AN EXPERIMENTAL STUDY ON *DUCKWEED* FOR IMPROVING POND WATER QUALITY

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Abstract— This paper deals with the laboratory experiments on the case studies prepared using pond water, '*Duckweed'* and a toxic herbicide '*Glyphosate*'. The water used in this study was collected from 'Mariyan Oorini' pond, 'Sattur', 'Virudhunagar' district of Tamilnadu. The experiments were performed on five cases for 10 days and the various physiochemical parameters such as DO (dissolved oxygen), temperature, Nitrate, Ammonia, Phosphate, Turbidity, pH were analysed. These results were very much useful in understanding the removal efficiency of pollutants from the water sample by *Duckweed*. This study is also helpful to understand the effect of *Glyphosate* dosage on *Duckweed* growth.

Index Terms — Ammonia, *Duckweed*, *Glyphosate*, Nitrate, Phosphate, Pond water, Removal efficiency.

1. INTRODUCTION

PONDS and lakes are meant for storing rain water in order to fulfill the basic human demands such as domestic and irrigation needs. In olden days ponds were maintained by the respective village people but nowadays, ponds are considered as a dumping site for solid wastes & drainage water. Most of the ponds are polluted due to human intervention and lack of public awareness. Unfortunately, ponds have got transformed as a sink for spreading harmful diseases and to create a polluted unhealthy living environment. Due to this, incident of water borne diseases such as Chikungunya, Dengue, Malaria, etc. has increased considerably over the recent years. Since these types of ponds contain less amount of water as compared to a river or stream, affording a treatment unit in every nook and corner of the town is not practically possible due to economic constraints. Sangeeta Dhote [15], stated that several water treatment technologies are available currently which consume large economic resources and are also highly power consuming as well as non eco friendly. Here, the phytoremediation has a major role in tackling the problem. Phytoremediation is one of the serious efforts towards sustainability. According to Anima Priya [1], the macrophyte based water treatment systems have several potential advantages compared with conventional treatment systems. Nayyef M. Azeez [10] conducted studies using *Duckweed* on waste water from 'Basrah Oil Refinary' and proved that *Duckweed* plant can be successfully used for waste water pollutant removal. J.M Dalu [8] concluded that significant reduction of parameters to within permissible limit was obtained except for COD, BOD and turbidity 60% of reduction were observed with the addition of *Duckweed* in stabilization ponds.

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Olah.V et al. [12], conducted studies on two species of *Duckweed* and observed that the physiological responses of the different species to same ambient concentration of a toxic chemical (hexavalent Cr VI) is in different manner. Anong Phewnil et al. [3], concluded that the growth rate of *Lemna Perpusilla Torr.* reduced when atrazine concentration were present in the range of 250 -32000 µg/l within 24 hours. In-Hwa Chang et al. [6], studies concluded that *Duckweed* uses different adaptive mechanism in order to counter balance high doses of a particular toxicant like NaCl. John. R et al. [7], conducted experiments on *Duckweed* and found that *Duckweed* growth rate increased at a concentration of 1, 10 and 20 mg/l of Cd and Pb while a reduced growth rate was observed in 30 and 40 mg/l concentration. Harini Santhanam [5] concluded that the Fuzzy quality index is better than Carlson's trophic state index for trophic status analysis. R. Sooknah [13] concluded that pollutant removal in water hyacinth system depends on the nutrient assimilative capacity of plant and the biochemical / physiochemical process taking place within the system. Thongchai Kanabkaew [16] concluded that as the HRT increases, the removal of BOD is increased. According to Nihan Ozengin [11], the maximum removal of the Total Phosphate, nitrate and COD by *Duckweed* (Lemna minor.L) occurs at 360minutes and the maximum removal of Total nitrate was observed at 1440 minutes for industrial and municipal waste water. M.D.Ansal [9] found that a dividing system of fish and *Duckweed* is more efficient than combined systems. Reeta D. Sooknah [14] in this paper, the potential of 3 floating aquatic macrophyte on anaerobically flushed dairy manure waste water was studied. The growth of water hyacinth was robust followed by polyculture and further followed by the other two monocultures. Bhupinder [4] in this paper, Salvinia exhibit for removing contaminants such as heavy metals, inorganic nutrients from waste water. In salvinia, physical process is fast (adsorption, ionic exchange and chelation) while biological process such as intercellular uptake is comparatively slow for removing heavy metals.

In this paper, the phytoremediation of the pond water from 'Mariyan Oorini', located near NH-7, 'Sattur' (taluk) of 'Virudhunagar' District of Tamilnadu was performed. This water sample was taken to form different experimental case studies using *Duckweed* and a toxic herbicide '*Glyphosate*'. In this study, the work has been divided into 2 phases

International Journal of Scientific & Engineering Research, Volume 4, Issue 5, May 2013
ISSN 2229-5518

Phase1: Efficiency of *Duckweed* on pond water quality.
Phase2: Effect of toxicant Glyphosate on the *Duckweed* plant growth.
The physiological parameters like DO, pH, CO_2, Ammonia, Nitrate, Phosphate, Temperature and Turbidity in all samples were analysed for 10 days using the standard procedures and % reduction in the parameters was found out to understand the maximum removal of pollutants by *Duckweed*.

2. MATERIALS AND METHODOLOGY

In this study, five artificial ecosystems has been studied using pond water taken from "MARIYAN OORINI", Sattur, Virudhunagar district, Tamilnadu. An aquatic plant macrophyte (*Duckweed*) belonging to lemnacea family is used for this experimental study. A toxic herbicide (*Glyphosate*) is also used to test the toxicity effects on the artificial ecosystem. Mariyan Oorini is a part of Sattur town and is situated at 9º27´ North latitude and 77º46´ East latitude. Fig. 1 and Fig. 2, show the image of Mariyan Oorini taken using digital camera as well as downloaded from Google Earth.

Fig. 1. Photo View of Mariyan Oorini

Fig. 2.Digital image of Mariyan Oorini

The pond water is formed by the collection of the wastewater from the surrounding areas of Sattur town thus making it unfit for domestic purpose. Further, there is a high risk of this waste water to affect the quality of the underground water through seepage as well as subsurface water flow. The depth of the pond water is very shallow and visibly green colour is due to the presence of algae.

Following different experimental ponds are prepared in this study.

Case 1 - Study of original pond water sample (control).
Case 2 - Study of pond water sample with introduction of a macrophyte *Duckweed* (15 gm wet weight).
Case 3 - Study of pond water sample after introduction of *Duckweed* (15 gm wet weight) along with a toxic herbicide *Glyphosate* with concentration of 0.125mg/l.
Case 4 - Study of pond water sample after introduction of *Duckweed* (15 gm wet weight) along with a toxic herbicide *Glyphosate* with concentration of 0.250mg/l.
Case 5 - Study of pond water sample after introduction of *Duckweed* (15 gm wet weight) along with a toxic herbicide *Glyphosate* with concentration of 0.500mg/l.
The functioning of these five artificial ponds was surveyed for a period of 10 days. Each artificial pond was initially filled with 14.8 litres of pond water.

2.1 EXPERIMENTAL PROGRAM

For all the above case studies, daily analysis of pH, temperature, Nitrate, Ammonia, Phosphate, Dissolved oxygen and Turbidity were performed using standard procedures. The Dissolved oxygen is measured using 'Winkler's method'. Electrode method was used to analyse pH, temperature using thermometer, Nitrate using Brucine sulphate method, Ammonia by titrimetric method, Phosphate using ammonium molybdate method and turbidity by Nephlometric turbidity metric methods respectively for 10 days i.e. from 11/10/2012 to 22/10/2012. Fig. 3 shows the laboratory setup of *Duckweed* ecosystem. The initial condition of the pond water analysed is shown in Table.1

Fig. 3.laboratory set up of *Duckweed* ecosystems

Table. 1. Initial Condition of Pond water.

Initial condition of pond water		
parameter	**unit**	**value**
Temperature	**° C**	**22**
Nitrate	**mg/l**	**45**
Phosphate	**mg/l**	**1.6**
Ammonia	**mg/l**	**1.703**
Turbidity	**NTU**	**167**
pH	**nil**	**8.74**
DO	**mg/l**	**6.72**

International Journal of Scientific & Engineering Research, Volume 4, Issue 5, May 2013
ISSN 2229-5518

3. RESULT AND DISCUSSIONS

The physiochemical parameters obtained and percentage reduction for different case studies are shown in Table 2 to 6.

Table. 2. Percentage Reduction in Case 1.

CASE:1					
No	Parameters	Unit	Initial concentration	Final concentration	Percentage reduction
1	Temperature	° C	22	20	-
2	Nitrate	mg/l	45	15.505	65.5
3	Phosphate	mg/l	1.6	0.8	50
4	Ammonia	mg/l	1.703	0.425	75.04
5	Turbidity	NTU	167	105.5	36.8
6	pH	nil	8.74	8	-
7	DO	mg/l	6.72	2.08	-

Table. 3. Percentage Reduction in Case 2.

CASE:2					
No	Parameters	Unit	Initial concentration	Final concentration	Percentage reduction
1	Temperature	° C	22	20	-
2	Nitrate	mg/l	45	17.72	60.62
3	Phosphate	mg/l	1.6	0.4	75
4	Ammonia	mg/l	1.703	0.425	75.04
5	Turbidity	NTU	167	135.5	18.86
6	pH	nil	8.74	7.8	-
7	DO	mg/l	6.72	3.04	-

Table. 4. Percentage Reduction in Case 3.

CASE:3					
No	Parameters	Unit	Initial concentration	Final concentration	Percentage reduction
1	Temperature	° C	22	21	-
2	Nitrate	mg/l	45	19.335	57.03
3	Phosphate	mg/l	1.6	1	37.5
4	Ammonia	mg/l	1.703	0.425	75.04
5	Turbidity	NTU	167	195.5	-17.06
6	pH	nil	8.74	8.23	-
7	DO	mg/l	6.72	2.9	-

Table. 5. Percentage Reduction in Case 4.

CASE:4					
No	Parameters	Unit	Initial concentration	Final concentration	Percentage reduction
1	Temperature	° C	22	20	-
2	Nitrate	mg/l	45	17.72	60.62
3	Phosphate	mg/l	1.6	1	37.5
4	Ammonia	mg/l	1.703	0.425	75.04
5	Turbidity	NTU	167	198.5	-18.86
6	pH	nil	8.74	7.56	-
7	DO	mg/l	6.72	2.8	-

Table. 6. Percentage Reduction in Case 5 .

CASE:5					
No	Parameters	Unit	Initial concentration	Final concentration	Percentage reduction
1	Temperature	° C	22	22	-
2	Nitrate	mg/l	45	15.505	65.54
3	Phosphate	mg/l	1.6	1	37.5
4	Ammonia	mg/l	1.703	0.425	75.04
5	Turbidity	NTU	167	190.5	-14.07
6	pH	nil	8.74	8.38	-
7	DO	mg/l	6.72	2.43	-

I- Efficiency of *Duckweed* on pond water quality.

The phosphate removal in original pond water and in the presence of *Duckweed* after 10 days was measured as 50 % and 75% respectively. The phosphate removal is more with the presence of *Duckweed* than original pond water due to the following reason (1) this may be due to phosphate uptake by *Duckweed* plant and assimilation into plant protein. (2) Adsorption on plant leaves, (3) Chemical precipitation and (4) Microbial uptake. The phosphate removal in control may be due to the uptake by micro organism and other biological activities taking place according to Anima Priya [1]. The turbidity removal in original pond water and in presence of *Duckweed* after 10 days was measured as 36.8 % and 18.86 % respectively. The turbidity removal is less with the presence of *Duckweed* than original pond water. The reason for this may be due to presence of some dead leaves of *Duckweed*. The pH value is decreased from 8.74 to 7.8 in the presence of *Duckweed*. This may be due to respiration by *Duckweed* plants. The ammonia removal in original pond water and with the presence of *Duckweed* was both 75.04 %. i.e., for ammonia removal, there is no difference between original pond water and pond water with *Duckweed*. Hence, *Duckweed* plant does not efficiently remove ammonia nitrogen. The nitrate nitrogen removal in the pond water and with the presence of *Duckweed* is namely 65.5 % and 60.62 % respectively. For nitrate removal, there is no considerable difference between original pond water and pond water with *Duckweed*. Hence, *Duckweed* plant is not effective in nitrate nitrogen removal as compared to phosphate removal. In the original pond water the dissolved oxygen (DO) level initially decreased from 6.72 mg/l to 1.6 mg/l and then increased to 2.08 mg/l. But in the presence of Duckweed, the DO initially decreased from 6.72 mg/l to 1.92 mg/l and then increased to 3.04 mg/l respectively. The reduction of DO may be due to the decomposition of organic matter by aerobic bacteria. Later, the DO starts to increase. When compared to the original pond water, the DO level is more in the presence of *Duckweed* at the end of the experiment. This may be due to (1) Supply of oxygen by *Duckweed* plants. (2) Atmospheric diffusion. When compared to original pond water sample, the DO level is more in the 3rd, 4th and 5th case at the end of the experiment. This may be caused by the presence of *Duckweed* in the latter case.

International Journal of Scientific & Engineering Research, Volume 4, Issue 5, May 2013
ISSN 2229-5518

II - Effect of toxicant *Glyphosate* on the *Duckweed* plant growth.

In the presence of *Duckweed*, without adding toxicant, the phosphate removal is 75 %. The phosphate removal is decreased from 75% to 37.5 % (almost half) when *Glyphosate* is added in the dosages namely 0.125 mg/l, 0.250 mg/l and 0.500 mg/l. From this observation, phosphate removal is reduced after adding *Glyphosate* toxicant. This may be due to the reason that plant growth is affected by *Glyphosate* toxicant.

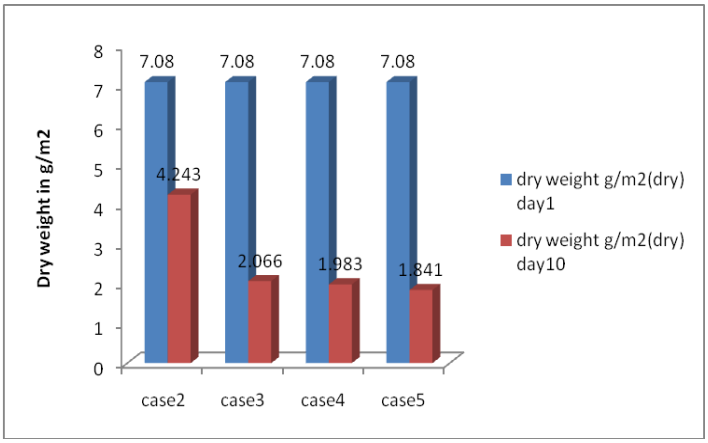

Fig. 4 Dry weight of *Duckweed* determined

The dry weight of *Duckweed* biomass in Case2 (without toxicant) is 4.243 g/m^2 (dry). The dryweight of *Duckweed* biomass after adding 0.125, 0.250 and 0.500 dosages of toxicant are 2.066 g/m^2 (dry), 1.983 g/m^2 (dry) and 1.841 g/m^2 (dry) respectively. With the increase of toxicant dosages, the dry biomass weight of the *Duckweed* plant decreases. From this observation, we can conclude that there is a negative effect of toxicant *Glyphosate* on plant growth. But several toxicant dosages are needed for complete analyses of growth of *Duckweed* plant. Interestingly, in 3rd, 4th and 5th cases, the turbidity increased at the end of the experiments when compared to the initial values. This is due to suspended impurities caused by dead plants.

4. CONCLUSION

From the experimental studies conducted, it was understood that the *Duckweed* plant efficiently removes 75% phosphate from pond water. Comparatively, the Duckweed growth rate enhancement is seen more in the pond water without toxicant *Glyphosate*. According to Anong Phewnil et al. [3], there is no current set of standard in toxicity of Atrazine in surface water. In particular, the toxicity to the aquatic plants which are primary producers will cause an imbalance of the aquatic ecosystem. Similarly *Glyphosate* is being used in large quantities in India causing contamination of surface water. The result obtained in this study may be used to develop *Glyphosate* application standards for the surface waters of India.

5. ACKNOWLEDGEMENT

This study was supported by Dr. Thillai Arasu, HOD, Department of Chemistry, Kalasalingam University, Dr. Sundar, HOD, Department of Biotechnology, Kalasalingam University and Dr. Palanivelu, Principal, Arulmigu Kalasalingam College of Pharmacy. Special thanks tribute to B.Tech students G. Magara Jothi, K. Lakshmi Devi and R. Gajalakshmi, for their assistance in collecting *Duckweed* and conducting chemical analyses.

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International Journal of Scientific & Engineering Research, Volume 4, Issue 5, May 2013
ISSN 2229-5518

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