygen, biological oxygen demand, suspended particulate matter, Electrical conductivity, Nitrate, Nitrite ammonium and reactive phosphate. The results revealed that the pH values lie slightly on the alkaline side, with a range of (9.07 -7.47), Electrical conductivity (EC) showed a wide range (590–5125µS/cm) with an average 1871.88 µS/cm. The values of dissolved oxygen (DO) and Biological oxygen demand (BOD) ranged (1.56 to 18.10 mgl^{-1}) and (0.91 and 15.90 mgl^{-1}), respectively. Suspended particulate matter ranged between 16 and 122 with an average 37.81 mg/l. The range and the average values of nutrients (µM) were; 0.22-67.3 (11.36), 1.54 - 80.04 (18.65), 0.11 - 37.29 (10.72), 1.33 - 108.38 (31.63), 1.36–70.97 (19.17) for reactive phosphate (PO4/P), ammonium (NH_4/N), nitrite (NO_2/N), nitrate (NO_3/N), reactive silicate (SiO_4/Si), respectively. The present study revealed that phosphorus is limiting nutrient factor (N/P > 5) in winter, spring and autumn but during summer (N/P < 5), nitrogen is limiting nutrient factor for plant growth. T The results of WQI of the investigated area ranged between1.59 and 32.79. Autumn, spring and summer recorded excellent water quality, while winter was lower of water quality comparing to other seasons.

Keywords Water Quality, Assessment, Nutrient Salts, Lake Edku

Introduction

With rapid urbanization and economic development, especially the coastal areas, this rapid economic growth has resulted in a series of severe environmental problems [1] such as increases in eutrophication [2], organic pollutants [3], heavy metals [4], and habitat degradation [5], which have placed new pressures on national sustainable development, as water quality may only partially reflect environmental impact [6], more attention should be given to the status of biological communities and conservation biodiversity in the management of aquatic eco systems [7]. Lake pollution is one of the serious environment problems in recent years with socio-economic development and pollutants discharge increase from industry, agriculture and domesticity. Increasing human populations and the expansion of industrial and agricultural activities have been important driving factors for the rapid deterioration of freshwater ecosystems. Water quality can be assessed by various parameters such as BOD, temperature, electrical conductivity, nitrate, phosphorus, potassium, dissolved oxygen, etc. Heavy metals such as Pb, Cr, Fe, Hg, etc. are of special concern because they produce water or chronic poisoning in aquatic animals [8] Lakes are one of the important water resources used for irrigation, drinking, fisheries and flood control purposes. Lakes also provide a habitat for invertebrates, fishes and aquatic birds [9]. A vast number of lakes have suffered varying degrees of

pollution across the world, and to monitor lake water quality, physical and chemical proxies have been commonly used [10]. Basic physical and chemical parameters are included, which determine the characteristics of an aquatic system and hence the biological population structure and composition [11]. WQI is defined as a rating reflecting the composite influence of different water quality parameters a water quality index based on some very important parameters can provide a single indicator of water quality. In general, water quality indices incorporate data from multiple water quality parameters into a mathematical equation that rates the health of a lake with number [9].Water quality in an aquatic ecosystem is determined by many physical, chemical and biological factors. Therefore, particular problem in the case of water quality monitoring is the complexity associated with analyzing the large number of measured variables, and high variability due to anthropogenic and natural influences [12]. Water quality index (WQI) can also be used to aggregate data on water quality parameters at different times and in different places and to translate this information into a single value defining the period of time and spatial unit involved [13]. During the year 1970, a Water Quality Index (WQI) was developed at the National Sanitation Foundation (NSF). It appears to be the most comprehensive form of WQI [14]. The present study aimed to follow the changes of physicochemical and nutrient salts (NH_4/N, NO_2/N, NO_3/N, PO_4/P, and SiO_4) and chlorophyll-a in Lake Edku water and assessment of water quality index (WQI)

Materials and Methods

Study Areas

Lake Edku is an important fishing area in Egypt, receives its water from two sources. The main source is the drainage water of KomBelag and Bersik drains ($1836.55 \times 10^6 m^{3)}$. The sea water of Abu Qir Bay enters the lake sometimes through the lake sea connection as subsurface water current under the action of wind especially in winter [15]. Its area has decreased from $28.5x\ 10^3$ to about $12x10^3$ Fadden's [16].Lake Edku receives huge amounts of drainage water from three main drains, namely, Edku, Bousaly, El-Khairy and Berseek, which open into the eastern basin of the lake, the drainage water contains unspecified quantities of urban, industrial, agricultural and chemicals from Beheira Governorate and beyond [17].

Sampling

Sampling stations are shown in Table 1 and Figure 1. Ten surface water samples were collected using in flatable rubber boat (Zodiac) during four seasons through 2016.The samples were taken into clean white Polyethylene bottles.

Table 1: Sampling stations

Station	Station Name	Latitude / Longitude	
I	Al-Tarfaya drain	31°15'20.64"N	30°10'18.92"E
II	Hantour Gate	31°14'53.55"N	30°10'33.66"E
III	Churches gate	31°14'9.46"N	30°11'54.28"E
IV	AL-Tawila gate	31°14'21.25"N	30°12'43.67"E
V	AL-charaship	31°15'13.63"N	30°13'54.63"E
VI	AL-Berka	31°15'9.55"N	30°12'42.18"E
VII	(Edku drain)	31°15'48.15"N	30°13'57.94"E
VIII	Allbany mosque	31° 15' 46.19"N	30° 12' 45.921"E
IX	International road	31° 15' 46.21" N	30° 11' 29.6592"E
X	Albogaz	31° 16' 0.4902"N	30° 10' 46.3182"E

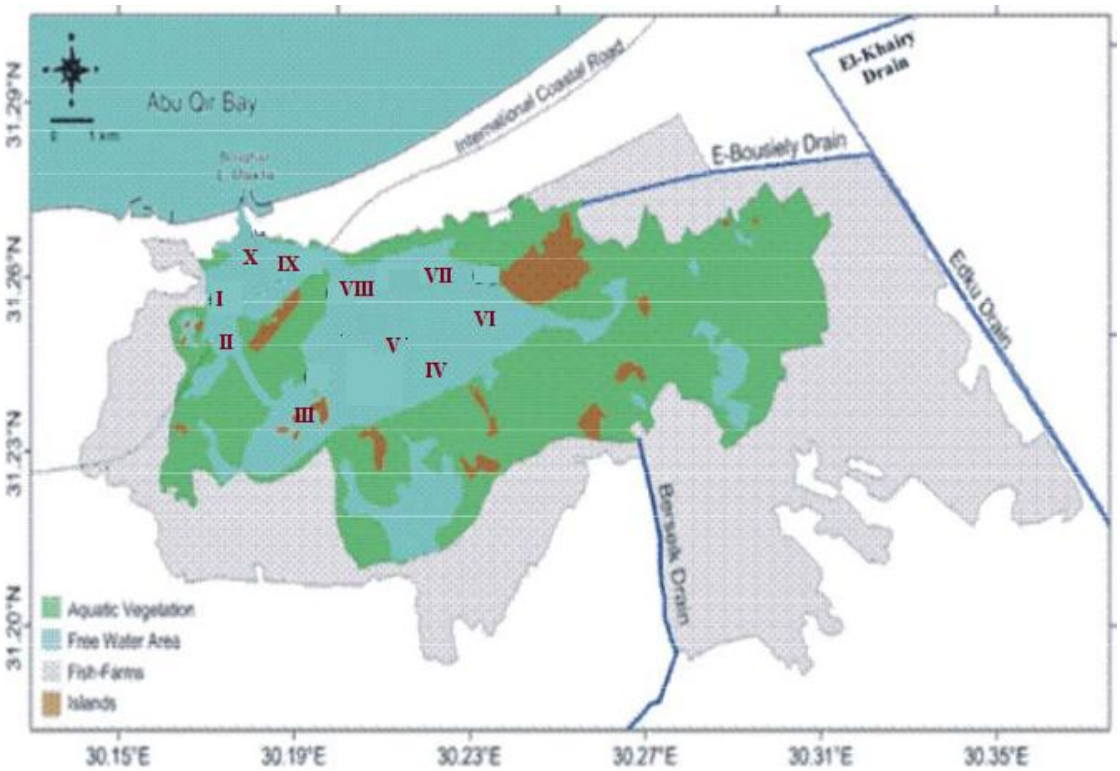

Figure 1: Study area and sampling stations

Chemical analysis

Dissolved oxygen and BOD was analyzed according to Winkler's methods [18].Conductivity determined by conductivity meter. pH determined using pH meter. SPM Determined by filtration of 250 ml of water sample through dried and weight 0.45 µm filter paper (Millipore) by vacuum pump. The residue was washed with afew of distilled water and then dried at inside a clean cabinet. Before and after filtration weight has record. Nitrate, nitrite, ammonium and reactive phosphate were determined according to Strickland and Parsons, (1972) and Grasshoff,(1983) [18,19].

Water quality index determination

Initially, WQI was developed by Horton (1965) [20] in United States by selecting 10 most commonly used water quality variables like dissolved oxygen (DO), pH, coli forms, specific conductance, alkalinity and chloride etc. and has been widely applied and accepted in European, African and Asian countries. The assigned weight reflected significance of a parameter for a particular use and has considerable impact on the index. Furthermore, a new WQI similar to Horton's index has also been developed by [14], which was based on weights to individual parameter. Recently, many modifications have been considered for WQI concept through various scientists and experts [21]. The physicochemical water quality characterization was made by calculating an alternative to (NSFWQI) for each sampling station as well as for the overall water body [22].

Weighted Arithmetic Water Quality Index Method

Weighted arithmetic water quality index method classified the water quality according to the degree of purity by using the most commonly measured water quality variables. And the calculation of WQI was made by using the following equation:

$$WQI = \sum QiWi \,/\, \sum Wi$$

The quality rating scale (Qi) for each parameter is calculated by using this expression:

$Qi = [(Vi - Vo)/(Si - Vo)]X100$

Where,

Vi: estimated concentration of the parameter in the analyzed water

Vo: the ideal value of parameter in pure water equal zero except pH =7.0 and DO = 14.6 mg/l

Si: recommended standard value of the parameter

The unit weight (Wi) for each water quality parameter is calculated by using the following formula: ***Wi = K/ Si***

Where: *K* =proportionality constant (=1) and can also be calculated by using the following equation:

$K = 1/(\sum(1/Si)$. The rating of water quality according to the WQI is given as the following; Excellent Water Quality (0-25), Good Water Quality (26-50), Poor Water Quality (51-75), Very Poor Water Quality (76-100) and Unfit (> 100).

Table 2: Standard values (***Si***), Ideal values (*Vo*) and Relative Weight (*Wi*) of testing parameters for WQI [11,23].

Parameter	**Unit**	**Standard values (*Si*)**	**Ideal values (*Vo*)**	**Relative Weight (*Wi*)**
Dissolved Oxygen	mg/l	5	14.6	0.3723
BOD	mg/l	5	0	0.3723
pH		9	7.2	0.0221
EC	(µS/cm	1000	140	0.0002
TSs	mg/l	25	2	0.0079
Nitrate	mg/l	11.29	0.056	0.0176
Nitrite (NO2)	µg/l	18	3	0.011
PO4	mg/l	0.4	0.09	0.4963
NH4	mg/l	0.777	0.011	0.02553
Iron, mg/L	mg/l	3	0	1.6666
Wn				2.99183

Result and Discussion

Hydrographic Conditions

Water temperature, the values of pH of the investigated area, Water Electrical conductivity (EC) and dissolved oxygen (DO) were studied and Total Suspended solid (TSS) the hydrographic conditions varied widely during the study period.

Water Temperature

In an established system the water temperature controls the rate of all chemical reactions and affects fish growth, reproduction and immunity. Drastic temperature changes can be fatal to fish. The rates of biological and chemical processes depend on temperature. Aquatic organisms from microbes to fish are dependent on certain temperature ranges for their optimal health. Temperature affects the oxygen content of the water (oxygen levels become lower as temperature increases); the rate of photosynthesis by aquatic plants; the metabolic rates of aquatic organisms; and the sensitivity of organisms to toxic wastes, parasites and diseases. Causes of temperature change include weather, removal of shading stream bank vegetation, impoundments, discharge of cooling water, urban storm water and groundwater inflows to the stream [24]. Seasonal values of water temperature over the coastal area ranged from 18.2 °C to 27.5 °C (Table3). The lowest temperature was recorded in winter and autumn and increased to reach the highest level in summer (Fig. 2).

Total Suspended solid (TSS)

The results of present study (Table3) referred that the lowest concentration of TSS was recorded at station V (16 mgl^{-1}) in winter season while the highest value was found in spring at station X (122 mgl^{-1}) with annual average (38.94±11.03mgl^{-1})(table 3 & Fig.2). Spatial variation of TSS ranged between 16 and 66 with an average

(36.07±17.11mgl^{-1}) in winter, ranged between 26.4 and 122 with an average (56.47±32.77 mgl^{-1})in spring, ranged between 16 and 54.67with an average (28.00±12.78mgl^{-1}) in summer and ranged between 23.6 and 55.8 with an average (37.20±11.36 mgl^{-1}) in autumn. The results showed that spring season was the highest of TSS content, while the summer was the lowest concentration.

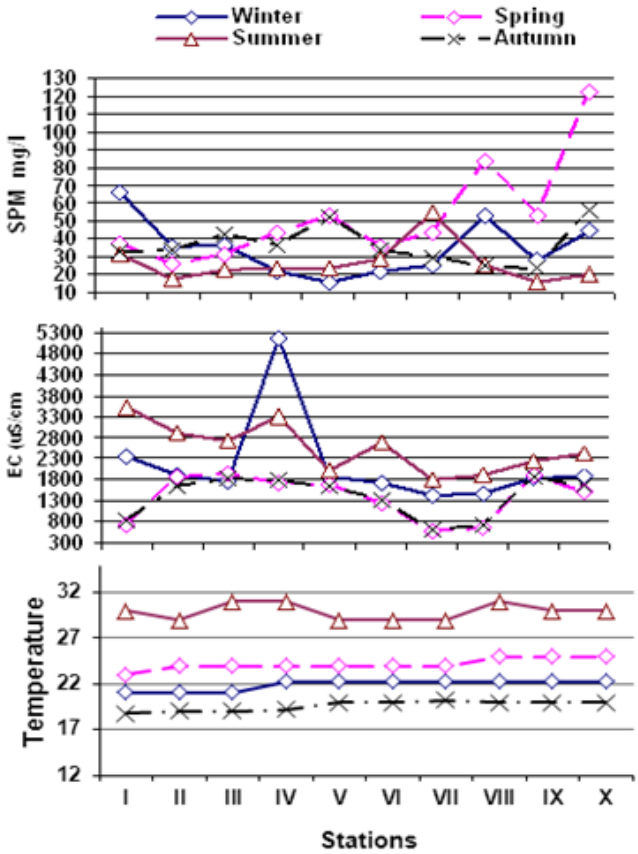

Figure 2: Regional and seasonal variation of SPM, EC and Temperature in Lake Edku water during 2016

Table 3: Range and Average ± SD. of some parameters (Lake Edku water, 2016)

Parameters	Winter	Spring	Summer	Autumn	Annual
pH	7.47 – 9.07	7.85 – 8.61	7.69 – 8.70	8.07 – 8.74	8.06 – 8.74
EC(µS/cm)	1440-5125	590-1960	1820-3530	625-1860	1118-2996
	2329± 1273	1373 ±550	2575 ±614	1373± 495	1902 ± 593
Temper.(°C)	18.20-20.01	25.20-27.10	26.20-27.50	19.80-20.60	23.80-24.30
	19.81± 0.57	26.01 ±0.65	26.98± 0.45	20.16 ±0.35	24.08± 0.19
DO, mgL^{-1}	11.30-18.10	7.48-14.02	1.56-9.35	4.99-13.09	7.65-11.83
	14.33± 2.32	11.50 ±2.59	5.58 ± 2.98	8.93 ±2.81	10.05 ±1.61
BOD (mg/l)	7.10-15.90	3.83-7.25	0.91-6.76	1.87-4.05	4.40-7.10
	11.88 ± 3.15	5.92± 1.40	3.65 ±2.26	2.88 ±0.75	5.97 ±1.10
NO_2/N(µM)	0.11 – 68.71	0.36 – 31.21	0.21 – 5.07	6.25 – 37.29	4.45 – 23.85
	19.58±23.54	12.21±10.77	2.09±2.01	17.61±11.23	12.12±6.27
NH_4/N(µM)	1.54 – 10.67	1.96- 26.88	1.88 – 72.00	3.00 – 80.04	3.67 – 43.83

	6.54±3.32	10.12±8.58	23.99±28.41	38.00±32.71	19.50±14.70
NO_3/N(µM)	2.90 – 71.33	9.10 – 84.05	1.33 – 19.95	16.76 – 108.38	18.02 – 52.84
	31.75±22.97	42.09±29.81	7.90±7.24	49.86±33.11	32.26±12.83
PO_4/P(µM)	1.07 – 7.74	0.22 – 6.30	2.63 – 67.30	1.33 – 25.77	3.62 – 25.56
	4.31±2.53	3.11±2.06	22.62±22.41	17.19±8.99	11.90±7.63
SiO_4/Si(µM)	3.64 – 70.97	4.28 – 40.40	3.24 – 22.60	1.36 – 47.88	7.95 – 44.41
	29.80±25.84	12.87± 12.90	9.04± 6.42	28.41± 14.91	20.34± 11.86
SPM (mg/l)	16.00- 66.00	26.40-122.00	16.00-54.67	23.60-55.80	28.70 – 60.55
	36.07± 17.11	56.47± 32.77	28.00± 12.78	37.20 ±11.36	38.94± 11.03
Chl-a(µgl^{-1})	1.96 – 73.47	18.19 – 300.2	29.60 -100.50	17.20 – 76.12	42.04 – 94.26
	39.50 ± 21.08	137.02± 87.48	57.99±27.55	35.47 ±22.21	65.63± 18.92
N/P ratio	3.7 - 58.3	5.50 – 65.40	0.30 – 4.10	1.80 – 47.30	5.40- 25.30
	19.80±18.90	28.10±20.03	1.80± 1.30	12.70 ± 15.80	14.30 ± 8.07

Electrical conductivity (EC)

The electrical conductivity is an important factor which reflects the changes caused by the mixing of fresh water, drainage water and seawater; it is directly related to the concentration of ions in the water [25]. Conductivity showed significant correlation with parameters such as temperature, pH value alkalinity, total hardness, calcium, total solids, total dissolved solids and chemical oxygen demand chloride and iron concentration of water. Conductivity in streams and rivers is affected primarily by the geology of the area through which the water flows. Streams that run through areas with granite bedrock tend to have lower conductivity because granite is composed of more inert materials that do not ionize (dissolve into ionic components) when washed into the water [26]. Streams that run through areas with clay soils tend to have higher conductivity because of the presence of materials that ionize when washed into the water. Ground water inflows can have the same effects depending on the bedrock they flow through. Discharges to streams can change the conductivity depending on their make-up. A failing sewage system would raise the conductivity because of the presence of chloride, phosphate and nitrate; an oil spill would lower the conductivity. The variation of electrical conductivity was recorded in Figure 2 and Table3.The results of EC maximum value was recorded at station IV (5125µS/cm) during the winter while minimum value (590µS/cm) was found at station VII during spring season. Electrical conductivity ranged between 1440 and 5125µS/cm with an average (2329±1273 µS/cm) during winter, ranged from 590 to 1960 µS/cm with an average (1373±550 µS/cm during spring, ranged between 1820 and 3530 with an average (2575±614 µS/cm) during summer and ranged between 625 and 1860 µS/cm with an average (1373±495 µS/cm) during autumn. The highest values of EC were recorded during summer period (average 2575 µS/cm) and decreased to 2329 µS/cm in winter, while the lower values were recorded in autumn and spring seasons (around 1373 µS/cm). The conductivity increased with increasing in the total dissolved solids and water temperature [27]. The lowest mean value was recorded nearby the drains in the north eastern parts of the lake. Generally, the EC can be arranged as the following; summer>winter>spring>autumn.

Hydrogen ion concentration (pH)

The values of pH play an important role in much life processes in aquatic system. It may also reflect the productivity and pollution levels of the aquatic environments. pH is most important in determining the corrosive nature of water. Lower the pH value higher is the corrosive nature of water. The reduced rate of photosynthetic activity and the assimilation of carbon dioxide and bicarbonates are ultimately responsible for increased pH the low oxygen values coincided with high temperature during the summer month. Various factors bring about changes in the pH of water. The higher pH values observed suggests that carbon dioxide, carbonate–bicarbonate equilibrium is affected more due to change in physicochemical condition.

The minimum pH value7.47 was recorded at station (VI) during winter season, while the maximum value 9.07 was found at station (II) during the same season (Table 3 and Fig. 3). This explains the effects of different effluents in

the surface water of Lake Edku. The spatial distribution of pH values in the lake showed slightly variation within the stations during the year of study, which may be controlled by the density of phytoplankton count and the water quality inflow to the lake. Thus, an increase in the phytoplankton population produces an increase in the pH value and oxygen super saturation due to high photosynthetic activity by green and blue green algae [28], which leads to reduce the amount of CO_2 in water [29].

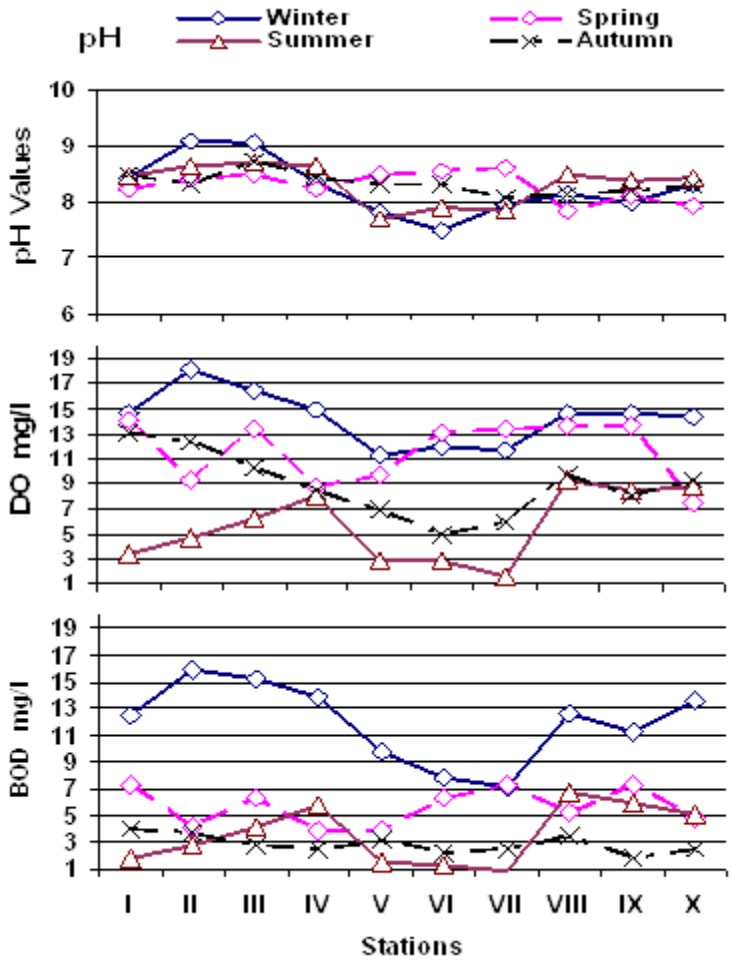

Figure 3: Regional and seasonal variation of pH values, DO and BOD in Lake Edku water during 2016

Dissolved oxygen (DO)

Dissolve oxygen is an important parameter of aquatic ecosystem and effects on the physical and biological process of water. The oxygen acts as indicators of planktonic development and plays a significant role in proper growth of aquatic life like fishes. The level of dissolved oxygen in the northern Lakes of Egypt is influenced by several factors such as temperature, wind, photosynthetic activity of phytoplankton communities, and respiration of heterotrophic, autotrophic organisms and decomposition of organic matter [30].The regional values of DO (Table3 &Fig.3) fluctuated between 1.56mgl^{-1} (station VII, summer) and 18.1mgl^{-1} (station II, winter), with an annual average (10.10±1.61mgl^{-1}). The seasonal distribution of DO concentration in Lake Edku water showed a wide range of variation (Fig.3), ranged from 1.56 to 9.35mgl^{-1} with an average (5.58±2.98 mgl^{-1}) in summer and ranged between 4.99 and 13.09 with an average (8.91±2.91 mgl^{-1}) during autumn. During winter season, the DO content of the lake water was relatively high (11.30±18.10mgl^{-1}) comparing with the other seasons, this may be due to phytoplankton

productivity, and vice versa the summer that recorded the lowest concentration especially stations (V, VI and VII). Generally, the increasing of water temperature leads to the decreasing of DO.

Biological oxygen demand (BOD)

BOD is the amount of oxygen required by bacteria while stabilizing decomposable organic matter under aerobic condition, break down organic material present in a given water sample at certain temperature over a specific time period. Sources of BOD include leaves and woody debris; dead plants and animals; animal manure; effluents from pulp and paper mills, wastewater treatment plants, feedlots and food-processing plants; failing septic systems; and urban storm water runoff. The discharge of wastes with high levels of BOD can cause water quality problems such as severe dissolved oxygen depletion and fish kills in the receiving water bodies [31]. Chlorine can also affect BOD measurement by inhibiting or killing the microorganisms that decompose the organic and inorganic matter in a sample. In chlorinated waters, such as those below the effluent from a sewage treatment plant, it is necessary to neutralize the chlorine with sodium thiosulphate [32]. The concentration of BOD in Lake Edku water ranged between minimum 0.91 mgl^{-1}at station (VI) during the summer and maximum 15.9 mgl^{-1} during winter at station (III). The annual variations of biological oxygen demand in Lake Edku water varied between 4.40 and 7.10 mgl^{-1} with an average of 5.97±1.10 mgl^{-1} (Table3). The seasonal distribution of BOD fluctuated between 2.88 ± 0.75 and 11.88 ± 3.15 mgl^{-1} in autumn and winter, respectively.

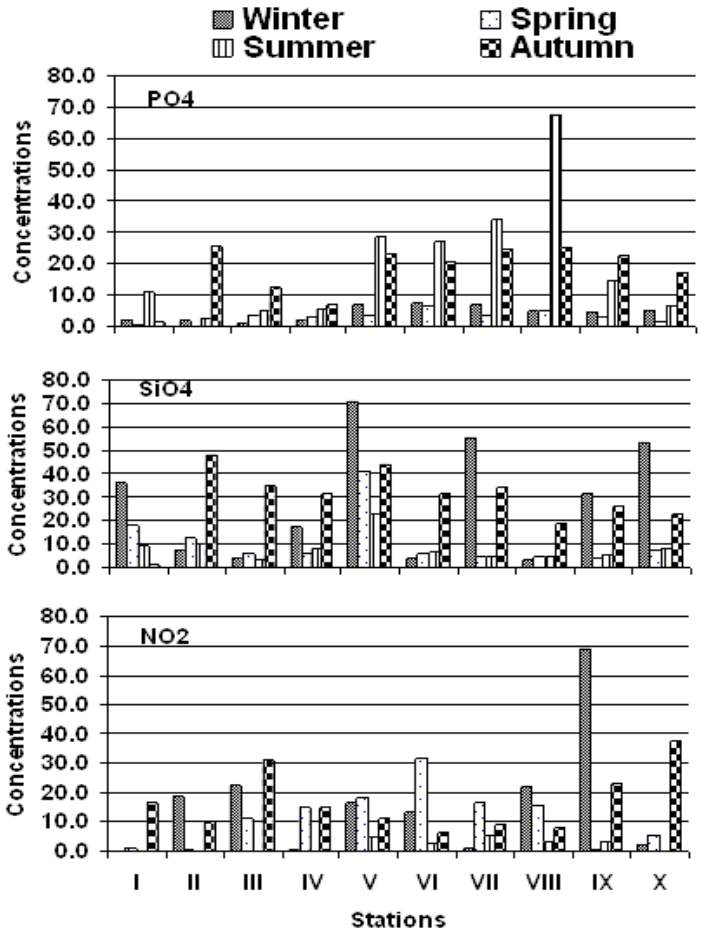

Figure 4: Regional and seasonal variation of PO_4/P, SiO_4 and NO_2 /N in Lake Edku water during 2016

Nutrients Salt

Reactive phosphate (PO_4/P)

Fig.4 showed the distribution of PO_4/P concentration in Lake Edku water, it ranged between 0.22µM in spring at station II and 67.3 µM in summer at station VIII, with an annual of average 11.90 ±7.63 µM (Table3). Seasonal variation of PO_4/P were in the range (1.07 - 7.74; mean 4.31 ±2.53 µM) in winter; (0.22 - 6.30; mean 3.11 ± 2.06 µM) in spring; (2.63 - 67.30; mean 22.62± 22.41 µM)in summer and ranged from 1.33 to 25.77 with an average 17.18 ±8.99 µM in autumn. The result of PO_4/P concentration can be arranged seasonally as the following: summer < autumn < winter< spring. The data showed that the highest concentrations were recorded at stations V, VI, VII and VIII, while stations I and II reveled the lowest levels. Generally, increasing or decreasing of PO_4/P concentration was associated with the biological uptake. The relative decrease of PO4 content maybe attributed to several factors lead to removal of phosphorus from the water, the consumption of PO4 by algae and aquatic plant, phosphate adsorption on the clay mineral and suspended matter or precipitation by iron, calcium and aluminum [30].

Reactive silicate (SiO_4/Si)

Seasonal and regional distribution of silicate content is shown in Table 3 and Fig. 4 of the investigated area. The average values of silicate content showed wide variation, it ranged from 9.04 ± 6.42µM in summer to 29.80±25.84µM in winter. Spatial variation of silicate content were in the range (3.64-70.97 µM); (4.28-40.40 µM); (3.24-22.60 µM); (1.36 - 47.88 µM) in winter, spring, summer and autumn, respectively. The results revealed that the concentrations of silicate in autumn and winter were the highest than those recorded in spring, and summer. There is an increase in silicate concentrations due to decrease in the activity of diatoms, and other microorganisms.

Nitrite (NO_2/N)

The seasonal distribution of NO_2/N concentration in Lake Edku water showed a wide range of variation (Table3 & Fig.4). It ranged from 0.11 µM in winter (station I) to 68.71µM in autumn (Station IX).The spatial distribution of NO_2/N concentration were in the range (0.11 -68.71); (0.36 to 31.21); (0.21 -5.07) and (6.25 - 37.29) in winter, spring, summer and autumn, respectively. The data showed decrease in the nitrite content in the summer may be due to the increase in the oxidation rate of nitrite to nitrate.

Ammonium (NH_4/N)

The regional and seasonal variations ofNH_4/N during the period of study are reported in Fig.5.NH_4/N concentration was fluctuated between the minimum of 1.54 µM at station (II) in winter and the maximum content of 80.04 µM at station V in autumn with an average of 19.50± 14.70 µM. The level of NH_4/N concentrations during the period of study can be arranged as the following: autumn > summer > spring >winter. The regional distribution of NH_4/N showed that the highest contents were reported at stations (V, VI, VIII, IX and VII), its content were represented about 80, 70, 76, 71 µM in autumn and 72 µM in summer, respectively. This may be attributed to the low oxygen content, which lead to reduction of nitrate to the other form in the reducing form of nitrogen as well as the high rate of organic matter degradation,

Nitrate (NO_3/N)

Nitrate is the final oxidation product of nitrogen compounds in the aquatic system. It is essential for most of biochemical reactions. There are several factors which may be affected on the distribution of nitrate content in the study area, the drainage water, organic matter decomposition, regeneration from suspended matter and bottom sediments as well as phytoplankton assimilation. Generally the investigated area, affected by wastewater from the neighboring cultivated land. The regional and spatial variations of nitrate concentrations in Edku Lake water are shown in Figure5 and Table3. The minimum concentration of 1.33 µM was recorded at station IV during the summer, while the maximum value of 108.38 µM at station III during the autumn. The spatial distribution of NO_3/N during the period of study can be arranged as the following: autumn > spring > winter > summer. The high value of

NO_3/N in the autumn may be due to the large amount of drainage water enter the lake, while the low content was observed in the summer due to its assimilation by phytoplankton and aquatic plants. The regional variation showed that stations III, IV, V and VI were the highest NO_3/N concentration compared with the other stations.

The relatively high concentration of NH_4/N, NO_2/N and NO_3/N may be due to the large amounts of drainage water from the agricultural areas through the drains, which are contaminated by anthropogenic material.

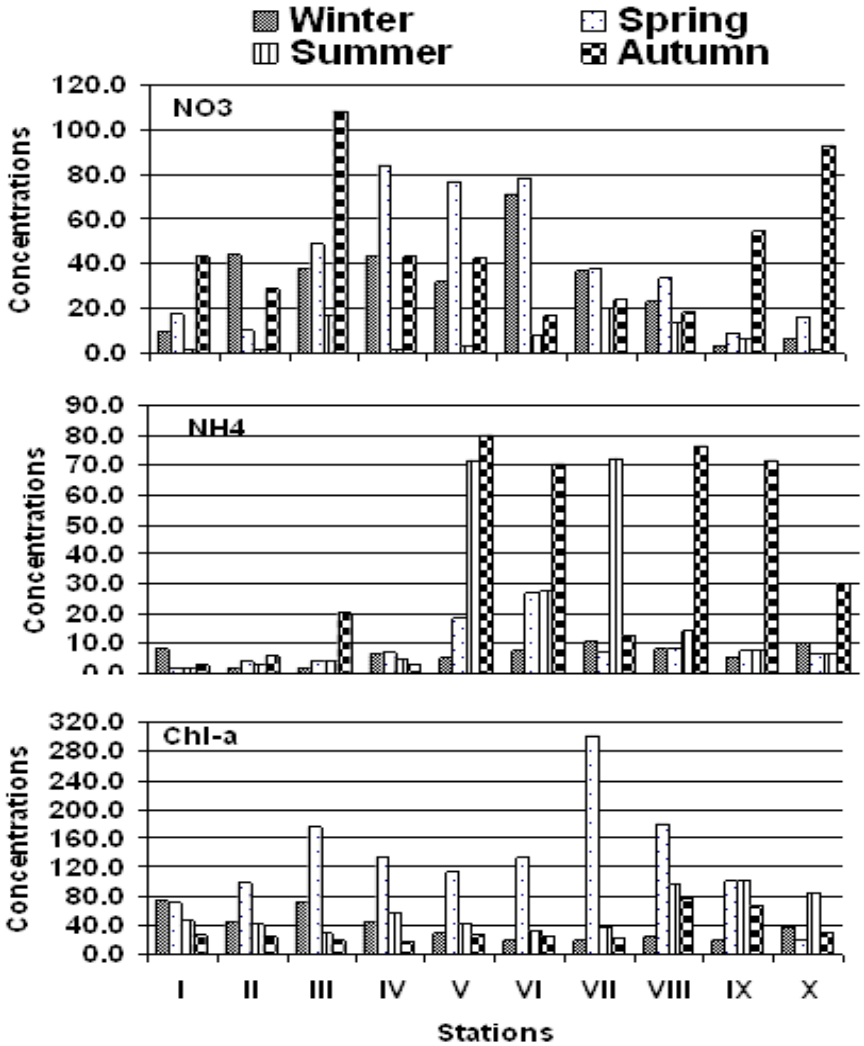

Figure 5: Regional and seasonal variation of NO_3/N, NH_4/N and Chl-a in Lake Edku water during 2016

Chlorophyll a (Chl a)

Phytoplankton is important components of lake ecosystems in that they are primary sources of organic carbon; however, excessive growth resulting from anthropogenic nutrient loads can lead to extreme water fouling [33], Chlorophyll a (Chl a) is often used as an estimate of algal biomass [35]. Chlorophyll a (Chl a) seasonality was investigated in lake Edku water located in the northern Nile Delta of Egypt. Chlorophyll a concentration maxima occurred during the spring (137±87.48 μgl^{-1}) and summer (57.99±27.55 μgl^{-1}) when the surface water temperature was highest. French and Petticrew (2007) [33] found Positive associations between instantaneous [Chl a] and temperature that forecast changes in phytoplankton productivity even if nutrient loading rates remain constant.

Data Statistical analysis

Water quality index (WQI)

Water quality index (WQI) provides information about water quality in a single value and to reduce higher number of parameters into a simple expression resulting into easy interpretation of water quality monitoring data. WQI is commonly used for the evaluation and assessment of water pollution and may be defined as a reflection of composite influence of different quality parameters on the overall lake water quality. WQI indices are classified into two types, they are physicochemical and biological indices. The physicochemical indices are based on the values of various physicochemical parameters in a water sample, while biological indices are derived from the biological information. In the present work, it has been made to calculate the water quality index of the study area based on physicochemical data. The ranges of WQI, the corresponding status of water quality and their possible use are summarized in Table 4 and Figure 6. The results of WQI of Lake Edku water ranged between1.59 and 32.79. Autumn and spring and summer recorded excellent water quality. In the other hand winter was lower of water quality comparing to other seasons, station (VI, VII and VIX) recorded excellent water quality , station ((I, II, III, IV,V,VIII, X) recorded a good water quality .

N/P ratio (Eutrophication)

Eutrophication of aquatic eco systems is due to enrichment of water with high amount of nutrient, mainly phosphorus and nitrogen. To evaluate the influence from urban, agricultural and industrial activities upon the physicochemical characteristics of Lake Edku water, the ratio of N/P was estimated. The N/P ratio has been calculated from the investigated area data for nitrogen as DIN ($+NH^4$, NO^{2-} and NO^{3-}) and phosphorus as reactive Phosphate (PO_4^{3-}) [36]. The most conservation ratio suggests that N/P ratio is laying betweens (5–10) in most lakes. If the values are less than 5, indicates that nitrogen is limiting for plant growth and if more than 5 indicates that phosphorus is limiting [37]. The N /P ratio of Lake Edku water was calculated as shown in Table3, the range and the average were 3.7-58.3 (19.8),5.5-65.4(28.1),0.3-4.1(1.8) and 1.8-47.3(12.7) during winter, spring, summer and autumn seasons, respectively. Therefore, the phosphorus is limiting nutrient factor (N/P > 5) in the investigated area during winter, spring and autumn (except stations II, VII and VIII) but during summer (N/P < 5), nitrogen is limiting nutrient factor for plant growth. This may be related to the higher rate of consumption of inorganic nitrogen than reactive phosphate, also the low values of the N/P ratio may be as a result of an allochthonous condition from wastewater drainage [16]. The low N/P ratio appears to favor green algae dominance in nature lakes in the temperate zone [38].

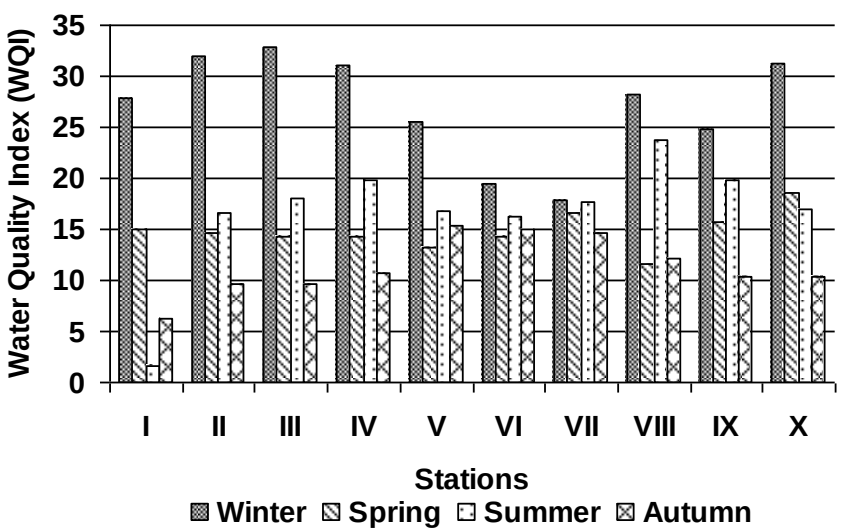

Figure 6: Water Quality Index of Lake Edku water durig 2016

Table 4: Water Quality Index during, 2016

Winter	DO	BOD	pH	EC	TSM	NO3	NO2	PO4	NH4	Fe	Sum QiWi	Wn	WQI
					QiWi								
I	0	93.08	1.51	0.05	2.2	-0.01	-0.22	-14.33	-0.01	1.24	83.51	2.99	27.93
II	-13.6	118.39	2.3	0.04	1.17	0	-0.22	-14.37	-0.03	2.12	95.81		32.04
III	-7.37	113.18	2.26	0.04	1.2	0	-0.22	-13.83	-0.03	2.83	98.06		32.79
IV	-1.16	103.5	1.41	0.12	0.7	0	-0.22	-13.95	-0.01	2.36	92.74		31.02
V	12.8	72.23	0.76	0.04	0.48	0	-0.22	-13.81	-0.02	4.05	76.3		25.52
VI	10.08	58.08	0.33	0.04	0.69	0	-0.22	-13.4	-0.01	2.47	58.06		19.42
VII	11.25	52.87	0.92	0.03	0.81	0	-0.22	-13.85	0	1.59	53.39		17.86
VIII	0	93.82	1.14	0.03	1.76	-0.01	-0.22	-13.58	-0.01	1.63	84.56		28.28
IX	0	84.14	0.98	0.04	0.91	-0.01	-0.22	-13.9	-0.02	2.19	74.11		24.79
X	1.16	101.27	1.35	0.04	1.46	-0.01	-0.22	-14.14	0	2.36	93.26		31.19
Spring	**DO**	**BOD**	**pH**	**EC**	**TSM**	**NO3**	**NO2**	**PO4**	**NH4**	**Fe**	**Sum QiWi**	**Wn**	**WQI**
					QiWi								
I	0.00	53.76	1.26	0.01	1.21	-0.01	-0.22	-14.33	-0.03	3.21	44.87	2.99	15.01
II	20.36	31.05	1.49	0.04	0.84	-0.01	-0.22	-14.37	-0.02	4.52	43.67		14.61
III	4.65	46.69	1.58	0.04	1.00	0.00	-0.22	-13.83	-0.02	2.95	42.85		14.33
IV	22.80	28.74	1.26	0.04	1.43	0.00	-0.22	-13.95	-0.01	2.60	42.71		14.28
V	19.16	28.52	1.60	0.04	1.76	0.00	-0.22	-13.81	0.03	2.51	39.58		13.24
VI	5.86	46.84	1.65	0.03	1.15	0.00	-0.22	-13.40	0.05	0.88	42.84		14.33
VII	4.65	53.98	1.73	0.01	1.44	0.00	-0.22	-13.85	-0.01	1.73	49.48		16.55
VIII	3.45	39.39	0.80	0.01	2.78	0.00	-0.22	-13.58	-0.01	1.90	34.52		11.54
IX	3.45	53.83	1.11	0.04	1.75	-0.01	-0.22	-13.90	-0.01	0.87	46.92		15.69
X	27.61	36.41	0.88	0.03	4.12	-0.01	-0.22	-14.14	-0.02	1.00	55.67		18.62
Summer	**DO**	**BOD**	**pH**	**EC**	**TSM**	**NO3**	**NO2**	**PO4**	**NH4**	**Fe**	**Sum QiWi**	**Wn**	**WQI**
					QiWi								
I	0	13.48	1.55	0.08	1.03	-0.01	-0.22	-12.7	-0.03	1.56	4.77	2.99	1.59
II	38.51	20.33	1.77	0.06	0.55	-0.01	-0.22	-14	-0.03	2.51	49.49		16.55
III	32.46	30.68	1.84	0.06	0.71	-0.01	-0.22	-13.6	-0.02	1.77	53.68		17.95
IV	25.21	43.41	1.76	0.07	0.76	-0.01	-0.22	-13.5	-0.02	1.62	59.05		19.75
V	45.76	11.17	0.6	0.04	0.76	-0.01	-0.22	-9.88	0.2	1.95	50.37		16.85
VI	45.76	9.98	0.85	0.06	0.92	-0.01	-0.22	-10.1	0.06	1.34	48.63		16.27
VII	50.57	6.78	0.79	0.04	1.81	-0.01	-0.22	-8.99	0.2	1.87	52.84		17.67
VIII	20.36	50.33	1.6	0.04	0.8	-0.01	-0.22	-3.63	0.01	1.85	71.13		23.79
IX	24.01	44.53	1.45	0.05	0.48	-0.01	-0.22	-12.1	-0.01	1.16	59.31		19.84
X	22.8	38.42	1.5	0.05	0.62	-0.01	-0.22	-13.3	-0.01	0.9	50.72		16.96
Autumn	**DO**	**BOD**	**pH**	**EC**	**TSM**	**NO3**	**NO2**	**PO4**	**NH4**	**Fe**	**Sum QiWi**	**Wn**	**WQI**
					QiWi								
I	0	30.16	1.57	0.02	1.07	0	-0.22	-14.2	-0.03	0.27	18.64	2.99	6.23
II	8.3	27.85	1.36	0.04	1.11	0	-0.22	-10.3	-0.02	0.47	28.6		9.56
III	16.75	20.85	1.89	0.04	1.4	0.01	-0.22	-12.4	0.03	0.63	28.97		9.69
IV	24.01	18.54	1.52	0.04	1.18	0	-0.22	-13.3	-0.03	0.18	31.91		10.67
V	30.06	23.23	1.38	0.04	1.72	0	-0.22	-10.7	0.23	0.03	45.76		15.3
VI	37.27	16.23	1.38	0.03	1.1	-0.01	-0.22	-11.1	0.2	0.13	44.97		15.04
VII	33.66	18.54	1.07	0.01	0.95	-0.01	-0.22	-10.5	0.01	0.13	43.69		14.61
VIII	19.16	25.54	1.15	0.01	0.8	-0.01	-0.22	-10.4	0.22	0.25	36.5		12.21
IX	25.21	13.92	1.23	0.04	0.74	0	-0.22	-10.8	0.2	0.71	31.02		10.37
X	20.36	18.54	1.34	0.04	1.85	0.01	-0.22	-11.7	0.06	0.73	31.05		10.39

Conclusion

Lake Edku has received agricultural domestic and industrial wastewater from the surrounding area. To study the effect of anthropogenic influence on the investigated area ten water samples have been analyzed seasonally during 2016 for physicochemical characteristics. The present data showed more significant variations in water quality index (WQI) and eutrophication parameter status There was a noticeable variation in nutrient salts (NH_4/N, NO_3/N and PO_4/P). The low values of N/P ratio may be a result of an allochthonous condition from the drainage of wastewater. This could suggest that nitrogen is the most limiting factor for the growth of phytoplankton.

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