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Effluent Removal Capacity of Water Hyacinth and Factors Affecting its Growth

Ankush Patekhede*, Ranjitsingh Gaikwad*, Pratik Pathare**, Akshay Naik**, Sooraj Prajapati**, Pranav Desai**.

* Professor, Department of Civil Engineering, Suman Ramesh Tulsiani Technical Campus, Faculty of Engineering, Kamshet, Pune 410405.

**Students, Department of Civil Engineering, Suman Ramesh Tulsiani Technical Campus, Faculty of Engineering, Kamshet, Pune 410405.

Abstract:

Water hyacinth (Eicchornia Crasspies) is fast growing perennial aquatic macrophyte and prolific free floating aquatic weed. It has ornamental as well as many economic and environmental uses. Nowadays, sewage treatment is posing serious techno-economic problem in cities, particularly in underdeveloped countries. A new sewage purification method by water hyacinth is being considered as feasible solution. In this Research Paper, we have stated the Effluent removal capacity of water hyacinth for sewage treatment by conducting lab-scale experiments like pH, BOD, COD, DO, and sulphate, phospate and nitrate content on specified amount of sewage water from sewage treatment plant at Kasarwadi, Pune and observed various factors affecting its growth.

Keywords-**Water hyacinth, Macrophytes, Constructed Wetlands, Phytoremediation, Industrial wastewater treatment, Sustainability**

I. INTRODUCTION

Water hyacinth is one of the fastest growing trophical free floating macrophyte plant species. Originated from South America, particularly in the Amazonian basin, this tropical plant spread throughout the world in late 19th Century It reached Australia in 1895, India in 1902, Malaysia in 1910, Zimbabwe in 1937 and the Republic of the Congo in 1952. It is abundantly found in India, Bangladesh and South East Asia. Its name Eichhornia was derived from well known 19th century Prussian politician J.A.F. Eichhorn. This plant has great ornamental value and is also known as 'queen flower' because of its attractive rosette leaves and beautiful pale violet flowers. It has also shown its ability to treat waste water by the process of Phytoremediation.

In spite of this, the weed has caused considerable damage to lakes and rivers around the world. It clogs waterways and impedes navigation. Water hyacinth occurs in habitats of widely differing water depth and nutrient level.

Water Hyacinth shows great potential for its ability to reproduce. Just ten plants can grow a population of 655,330 in merely eight months. They reproduce both sexually and asexually. It commonly forms dense, interlocking mats due to its rapid reproductive rate and complex root structure.When flowering cycle ends, flower stalk bends due to that spike reaches under the water surface and seeds are released directly into the water. The height from flower top to root top of water hyacinth usually reach upto 1.5 m and more.

II. FACTORS AFFECTING THE GROWTH OF WATER HYACINTH

1) Climatic Conditions:-

During summer, the mortality of water hyacinth increases and suffers during the next winter but rapidly comes up in the spring season. Optimal

water temperature for its growth is 28-30℃. Temperature above 33℃ inhibits further growth.It cannot be grown in an area with average temperature around 1℃. It can only survive for 24 hours in temperature around 0.5 and -5 ℃. Therefore, it is not suitable for temperate or frigid areas due to their sensitivity to cool temperature.

2) Eutrophication:-

The growth rate of water hyacinth is strongly dependent upon the concentration of dissolved nitrogen (N) and phosphorus (P) in the water. Rivers and Lakes receive polluted water, which are rich in the amounts of nitrates and phosphates, from agricultural fields due to use of chemical fertilizers and pesticides as well as industries. The levels of available nitrogen and phosphorus have often been cited as the most important factors in limiting water hyacinth growth. 5.5 mg of N/L and 1.06 mg of P/L is required for survival of water hyacinth growth whereas to achieve maximum growth N, P and K (potassium) added at the rate of 20 mg N/L, 3 mg P/L and 52 mg K/L, respectively.

3) Salinity:-

Water hyacinth is killed in waters that are more than about 0.2% saline. They require fresh water generally for their growth with enough level of organic matter.

4) Disturbance:-

Flooding can break up large mats of water hyacinth and leave plants stranded on land. Similarly, currents flush water hyacinth downstream. However, water hyacinth can still build up on sheltered edges and at blockages. Wave action may itself limit growth by directly damaging plants and by forcing the weed to maintain aerenchymous tissue.

5) Reproduction:-

Eicchornia crassipes is a flowering plant that germinates seeds during the spring, which is also its highest growing season. The Ovary of the plant, incased in hypathium, will produce about 500 ovules but only 50 seeds per capsule once fertilized. The seeds are released by the "spitting of the hypathium, and seeds are caught in the mat of the plant orsink to the bottom of the water body.. E. crassipes is a colonizing plant with a rapid rate of growth. Any damage to the colony is repaired by re-growth and resprouting. Though E. crasssipes is an aquatic plant, it has the ability to grow on land, though not as successful as being in an aquatic environment.

6) pH factor:-

It is found out that E crassipes growth has decreased in both lower and higher pH values. Statistical analysis of variance showed that there were no significant differences among plants grown in the following pH values: 4.5 and 10; 5.5 and 8.5; 5.5 and 9.5; 7.5 and 8.5; 6.5 and 9.5; and 8.5 and 9.5 respectively. However the decreased growth was found out to be more under lower pH values. The optimum pH where the plant grew is at 7.5 with a slight drop at 6.5 and 8.5

7) Hydraulic Factors:-

Water Hyacinth requires sufficient depth for its growth. Depth of more than 2m is preferred. Along that the wind velocity must be optimum.

8) Nutrient Availability:-

Nutrient availability also affects the growth and performance of aquatic plants. It comprises of 95% water and 5% dry matter, out of which silica, potassium, nitrogen and protein is 50%, 30%, 15% and 5%, respectively. The weight and size of aquatic plants are a function of these factors.

9) Sunlight Shading:-

It is observed that the water hyacinth receiving full sunlight conditions grow very well. The rapid rate of increase in number of leaves, floats, root length of the plant is observed in full sunlight conditions than those plants receiving less sunlight.

III. MATERIALS AND METHODS

In order to check the effluent removal capacity, water hyacinth was grown outdoors in tanks at the Kasarwadi sewage treatment plant. Over the period

of a month the physio-chemical parameters of water like pH, DO, BOD, COD, sulphate, phosphate and nitrate content were checked at the outlet by conducting tests

A rectangular tank with dimension of 1.5m X 1m X 0.5m (L X B X H) was the setup where sewage of about 700 litres was filled from the kasarwadi sewage plant itself. The Raw sewage from plant was fed manually. Top surface of tank was kept open to atmosphere. About 4.55kg mass of water hyacinth were placed at the surface of water at the initial stage of experiment. Inlet and outlet arrangement were given according to standard practices.

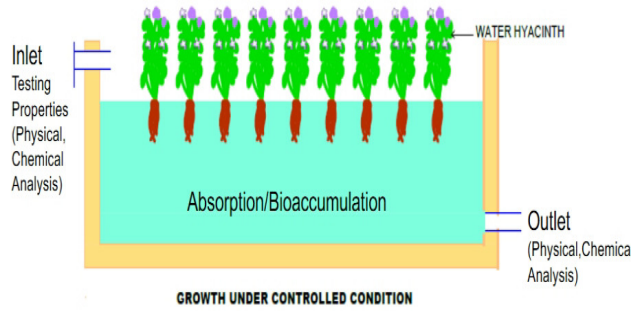

Fig 1 Representation of Experimental Model

The water hyacinth was collected from local water body source. The roots of the collected plants were washed carefully with tap water to remove any adhering dirt material.

Fig No 2 Actual Model Set-up

IV. OPERATIONAL PROCEDURE

As the Model was installed outdoors, the Raw sewage water from the inlet of the treatment plant at Kasawadi was fed into the tank. This water was tested prior filling it into the tank for its physio-chemical analyis i.e pH, DO, BOD, COD, sulphate, phosphate and nitrate content.

Now after filling the tank, it was left open to atmospheric condition. Climatic condition of Pune was favourable for water hyacinth's growth. The water hyacinth began to feed on the nutrient effluent for its growth. The system provided better conditions for microbes inside the tank, which in turn lead to degradation of many pollutants particularly organic matter.

Over the period of about 32 days, water sample was collected from the outlet at every 6 days interval and the sample collected was tested to calculate the difference in physio-chemical as well as biological parameters.

Tests were carried out in following manner at the Kasarwadi and Akurdi Sewage water treatment lab facility under strict supervision.

1) pH

pH was determined standard pH meter

2) Dissolved Oxygen

Dissolved oxygen content was measured by titrametric method which is based on the oxidising property of DO. Titration was done against Sodium thiosulphate for sample of 200 ml prepared by mixing manganese sulphate and Alkali Iodide Azide solution.

3) Biochemical Oxidation Demand

Sample is filled in an airtight bottle and incubated at specific temperature for 5 Days. The dissolved oxygen content is determined prior and after five days of incubation at 20^{o}C and the BOD is calculated from the diference between initial and final readings.

4) Chemical Oxidation Demand

The organic matter pesent in sample gets oxidized completely by potassium dichromate ($K_2Cr_2O_7$) in the presence of sulphuric acid (H_2SO_4), silver sulphate (A_2SO_4) and mercury sulphate ($HgSO_4$) to produce CO_2 and H_2O. The sample is refluxed with a known amount of potassium dichromate in sulphuric acid medium and the excess potassium dichromate is determined by titration against ferrous ammonium sulpahte using ferroin indicator. The amount of dichromate consumed by the sample is equivalent to the amount of O_2 required to oxidize the organic matter.

5) Sulphate, Nitrate and Phosphate Content

Amount of these substances were measured by means of a spectrometer. Spectrometer used was HACH DR 3900. 10ml sample was mixed with reagent of specified test and was placed in the spectrometer to determine the content.

Fig No 3. Spectrometer Used in Experiment

V. RESULTS AND DISCUSSION

After conducting the tests as per the procedure described results obtained as as shown below.

A) Inlet Parameters

Inlet sample was obtained from inlet of sewage treatment plant at kasarwadi and tests were conducted only one time. Results obtained were as follows

- pH= 6.75
- DO= Nil
- BOD= 180mg/lit
- COD=528mg/lit
- Sulphates= 8mg/lit
- Phosphates= 9.89mg/lit
- Nitrates= 22.6mg/lit

B) Outlet Parameter

Samples were collected from the outlet at interval of 6 days for a period of about 32 days. Results obtained are as follows

1) pH

TABLE NO:- 1
pH PARAMETERS

Date	pH
6/1/2017	6.9
12/1/2017	7.52
18/1/2017	7.4
25/1/2017	7.23
1/2/2017	7.6
8/2/2017	7.86

pH reading as observed initially was 6.75 and it increased upto 7.86 coming under standard to potable water of 6.5-8.5. Hence this was acceptable

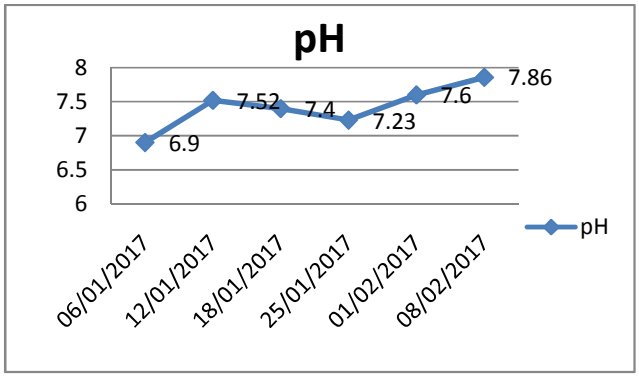

Fig No 4 Graph showing details of pH

2) DO

TABLE NO:- 2
DO PARAMETERS

Date	DO
6/1/2017	2.0
12/1/2017	2.9
18/1/2017	3.9
25/1/2017	4.0
1/2/2017	4.0

8/2/2017	4.1

The dissolved oxygen content of water is influenced by the source, raw water temperature and chemical or biological processes taking place in the distribution system.

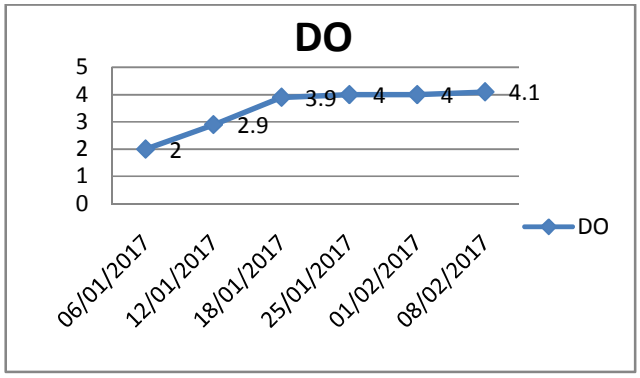

Fig No 5 Graph showing details of DO

We can see that water hyacinth influence the growth of aerobic microbes which in turn increases the DO from NIL to 4.1. However as time passes and no. of biomass of plants increases it cover the surface area of water area totally as a result sun rays are blocked causing decrease in microbes and the rate of increase of oxygen decreases.

3) BOD

The initial DO is determined shortly after the dilution is made all oxygen uptake occuring after this measurement is included in the BOD measurement

TABLE NO:-3
BOD PARAMETERS

Date	BOD
6/1/2017	100
12/1/2017	28
18/1/2017	26
25/1/2017	25
1/2/2017	10
8/2/2017	8

BOD is significant to give an idea about the biodegradibility of any sample and strength of the waste matter. By use of Water hyacinth the BOD of sewage was reduced drastically(about 92%) making it closest to acceptable standard to be released into the local water body

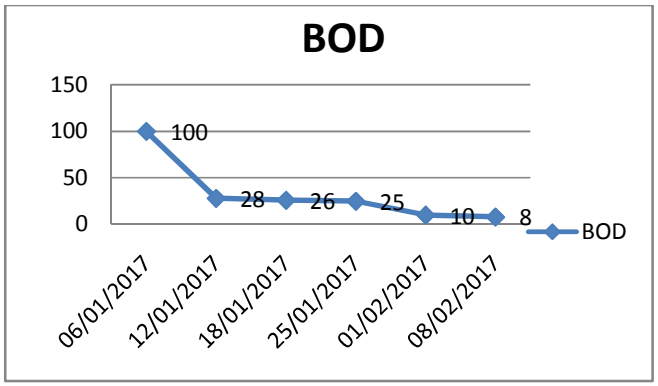

Fig No 6 Graph showing details of BOD

4) COD

COD is useful to assess strength of wastes, which contain toxins and biologically resistant organic matter

TABLE NO:-4
COD PARAMETERS

Date	COD
6/1/2017	250
12/1/2017	126
18/1/2017	80
25/1/2017	76
1/2/2017	60
8/2/2017	40

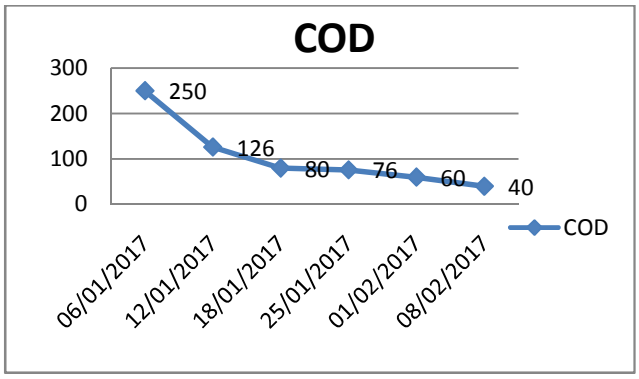

Fig No 7 Graph showing details of COD

Significant reduction in Chemical oxygen demand was found out which made acceptable condition for disposal. BOD value is always lower than COD value. For domestic and industrial wastewater, COD applicable value is about 2.5 times BOD value.COD reduction was about 84%

5) SULPHATE CONTENT

TABLE NO:-5
SULPHATE PARAMETERS

Date	SULPHATE
6/1/2017	28
12/1/2017	26
18/1/2017	27
25/1/2017	23
1/2/2017	21
8/2/2017	32

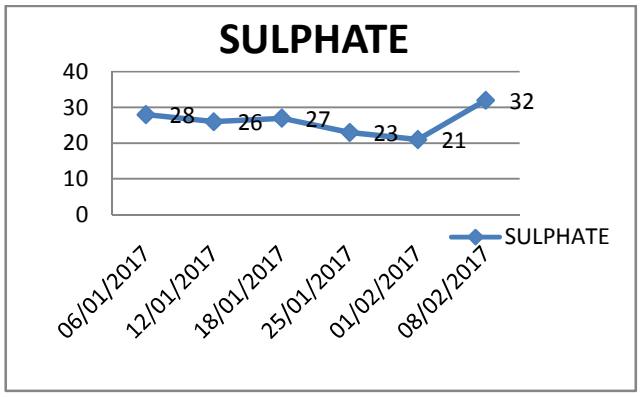

Fig No 8 Graph showing details of sulphate content

Surprising the sulphate content rose up from its initial parameter as observed. This was due to botanical factors of water hyacinth. Due to this sulphate treatment might be required prior to disposal

6) PHOSPHATE CONTENT

TABLE NO:- 6
PHOSPHATE PARAMETERS

Date	PHOSPHATE
6/1/2017	8.01
12/1/2017	5.0
18/1/2017	2.47
25/1/2017	0.15
1/2/2017	0.11
8/2/2017	0.14

Phosphate content plays important role in biochemical processes and is a key factor in the eutrophication of surface water. The decreasing rate of phosphate content is due to consumption of phosphate by the water hyacinth for its growth.

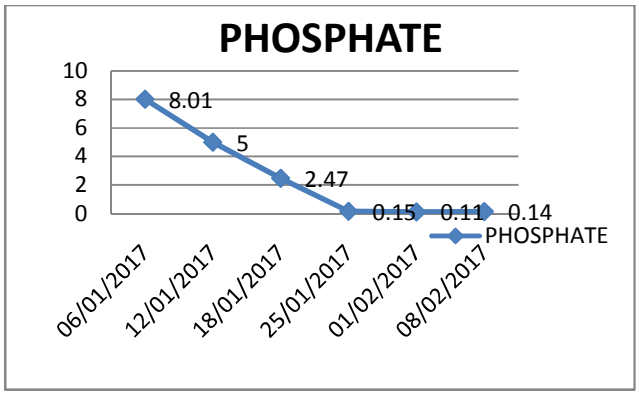

Fig No 9 Graph showing details of phophate content

7) NITRATE CONTENT

TABLE NO:- 7
NITRATE PARAMETERS

Date	NITRATE
6/1/2017	15.0
12/1/2017	2.1
18/1/2017	1.5
25/1/2017	1.2
1/2/2017	1.0
8/2/2017	1.3

Nitrate content is vastly influenced by the rising mat formation of water hyacinth. Water hyacinth uses nitrate for its growth. An inverse relationship which is statisically insignificant can be observed between nitrate content and DO of sewage.

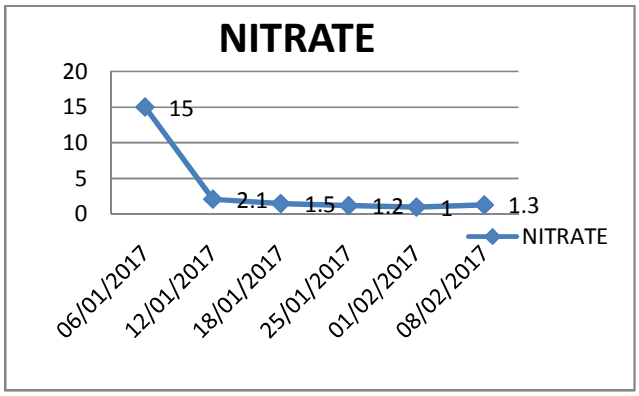

Fig No 10 Graph showing details of nitrate content

VI. CONCLUSION

Results obtained from various physio-chemical analyis shows that water hyacinth based treatment system are effective for reducing the effluent concentration of sewage. This Research shows the performance of an improved sustainable water hyacinth phytoremediation system coupled with attached microbial growth in sewage treatment. The system provides efficient oxygen transfer efficiency to sustain high levels of aerobic microflora for degradation of many pollutants, particularly organic matter. It can be implemented to reduce level of BOD upto 92% and COD upto 84%. About 90% of phosphate and nitrate content can be reduced. However due to botanical and chemical factors of water hyacinth the sulphate content increases, which might require treatment seperately.

This system can be worked out in form of constructed wetland or shallow pit for treatment of effluent matter of industrial as well as domestic sewage. It has low space requirement, low capital investment and most impotantly high degradation capacity of organic and inorganic pollutants . Wate hyacinth can be effective practice to promote low cost green technology for organic pollotant removal and impurity elimination. For using it simultaneously with other treatment process of sewage treatment plant, detailed pilot scale and field test studies will be needed.

VII. ACKNOWLEDGEMENT

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VIII. AUTHOR CONTRIBUTION

Overall implementation of research including model set-up, experiment conduting, data analysis and manuscript preparaion were done by students of Suman Ramesh Tulsiani Technical Campus, Faculty of Engineering, kamshet and were guided by professors of the said institute

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