NATURAL METHODS OF CONTROLLING ALGAE GROWTH IN OUTDOOR SWIMMING POOLS

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Abstract

Outdoor swimming pools are among the places prone to algae growth thanks to having nutrients including nitrate and phosphate, as well as having exposed to enough light. Also, the algae existing in the swimming pools may engender likely troubles such as smell, color, or bad scenery, whence making the algae treatment a must. Reducing the nutrients by growing aquatic plants is amongst effective methods to control algae in the swimming pools. In this research, a pilot test sample was fabricated via simultaneous planting of three aquatic plants- water lily, lemna, and sea lettuce- in the separated section of the main area so that the pool water is used, to study the effects of the plants on the number of algae, on concentration of nitrate, phosphate, and water turbidity. The results showed that the concentration of nitrate, phosphate, and water turbidity in the pilot was getting low by a large amount compared with the control sample. This was evidence that the three plants water lily, Lemna, and sea lettuce were conducive to algae decline. Therefore, one could hold in check the algae growth in swimming pools through developing the research results without using chemical materials.

Key words: *swimming pool, algae, phytoremediation, nitrate, phosphorous, sea lettuce, Lemna, water lily.*

Introduction

In recent years, swimming pools and artificial ponds are used for parks and gardens as an item in landscape design. Most of hotels, motels, schools, and even private gardens are interested in having swimming pools. Of late, some hospitals are equipped with swimming pools in order for hydrotherapy (Angenent et al., 2005; Lumib et al., 2004). Various investigations have shown that the number of outdoor swimming pools with acceptable bacteriologic standards is greater than that of indoor ones. Also, it is verified that the outdoor pools are less infected to pseudomonas bacteria group (Aboulfotoh, 2017) which may be due to the effect of sunlight. Furthermore, the swimmers in the indoor pools are faced with Chlorine gas and THM (Dyck et al., 2011). Contact with the Clorine by-products and disinfectants may bring about Leukemia as well as acute and chronic diseases such as athma (Thickett et al., 2002; Levesque et al., 2006; Jacobs et al., 2007). Also,

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penchant in outdoors sports exposed in sunlight has yielded inclination to the outdoor pools. Likewise, fountain basins and artificial ponds are taken into consideration as regards recreational and sports activities. However, the usage of outdoor swimming pools and recreational fountain basins has always been home to rapid algae growth. In the areas with proper light radiation, the algae nutrients grow rapidly (Buchanan, 2005; Paerl et al., 2007). Existence of algae in water resources, tanks, swimming pools, and fountain basins has unfavorable effects as to smell, taste, making bad suuoundings, turbidity, and even toxicity (Kabzinsky, 2005; Hamzeian et al., 2017).

Various methods are applied to control algae in water resources, for instance, the use of Chlorine compounds (Ibrahim et al., 2007), Copper compounds (Toth and Riemer, 1968), or shadow creation methods (Rubeen et al., 2014). The algae deleting methods have always been encountered certain problems. For example, as to chemical methods, other than high costs, toxic pollution and environmental hazards are inevitable through addition of chemical materials to aquatic environments. Roofing the pools and shadow creation, though a more suitable way of controlling the algae, cause deprivation of the advantages of using sunlight to equilibrate water temperature as well as to eliminate pathogenic bacteria (Buchanan et al., 2005; Paerl et al., 2007). On the other hand, survival of the controlled algae in the swimming pools and ponds has a lot of benefits such as supply of oxygen to decompose organic matters by bacteria. Making periodic changes in pH brings about algae elimination. Preserving the aquatic ecosystem results in control of chemical materials as well as predomination of non-pathogenic and predator bacteria. Hence, complete annihilation of the algae would be objectionable.

One important method of controlling algae is on the basis of regulating nutrients containing nitrogen and phosphor. The latter are the most important elements required in algae growth (Conley et al., 2009; Munn et al., 2010). Also, studies confirm a direct relationship between frequencies of planktons and the concentration of water phosphor (Soininen and Meier, 2014).

Growing aquatic plants in ponds and pools causes absorption and use of the nutrients in the water, not having negative impacts of algae in coloring and turbidity of water. As the studies show, growing of the plant Lemna which is compatible with water resources and weather conditions of Iran, is so effective upon reducing of toxic metals (Iram et al., 2012) in the wastewater stabilization ponds. Sea lettuce which is considered as a green algae, in addition to being of economic value and contributive to beautification of the environment, has a rapid growth in the aquatic resources in Iran, and the absorption rate of nutrients in which is high (Gaevert et al., 2007; Nielsen et al., 2011).

Water lily bearing beautiful flowers is also beneficial both in the environmental decoration and from economic viewpoint. In addition to a suitable growth, it is useful in purification of water from toxic elements (Galadima et al., 2015).

Our goal in this research is to study the effects of simultaneous growing of the above-cited three aquatic plants in the separated water-involved section of the outdoor pool upon decline of nutrients in water such as nitrogen and phosphor, and upon the number of algae. Indeed, the main aim is to investigate usability of water lily, sea lettuce, and lemna as the filters of water nutrients and of water turbidity in pools, artifitial ponds, and fountain basins.

Methods and Materials

To meet the research's end, two concrete basins were manufactured, one devoid of aquatic plants cultivation as a control, and the other possessing a part earmarked for aquatic plants growing, as in Figure1.

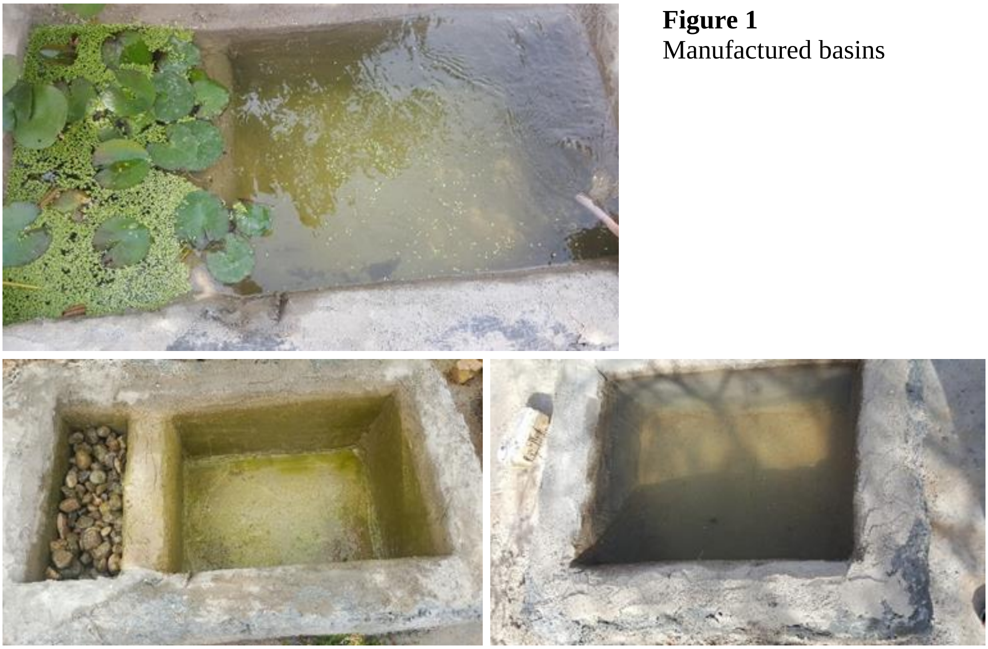

Figure 1
Manufactured basins

The control basin was 1m in length, 0.8 m wide, and 5 m altitude, with a volume totaling 4 m^3.The pilots was comprised of two parts, one basin special to the aquatic plants, and the other for the studied basin. Its dimensions were adopted similar to those of the control basin, and the dimensions of the pool for aquatic plants were taken as 0.8 m long, 0.5 m wide, and 0.5 m in height. The bottom of the pool dedicated for the plants was poured with rubbles up to 8 cm as a plants bed. Also, the separated wall was put up 10 cm lower than the walls around so that the water levels of the two basins were in touch. The plants used were Lemna, water Lily, Lagoon palm, and Sea Lettuce. In the adjacent pool, the three aquatic plants of water Lily, Lemna, and Sea Lettuce were cultivated at the stone filter part. In the lower part of the pilot, sand and pebbles was used and in the upper part, 3 cm thicker stones were employed.
For one month, the water in the plants basin was pumped, with two rotating modes,

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into the adjacent basin in three replays per day: at 7, 15, and 21 o'clock each for an hour. The reason for water rotation was to create a link between the water and the plants roots. Both at the beginning and end of the project, the concentrations of phosphor, nitrogen, and turbidity were examined. The test method was as in the book "Standard methods for examination of water and wastewater" (Eaton et al.1998). The physiological apparent changes in the plants with regard to shoot dimensions and the number of leaves were recorded. Identification of algae family along with their enumeration was inspected at the first and last stages. The duration of the pilots monitoring lasted in 45 days. A low evaporation happened due to the experiment temperature, which was compensated by the re-increase of water.

Results and Discussion

The results concerning the changes in concentration of nitrate are depicted in Figure 2.

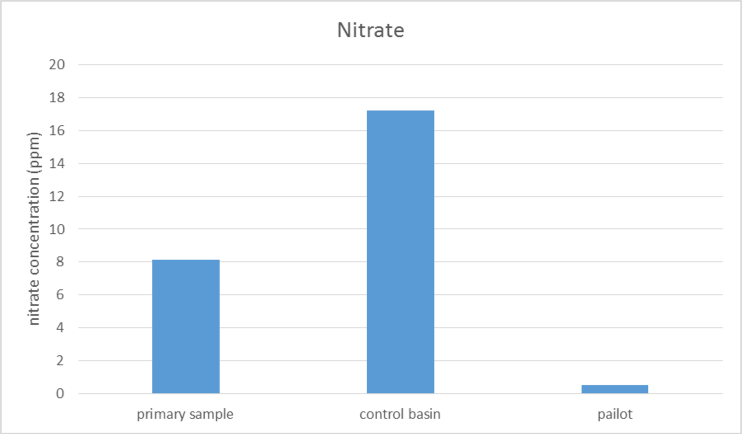

Figure2
Comparison of nitrate concentration in the stage of Lemna, Sea Lettuce, and water lily

This diagram compares the concentration of nitrate in the primary sample, the control basin, and in the pilot. The concentration of nitrate for the primary sample was 8.14 mg/l, and after the end of experiment, the concentration reached 0.51 mg/l under the influence of the plants in the pilot. The observed concentration in the control basin was 17.19 mg/l.

The actual nitrate of the water is not the real checker of the aquatic plants and algae, because it is readily provided from the inorganic nitrogen of the water and the air by the Cyanobacteria in appropriate weather conditions (Howarth et al., 1988; Scott et al., 2007; Marcarelli and Wurtsbaugh, 2009). So, one could infer that the increase of nitrate in the control basin would be an outcome of fixation of inorganic nitrogen of the water or the air by the nitrogen fixing bacteria. The decrease of nitrate up to 0.54 mg/l could be due to nitrogen discharge by the aquatic plants.

Figure 3 shows the alterations of phosphate concentration in the primary sample, control basin, and the pilot when the three plants Lemna, Sea Lettuce, and water Lily were used in the plant basins.

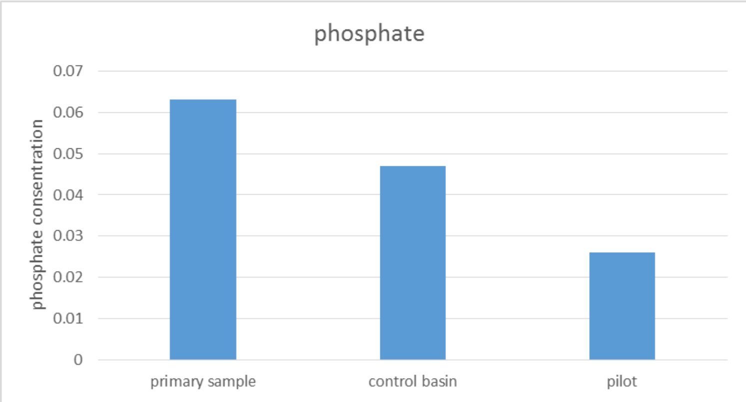

Figure 3
Comparison of Phosphate concentration in the stage of Lemna, Sea Lettuce, and water lily.

As seen, the concentration in the primary sample was 0.063 mg/l, as for the pilot it was 0.026 mg/l, while in the control basin it reached 0.047 mg/l. This verified a substantial decrease of phosphate affected by the aquatic plants in the pilot basin.

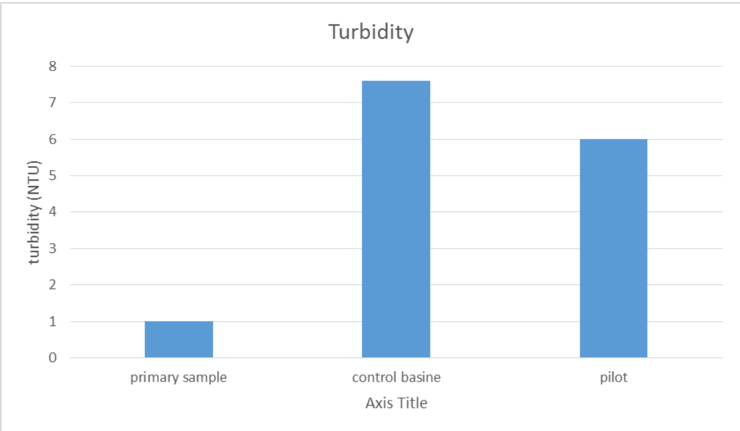

Figure 4
Changes in turbidity concentration in primary sample, control basin, and pilot in the stage of lemna, sea lettuce, and water lily.

Figure 4 shows turbidity concentration in the primary sample, the control basin, and the pilot when the three aforementioned aquatic plants were used in the plants basin. As observed, the concentration has touched the values1, 6, and 7.6, respectively, for the primary sample, pilot, and the control basin. Turbidity increase has been due to the growth of suspended algae and microalgae in the basin, whereas the decrease in turbidity as for the pilot was attributable to the lower growth of algae.

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Table 1
The number of biological agents in primary sample, control basin, and pilot in the stage of lemna, sea lettuce, and water lily (per 100 ml).

Pilot	Control basine	Primary sample	Planktons
1,413,830	4,300	115,000	Chlorophyta
7,250	23,550	12,850	Bacillariophyta
0	30,000	0	Chrysophyta
1,421,080	27,880	127,850	Total NO

According to Table 1, the number of planktons in the control basin has gotten 4 times higher, which has led to an increased development of phytoplankton in the control basin as well. Also, one could see a manifest discrepancy between the populations of different species in the control and pilot basins, which might be owing to changes in nutrient rates in the two basins.

At the outset, the number of water lilies was about 4 each having 4 or 5 leaves. However, at the final stage, there observed a good growth of leaves with bigger sizes, and the number of them attaining 7. As for Lemna, the root was nearly 0.5 cm at first, and reaching 1 cm at the last stage, whilst no observed changes in the leaves thereof.

The root of sea lettuce had a 4cm length at the beginning, and come up to 7 cm at the end, while the leaves of the plant grew a few millimeters. The detected growth in the aquatic plants could be the result of consumption of water nutrients including nitrate and phosphate. It is a fact that a lot of algae growing ingredients are getting used to generate plants inducing no odor, color, or turbidity in the water.

Conclusion

By the activities of the nitrate fixing bacteria in the outdoor swimming pools, we have increase in the nitrate over time, even though the initial nitrate is low, prompting change in water color and producing growth conditions for algae.

Phosphate may increase through the medium of various sources such as insects and feces of birds, though it may be more important to control phosphate entry to the sources since the need for algae to phosphate is less than that to nitrate.

The control pool was an evidence to show that algae grow extremely in the static aquatic sources. The usage of aquatic plants in the separated sections of the pools is a first-rate rival of the algae, and is their de facto controller. Reducing the number of algae in the pools, the aquatic plants also diminish tremendously the rates of nitrate, phosphate, and turbidity.

Developing the investigations in this regard, one could get rid of the drawbacks of employing chemical controllers of algae, environmental hazards, and the carcinogen byproducts of the chemicals. While using antiseptic effects of sunlight and applying eco-friendly control methods, one may also produce and sell beautiful and luxurious aquatic plants without spending for chemical materials, to acquire completely economic advantages.

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