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Effect of Covering of Macrophytes, Detention Time on Improving Water Quality

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Abstract: In this work three experimental tanks are made serially (Sequentially), primarily treated sewage is collected and poured in first tank containing aquatic macrophyte pistia, secondly the water treated in pistia is passed through duckweed tank and finally the water from duckweed tank is passed through hyacinth tank. In this experiment macrophytes are introduced to system in two methods namely partly covered and surface covered, in (partly covered) only part of the surface will be covered by macrophytes and in (surface covered) macrophytes will cover entire surface of the water. Retaining of water in tank is also adopted in two methodologies, in first method, water is allowed for one day (one day detention time) in each tank and in second method water is allowed for two days (Two day detention time) in each tank. Water quality parameters such as pH, Temperature, Turbidity, Electrical Conductivity (EC), Total Suspended Solids (TSS), Total Dissolved Solids (TDS), Biochemical Oxygen Demand (BOD), Chemical Oxygen demand (COD) and Fecal coliform (FC) are checked regularly in each tank. From the obtained results, it is observed that two day detention time with fully surface covered macrophytes is very effective, another advantage in this experiment is the sediments from one tank is not allowed to pass to other this helps to treat sewage faster than conventional methods of storing sewage in same tank.

Key words: one day detention time, two day detention time, partly covered, fully surface covered, water quality.

Introduction

India is the second most populous countries in the world, about 72.2% of the population lives in villages and the rest 27.8 % lives in towns and urban agglomerations. Generation of waste water is very high due to the huge population hence safe disposal of waste water is one of the major concerns of waste water discharge regulatory authorities[15]. Conventional methods and steps such as treatment by sewage treatment plant have been undertaken by the government to treat the sewage but it covers only 1/4 of the sewage produced, while 3/4 of untreated sewage is released into rivers which affect the water quality severely [21]. In developing countries, implementation of conventional treatment plants at all places is impractical due to limited financial resources; hence implementing economically feasible and efficient alternative technologies for waste water treatment is significant[13].

Aquatic macrophyte systems for waste water are suitable for developing countries, because they are cheaper to construct and little skill is required to operate[20]. The main objective behind the development of phytoremediation technologies is their eco friendly and cost effective nature[2]. Macrophyte treatment is easy to make and does not require complex unit and it does not inve any elaborate mechanism[11]. The macrophytes commonly found in eutrophic water bodies are free floating macrophytes, emergent macrophytes and submerged macrophytes[25]. Among these free floating aquatic macrophytes have several potential advantages like high productivity, high nutritive value, easy to stock and harvest[4]. Common free floating plants used in water treatment are water hyacinth, duckweed, water lettuce, azolla, salvinia, pennywort etc.

Several lab scale studies were conducted to improve the water quality through macrophytes. Among these water hyacinth, pennywort and duckweed species are known to be more effective in single pond waste water treatment[12,30]. Several researchers compared the effect of single species or multispecies on removal of pollutants. Pistia, Ecchornia crassipes, Azolla, Salvinia, Lemna, Paspalum repens, Lpomeoa acuatica are used in waste water treatment, in this Pistia, Ecchornia crassipes dominates other plants and suggested that the efficiency of wetland to treat effluent from different sources varies so modification is necessary to improve water quality further[3]. Pistia, Ecchornia crassipes, Pennywort, Salvinia, Lemna, Spirodela Egeria were used for nutrient removal, also during summer season water hyacinth ranked first, while winter pennywort ranked first[22]. Some researchers suggested mixed species having better purification than individual[5]. The removal efficiency of water hyacinth was higher due to high biomass production and the most favorable climatic condition[24]. It is a useful strategy to grow Echhornia crassipes and Lemna together in winter temperature[9]. Water hyacinth is more effective than polyculture treatment (water hyacinth + water lettuce + pennywort) [23].

Many researchers adopted different methodologies for improving water quality using aquatic plants. In this method, biofiltration system consists of aquatic plants Echhornia crassipes and Salvinia natans aerated through multi pore fine bubble aeration system for the treatment of municipal waste water and suggested that removal of pollutants may be enhanced further with the aeration[15]. In this work free floating plants with option of circulation improve water quality[30]. In this paper clay soil at bottom supports bacteria for improving water quality[28]. The aquatic plant showed better pollutant removal in diluted waste water than undiluted waste water[23].

In normal batch study, the sewage is kept in same tank till the completion experimental period; which is similar to stagnant pond system as flow is not taking place but in case of natural wetland flow takes place. In this study flow happens from one tank to another which simulates natural floating wetland however in natural wetland, sediments are deposited at every point and deposited sediments are not going to next point and in this study, the deposited sediments from one tank are not allowed to pass through the next tank, only the treated water is allowed.

Methodology

Primary treated sewage is collected from sewage treatment plant, Kalasalingam University, Krishanakovil located at Virudhunagar district, Tamilnadu. Three experimental tanks were arranged serially. Outlet is provided 2 cm higher than the bottom of each experimental tank. Table.1 shows the experimental set up of treatment units. Table.2 shows characteristics of primary treated sewage and Fig.1 shows the arrangement of experimental tank.

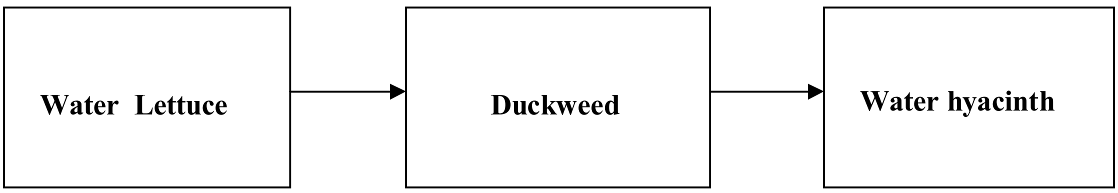


Fig1: Sequence of free floating macrophytes

Aquatic plants Eichhornia crassipes (Water hyacinth), Pistia stratiotes (Water Lettuce), Spirodella Polyriza (Ducweed) were collected from fresh pond located at Virudhunagar district. Plants were thoroughly cleaned by distilled water. In this study, macrophytes were introduced by two different methods. In method 1, entire surface of water body was covered by aquatic plants (surface covered). In method 2, part of the surface of water was covered by aquatic plants (partly covered). In method 3, no aquatic plants were introduced and kept as control.

Table 1: Experimental setup of treatment units.

Method	Method of spreading of plant	Detention Time	Total Duration	Aquatic Plants
Method 1	Full surface covered	One day detention time.	3	Pistia Duckweed Water hyacinth
		Two day detention time.	6	
Method 2	Partly surface covered	One day detention time.	3	Pistia Duckweed Water hyacinth
		Two day detention time.	6	
Method 3	No plants	One day detention time.	3	No plants
		Two day detention time.	6	

Table 2: Characteristics of primary treated sewage

S.No	Parameters	Values
1	pH	7.88
2	Temperature (◦C)	28
3	Turbidity (NTU)	80.2
4	Electrical Conductivity (ms/cm)	2.6
5	BOD (mg/l)	150
6	COD (mg/l)	496
7	TS (mg/l)	2724
8	TSS (mg/l)	1630
9	TDS (mg/l)	1094
10	Fecal Coliform (colonies)	40000

Effect of One Day Detention Time on Water Quality

30 litres of primary treated sewage is poured into first tank called pistia tank, where pistia are introduced in part of the surface water is allowed for 1 day and water quality was checked in pistia tank. The water from pisitia tank is now passed to the next tank called duckweed tank, duckweed plants were introduced in part of the surface, the water is allowed for one day and water quality is checked. The water from duckweed tank is then passed to water hyacinth tank where water hyacinth is spread on part of the surface and allowed for one day. Sample water is collected from water hyacinth tank for testing. The same procedure is repeated for fully surface covered with one day detention time.

Effect of Two Day Detention Time on Water Quality

In one day detention time, water is allowed for one day in each tank but in two day detention, water is allowed for two days in each tank ie. Water is transported from one tank to other after two days detention in each tank.

Water Quality Testing

Various water quality parameters are analyzed using standard methods as follows: pH is measured by pH electrode method, Temperature is measured by Thermometer. TDS and TSS were analyzed by gravimetric method; the standard 5day BOD test at 20° was used to assess reduction in Biochemical Oxygen Demand. COD was measured by digestion method. Turbidity was measured by digital turbidity meter and conductivity was measured by digital conductivity meter method. Table.3 shows the percentage removal of pollutants in control tank. Table 4 and 5 shows percentage of pollutant removal performance of each plant in partly covered and fully covered tank.

Table 3: Removal efficiency of pollutants in control tank

Parameters	**Percentage of pollutant removal in each tank (%)**					
	One day detention time			**Two day detention time**		
	First tank (1st day)	**Second tank (2nd day)**	**third tank (3rd day)**	**First tank (2nd day)**	**Second tank (4th day)**	**Third tank (6th day)**
Temperature (◦C)	35	38	37	34	27	28
pH*	8.19	8.36	8.44	8.22	8.62	8.94
Turbidity	37	-22	13	21	-17	25
EC	19	0	0	8	32	-13
BOD	2	3	7	9	-10	-10
COD	12	13	10	11	19	19
TSS	29	-44	-26	47	6	7
TDS	51	25	-30	23	17	43

Table 4: Removal efficiency of pollutants in partly surface covered tank

Parameters	**Percentage of pollutant removal in each tank (%)**					
	One day detention time			**Two day detention time**		
	Pistia tank (1st day)	**Duckweed tank (2nd day)**	**Hyacinth tank (3rd day)**	**Pistia tank (2nd day)**	**Duckweed tank (4th day)**	**Hyacinth tank (6th day)**
Temperature(◦C)	35	34	32	32	31	36
pH*	8.07	8.53	8.86	7.78	8.26	9.4
Turbidity	39	32	6	67	-23	-17
EC	12	0	5	12	22	6
BOD	2	32	7	14	-4	-13
COD	6	9	7	13	22	-4
TSS	17	4	9	46	-72	-14
TDS	22	14	14	23	-14	-55

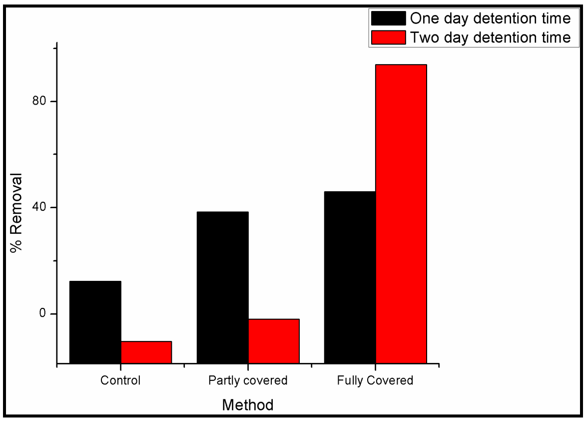
Table 5: Removal efficiency of pollutants in fully surface covered tank

Parameters	**Percentage of pollutant removal in each tank (%)**					
	One day detention time			**Two day detention time**		
	Pistia tank (1 st day)	**Duckweed tank (2nd day)**	**Hyacinth tank (3rd day)**	**Pistia tank (2nd day)**	**Duckweed tank (4th day)**	**Hyacinth tank (6th day)**
Temperature(◦C)	31	37	30	37	30	31
pH*	8.52	8.78	9.07	8.62	8.94	9.37
Turbidity	38	-5	23	15	20	16
EC	8	4	9	32	12	13
BOD	9	30	16	40	50	80
COD	8	9	32	37	50	76
TSS	35	-25	24	12	24	55
TDS	-17	13	33	73	55	55

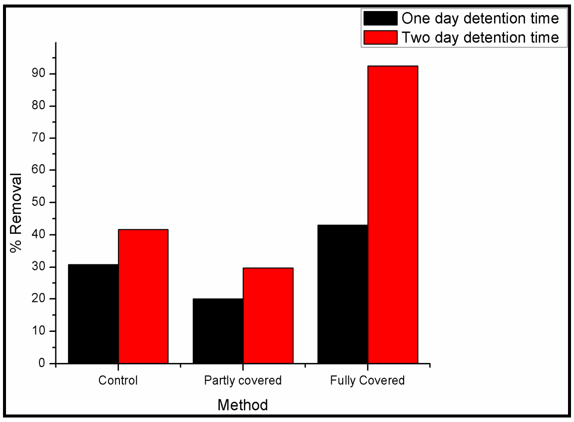
Table 6: Overall removal efficiency of experimental setup

Parameters	Percentage of pollutant removal in each tank (%)					
	One day detention time			Two day detention time		
	Control 3rd day	Partly covered 3rd day	Fully covered 3rd day	Control 6th day	Partly covered 6th day	Fully covered 6th day
Turbidity	33	62	67	61	52	86
EC	19	15	19	35	35	29
BOD	12	38	47	-11	-2	94
COD	31	20	43	42	30	92
TSS	-29	28	39	53	-4	71
TDS	53	43	32	64	-37	95
FC	29	40	81	48	51	91

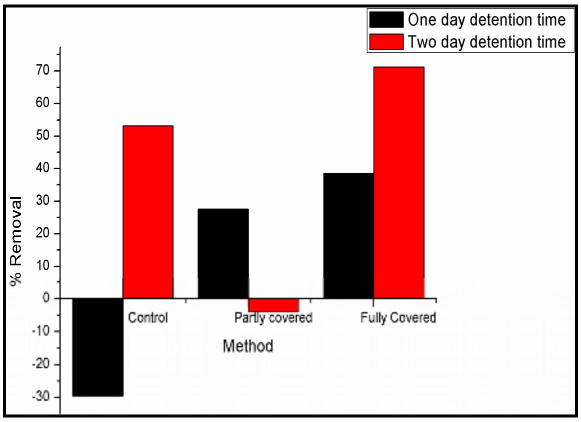
pH and Temperature values are not in percentage



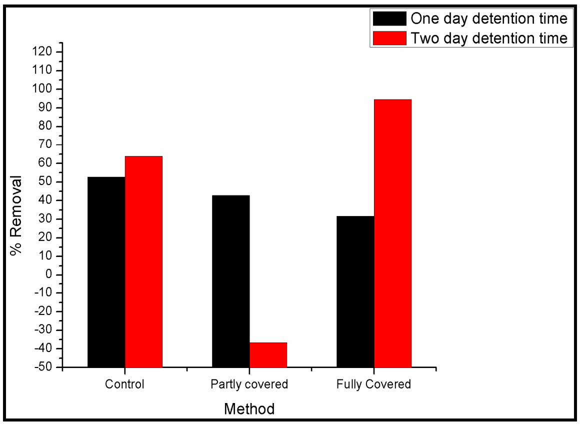
(a) Removal of BOD



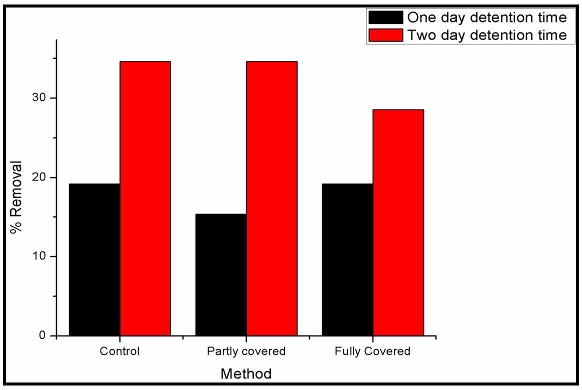
(b) Removal of COD

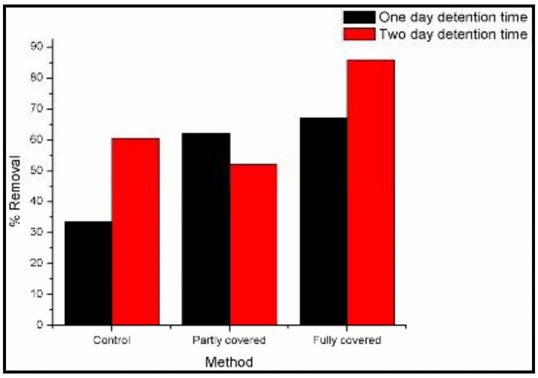


(c)Removal of TSS



(d) Removal of TDS





(a) Removal of EC **(f) Removal of Turbidity**

Fig 2: Performance of control, partly surface covered, fully surface covered on water quality.

Table 7 shows comparison of normal batch scale study with sequential batch method. The detention time of two methods is 6 days. From table 7, it can be clearly seen the removal is fast in sequential method.

Table 7: Comparative study of pollutant removal efficiency of experimental setup

S.No	Parameters	Total removal efficiency (%)	
		General Batch method (6^{th} day)	Sequential Batch method (6^{th} day)
1	Turbidity	67	86
2	EC	15	29
3	BOD	74	94
4	COD	31	93
5	TSS	70	71
6	TDS	67	95
7	FC	72	91

Results and Discussions

Throughout the experiment, pH value ranges from 7.88 - 9.40 and it is observed that the pH value increases in all the treatment setup. The presence of other aquatic photosynthetic autotrophs can deplete dissolved CO_2 in water during the period of high photosynthetic activity. This increases dissolved oxygen in the waste water thus resulting in increased water pH[22]. Temperature of treatment unit varies from 28°C to 38°C. Temperature of sewage is increased due to experimental tanks are present in direct sunlight.

From Table 3, 4 and 5 the individual performance of plants can be seen. It should be noted that the pistia receives primary treated sewage directly but in case of duckweed and hyacinth is received after treatment of sewage by pistia, this is also one of the reason that pistia could not take more pollutants due to high sewage concentration. Table.6 shows overall pollutant removal performance of each experimental setup. In method 1 (fully covered), removal of pollutants are higher than method 2 (partly covered). Specifically two day detention time with fully covered shows better results than one day detention time.

In control tank, minimal amount of BOD and COD is removed. Algae's appears during experimental period because of availability of more free space on the surface of water and sunlight directly reaches the water. From second day onwards, negative removal takes place in control tank. In method 2 with two day detention time method showed negative removal and one day detention method showed better removal. Specifically in duckweed treatment unit more algae was appeared in partly covered two day detention time. Hence, Turbidity and TSS are increased abruptly. In method1 with two day detention time, BOD removal is up to 94% , COD removal is around 92%, Dissolved solids are removed around 95%, Fecal coliform removal extends up to 91% and Suspended solids removal extends up to 71%. In fully covered method macrophytes with water is allowed for two days in each tank (three tanks) resulting in more removal of pollutants.

Table.7 shows the comparison of sequential batch method with regular lab scale method. From the results, sequential method is found to be more effective than normal batch scale study. In sequential batch method, water is transferred from pistia tank to duckweed tank, leaving the sediments. The water enters into duckweed tank little bit free of sediments. Similarly the water is transferred from duckweed tank to hyacinth tank without sediment. Therefore at each and every tank, sediments are deposited at bottom and the outlet water is free of sediments. In General batch studies plants are not removed until experimental work was over, so plant adsorbs pollutant and return back after some day (Ahmet sasmaz and Erdal obek, 2009) which causes fluctuation of system results but in this study, everyday sewage is introduced into new tank containing fresh plants, hence rate of removal is fast and return back of pollutants is absent. In general batch studies, every day the water is stored in the same tank with bottom sediments. While doing long term experimental studies, sediments disturb the experimental results, whereas in this study each and every day the water is introduced into fresh tank.

Conclusion

In this work effect of sequence of experimental tanks with free floating macrophytes on improving water quality was studied and the study results proves that this method removes BOD, COD, TSS, TDS, Turbidity, Electrical conductivity and Fecal coliform more effectively than normal lab scale batch system. In sequential batch study BOD, COD, TSS, TDS, FC removal is 94 %, 92%, 71%, 95% and 91% respectively and in sequential batch method, sediments are deposited at bottom and only supernatant is going to next tank. Every time, sediments are removed vide mechanical sludge removal unit provided in sewage treatment plant.

Secondly, partly spread of macrophytes and fully spread of macrophytes was compared for improving water quality. Similarly effect of one day as well as two day detention time in each tank on water quality was studied. From the results it is observed that, two day detention time with fully surface covered gives better results for removing pollutants.

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