

Removal of Algae from Surface Water by Deep Flotation

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ARTICLE INFO

Article History

Received: 9/11/2018

Accepted: 15/12/2018

Keywords:

Algae, Deep flotation, air pressure, depth of diffuser, water treatment

ABSTRACT

When algae are present in surface water it becomes an important issue in the production of drinking water, causing problems such as the interruption of coagulation and sedimentation processes and blockage of the filter. In this research, an evaluation is carried out on the effectiveness of deep flotation as an alternative method for algae removal from water. Different pressures of air and different depths of diffusers were applied. Results indicated that using deep flotation increases percentage removal of algae from 32 % (without any air) to 65% (at 6 bar pressure). Also the percentage removal of algae from raw water increases from 18 to 65 % when the applied air pressure increases from 1 bar to 6 bar, also percentage removal of algae increases from 53 to 65 % when the depth of diffuser increased from 5 to 10 m.

INTRODUCTION

As a result of building Aswan high dam, there has been a significant change in the quality of Nile River water. Consequently, the characteristics of raw water entering all water treatment plants have been changed. One of the disadvantages of the high dam is that when water downstream the dam flows more slowly, there is greater growth of phytoplankton (Ramadan, and Shehata. 1976).

The main reason for this change is that all coarse suspended particles have been deposited upstream the dam in Naser Lake where the water has been retained there for a long period of time. Therefore, suspended solids have decreased in size and ratio to a great extent, meanwhile the rate of growth of algae has increased due to the increment of the Nile water degree of transparency, the relatively hot and sunny weather (Garret, M.K., Weatherap, S.T.C and Alan, 1978). And the drainage of cities wastes either domestic or industrial into the Nile River (Elgohary and Abu- El-Ela, 1982).

Immaculate and safety waterbodies is an essential component for human health and environmental quality (kotak, 1991). Different methods of algal assays are highly effective in the evaluation of water quality and the Continuous availability of safe drinking water is very healthful. (Schmidt, 1994; Henderson and Seaby 2014). Algae are known to cause a variety of problems for water treatment facilities, from both the operational and finished water quality standpoints.

It was normal in the past, before the high dam construction, that suspended solids concentration was about 1000 mg/l and could reach 1200 mg/l during flood periods

meanwhile the algae count was about 300 cell/ml. Comparing these data with the present suspended solids concentration ranging from 10 to 45 mg/l and algae count ranging from 2000 – 15000 cell/ml (Shehata, S. A. and Bader, 1985), reveals the principle change in water quality which has taken place.

As a result of this change, various problems in the water treatment operations have arisen. (Erin Lyons, 2006) analyzed the different algae issues within the treatment plant such as the followings:

Clogging of raw water intake screens; Many species of algae produce objectionable taste and odor due to the characteristics oil secretions; Clarification prior to filtration by sedimentation became inefficient because of the low density of algal cells and the small ratio of tiny suspended solids; Fouling of flow control structures; Algae "mats" rise and sink in sedimentation basins, affecting settling characteristics of alum floc and decreasing overall particulate removal in sedimentation basins; Clogging of filter media, increasing head loss, shortening filter runoff times, and increasing filter backwash requirements; Increasing coagulant demand and sludge production; Increasing chlorine demand and disinfection by-products (DBPs) formation, in addition to Fluctuation in PH and dissolved oxygen causing undesirable precipitation/dissolution reactions.

There are various processes for the removal of algae from water as Micro strainers; Peroxidation; Filtration and flotation (Mark and Kwok-Keung, 2004).

Different methods of producing gas bubbles lead to different types of flotation as: Dispersed air flotation; Vacuum flotation; Electrolytic flotation; Dissolved air flotation; Biological flotation and Deep shaft flotation (Mark and Kwok-Keung, 2004).

The objective of this study is to removal of Algae from surface water by Deep flotation. Column flotation units use a vertically oriented cylindrical vessel to contain the produced water for treatment. The produced water often enters the vessel near the top and flows downward. Column flotation is one of the most important unit operations. Mainly, it has been applied to many separation plants in many countries and is also used in concentrator at Toyoha Mine, Hokkaido, Japan (Julius B. Rubinstein, 1989).

MATERIALS AND METHODS

Samples Locations and Parameters:

Water Samples used in this study was collected from Bahar Mowas Canal the water were taken from six locations. The first sample (S1) is for the raw water. The (2nd, 3rd, 4th, 5th, and 6th) named (S2), (S3), (S4), (S5), and (S6) and are taken at a distance of about 2, 4, 6, 8, and 10 m respectively from the top.. During this study all samples were analyzed at Al-Zagazig water treatment plant laboratory. Temperature, turbidity, and pH-value were measured. All these parameters were measured according to the American Standard Methods for the Examination of Water and Wastewater (APHA, 2005).

Productivity, Species Abundance, Identification and Counting of Phytoplankton Analysis:

For quantitative as well as qualitative studies of algal phytoplankton species, one liter of the collected water was fixed and concentrated using 1% of Lugol's solution (Utermohl, 1958). Concerning diatoms, it was necessary to clear it using conc. H₂SO₄. The concentrate sample was subjected to algal identification and counting using a Sedgwick-Rafter cell (APHA, 1985). The standing crop was then calculated as the number of cells per liter. Fresh samples for identification of some phytoplankton were collected. Also cell counting

(X100 magnification) and species identification (X500-X1000 magnification) were made using an inverted microscope; Olympus 1X70 equipped with Panasonic color monitor TC-1470 Y.

Identification of algal taxa was carried out according to Desikashary,(1959), Hendei,(1964), Bourrely, (1970),Vinyard,(1975), Taylor,(1976), Prescott, (1978), Humm and Wicks, (1980), Sykes, (1981), Hindak, (1984, 1988, 1990) Anagnostidis, and Komárek (1990), Van Vuuren *et al* (2006), McLaughlin (2012), Komárek, *et al* (2013), and Nienaber and Steinitz-Kannan (2018). The algal productivity in the form of chlorophyll "a" was measured using the method given by APHA (1995).

Pilot Plant Description:

A pilot flotation column used in the experiments was installed and operated at Al-Zagazig water treatment plant (Elsharkaia governorate, Egypt).

Figure (1) shows a schematic diagram of the column flotation model. The column flotation model performed here is composed of a cylindrical PVC pipe with 40 cm diameter, 10 m height, and six ports for samples.

Raw water was lifted from the canal by 1.0 hp pump. The compressor used could achieve pressure up to 10 bar and has 2 horse power (Fig 2.a). Air introduced into the lower part of the cell, the fine diffuser used in this study is like that one used in fish tanks (Fig. 2.b).

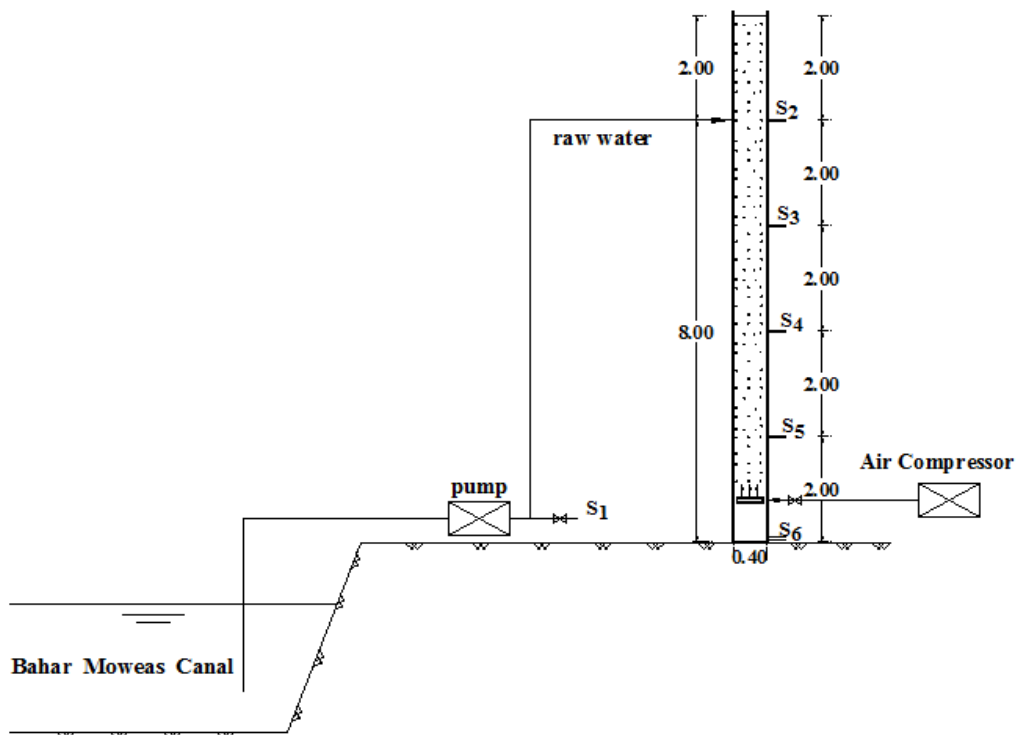


Fig .1: Schematic diagram of the pilot flotation column

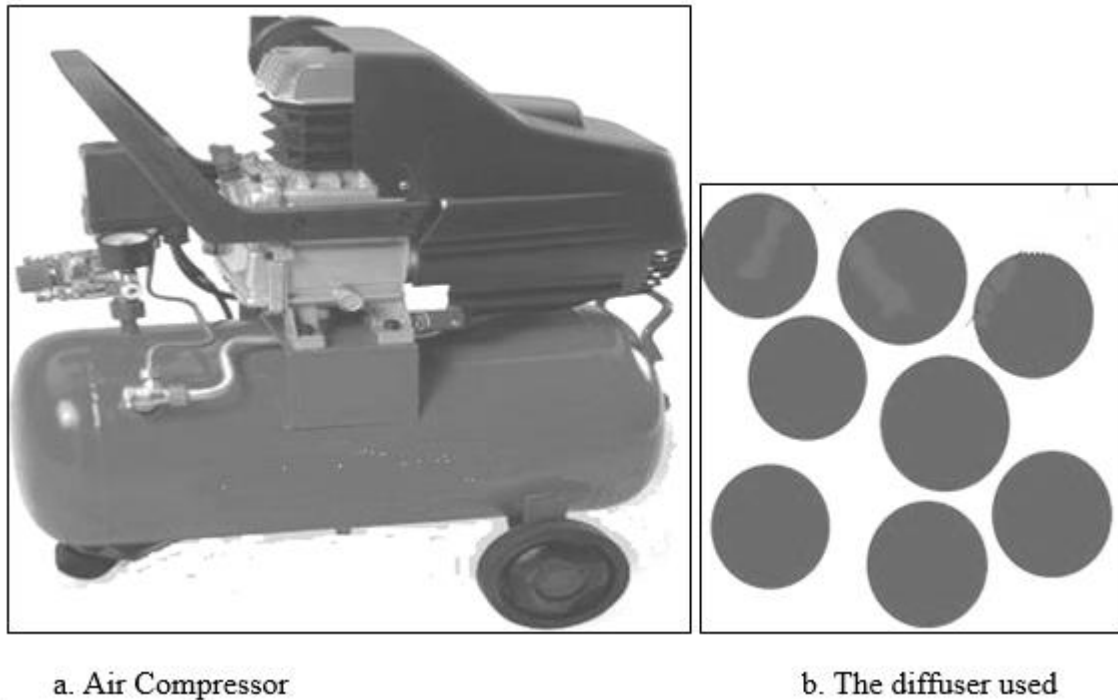


Fig .2: The diffuser and compressor used

Column Flotation Operation:

Raw water enters into the upper portion of the column at 2 m depth from the top, and flotation tailings are discharged in the bottom part of the column since the aerators are mounted in the lower part of the cell.

The most important parameters that affect the flotation process greatly are flotation time, overflow rate, air pressure, and depth of diffuser. These parameters were investigated experimentally to examine their effect on the column flotation performance. Each parameter was changed alone while fixing the others.

Experimental Procedure:

In order to provide the corresponding reference to the natural removal of algae, the first run was done free from any air. In the following runs, the diffuser was installed at different depths, and the pressure changing from 1 to 6 bar as shown in table 1.

Table 1: The experimental program

Run	Diffuser depth from the top of column (m)	Pressure range
1 st	No diffuser	Without pressure
2 nd	5	1,2,3,4,5, and 6 bar
3 rd	6	1,2,3,4,5, and 6 bar
4 th	7	1,2,3,4,5, and 6 bar
5 th	8	1,2,3,4,5, and 6 bar
6 th	9	1,2,3,4,5, and 6 bar
7 th	10	1,2,3,4,5, and 6 bar

RESULTS AND DISCUSSION

Drinking water quality had a critical significant in relation to human health. Hygienic acceptability and microbiological aspects are the most significant requirements related to domestic uses and human consumption (WHO, 1984 a, b). Phytoplankton distribution pattern are significant for the general aspects of the environment monitoring, such as eutrophication, warming trends, signs of environmental disturbances as long-term changes, hydrographic events, and pollution, (Moss, 1998; Baruah, and Das 2001; Henderson and Seaby 2014). These aspects may affect other scientific and biological research and investigation. The results of our research indicating that the general pattern of typical freshwater bodies noticed in the contributions of taxonomic groups and are likely similar to it. Where Chlorophyta and Bacillariophyta are always the richest in species. An assemblage of 106 phytoplanktonic species Fig .3, including 40 species of Chlorophyta (About 37.74%), 34 Bacillariophyta (32.08%), 31 Cyanophyta (29.24%) and only one species (0.94%) belonging to one genus of Euglenophyta were identified from the study area in the water samples collected from Bahar Mowea Canal represented as raw water.

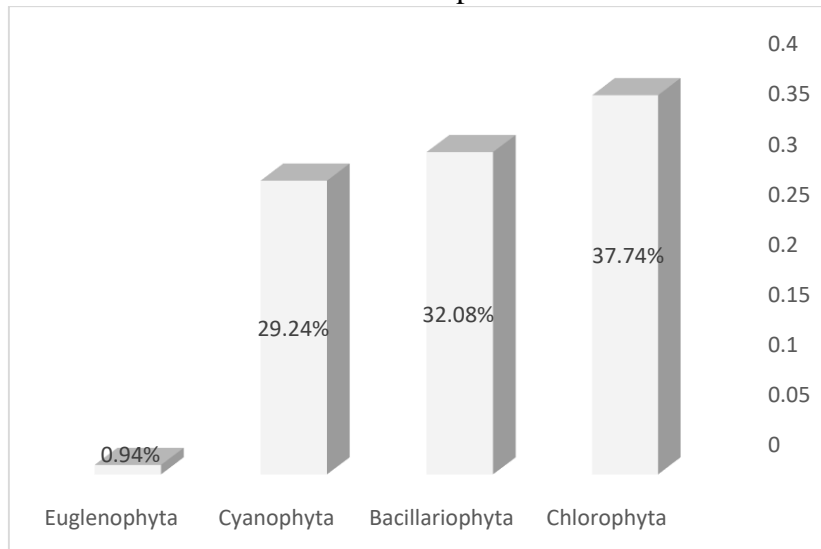


Fig .3: Number of species in different algal group expressed as percentage in the selected sites.

Characteristics of Raw Water:

Temperature, turbidity, and pH-value were measured. All these parameters were measured according to the American Standard Methods for the Examination of Water and Wastewater (APHA, 2005). The value of algae count is the most important parameter in this study, showing the effect of flotation on algae. Table 2 shows the characteristics of water for all samples taken during the study and The concentration of algae (algae count), .

Table 2: The proprieties of the raw water during the study

Parameter	Values
Algae count	3700 – 12200 cell /ml
Turbidity	4- 11 N.T.U
pH-value	7.6 – 8.3
Water temperature	14.5 – 18.3° c

Figure (4) shows the effect of depth of column on algae count removal ratio without air. The algae count removal ratio increase with increasing depth in the range of 2 to 32.7 % according to the outlet point. This showing those, without any air, the algae count in the lower part of the column are lower than that in the upper part of the column because they depend on light in their life, so they move towards the top of column (Round, 1984).

Figures from (4) to (10) illustrate the effect of applied pressure of air and sample depth on algae count removal ratio. Algae count removal ratio increased from 18 % (at 1 bar pressure, 5 m diffuser depth, and sample depth 2 m) to 65% (at 6 bar pressure, 10 m diffuser depth, and sample depth 10 m) according to sample point and the pressure applied. The reason for increasing percentage removal by increasing pressure; the amount of air dissolved in water decreases with increasing temperature (Linus Pauling 1988, Morse 1983, John Wallace, Hobbs 2006). If the pressure is doubled, the solubility of air in water is doubled (Linus Pauling, 1988).

Figure (11) shows the effect of depth of diffuser on algae count removal ratio. At pressure equal 6 bar and sample depth 10 m, the algae removal ratio when the depth of diffuser 5m was 53% and increase to 65% when diffuser depth was 10m. This means that the efficiency of algae removal increases by 12% when the depth of diffuser increase from 5m to 10m.

Algal survey in the study detected the presence of different genera for some groups, which directly or indirectly, implicate health hazards Chorus and Bartram, (1999). However, further periodical surveillance should be considered for detection of the possible pollution in all other different type of surface waters that are not subjected to water treatment process and considered as raw waters to devised different ways to get rid of them without affecting human health

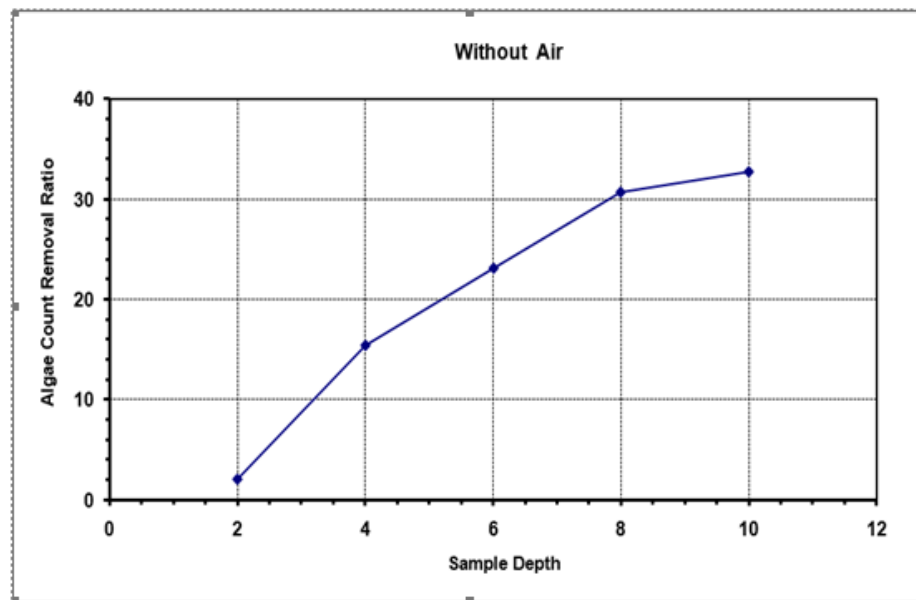


Fig .4: The effect of depth on algae count removal ratio (without air)

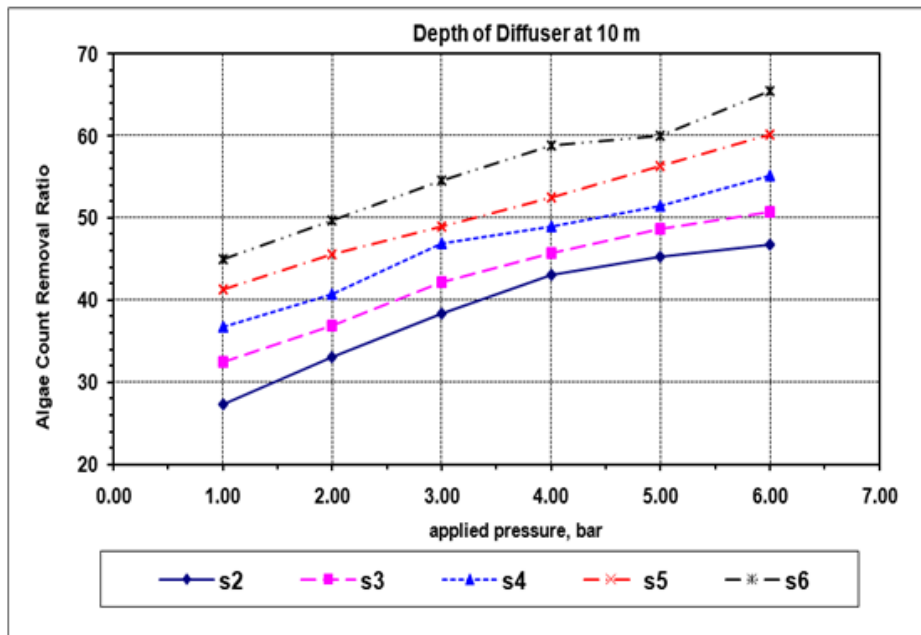


Fig.5: The effect of pressure on algae count removal at diffuser depth 10.00m

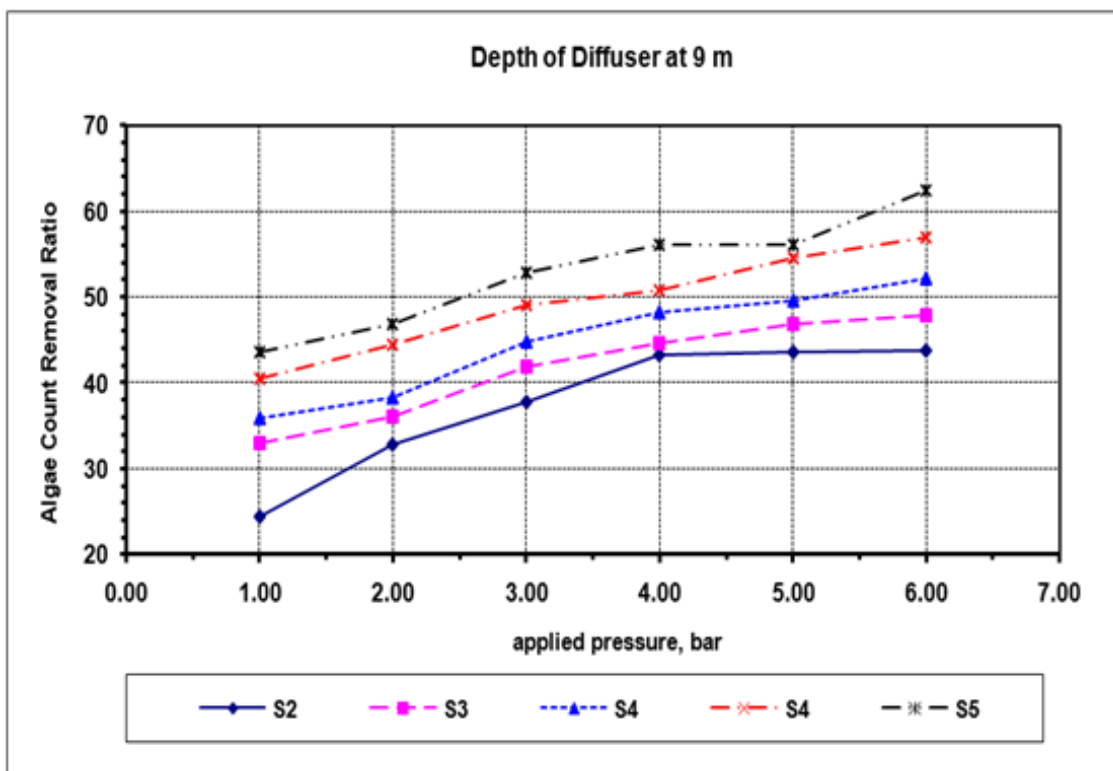


Fig.6: The effect of pressure on algae count removal at diffuser depth 9.00m

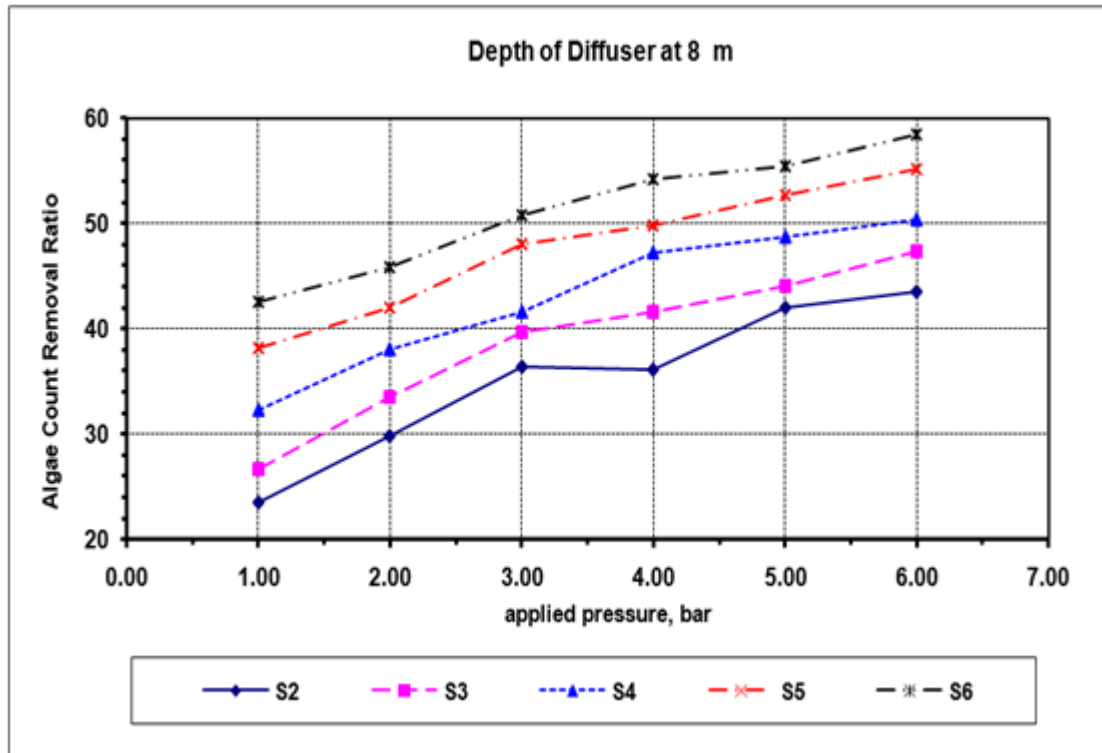


Fig.7: The effect of pressure on algae count removal at diffuser depth 8.00m

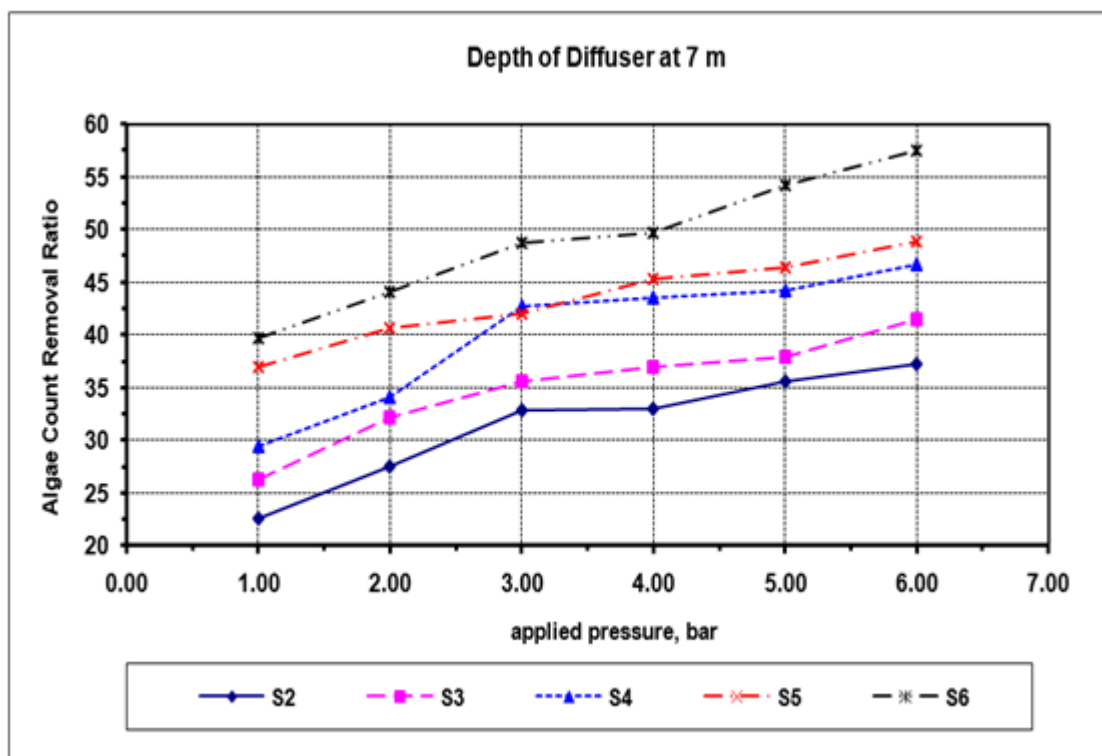


Fig.8: The effect of pressure on algae count removal at diffuser depth 7.00m

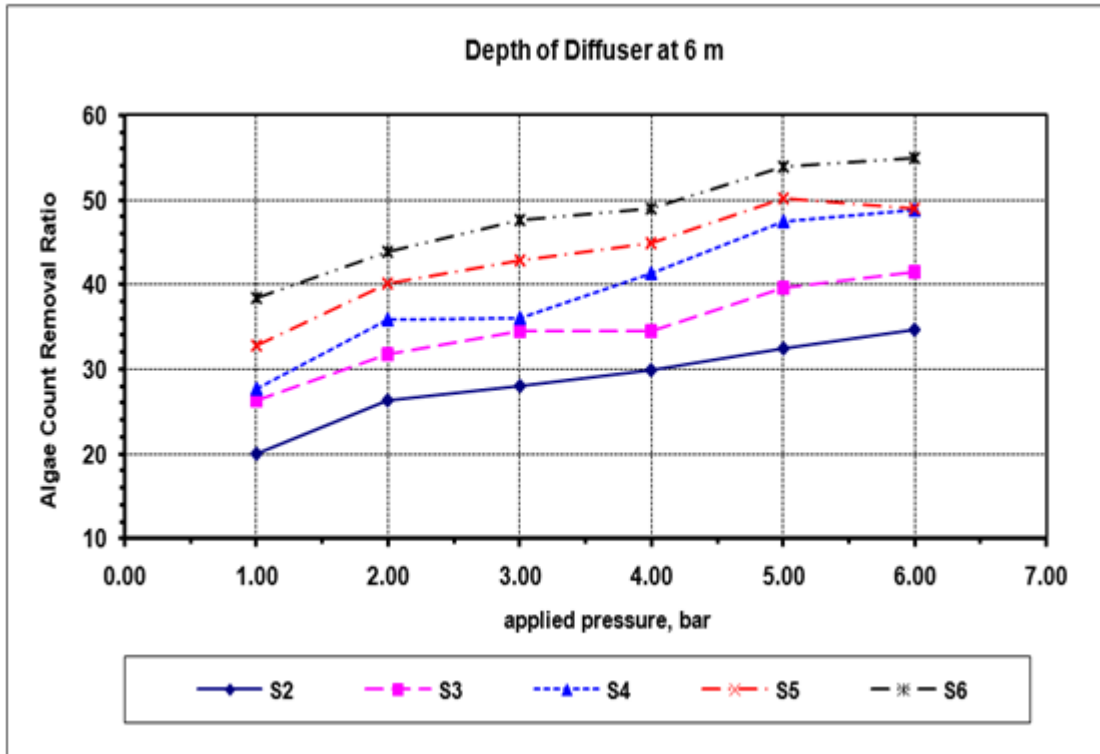


Fig.9: The effect of pressure on algae count removal at diffuser depth 6.00m

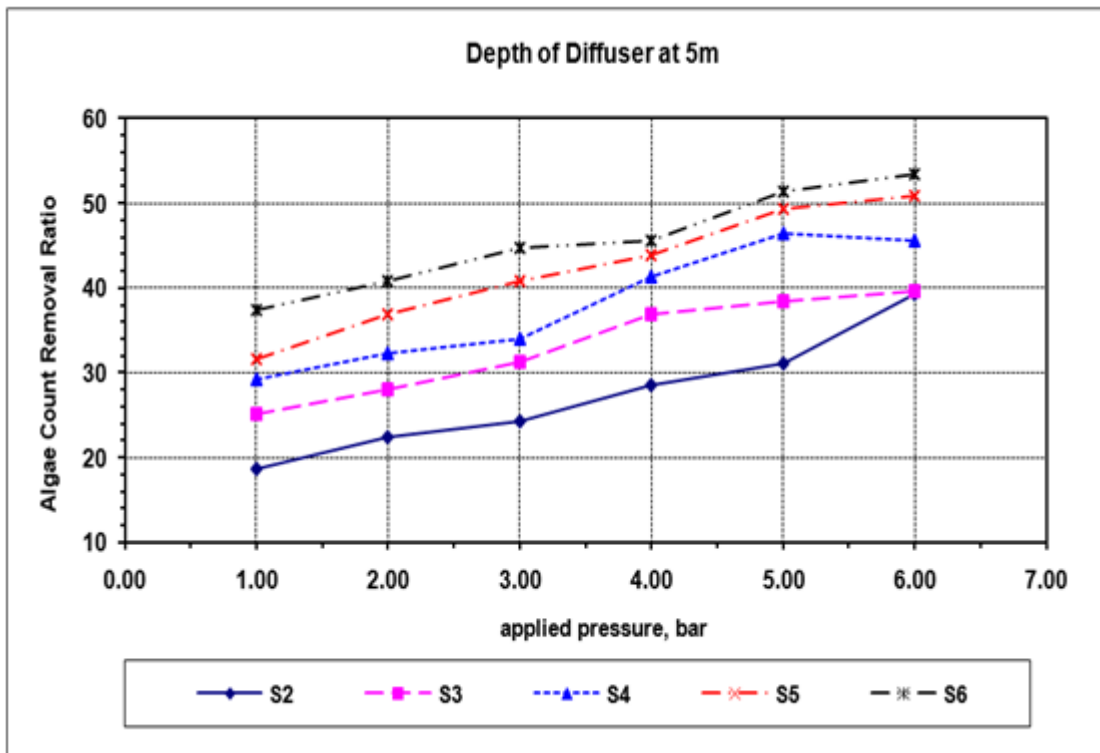


Fig.10: The effect of pressure on algae count removal at diffuser depth 5.00m

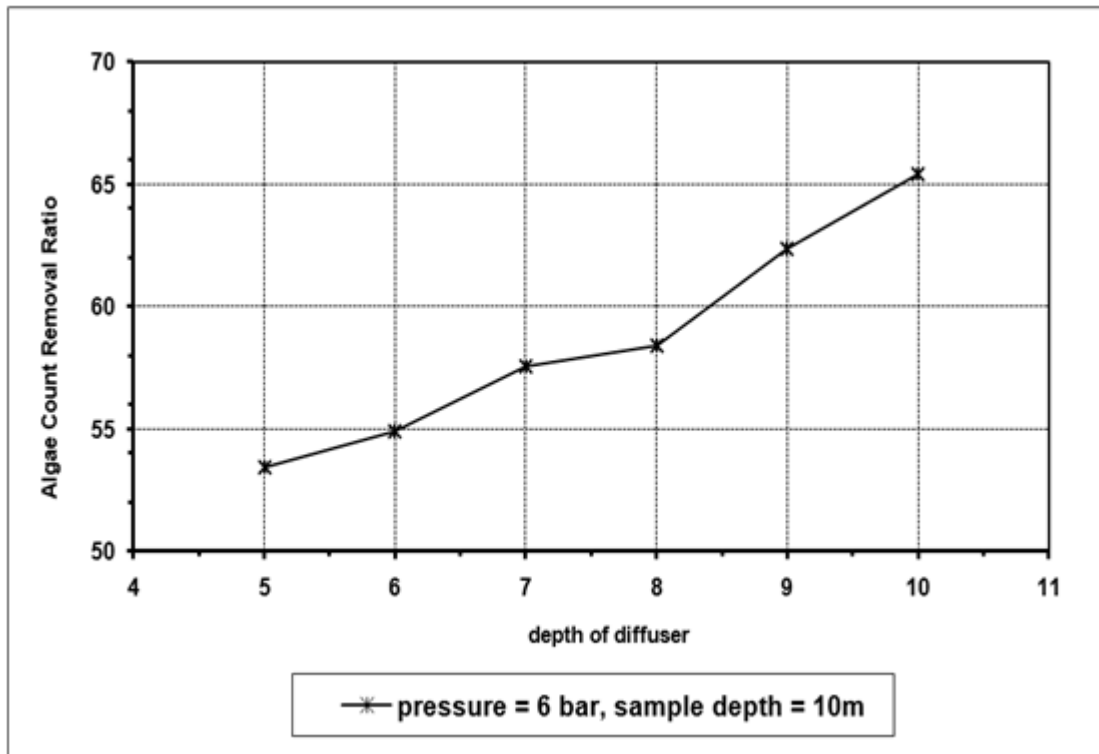


Fig.11: The effect of depth of diffuser on algae count removal

CONCLUSIONS

- It could be concluded that using of deep floatation increases percentage removal of algae from 32 % (without any air) to 65% (at 6 bar pressure)
- By increasing the depth of diffuser from 5m to 10 m, the algae count removal ratio increased from 53% to 65% at 6 bar pressure and 10 m sample depth.
- In addition to the increasing pressure of air from 1 bar to 6 bar, the algae count removal ratio increased from 18% to 65% according to sample depth.

ACKNOWLEDGEMENTS

The authors would like to thank the staff and personnel of SHRKIA potable water and sanitation Co. for assistance, facilities, and help during the preparation of this study.

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