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# Physicochemical Characteristics of Water Quality in Lake Nasser Water

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**Abstract:** The variations of physicochemical parameters as temperature, electrical conductivity, turbidity, total dissolved solids (TDS), dissolved oxygen (DO), hydrogen ion concentration (pH) and major anions namely; carbonate, bicarbonate, sulphate, chloride have been investigated in the main channel of Lake Nasser during the year, 2005. Results indicated wide variations in the concentrations of different physicochemical parameters between surface and bottom layers during summer season especially in northern part of Lake. During winter, the variation in concentrations of these parameters between surface and bottom layers was of low value. Correlations coefficient matrix between each two pairs of parameters were estimated to throw light on relationships between different physicochemical parameters. In conclusion the various parameters under investigation in different seasons and regions in Lake Nasser lie within the permissible range and it is a good quality for drinking, irrigation and fish culture purposes.

**Key words:** Lake Nasser · National River Water Quality · Physicochemical parameters

## INTRODUCTION

High Dam Lake is one of the largest man-made Lake in Africa. It is bounded by latitudes 24°N in Egypt and 21°S in Sudan. It includes Lake Nasser which extends for about 330 Km in Egypt and Lake Nubia 160 Km in Sudan. Lake Nasser water is a major source used for drinking, irrigation and domestic purposes in Egypt. Two major changes in water quality occurred following the construction of High Dam including, firstly fine suspended solids, dissolved solids and algel content. Secondly, formation of chemical stratification due to thermal effect and biological activities. These changes can directly affect physical, chemical and biological transformation [1]. The shoreline of Lake Nasser at 160 m (MSL) is 5416 Km and at 180m (MSL) level, with 7875 Km length. The length of eastern shoreline is almost double that of the western shoreline. The surface area of the entire reservoir is 3084 $Km^2$ at 160m level, when the reservoir is nearly full at 180m level it has a surface area of 6276 $Km^2$ [2]. The sequence of seasonal and regional changes in the physical and chemical characteristics of water at different depths in Lake Nasser was followed up by several authors [3-9]. Major anions and cations in the northern area of Nasser Lake were studied by *Sayyah et al.* [10]. Also, the concentrations of carbonate, bicarbonate, sulfate and chloride in surface and bottom water layers in different seasons were measured. And the effect of flood water on the distribution of metals in fresh water was reported [11].

The present work investigated the physical and chemical parameters to make comparisons with their levels of National River Water Quality (NRWQ) standards for utilization like drinking, irrigation and other aquatic organisms.

## MATERIALS AND METHODS

Water samples were collected from 10 stations of main channel of Lake Nasser. The sampling program was carried out during winter and summer, 2005 (Fig. 1) using Van Dorn bottle and kept in polyethylene bottle. Table, 1 illustrates the sampling stations and its distance south High Dam (Km) and total depths (m) for each site.

**Methods of Analysis:** The physical and chemical parameters were analyzed according APHA [12] to determine regional variation in different sites. Hydrological parameters such as temperature, dissolved oxygen, electrical conductivity and pH value were measured directly in the field. Temperature in water was measured by thermometer while electrical conductivity by electrical conductivity meter (YSI Model 33. S.C.T).

Dissolved oxygen was determined by Winkler's method using azid modification of iodometric method [12]. Carbonate and bicarbonate were determined directly by

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Table 1: Some data about sampled stations

| Sites,No. | Locations | Average Depths | Distance South, H.D | Sites No. | Locations | Aver. Depths |
|---|---|---|---|---|---|---|
| 1 | Arkeen | 37 | 330 | 6 | Wadi.-El-arab | 68 |
| 2 | Adindan | 44 | 300 | 7 | El-Madiq | 77 |
| 3 | Abo-Simple | 53 | 180 | 8 | Garf-Hussein | 81 |
| 4 | Masmas | 58 | 235 | 9 | El-Allaqi | 90 |
| 5 | Abrium | 55 | 2280 | 10 | Kalabsha | 96 |

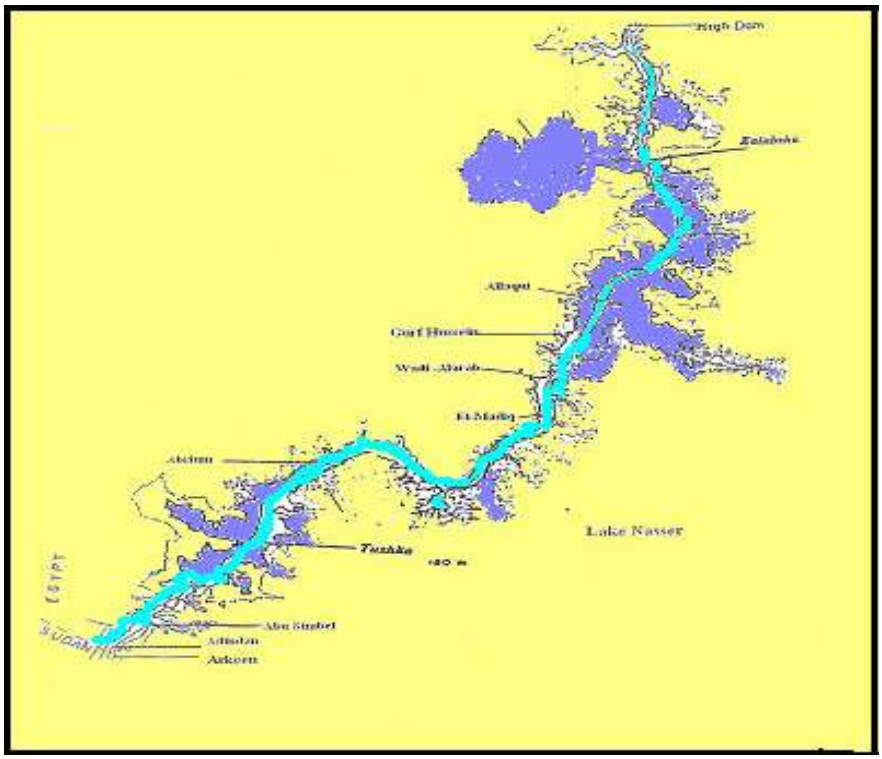


Fig. 1: Map of Lake Nasser showing stations of study

titration with standard 0.02 N $H_2SO_4$ using phenolphthalein and methyl orange as indicators. The pH value was determined using a portable pH meter. The total chloride was measured by titration of 50 ml of sample against silver nitrate (0.0141 N) solution using potassium chromate as indicator, while sulphate value in water was measured by turbid metrically using barium chloride crystal and condition reagent used spectrophotometer [12].

**Statistical Analysis:** Interpreting results from a large quantities of data involving many variables, could be used a computer (Minitab program). Correlation coefficients matrixes were estimated between all pairs of measured variables to understanding the dynamic distribution of different parameters under investigation.

## RESULTS

The frequencies of different physicochemical parameters are represented in Figures 2-11 and the correlations coefficient matrix between each two pairs of parameters were estimated to conclude the relationships between different physicochemical parameters (Table 2). It can be Summarizes as the following:

**Temperature:** Water temperature in Lake Nasser water ranged between 19.8-21.2 and 21-31.6 °C during winter and summer respectively Fig. 2. There was a wide variation in water temperature between surface and bottom layers during summer while, the variation between surface and bottom layers was low value in winter.

Table 2: Correlation coefficient matrix between different physicochemical parameters in Lake Nasser water

| | Temp. | pH | DO | EC | NTU | TDS | $PO_4$ | $NH_4$ | $NO_2$ | $NO_3$ |
|---|---|---|---|---|---|---|---|---|---|---|
| pH | 0.506 | | | | | | | | | |
| DO | -0.887 | -0.36 | | | | | | | | |
| EC | 0.501 | 0.199 | 0.278 | | | | | | | |
| NTU | 0.155 | -0.007 | -0.242 | 0.186 | | | | | | |
| TDS | 0.60 | 0.529 | 0.068 | 0.666 | -0.144 | | | | | |
| $PO_4$ | 0.536 | -0.506 | -0.640 | -0.452 | 0.532 | -0.508 | | | | |
| $NH_4$ | -0.189 | -0.024 | 0.091 | 0.478 | 0.872 | 0.024 | 0.084 | | | |
| $NO_2$ | 0.191 | 0.071 | -0.219 | -0.038 | -0.131 | 0.054 | -0.031 | -0.201 | | |
| $NO_3$ | 0.665 | 0.511 | -0.634 | -0.061 | 0.520 | -0.261 | 0.678 | 0.278 | 0.387 | |
| $SiO_3$ | -0.636 | -0.418 | 0.545 | -0.468 | -0.307 | -0.526 | -0.185 | -0.183 | -0.056 | -0.351 |
| $SO_4$ | -0.378 | -0.052 | 0.527 | 0.421 | -0.630 | 0.477 | -0.885 | -0.305 | 0.177 | -0.559 |
| Cl | 0.089 | 0.390 | 0.109 | 0.620 | 0.155 | 0.309 | -0.309 | 0.386 | -0.097 | -0.007 |
| $CO_3$ | -0.588 | 0.707 | 0.598 | 0.276 | -0.167 | 0.231 | -0.030 | -0.151 | -0.313 | 0.105 |
| $HCO_3$ | -0.532 | 0.581 | 0.555 | 0.173 | -0.051 | 0.074 | -0.324 | 0.096 | -0.053 | -0.237 |

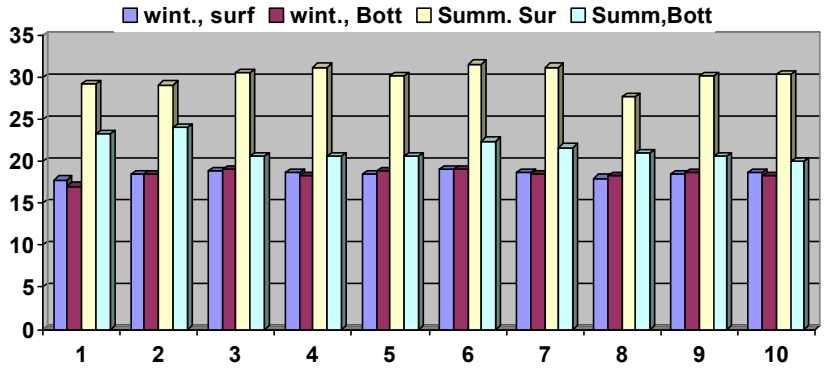


Fig. 2: Water temperature °C in Lake Nasser Water, 2005

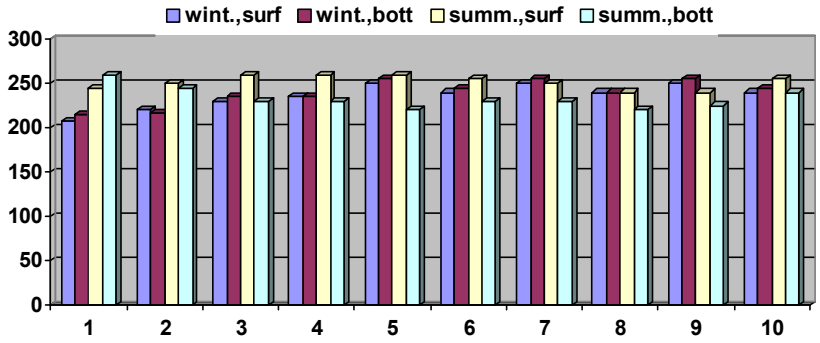


Fig. 3: Electrical conductivity µmoh $cm^{-1}$ in Lake Nasser, 2005

Electrical conductivity (E.C) Electrical conductivity values in Lake water varied between 216-252 and 220-260 µmoh $cm^{-1}$ during winter and summer respectively (Fig. 3). The absolute maximum value was recorded at Masmas site 5 during summer while the absolute minimum value was measured at Arkeen (site 1) in southernmost part of Lake Nasser.

**Turbidity (NTU):** Water turbidity measured by Nephelometric method. Showed that the maximum value was 116 NTU recorded at site 1 in southern area during summer as compared with the minimum value 0.9 NTU detected at site 10 in northern part of Lake during winter (Fig. 4).

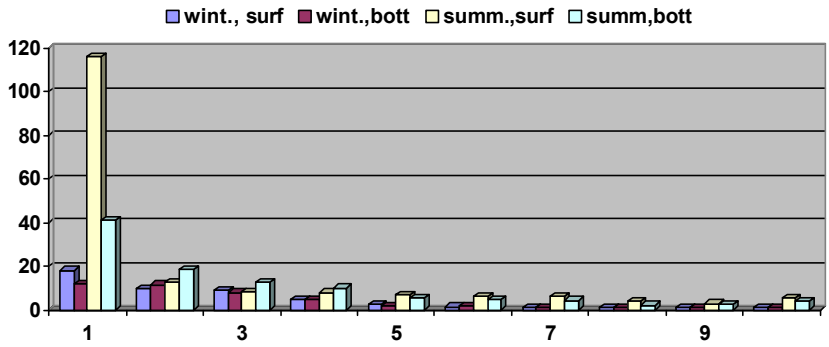


Fig. 4: Turbidity (NTU) in Lake Nasser Water during the period of 2005

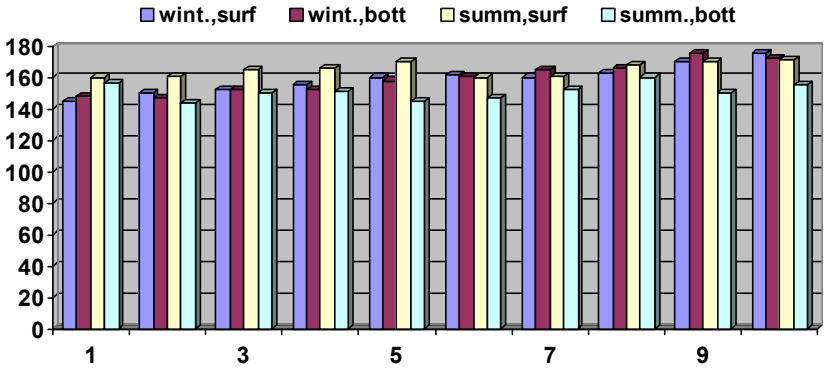


Fig. 5: Total dissolved solids content $mgl^{-1}$ in Lake Nasser, 2005

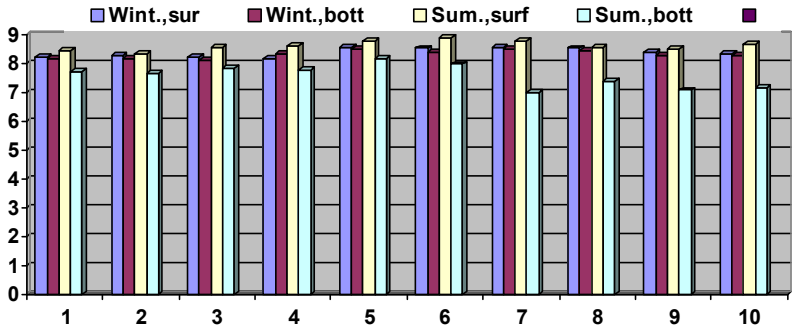


Fig. 6: Hydrogen ion concentration ( pH ) in Lake Nasser, 2005

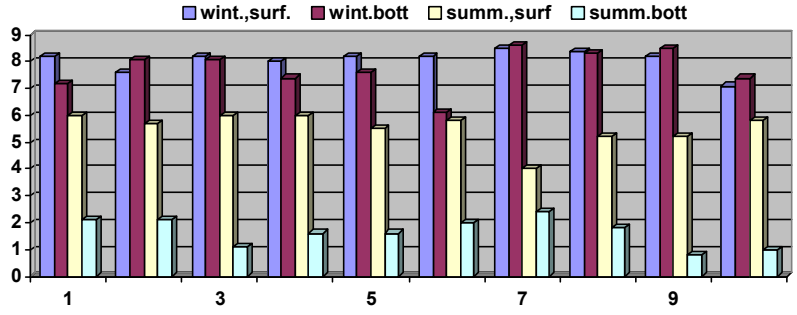


Fig. 7: Dissolved oxygen content $mgl^{-1}$ in Lake Nasser, 2005

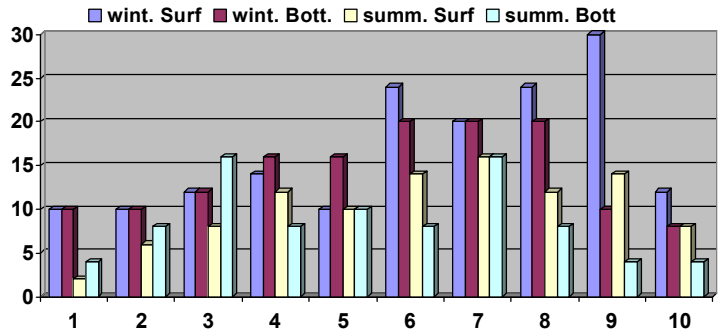


Fig. 8: Concentrations of carbonate $mgl^{-1}$ in Lake Nasser water, 2005

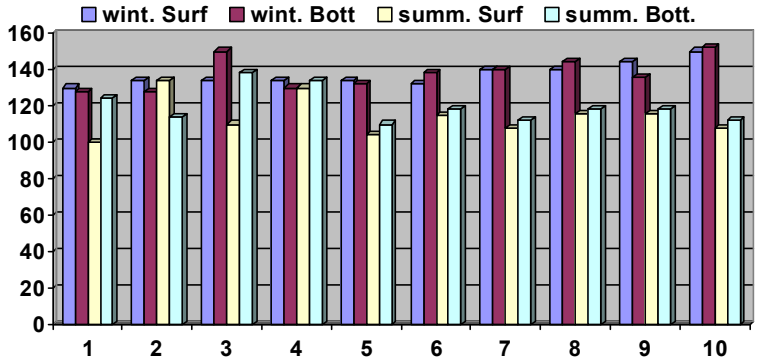


Fig. 9: Concentrations of bicarbonate $mgl^{-1}$ in Lake Nasser water, 2005

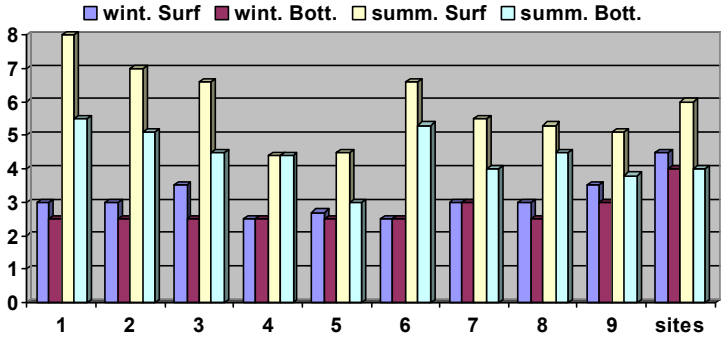


Fig. 10: Concentrations of chloride $mgl^{-1}$ in Lake Nasser water, 2005

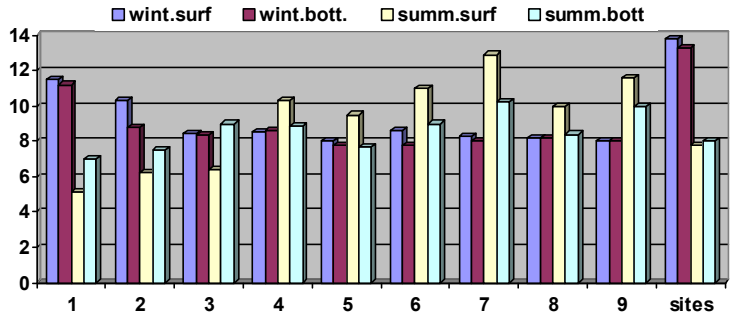


Fig. 11: Concentrations of sulphate $mgl^{-1}$ in Lake Nasser water, 2005

**Total Dissolved Solids (TDS):** The highest concentration of dissolved solid was 175 $mgl^{-1}$ measured at site 10 during winter while the lowest value was 144 $mgl^{-1}$ at site 1 during summer. The data showed a wide variation in dissolved solids content along the whole of Lake during summer season (Fig. 5).

**Hydrogen Ion Concentration (pH):** The maximum pH value was 8.89 recorded in the surface water layer at site, 6 as compared with the minimum value 7.0 present in the bottom water layer at sites 9 and 10 during summer in the northern part of Lake Nasser (Fig. 6).

**Dissolved Oxygen (DO):** The concentration of dissolved oxygen varied between 0.8-6.3 mg $l^{-1}$ during summer, the highest value recorded in the surface layer at site, 5,while the lowest value found in bottom layer at site, 9 (Fig.7). In winter, DO content is higher than those present in the other seasons with the difference is limit between surface and bottom layers. The phenomenon was reversed in summer since the water column stratified and free oxygen was depleted in bottom water layer especially in the northern part of Lake.

**Carbonate:** The absolute highest $CO_3^2$-value was 30m $gl^{-1}$ measured at site 9 during winter while the minimum value was 2 mg $l^{-1}$ registered in site 1 during summer. The high $CO_3^{-2}$ values were recorded in the surface water layer while the low levels were found in bottom layer (Fig. 8).

**Bicarbonate:** The concentration of bicarbonate varied between 100-130 mg $l^{-1}$during summer while it ranged between 128-152 mg $l^{-1}$ during winter (Fig. 9 ). The lowest value was measured at site, 1 in southernmost part of Lake during summer resulting the income of flood water which contain low value of dissolved salts.

**Chloride:** The chloride concentrations in the Lake water ranged between 2.5 and 4.5 $mgl^{+}$ during winter while it varied between 3.8 and 8.0 $mgl^{-1}$ in Lake water during summer (Fig. 10). The absolute maximum value was measured at site 1 during summer as compared with minimum value detected during winter season.

**Sulphate:** Seasonal and regional variation of sulphate content exhibits high values during summer in median area of Lake at sites 6 and 7 as compared with the low value measured in southern area at sites 1 and 2. The low sulphate value was measured during winter (Fig. 11).

## DISCUSSION

Temperature plays an important role in the physical and chemical characteristics of the Nasser Lake environment; it seems to have pronounced effect on the rate of $CO_2$ fixation by phytoplankton (primary productivity). In addition, temperature affects the bacterial activities, which responsible in the decomposition of organic matter for nutrient recycling, as well as solubility and libration of dissolved gases like $O_2$, $CO_2$, $NH_3$ and $H_2S$. Also, it may affect the best fishing and thus total fish catch [13]. Available data show that the Lake water was vertically and horizontally homothermal in winter season mainly ascribed to the complete mixing between different water masses [14]. In contrast, there is a wide variation between surface and bottom water layer during summer indicating progressive development of thermocline consequently formation strong thermal stratification in water column especially in northern part of Lake. The low EC value recorded at site 1, could be related to the adsorption of dissolved salts in the surface of suspended particles which coming with water flood and discharged to bottom sediment, where E.C is positively correlated with total dissolved solids (0.666) and chloride (0.620).

The high turbidity value measured in southern part of Lake Nasser at sites 1 and 2 during summer may be mainly related to flood water originating from Ethiopian highland which is known by its high turbidity. The total amount of silt carried by flood discharged in northern part of Lake Nubia and southernmost part of Nasser Lake. The National River Water quality (NRWQ) standard is 500 $mgl^{-1}$ for drinking and 2100 $mgl^{-1}$ for irrigation water [15]. The TDS in Lake Nasser water is ranged between 144 and 175 $mgl^{-1}$ indicate that the Lake Nasser has a high water quality for drinking, fisheries and irrigation.

Hydrogen ion concentration (pH) values from 7.2 to 8.7 are suitable for aquatic organisms [16]. The available data indicated that the Lake Nasser is slight higher than the limit of according to National River Water Quality standard which is ranged between 6.5 and 8.5. On the other side, the pH value of water according to Target Water Quality Range (TWQR) for domestic use is 6.0 to 9.0 [17]. In general, it can be concluded that the pH value in Nasser Lake water lies within the permissible range. There is a wide variation in pH values between surface and bottom water layers during summer [3], where the surface layer usually is more higher than bottom layer specially in northern part at Allaqi and Kalabsha (sites, 9 and 10).

Temperature is positively correlated with pH value (0.507). This is resulted to diminishing of $H_2CO_3$, consequently $CaCO_3$ crystallized out to the sediment and $CO_2$ escapes. During summer due to the high water temperature in the surface layer, the $HCO_3$-and $CO_3^{2}$-are hydrolysis and appearance of hydroxyl ions with an accompanying increase of pH value as the following equations:

$$Co_3^{2-} + H - oH \rightarrow HCo_3^{-} + oH^{-}$$
$$HCo_3^{-} + H - oH \rightarrow H_2Co_3 + oH^{-}$$

Whereas pH value has a strong positive significant relationship with $CO_3^{2}$-(0.707) indicate that carbonate is the main components contributing alkalinity in Lake water.

Importance of dissolved oxygen (DO) in an aquatic ecosystem brining out various biochemical changes and many ecologists discussed its effect on metabolic activities organisms.[17]. The low oxygen level was recorded during summer mainly due to the removal of free oxygen through respiration by bacteria and other animals [18] as well as the oxygen demand for decomposition of organic matter. Free oxygen (DO) is the single most important gas for most aquatic organisms. When the aquatic organisms exposure to less than 2.0 $mgl^{-1}$ free oxygen for few days may kill most of biota in the aquatic system [19].While values of 5.0 to 6.0 mgl-1are usually for most of fish population [15]. So it could be thinking that the bottom water layer of main channel of Lake Nasser is free from fish population during summer especially in northern part of Lake where DO below 1 $mgl^{-1}$ will not support for fish respiration.

Dissolved oxygen is positively correlated with sulfate (0.527), indicating that these anions increase with increasing dissolved oxygen content where sulfide and sulfite are oxidized to sulfate in presence oxidized sulphur bacteria at high oxygen content.

There is a strong negative significant relationships between dissolved oxygen and water temperature (-0.887), indicating progressive development of thermocline during hot seasons and formation strong thermal stratification in water column. The high $CO_3^{2}$-value recorded in the surface water layer is mainly due to dissociation of Ca $(HCO_3)_2$, forming $CaCO_3$ while $CO_2$ is lost as the following equation.

$$Ca(HCO_3)_2 \leftrightarrow CaCO_3 + CO_2 + H_2O$$

The low $CO_3^{2}$- during summer may due to decrease of dissolved $CO_2$ by rising water temperature and evaporation, $CaCO_3$ crystallized out to bottom sediment. While $CO_3^{2}$-content exhibits high values during winter may be attributed to the uptake of combined $CO_2$ and $H_2O$ interaction during photosynthetic process in surface water layer. From available data, it could be concluded that Lake Nasser water is considered as a soft Lake, since carbonate content is less than average national river water quality standard range ($70mgl^{-1}$).

The lowest bicarbonate value was measured at site, 1 in southernmost part of Lake during summer resulting the income of flood water which contain low value of dissolved salts [11],while the highest value was recorded during winter in the northern part of Lake related to the nature of this area which rich by carbonate and bicarbonate. The reversible relationship between carbonate and bicarbonate resulted in the hydrolysis of carbonate as following equation:

$$Co_3^{2-} + H - OH \rightarrow HCo_3^{-} + oH^{-}$$

From the available data it could be concluded that the bicarbonate increases with increasing DO and pH value in Lake water.

It was noticed that the concentration of Cl was high in the surface water than bottom layer. This could be attributed to evaporation from surface water leaving the relative high content of chloride. Chloride contaminates of Lake Water considerable harmful for humans to drink and irrigation at high levels, where it is made of chlorine chemically combined with a heavy metals. The National River Water Quality (NRWQ) standard range 45 to 155 $mgl^{-1}$.Observed that the chloride content is very low in Lake indicate that Lake Nasser water is very soft and suitable for drinking and other aquatic organisms. The results reveal that chloride is positively correlated with electrical conductivity (0.620) indicate that electrical conductivity is sharply increases with increasing chloride concentration in water. The average NRWQ standard range for sulphate is 250 $mgl^{-1}$ as compared with the level of sulphate in Lake Nasser varied between 5.15 to 13.8 $mgl^{-1}$, indicates the Lake water is very high quality for drinking, irrigation and fish culture. The high sulfate content probably to decay of phytoplankton and aquatic macrophytes or due to the oxidation of sulphide or sulphite to sulphate in the presence of photo synthetic sulphur bacteria oxidize $S^{2}$-and $SO_3^{2}$-to sulphate [20, 21]. The relative low sulphate content was recorded in the southern area of Lake during summer season may due to the water flow from flood has low $SO_4^{2}$-value [12]. The low

sulphate value measured during winter mainly due to its uptake and accumulation by plankton and aquatic macrophytes [22] as well as bacteria is able to reduce sulphate to a form which can be incorporated into organic compounds [23]. *Conclusion*: The wide variation in different physicochemical parameters between surface and bottom layers during summer season especially in northern part of Lake. This is due to formation strong stratification in water column. In conclusion the various parameters under investigation in different seasons and regions in Lake Nasser lie within the permissible range and it is a good quality for drinking, irrigation and fish culture purposes.

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## REFERENCES

1. Mancy, K.H., 1978. The environmental impact of Aswan High Dam proceeds to Inter. Symp. On the environmental effects of hydraulic engineering work Knoxville,12-14 Sept.
2. Elewa, A.A., 1980. Studies on the distribution of some chemical elements in water and sediments of Lake Nasser. Ph.D Thesis, Fac. Of Sci. Al-Azhar University, pp: 274.
3. Saad, M.A.A., 1980. A limnlogical study on lake Nasser and the Nile in Egypt. Water supply and management, 4: 81-92.
4. Toufeek, M.E.F., 1988. Some physical and analytical studies on River Nile in Aswan zone, High Dam reservoir. M Sc Thesis Al-Azhar Univers., pp: 128.
5. Toufeek, M.E.F., 2005. Distribution of some heavy metals in Lake Nasser water,Egypt. Egypt.J. Aquat. Biol. and Fish, 9: 131-149.
6. Elewa, A.A., S.M. Sayyah, A.F.A. Latif and M.E.F. Toufeek, 1988. Nutrients status in lake Nasser and River Nile at Aswan(Egypt). Bull.Inst.Oceanogr. and Fish (NIOF) A.R.E, 1.4: 177-188.
7. Elewa, A.A., S.M. Sayyah and A.F.A. Hassoum, 1990. Distribution of some pollutants in lake Nasser and river Nile. atAswan. Reg. Symp. Environ. UNARC. Alexanderia, pp: 382-402.
8. Elewa, A.A. and M.E.F. Toufeek, 1997. Some physicochemical characteristics of Lake Nasser. Egypt. J. Appl. Sci., 12: 58-85.
9. Korium, M.A., 2001. Some studies on the distribution of trace and major elements in High Dam Lake. Ph.D. Fac. Of Sci. Al-Azher Univer. Cairo, Egypt, pp: 213.
10. Sayyah, S.M., A.A. Elewa, A.F.A. Latif and M.E.F. Toufeek, 1988. The major anions and cations in Lake Nasser-River Nile at Aswan, Egypt. Bull. Nat. Inst. Oceanogr. and Fish, 14: 213-226.
11. Latif, A.F.A. and A.A. Elewa, 1988. Effect of physicochemical conditions of Aswan High Dam reservoir water on the deposition of some elements. Bull. Inst. Oceanogr. And Fish, 14: 189-212.
12. Entz, B. and B. Ramzy, 1970. Some physical, chemical and limn logical characteristics of Lake Nasser reservoir. UAR Knoxville. USA.
13. Entz, B., 1974. Report on the limnlogical conditions of Lake Nasser on the report of survey of Lake Nasser and Lake Nubia. Working paper No.6 (LNDC-RPA) Aswan, Egypt.
14. American Public Health Association (APHA), 1998. Standard Methods for the Examination of water and waste water 20 $^{edition}$. Washington D.C.
15. Singh, J., D.K. Agrawal and S. Panwar, 2008. Seasonal variation in different physicochemical characteristics of Yamuna River water quality in proposed lakhwar project influence area. Intl. J. Appl. Environ. Sci., 3: 107-117.
16. Klein, L., 1973. River pollution ∏-causes and effects ( S″ IMP). Butter worth and Co.Ltd.
17. Mishra, G.P. and A.K. Yadav, 1978. A comparative study of physicochemical characteristics of Lake and river water in central India. Hydrobiol., 59: 275-287.
18. Korium, M.A. and M.E.F. Toufeek, 2008. Studies of Some physicochemical characteristics of old Aswan Dam reservoir and River Nile water at Aswan. Egyptian. J. of aquat. Resear., 34: 149-167.
19. Geol, P.K., B. Gopal and R.K. Trivedy, 1980. Impact of sewage on freshwater ecosystem.1. General features of water bodies and sewage. J. Ecol. Environ. Sci., 6: 83-86.
20. Dunette, D., P. David and R. Mancy, 1985. The sources of hydrogen sulfide in anoxic sediment. Wat. Res. 19: 879-894.
21. Fayed, S., 1980. Europhication of the River Nile. River Nile and lake Nasser project. the Egyptian Academy of Scientific research and Technology. Cairo. Egypt.
22. Sabre, S.Z. and A.M. Abdel-Satar, 2001. Chemical and bacteriological studies on El-salam Canal, Egypt. J. Egypt. Acad. Soc. Environ. Develop., 2: 173-179.
23. Toufeek, M.E.F., M.A. Korium, 2008. Nutrient salts in Aswan Dam reservoir and River Nile water at Aswan. Egyptian. J. of aquat. Resear., 34: 218-236.