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# Distribution Pattern of Nile Water Algae with Reference to its Treatability in Drinking Water

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**Abstract:** The river Nile is the main source of potable drinking water supply in Egypt. River Nile water showed various phytoplankton structures belonging to three main groups, namely, Chlorophyceae (Green Algae), Cyanophyceae (Blue-Green Algae) and Bacillariophyceae (Diatoms). The green algae and diatoms were present throughout the entire period of examination, with 22 and 24 species respectively. It may be important to note that, diatoms represent the most abundant group in all investigated samples. Blue-green algae were present during the year with 7 species number. Treatment of raw water using two chemical coagulants, namely, aluminium sulphate and aluminium oxide remove algae by about 80.6% and 85.7% respectively. Powdered Activated Carbon (PAC) remove the odour and function as coagulant aid which enhance the algal removal as well as decrease the alum dose by 5 mg/L. *Moringa oleifera* seeds present a viable alternative natural coagulant, which raise the removal efficiency for the three algal groups and over 97% algal removal was achieved.

**Keywords:** River Nile, Chlorophyll "a", Algal Count, Coagulants, Powdered Activated Carbon, *Moringa oleifera*.

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## INTRODUCTION

The provision of safe drinking water plays an important role in preventing the incidence of many water transmissible diseases. Algae especially those belonging to cyanobacteria (blue-green algae) are of interest to water treatment authorities because of their production of taste-and-odor compounds and natural toxins according to their exposure to some environmental conditions. Also, they interfere with certain water treatment processes for drinking water production. While, diatoms generally produce obstructions in filters because of their silicon frustules.

In the recent years, several experimental studies have demonstrated the presence of mutagenic and carcinogenic substances produced by algae in the water, are important because their chronic effect on human physiology[12,15,18,14]. Conventional treatment of drinking water (flocculation and filteration) can remove substantial amounts of algal toxins by removing the algal cell intact. Toxins are secondary metabolites which are largely contained within the cell until lyses or damage of the cell. Velzeboer *et al.*[25] found that alum coagulation under conditions which simulated operating water treatment plants did not damage the cells of *Anabaena*. However, studies by James and Fawell[11] and Lam *et al.*[13] found that alum coagulation released substantial amounts of intracellular toxin, although the conditions used in these studies did not simulate normal water treatment practice.

Therefore, the main objectives of this paper are: 1) To monitor the changes in algal community structure of River Nile water. 2) To assess and evaluate the effectiveness of water treatment processes in removing the nuisance algae as well as algal toxins.

## MATERIAL AND METHODS

**Sampling Site Description:** Water samples were collected at monthly intervals for one year (March 2000-Febrauray 2001) at the Intake of El-Giza water treatment plant (Fig. 1). According to the Egyptian Ministry of Irrigation, 2001, annual average of El-Giza water treatment plant depth was 7 m, discharge was $142 \times 10^6$ $m^3$ /day and water velocity was 0.8 m/Sec. The selecting site of river Nile far from the industrial stations by $\cong$ 21 km at which the water undergoing natural self-purification processes.

### Water Quality:

**Physico Chemical Characters:** The physicochemical characteristics were carried out according to APHA[2].

**Biological Parameters:** Enumeration of phytoplankton and quantification of biomass production in terms of chlorophyll “a” concentration were accomplished according to APHA[2].

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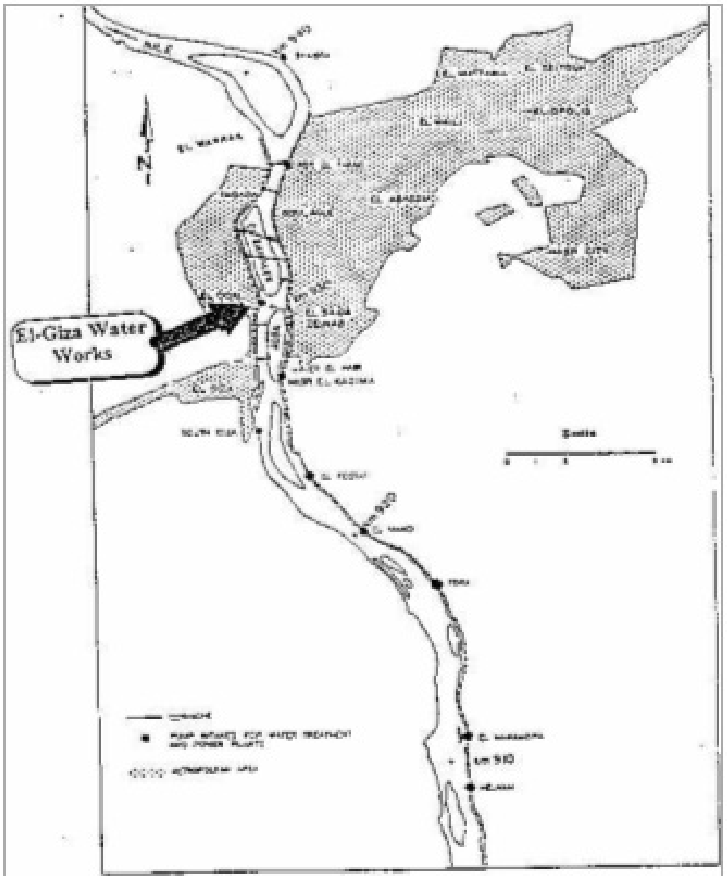

**Fig. 1:** Location map of River Showing Sampling Site.

**Water Treatment Processes Used for Algal Removal:**

**Chlorine:** Saturated chlorine water solution was used. The power of the available chlorine (concentration) was determined iodometrically before running each experiment[2].

**Jar Test:** Coagulation and flocculation was conducted via the "Jar test" procedure which devised by Cohen[4] and Bulusu & Sharma[3].

**Powder Activated Carbon:** Different dose of powder activated carbon, namely; 10, 20, 30, 40, 45, 50 and 55 mg/L were used in this study to determine the most effective concentration for taste and odor removal.

**Coagulants Used:** Two chemical formulas of aluminum salts namely; aluminum sulphate and aluminum oxide in addition, natural seeds flocculants (*Moringa oleifera*) were tested for their coagulating powers on Nile water algae.

## RESULTS AND DISCUSSIONS

**Quantitative Estimation of Phytoplankton:** River Nile water showed various phytoplankton structures belonging to three main groups, namely, Chlorophyceae (Green Algae), Cyanophyceae (Blue-Green Algae) and Bacillariophyceae (Diatoms). The general distribution of phytoplankton is demonstrated in Table (1). It may be shown that the green algae and diatoms were present throughout the entire period of examination, with 22 and 24 species respectively. It may be important to note that, diatoms represent the most abundant group in all investigated samples. Blue-green algae were present during the year with low species number which was 7 species only.

**Algal Count:** The grouping of phytoplankton, green algae, blue-green algae and diatoms varied in their numbers for different months of the study year in the waters of River Nile (Fig. 2). In all months diatoms exceed the other two groups in numbers. Diatoms numbers of Nile water ranged

**Table 1:** Algal species of River Nile Water.

| Algal Species | Quantitative Estimation | Algal Species | Quantitative Estimation |
|---|---|---|---|
| Green Algae | | | |
| | | *Merismopedia glauca* | + |
| *Actinastrum hantzschii* | + | *Microcystis aeruginosa* | + |
| *Ankistrodesmus acicularis* | + | *Oscillatoria limnetica* | + |
| *Botryococcus braunii* | + | Total Blue-Green Algal Species | 7 |
| *Chodatella cilliata* | + | Diatoms | |
| *Chlamydomonas ehrenbergi* | + | *Amphora ovalis* | + |
| *Coelasterum microporum* | + | *Asterionella formosa* | + |
| *Cryptomons erosa* | + | *Ceratium hlrundinelia* | + |
| *Crucigenia rectangularis* | + | *Cocconeis placentula* | + |
| *Dictyosphaerium ehrenbergianum* | + | *Cyclotella comta* | + |
| *Glonkinia radiate* | + | *Cyclotella catenata* | + |
| *Kirchneriella obesa* | + | *Cymbella prostrata* | + |
| *Micractinium pusillum* | + | *Diatoma elongatum* | 9 |
| *Mougeotia sp.* | – | *Fragilaria capucina* | + |
| *Nephrocytium lunatum* | + | *Gomphonema olivacum* | + |
| *Oocystis parva* | + | *Gyrosigma attenuatum* | + |
| *Oocystis solitaria* | + | *Melosira granulata* | + |
| *Pediastrum clathratum* | + | *Navicula bacillum* | + |
| *Pediastrum simplex* | + | *Navicula cuspidata* | + |
| *Phacus sp.* | – | *Navicula exigua* | + |
| *Scenedesmus obliquus* | + | *Navicula mutica* | + |
| *Scenedesmus quadricauda* | + | *Nitzschia acicularis* | + |
| *Sphaerocystis schroeteri* | + | *Nitzschia filiformis* | + |
| *Spyrogira sp.* | – | *Nitzschia holistica* | + |
| *Tetraedron minimum* | + | *Nitzschia hungarica* | + |
| *Ulothrix subtilissima* | + | *Nitzschia linearis* | + |
| Total Green Algal Species | 22 | *Peridinium cinctum* | + |
| Blue-Green Algae | | *Stephanodiscus astrea* | + |
| *Anabaena flos-aquae* | + | *Synedra ulna* | + |
| *Chroococcus turgidus* | + | Total Diatoms Algal Species | 24 |
| *Coelosphaerium kuetzinglanum* | + | Total Present Algal Species | 53 |
| *Cylindrospermum stagnale* | + | | |

– Absent + Present

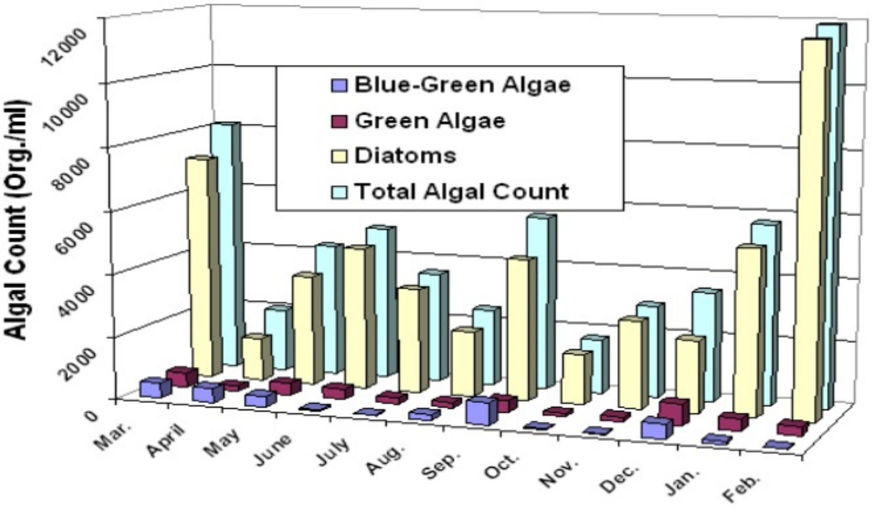

**Fig. 2:** Changes in Algal Groups Count of River Nile Water.

between 1.4×10$^6$ to 1.16×10$^7$ Organism/L. This was followed by green algae which ranged between 1.20×10$^5$ to 6.97×10$^5$ Org./L, while the lowest number was observed for blue-green algae which ranged between 1.5×10$^3$ to 7.03×10$^5$ Org./L. 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 increase one tenfold after impoundment (Fig. 3). This is due to the changes in flow rate and turbidity levels (Figs. 4&5)[21,23].

**Chlorophyll "a" Concentration:** Nile water revealed high concentration of chlorophyll "a" which ranged between 11.8 to 37.2 µg/L. The biggest value of chlorophyll "a" was found at December (Fig. 6). This is due to the most common filamentous forms with high chlorophyll "a" content especially those belonging to diatoms, namely, *Melosira granulata.* In addition, chlorophyll "a" per cell depends on its physiological state.

In general, no correlations were detected between phytoplankton count and biomass in terms of chlorophyll "a" content. In contrast, significant correlations were found between the phytoplankton (abundance and biomass) and chlorophyll "a" in Izmit Bay at Turkey[1].

It may be worthy to note that algal count is the most reliable technique for determination of phytoplankton composition in freshwater. Similar results was obtained by Shehata *et al.,*[23] who found that Sedgwick-Rafter method is reliable to overestimate the normal picture of phytoplankton distribution in the river Nile water. On the other hand, Gregor & Marŝálek[8], stated that the determination of chlorophyll "a" seems a promising method for routine monitoring of phytoplankton.

**Changes in Water Quality:** Results of physico-chemical characteristics of Nile water are illustrated in Table (2). The results revealed that the concentration of phytoplankton nutrients (phosphorus and nitrogen) was always low not exceed than 0.12 mg P/L and 0.3 mg N/L. However, poor relations between algal biomass and concentrations of phosphorus or nitrate were detected. In the yellow stone River, also concentration of total phosphorus and total nitrogen in water samples were relatively low between 0.3 mg/L and 0.4 mg/L for nitrogen and increasing from 0.016 mg/L to about 0.03 mg/L for phosphorus. Watson *et al.* proposed a total phosphorus target level of 0.02 mg/L to control nuisance filamentous algal growth in a western Montana river. Silica ranged between 0.4-3.5 mg $SiO_2$/L. Low silica levels was associated with high numbers of diatoms. Also, high algal biomass affect the concentration of dissolved oxygen and oxygen saturation (98 %) was recorded when algal biomass increased. No clear variation took place in other criteria like pH, dissolved solids, total alkalinity, total hardness and chloride content between different months of the study year. Accordingly, water quality evaluation could be estimated on the basis of biological analysis. This is in agreement with Shehata *et al.*[23] which they recommended the use of biological analysis for water quality evaluation. This is due to the values of chemical

**Table 2:** Physico-Chemical Characteristics of River Nile Water.

| Parameters | | *Min.* | *Max.* |
|---|---|---|---|
| pH | | 7.6 | 8.6 |
| Turbidity | NTU | 2.2 | 5.0 |
| Electric Conductivity | µmohs/Cm | 320 | 420 |
| Total Dissolved Solids | mg/L | 175 | 245 |
| Total Residue at $105^0$C | mg/L | 193 | 356 |
| Total Residue at $550^0$C | mg/L | 115 | 194 |
| Dissolved Oxygen | mg $O_2$/L | 7.5 | 9.8 |
| Total Alkalinity (as $CaCO_3$) | mg/L | 104 | 146 |
| Total Hardness (as $CaCO_3$) | mg/L | 116 | 140 |
| Calcium Hardness (as $CaCO_3$) | mg/L | 70 | 88 |
| Magnesium Hardness (as $CaCO_3$) | mg/L | 46 | 52 |
| Chlorides | mg/L | 12 | 30 |
| Sulphate | mg/L | 5.3 | 16 |
| Dissolved Silica | mg $SiO_2$/L | 0.4 | 3.5 |
| Nitrite | mg N/L | 0.0 | 0.02 |
| Nitrate | mg N/L | 0.04 | 0.16 |
| Ortho-Phosphorus | mg P/L | 0.002 | 0.12 |
| Dissolved Phosphorus | mg P/L | 0.02 | 0.12 |
| Total Phosphorus | mg P/L | 0.06 | 0.16 |
| Iron | mg/L | 0.2 | 0.8 |
| Manganese | mg/L | 0.2 | 0.75 |

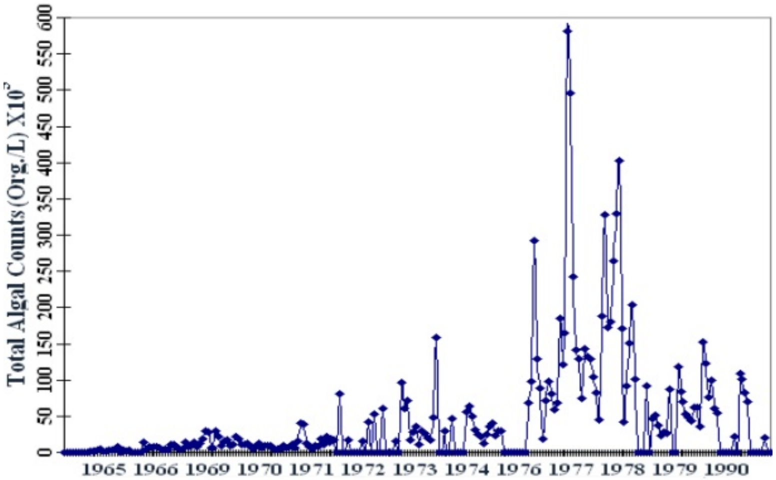

**Fig. 3:** Long-Term Effect of Impoundment on Nile Water Algal Number.

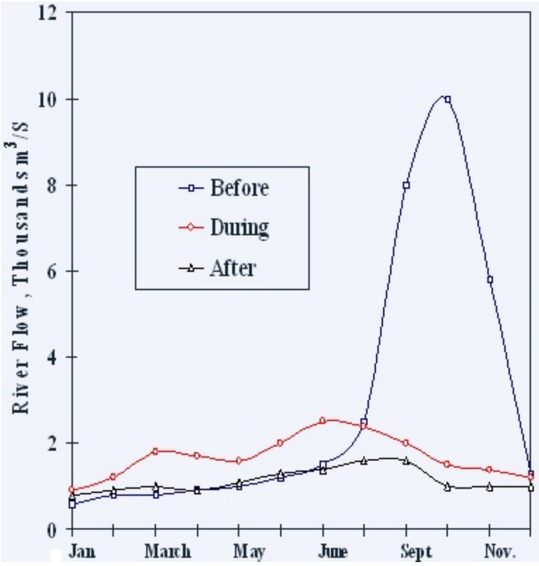

**Fig. 4:** Monthly Changes in Flow Rates of River Nile Before, During and After High Da

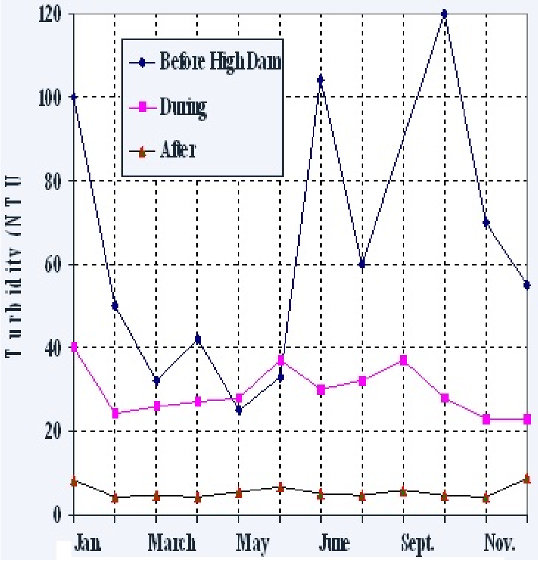

**Fig. 5:** Effect of Impoundment on Turbidity Level of River Nile.

parameters of water samples collected from river Nile during a period of three years (1993 - 1995), showed fewer variations.

**Algal Removal:**

**Conventional Treatment:** Conventional treatment (prechlorination and coagulation) as a process for removing freshwater algae using two forms of alum ($Al_2$ $(SO_4)_3$. 16 $H_2O$ and $Al_2O_3$) were studied. The results showed that blue-green algae was the most sensitive algal groups and completely removed from the water for both two alum formula. Also, the response of other two algal groups (green algae and diatoms) was relatively high. However, the removal of total algal groups number was 85% for aluminium sulphate and 90% for aluminium oxide (Figs. 7&8).

**Activated Carbon:** Conventional water treatment facilities can remove the algal cells but it can not remove potentially harmful cyanobacterial metabolites (cyanotoxins & taste-and-odor compounds). Water treatment technology, especially the use of activated carbon, should be adopted to help manage cyanotoxins and to ensure that they are kept at or below guideline levels proposed by the WHO[26] or other governmental agencies. The combination of 40 mg/L PAC mg/L and alum was efficient in the removal of Nile water algae and their producing odour. When comparing percentage removals obtained from treatment by combination of PAC + alum by those obtained from treatment of prechlorination and alum, one finds that PAC + alum was more efficient for different algal groups removal especially nuisance forms and their producing compounds (Figs. 7 & 8). Hargesheimer & Watson[9], stated that, ozone altered the fishy odor to an undesirable "plastic like" odor. Only filteration through GAC / sand filters removed all odors.

Steffensen *et al.,*[24] stated that the physico-chemical techniques are ineffective for microcystins removal when used alone and need to be combined with activated carbon adsorption (PAC or GAC) or with an oxidation techniques (Ozonation or Chlorination). Therefore, they concluded that a combination of conventional water treatment, supplemented with advanced techniques such as ozonation and/or activated carbon adsorption can readily remove cyanotoxins and give a high level of security to the drinking water supply in the event of toxic blooms.

***Moringa oleifera:*** In recent years there has been a focus on the use of appropriate , low cost technology for the treatment of drinking water in the developing country. The presence of different algal groups with high numbers especially nuisance forms in the river Nile has promoted re-evaluation of traditional treatment technologies. This study has focused on modified or innovative approaches that more adequately address that removal of different types of algae. The treatment of Nile water algae was modified by halting the use of alum and using natural seeds namely, *Moringa oleifera* for water clarification. Algal removal from raw Nile

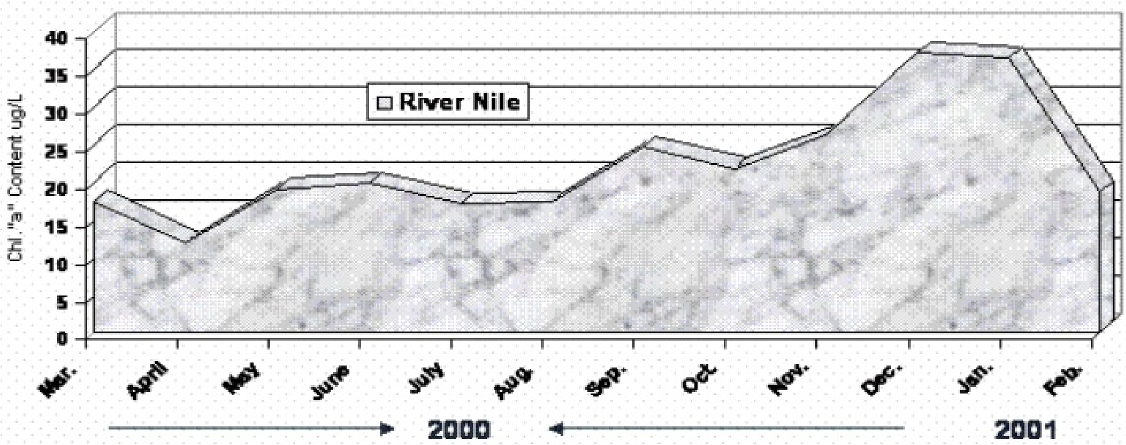

**Fig. 6:** Cholorophil "a" Content of Nile River Water.

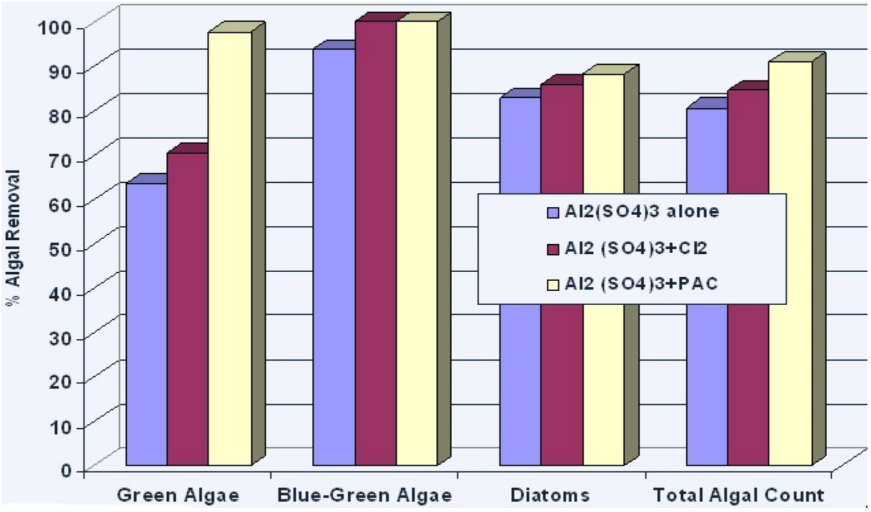

**Fig. 7:** Efficiency of $Al_2(SO_4)_3$ in Algal Removal.

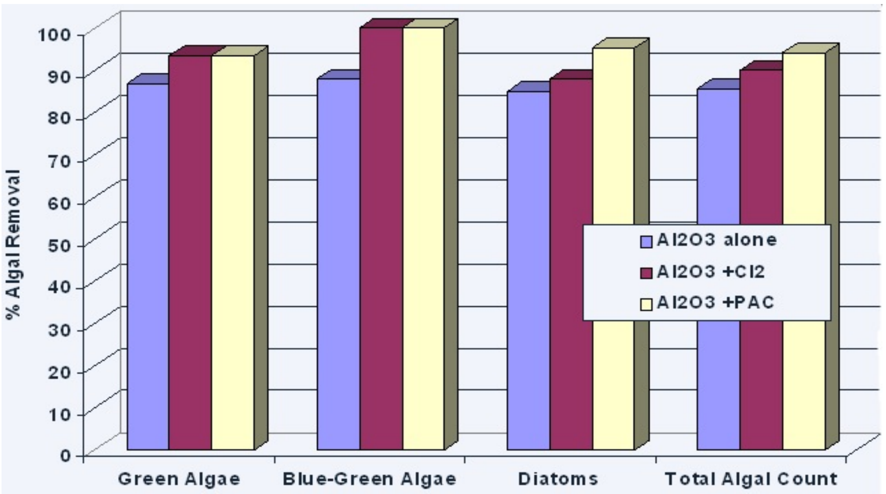

**Fig. 8:** Efficiency of $Al_2O_3$ in Algal Removal.

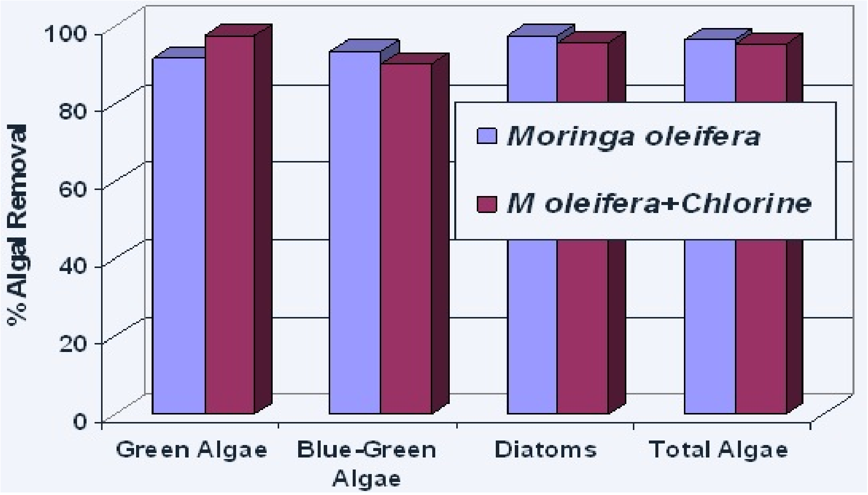

**Fig. 9:** Efficiency of *Moringa oleifera* on Nile Water Algal Removal

waters treated with optimal condition of *M. oleifera* was very high and reached 97% removal. It is important to note that *M. oleifera* was the most effective coagulant and has ability to remove all algal groups from raw Nile water without prechlorination (Fig. 9).

The seed *M. oleifera* contain a coagulant protein[7,20] which can replace conventional coagulant such as aluminium salts, in both domestic[16] and larger scale water treatment[16]. Nadabigen-gesere & Narasiah[19] suggested that *M. oleifera* seeds be used as a coagulant in water and wastewater treatment after a suitable purification of the cationic active proteins.

**Conclusion:** It can be concluded that, Nile water algal removal may be more or less easy depending on the nature of the prevailing group. On the other hand, treatment plants must be modified their treatment method according to the numbers and types of algae to provide an aesthetically acceptable and biologically safe supply of water to the customers.

## REFERENCES

1. Aktan, A., Y. Tufekci, H. Tufekci, G. Aykulu, 2005. Distribution patterns, biomass estimates and diversity of phytoplankton in Izmit Bay (Turkey). Esturine, Coastal and shelf Science. (In Press).
2. APHA, 1998. Standard Methods for the Examination of Water and Wastewater, 20th Edition (American Public Health Association)
3. Bulusu, K.R. and V.P. Sharma, 1967. Significance of point of application of a coagulant in jar test. Environ. Health (India), 9: 339.
4. Cohen, J.M., 1957. Improved Jar-test. J. AWWA, 49: 1427-1431.
5. Egyptian Ministry of Irrigation, 2001. Annual Report.
6. Ferguson, D.W. Et Al., 1990. Comparing peroxone and ozone for controlling taste and odor compounds, disinfection by-products, and microorganisms. J. AWWA, 82(4): 181.
7. Gassenschmidt, U., Jany, K.D., B. Tauscher and H. Niebergall, 1995. Isolation and characterization of a flocculating protein from *Moringa oleifera* Lam. Biochem . Biophyhs. Acta Gen. Subj., 1243: 477-481.
8. Gregor, J. and B. MarŜálek, 2004. Freshwater phytoplankton quantification by Chlorophyll a:a comparative study of in vitro, in vivo and in situ methods. Water Research, 38: 517-522.
9. Hargesheimer, E.E. and S.B. Watson, 1996. Drinking water treatment options for taste and odor control. Water Research, 30(6): 1423-1430.
10. Jahn, S.A.A., 1988. Using *Moringa* seeds as coagulants in developing countries. J. AWWA, 90: 43-50.
11. James, H. and J.K. Fawell, 1991. Detection and removal of cyanobacterial toxins from freshwaters. Report No. FRO 211 Foundation for Water Research, Marlow, UK.
12. Kraybill F.H., 1981. Carcinogenesis of synthetic organic chemicals in drinking water. J. Am. Wat. Wks Assoc., 73: 370-376.
13. Lam, A., E. Prepas, D. Spink and S.E. Hrudey, 1995. Control of hepatotoxic phytoplankton blooms; implications for human health. Water Res., 29: 1845-1854.

14. Ledra, D.E. and C.H. Prosperi, 1996. water mutageniciy and toxicological in Rio Tercero (Cordoba, Argentina). Wat. Res., 30(4): 819-824.
15. Loper, J.C., 1989. Mutagenic effects of organic compounds in drinking water. Mutat. Res., 67: 241-245.
16. McConnachie, G., A. Mtaweli and R. Young, 1994. Design Aspects of Hydraulic Flocculator, pp: 284-288. In Proc. 20th WEDC Conference, Colombo, Srilanka
17. McGuire, M.J. and J.M. Gaston, 1988. Overview of technology for controlling off - flavours in drinking water. Wast. Sci. Technol., 15: 327-328.
18. Monarca, S., 1989. Acqua potabile e mutageni, e Igiene dell' ambiente e del territorio, C.G. Edizioni Medico Sci entifiche, Torino.
19. Nadabigengesere, A. and K.S. Narasiah, 1998. Quality of water treated by coagulation using *Moringa oleifera* seeds. Wat. Res., 32(3): 781-791.
20. Nadabigengesere, A., K.S. Narasiah and B.G. Talbot, 1995. Active agents and mechanism of coagulation of turbid waters using *Moringa oleifera*. Wat. Res., 29: 703-716.
21. Ramadan, F.M. and S.A. Shehata, 1976. “Early Changes in Phytoplankton of Nile Water (1965-1974).” Symposium on Nile Water and Lake Dam Projects, National Research Center, Cairo, March 1-4, (1976).
22. Reckhow, D.A. P.C. Singer and R.R. Trussell, 1986. Ozone as a coagulant aid, Proc. 1986 AWWA Conf. Denver, Colo.
23. Shehata, S.A., S.A. Bader and S.Z. Wahba, 1997. Phytoplankton composition of the River Nile at the intake of El-Giza water works. Egypt [J. Appl. Sci., 12(2): 389-412.
24. Steffensen, D., M.D. Burch, G. Newcombe, B. Nicholson, J. Brookes and P. Baker, 2003. Management of Cyanobacteria in water supplies. 9th International Workshop on water Quality Management and Treatment Technology, September 8-10, 2003 National Taiwan University, Taipei.
25. Velzeboer, R., M. Drikas, C. Donati, M. Burch and D. Steffensen, 1995. The removal of cyanobacterial cells by alum flocculation. In: Proceedings of the Australian Water and Wastewater Association 16th Federal Convention, Sydney.
26. World Health Organization (WHO), 1998. Guidelines for Driking Water Quality, 2nd ed. Addendum to Vol. 2 Health Criteria and Other Supporting Information. Geneva- WHO.