Potential of Phytoremediation for dairy wastewater treatment

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Abstract:

The dairy industry is generally considered to be the largest source of food processing waste water in many countries. Huge amount of water is used during processing of milk and this result in generation of high volume of effluent containing dissolved sugars, proteins, fats etc. which are mainly organic in nature. Thus dairy effluent is characterized by high concentration of organic matter and high BOD. The effluent with such characteristics cannot be used for land irrigation purpose and also cannot be discharged into public sewer or surface water. Thus proper treatment of dairy wastewater is necessary before disposal. The dairy wastewater is readily biodegradable and can be treated easily with conventional treatment techniques like activated sludge process, trickling filter, waste stabilization pond, aerated lagoon or anaerobic digestion etc. But conventional treatment has some limitations like - High cost of operation, o & m,Requirement of technically skilled labour. And Disposal problem of biological sludge (i.e. hazardous waste) etc. Hence there is need for developing low cost technique for dairy wastewater treatment.

Phyto remediation is one of such technique which is defined as use of plants as well as micro-organisms to remove or render harmless pollutants from contaminated water. In this study an attempt will be made to assess the efficiency as well as suitability of aquatic plants like water hyacinth, duckweed to treat dairy waste water.Aquatic plants have drawn attention because of rapid growth, High biomass production and capability to remove varieties of pollutants from domestic and industrial effluents. They have the ability to remove even nutrients and other chemical elements from sewage and industrial effluents.

Keywords: Phytoremediation, water hyacinth , COD, USAB

Introduction:

Gokul dairy projects:Gokul milk project was established in November 1985. This project was financed & constructed by national dairy development board. Kolhapur Zilla Sahakari Dudh Utpadak Sangh Ltd., Kolhapur which is the parents organization was established on 16th March 1963 under co-operative societies act.

Actually Gokul Milk project was started on 18th November 1985. Now Gokul Milk project is collection 7,00,000 lit. of milk per day from 3000 milk society.It is located on industrial area of Gokul Shirgaon, which is at south of Kolhapur. The address of milk dairy is Kolhapur Zillah Sahakari Dhudh Utpadak Sangh Ltd., Dist. Kolhapur 416234

D)	Butter Manufacturing	
	Top Churn	8 MT/Day
E)	Ghee Manufacturing	6 MT/Day
F)	Packaging Lines	
	Milk Packaging	1 Lakh Litre/day
	Powder Packing-Nichrome (Pouch)	10 MT/day
	Ghee Packaging (Pouch)	4.5 MT/Day
	Table Butter Packaging	
	In 500 gm	3 MT/day

Table 1 Gokul's present set up:

Manufacturing process at Gokul dairy:

Manufacturing process of dairy was study in detail which is presented as follows

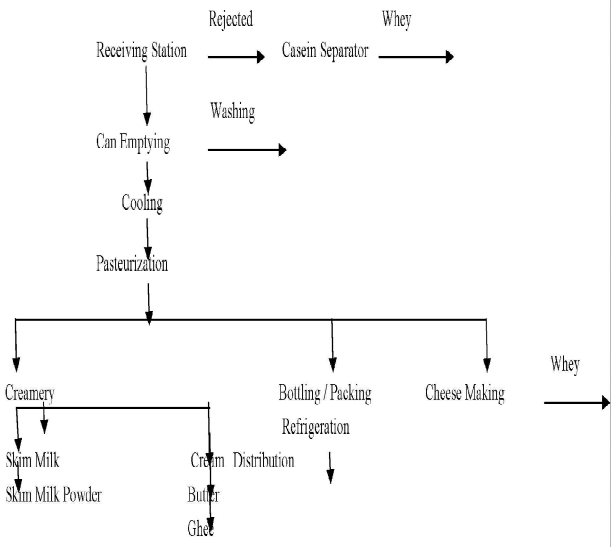


Fig. 1 Flow Diagram of Manufacturing Process:

Water Requirement: Details of water requirement for dairy is as follows-

Source of Water Supply –M.I.D.C. Water supply scheme.

Water Requirement -

- Water Reservoirs –6 lakh liters. 2 nos.
- Pumped to Overhead Tank of 1 lakh liters. & distributed to entire Dairy Premises by gravity.Daily water consumption: 1120 m3 (collected from dairy)
- Water Requirement / Lit. Of Milk Handled: 1.6lit.
- Cost of Water : Rs.13.50/ m3

Wastewater generation: As per the Indian Standard IS - 8682, 1977, 6 to 10 liters of wastewater is generated per liter of milk processed. At Gokul dairy, the processing capacity is 7lac liters of milk per day with 14000 m3 of wastewater generation per day. This indicates that about 20ltr of wastewater is produced per liter of milk processed. This is double of the standards volume and indicates lot of waste of water.

Wastewater treatment facility at Gokul Dairy: The treatment scheme is designed on following basis-

a) Effluent quantity: The quantity of combined effluent discharged from the dairy is 1400 m^3/ day. The peak flow is of 150m^3/hr.

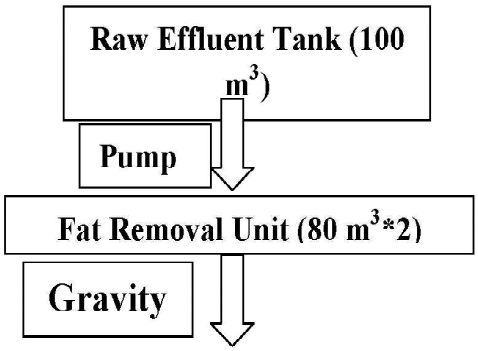
b) Characteristics of effluent: The characteristics of raw effluent & treated effluent are presented in the tables given below-

Sr. no.	Parameters	Concentration
1.	pH	6.5 to 7.5
2.	Total suspended solids	650 mg/L
3.	BOD	1200 mg/L
4.	COD	2000 mg/L
5.	Oil & Grease	320 mg/L

Table no. 2 Expected characteristics of untreated effluent

Sr. no.	Parameters	Concentration
1.	pH	6.5 to 7.5
2.	Total dissolved solids	<2100 mg/L
3.	Total suspended solids	<100 mg/L
4.	BOD	<30 mg/L
5.	COD	<250 mg/L
6.	Oil &Grease	<10 mg/L

Table no.3 Desired treated effluent characteristics



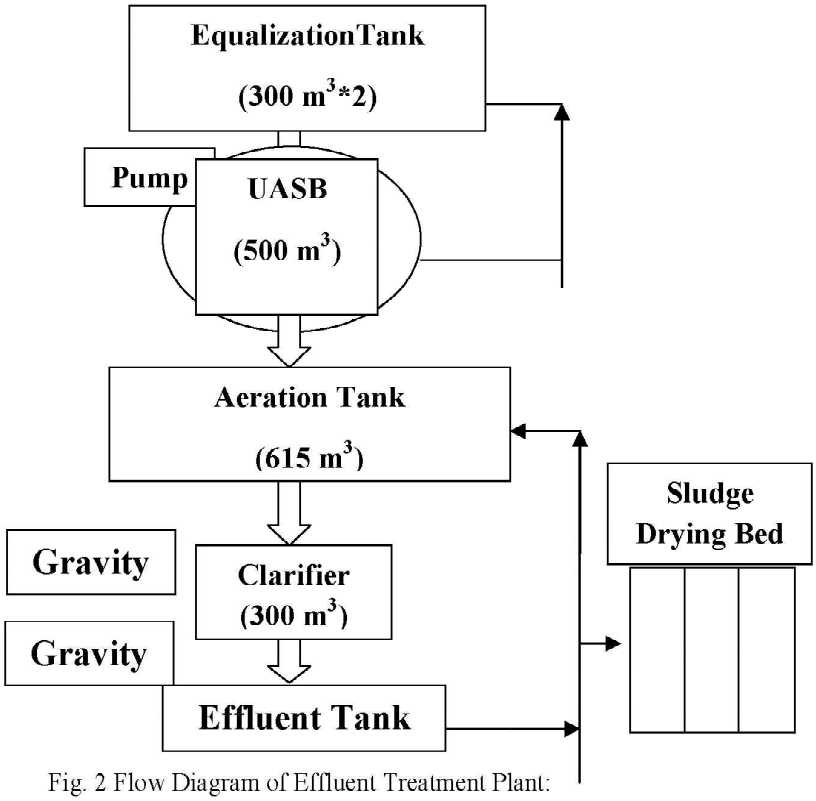


Fig. 2 Flow Diagram of Effluent Treatment Plant:

METHODOLOGY

The objective of the present study is to find potential of aquatic plants as an alternative and cost effective treatment. It is also planned to check the suitability of dairy waste water for floriculture.

Experiment 1:To find out characteristics of effluent of dairy, a sample was collected from inlet point of ETP of Gokul Dairy and parameters like pH, alkalinity, COD, DO were analyzed in laboratory.

Experiment 2:For the second set of experiment, sample was collected from the equalization tank of ETP. The sample was tested for initial concentration of pH, alkalinity, COD, total solids, dissolved solids. Since COD of sample was found to be 2000mg/lit, which is high. (Munavalli and Saler[1]). It is found that aquatic plants cannot tolerate organic loading in terms of COD than 1000mg/lit, hence the sample was diluted to50% with tap water.

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Fig. (a)Reactor with Water hyacinth

Fig. (b)Reactor with Salvinia molesta

Experiment 3: Waste water from outlet of Up flow Anaerobic Sludge Blanket (UASB) was taken and analyzed for COD which was found to be in the range of 800-1000mg/l.In this experimental setup two tubs were taken. Both the tubs were filled with prepared sample and plants of Water hyacinth were kept in one tub and other one was kept as blank. The samples were monitored for COD, pH, Alkalinity and DO on alternate days.

Fig. (c)Reactor with Blank

Fig. (d)Reactor with water hyacinth

Experiment 4: Based on results of previous experiments, it was decided to carry out further experiments by aerating the partially treated dairy wastewater [at the outlet of UASB]. For this experiment, wastewater sample was collected and analyzed for DO. The sample then was aerated till DO raised to 4 mg/l. Now this sample was filled in a reactor, all the parameters were analyzed. Water hyacinth plants were kept in prepared sample. Subsequently on alternate days sample from reactor was taken, analyzed. This was continued till COD concentration was below 250 mg/l.

Fig. (e) Reactor with Water hyacinth

Experiment 5:After getting COD below 200 mg/l, the sample was used for irrigation purpose. Two varieties of marigold flower species are planted in bucket and pour treated wastewater. In this set up, two buckets were taken and tap was fitted at a distance of about 10cm from the bottom of the bucket. The lower part of bucket was filled with gravel of size ranging between 2.5 cm-3 cm up to height of 15cm from bottom of bucket. Another layer of sand was filled up to height of 15cm and soil was filled over sand layer up to height of 20cm. To prevent leakage from outlet tap it was sealed with M-seal.

Fig. (f) Marigolds plants

Experiment 6:In this set up, two bucket were taken and tap was fitted at a distance of about 10cm from the bottom of the bucket. The lower part of bucket was filled with gravel of size ranging between 2.5 cm-3 cm up to height of 15cm from bottom of bucket. Another layer of sand was filled up to height of 15cm and soil was filled over sand layer up to height of 20cm. To prevent leakage from outlet tap it was sealed with M-seal. Gravel was used for proper drainage. Further varieties of Marie gold plants were planted and irrigated with treated waste water. This was done for the confirmation of the previous experiment.

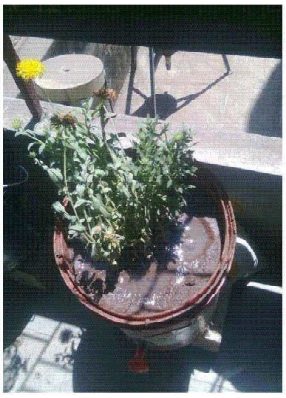


Fig. (g)Two varieties of Marigold plants

Experiment No.7: In this experiment sample of percolated waste water from the reactor was collected through the tap fitted at the bottom of the reactor. This sample was analyzed for COD, pH and alkalinity.

Results and discussion:

Batch 1: Inlet sampling: Analysis results of sample of untreated dairy wastewater at ETP inlet are given below

Parameter	PH	Alkalinity(mg/l)	COD (mg/l)	BOD(mg/l)
Measuredvalue	8.8	790	2100	1200

Table 3.1: Analysis results of sample of untreated dairy wastewater

Batch 2: (equalization tank sample): Analysis result of dairy waste water at equalization tank outlet are given below as per table 3.2

Time	COD (mg/L)			pH			Alkalinity (mg/L)			DO (mg/L)		
	S1	S2	S3	S1	S2	S3	S1	S2	S3	S1	S2	S3
1st Day	1352	1344	1328	7.77	7.26	8.77	580	560	590	0.94	1.67	0.65
3rd Day	720	456	824	7.33	7.26	8.3	620	610	630	0.4	.59	0.2
5th Day	640	328	715	7.26	7.40	7.56	650	690	610	0.254	1.129	0
7th Day	280	240	608	7.79	7.63	8.31	700	650	640	0.265	1.049	0

Table no- 3.2: Analysis results of equalization sample with 50% dilution

S1-water hyacinth, S2-*Salvinia molesta*, S3-blank

Fig no.3.2.2 Variation in COD concentration

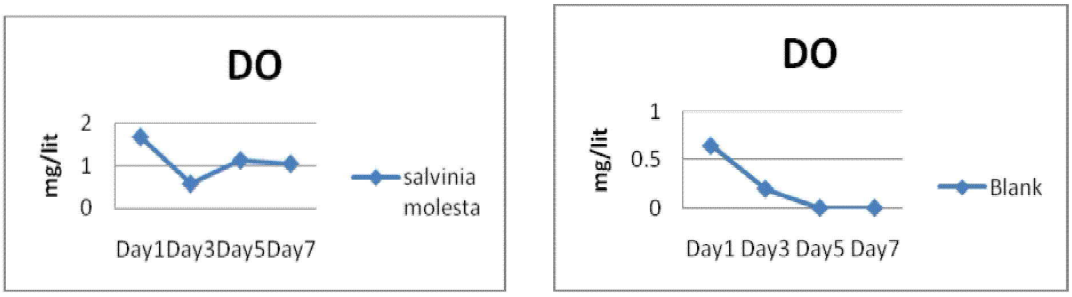


Fig no.3.2.3 Variation in DO concentration

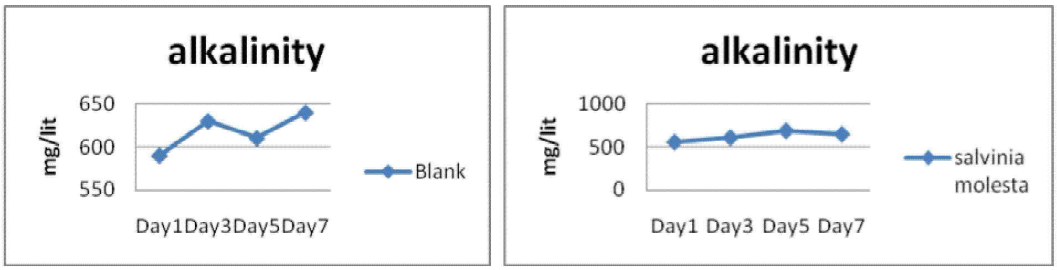


Fig .no 3.2.4 Variation in alkalinity

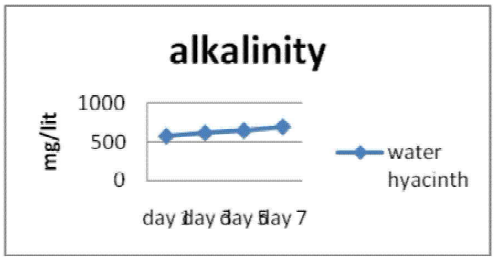


Fig .no 3.2.4Variation in alkalinity for water hyacinth

1.3 Batch no 3- UASB outlets (without aeration)

Analysis results of dairy waste water at UASB outlet are given below as per table 3.3.

Time	COD (mg/L)		Percent removal (%)		pH		DO (mg/L)		alkalinity (mg/L)	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
1th day	784	784	0	0	9.21	9.21	0	0	850	850
3nd day	428	486	45.4	37.91	7.77	7.81	1.5	1.91	410	420

Table no- 3.3: Analysis results of UASB outlet sample without aeration

S1-water hyacinth S2-blank

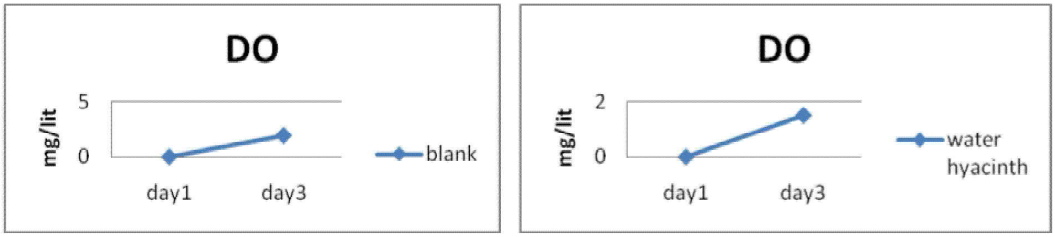


Fig no3.3.2 Variation in DO concentration

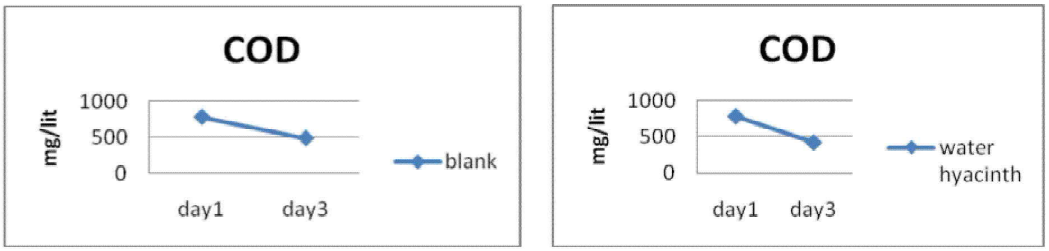


Fig no3.3.3 Variation in COD concentration

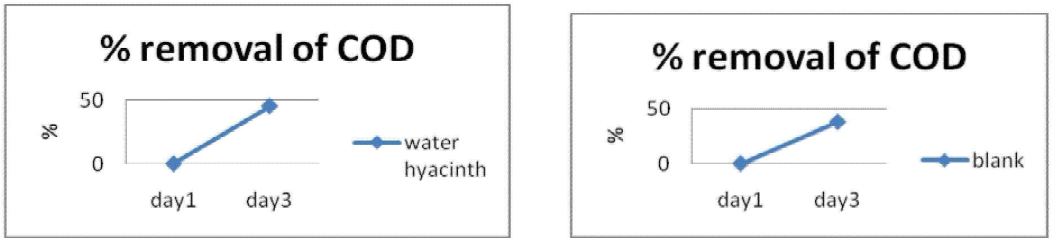


Fig. no.3.3.4 Percentage removal of COD

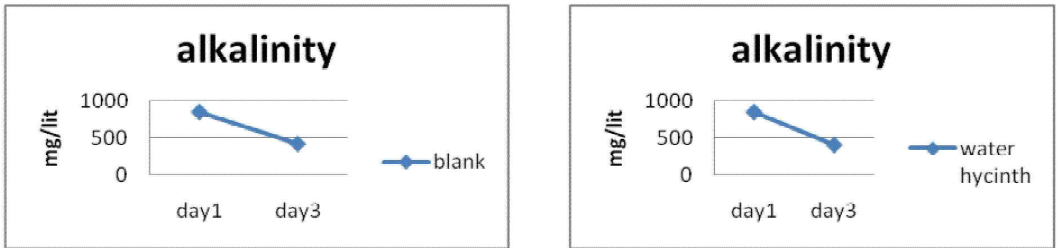


Fig no3.3.5 Variation in alkalinity

3.4 Batch no 4 - UASB outlet (with aeration) : Analysis results of dairy waste water at UASB outlet are given below as per table 3.4.

parameters	pH	COD	Alkalinity	DO
Day1	7.9	648	720	3
Day3	7.64	360	670	3.7
Day6	7.4	200	630	4.1

Table no- 3.4: Analysis results of UASB outlet sample with aeration

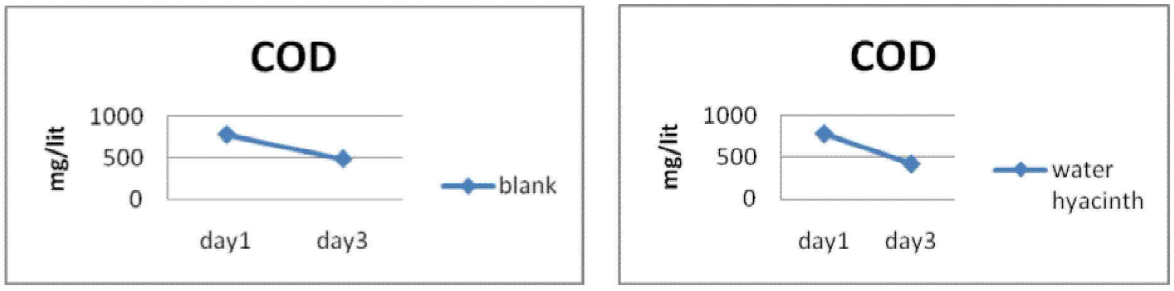


Fig no3.3.3 Variation in COD concentration

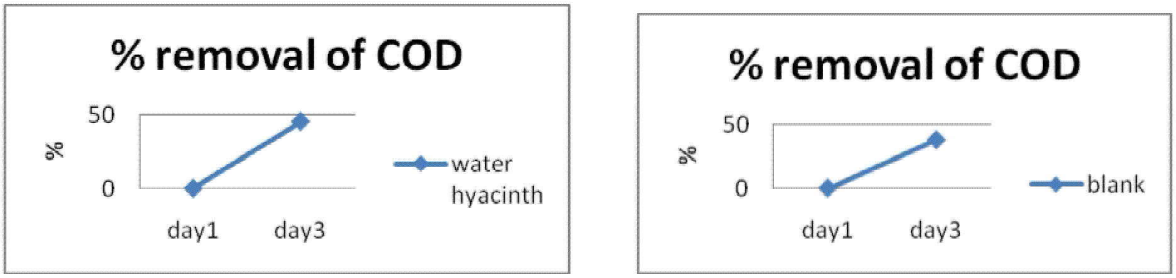
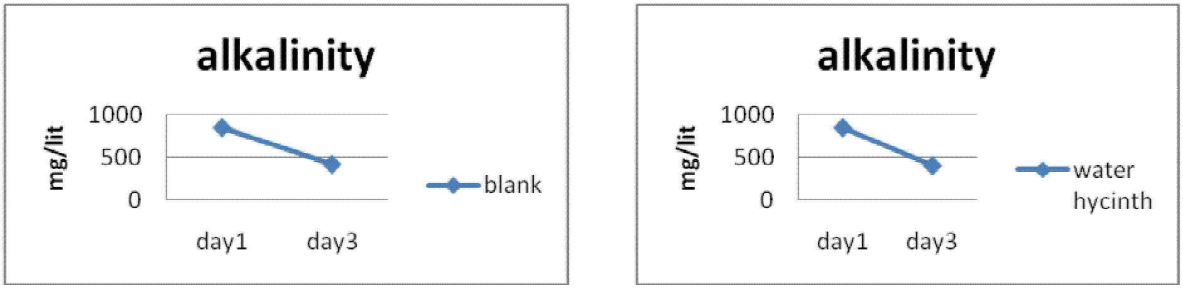


Fig. no.3.3.4 Percentage removal of COD



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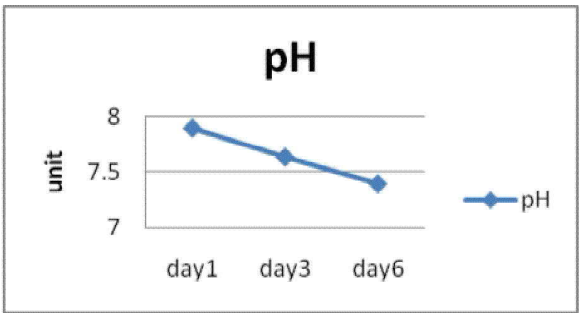


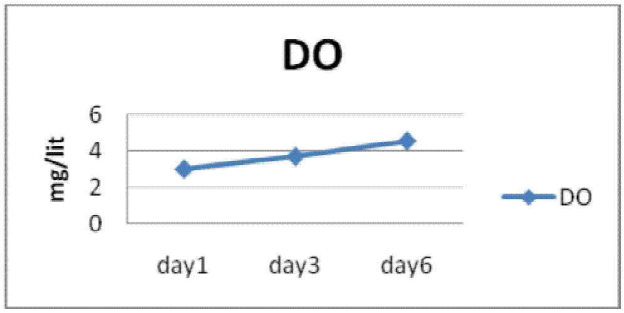
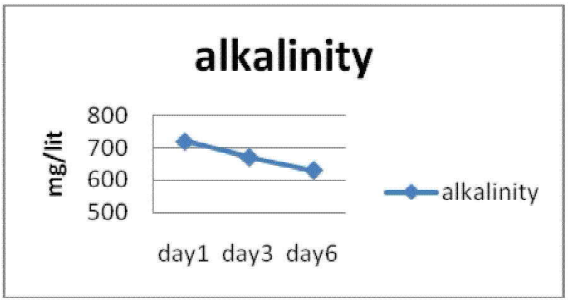


Fig no 3.4.1Variation in pH and DO value for water hyacinth



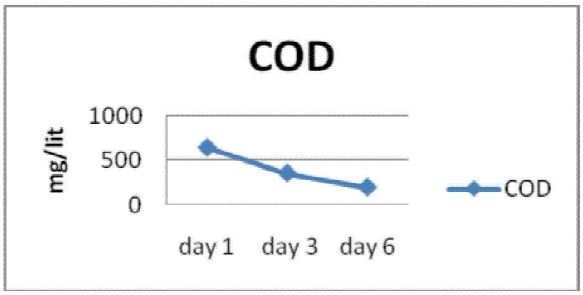


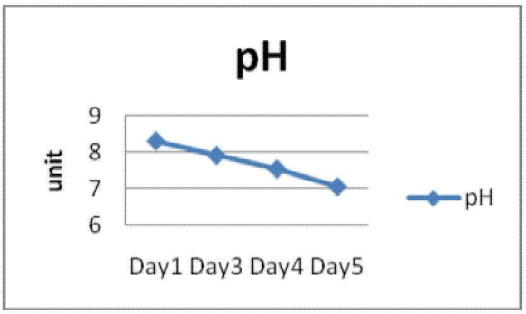
Fig no 3.4.2Variation in Alkalinity and COD for water hyacinth

3.5 Batch no 5 :(digester outlet with aeration)

Analysis results of dairy waste water at UASB outlet are given below as per table 3.5.

Table no- 3.5: Analysis results of UASB outlet sample without aeration

parameters	COD(mg/lit)	DO(mg/lit)	Alkalinity(mg/lit)	pH
Day1	810	0	600	8.3
Day3	412	2.006	730	7.9
Day4	260	1.64	850	7.53
Day5	160	2.05	480	7.04



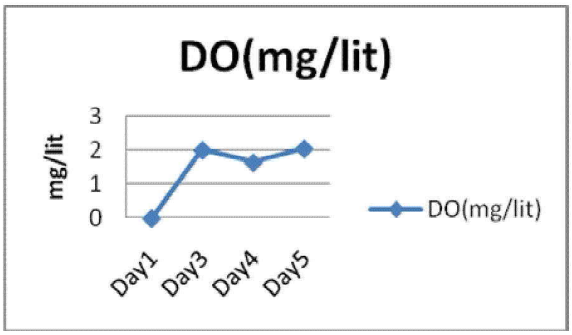


Fig no 3.5.1 Variation in pH and DO value for water hyacinth

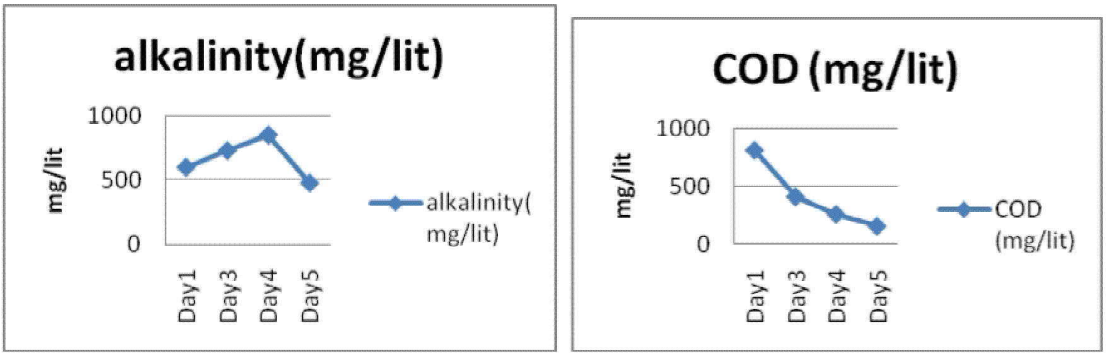


Fig no 3.5.3 Variation in alkalinity and COD value for water hyacinth

3.6 Batch No.6 (Reactor outlet)

Analysis results of sample of Reactor outlet is given below

Sr.No	Parameters	Measured value
1	COD(mg/lit)	123
2	Alkalinity(mg/lit)	456
3	pH	7.54

Conclusion:

The present study was aimed at evaluating the potential of aquatic plants for treatment of dairy wastewater and also potential use of treated waste water for irrigation purpose. It was also planned to assess the suitability of such treated waste water for floriculture. In batch experiments, the untreated dairy wastewater samples were kept in a module with water hyacinth, salvinia molesta, duck weed plants and blank. The samples were observed for temporal changes in COD, pH, DO, and Alkalinity.

As the water hyacinth plants were found to be the most suitable for growth in dairy wastewater, the potential of water hyacinth plants for its application as alternate to secondary (biological) treatment system was further evaluated. Since it was observed that water hyacinth system cannot tolerate high initial COD concentration (above 1000mg/l) the further experiments were carried out to evaluate the potential of these plants for treatment of partially treated dairy wastewater. For the present study, the partial treatment given was UASBBased on the results and discussions, following observation and conclusions can be drawn.

a) Water hyacinth and Salvinia molesta plants play significant role in COD removal from dairy wastewater compared to duck weed plants and blank (without plants).

b) The detention time required for initial COD concentration of about 1000mg/l to be brought to below 200 mg/l was above 8 days which is very high. When the waste water volume is high as 1400 m^3/day like at Gokul dairy, to provide such high hydraulic retention time (HRT) requires huge land and hence it is uneconomical.

c) The water hyacinth is the most suitable plants as it can grow in dairy wastewater with high initial COD concentration like 1000-1200 mg/l When the same organic land was applied to water hyacinth system after raising the initial DO from 0 to 4 mg/l the plant grew very well with significant reduction in term of COD.

d) The hydraulic retention time(HRT) for water hyacinth based treatment system having initial COD 810 mg/l was found to be 5 days to bring COD level below 200 mg/l which requirement for its utilization for irrigation.

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