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PHYTOREMEDIATION EFFECT IN DAIRY WASTE WATER AND DOMESTIC WASTE WATER USING CONSTRUCTED WETLANDS OF AZOLLA PINNATA

[1] Neethu .V .C, [2] Prof. M. A. Chinnamma
[1, 2] Department of Civil Engineering, KTU University, Malabar College of Engineering and Technology,
[1, 2] Thrissur, Kerala, India.

ABSTRACT: Water pollution is one of the major environmental issues in the present scenario. Increased population and industrialization fasten the water pollution rate. Every day, dairy industries produces large amount of waste water during processing. Increase in population leads to high domestic water consumption and domestic waste water production. Domestic waste water also plays an important role in polluting water resources. In this study an attempt is made to assess effectiveness of phytoremediation technique using azolla pinnata plant over dairy waste water and domestic waste water by constructed wetland units. Parameters like pH, Turbidity, Total Dissolved Solids (TDS), Total Suspended solids (TSS), Chloride, Sulphate, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Dissolved Oxygen (DO), Ammoniacal Nitrogen, Total Nitrogen (TN), Total Phosphorous (TP), were analyzed for the influents and effluents. Constructed wetlands over dairy waste water and dairy waste water observed with a high removal efficiencies in all tested parameters except pH and DO. Comparative study showed that removal efficiency of parameters like Turbidity (99.42%), TDS (91.30%), BOD (98.37%) and COD (97.53%) were slightly greater for dairy waste water wetland unit. Removal efficiency of parameters like Chloride (88.53%), Sulphate (92.87%), TN (80.56%), TP (94.93%) and Ammoniacal nitrogen (91.12%) were greater for domestic waste water. TSS removal efficiency is 100% for both systems. After 28days of detention period both constructed wetland units produced, good quality effluents that can be reused and recycled for non-potable purposes. Remarkable yield of azolla pinnata is an added advantage of this system.

Keywords: **[Phytoremediation, Constructed wet lands, Dairy waste water, Domestic waste water, Azolla pinnata, Detention time]**

1. INTRODUCTION

Water pollution is one of the biggest issues India facing right now. Almost 80% of the water bodies in India are highly polluted. Industrialization and over population are main causes of water pollution. Dairy industries are well established in India. Dairy industries produce largest amount of waste water day by day. Nowadays Domestic waste water is also Play a vital role in polluting water resources. Modern community life styles, irrigated gardens and household appliances are responsible for the increase in domestic water consumption. Population increase lead to a rapid increase in agricultural water consumption. There are several physical or chemical methods are adopted for treatment of these dairy waste water and domestic waste water. Most of them are very costly due to high initial investment, operational and maintenance cost. They demands skilled labours and produce highly concentrated toxic wastes. Hence we need an effective eco-friendly, low cost natural way to purify waste water. Phytoremediation is one among such methods [6].

Wetlands are usually known as our natural boons. Wetlands have natural purification capacity to control pollution of water. Wetland atmosphere can be artificially recreated by constructed wetlands units. Phytoremediation using constructed wetland is one of the eco-friendly waste water purification methods. Constructed wetlands are not only eco-friendly but also efficient in treating waste water with low energy consumption. More over it is an economical method too.

Aquatic plants are widely used for constructing wetland units. They are able to remove various pollutants, toxic contaminates, metals, and nutrients from various waste waters having whether industrial or domestic origin. High biomass production, high growth and reproduction rate are also the reason for this acceptance [1].

In this study an attempt is be made to assess effectiveness of aquatic fern azolla pinnata for wetland construction over dairy waste water and domestic waste water using phytoremediation technique. The purpose of this project is to assess phytoremediation as an emerging technology and to interpret its potential in the removing pollutants from dairy waste water and domestic waste water. This work is intended to obtain quality water that can be reuse and recycle along with a yield of azolla pinnata.

2. MATERIALS AND METHODS

A. Back ground

The experiments were carried out between the months of January to February in 2017 in Vallachira village of Thrissur district in Kerala. Vallachira is located between latitude 10°26’0‟N and longitude 76°14’0‟E.

B. Material Used

The experiment was carried out with aquatic fern azolla pinnata. Azolla pinnata species purchased from Agricultural University- Mannuthy, Thrissur and transplanted on the same day in a bucket filled with water and maintained for a period of one day to remove all previous impurities from the roots. The plants were washed with distilled water before phytoremediation.

C. Sample Collection

Dairy waste water samples were collected from Milma dairy plant, Ramavarmapuram, Thrissur. Domestic waste water samples were collected from 10 houses in Vallachira village. This water contained cleaning water, washing water and kitchen waste water etc. Sterilized containers were used for sample collection. Dairy waste water raw sample was diluted by 50% tap water before treatment due to COD (chemical oxygen demand) value greater than 1000mg/l.

D. Experimental Setup

The experimental setup mainly consisted of 3 main parts-inlet zone, constructed wet land unit and outlet zone. Two rectangular shaped constructed wetland (CW) basins with dimensions 70 cm x 30 cm x30 cm were designed and developed. The volume of the basin was 0.063m^3. The CW units made from glass were set up in a controlled atmospheric condition in a poly house with other accessories such as two containers that served as the supply for the influents and effluents collection through outlet pipes.

The inlet zones having feed buckets were used to hold the wastewater samples. The capacity of each vertical bucket was 25 litters. The feed water flow rate control is ensured by half inch taps connected in the bottom of feed buckets followed by 1m length pipe without any leaks and losses. Everyday feed provided according to the level difference from the marked initial water level in each basin to that of present water level. The influent entering the CW is controlled manually by adjusting the valve attached to the inlet pipe. The flow between inlet and outlet was by gravity.

Constructed wetland unit basin or channel with beds filled with a suitable depth of porous media/substrate media. 1 to 2% slope is provided at the bottom of the tank with slurry of cement and sand (ratio1:3). Before filling gravel particles a small screen net was provided near effluent outlet in order to avoid scouring of substrate medium. The substrate media was filled as layers at the base up to 5cm gravel layer followed by sand layer of 5cm were well sieved. The size of sand and gravel used in the substrate media were 0.075mm 0.2mm and between 4.75 and 6 mm respectively. A mesh mat of size less than 0.075mm provided in between the gravel layer and sand layer. These gravel particles were washed with tap water and followed by distilled water washing, then sun dried for 4 days before filling. Sand particles were also washed with tap water and followed by distilled water washing; then sun dried for 4 days and dried in Hot Air Oven at 110^{o}C for 3 hour before filling. 25ml of dairy waste water and 25 ml of domestic waste water were being poured after the substrate arrangement. The water levels were marked. 20 grams (wet weight) of azolla pinnata plants were transplanted from the bucket to constructed wet land units after weighing.

Outlet zone consist of an effluent collecting outlet. The outlet pipe of half inch is fixed above 1cm from the bottom of constructed wetland unit tank. This constructed wetland system function as a free surface flow constructed wetland and effluent flow was vertically through the layered substrate medium.

Figure - 1 Azolla pinnata planted in dairy waste water wetland unit (Before treatment)

Figure - 2 Azolla pinnata plant growth in dairy waste water wetland unit (After treatment)

Figure - 3 Azolla pinnata planted in dairy waste water wetland unit (Before treatment)

Figure - 4 Azolla pinnata plant growth in domestic waste water wetland unit (After treatment)

Figure - 5 Experimental set up after 28 days

E. Qualitative Analysis

Effluent samples were collected from the outlet points of the constructed wetlands units weekly basis to determine the following parameters: pH(IS 3025 (P) 11-1983), Turbidity(IS 3025 (P) 10-1984), TDS(IS 3025 (P) 15-1984), TSS(IS 3025 (P) 15-1984), Chloride(IS 3025 (P) 32-1988), Sulphate(IS 3025 (P) 31-1988), BOD(IS 3025 (P) 44-1993), COD(IS 3025 (P) 58-2006), DO(IS 3025 (P) 38-1989), TN(IS 3025 (P) 34-1988), TP(IS 3025 (P) 31-1988) and Ammoniacal nitrogen(IS 3025 (P) 34-1988) were determined using standard laboratory procedures.

F. Percentage Removal Efficiency

Percentage removal efficiency was calculated using the formula:

%Removal efficiency= $\frac{\text{influent pollutants} - \text{effluent pollutents}}{\text{influent pollutants}}$ x100

3. RESULTS AND DISCUSSIONS

A. Results

The results of the analyses carried out on the dairy waste water effluent samples and domestic waste water effluent samples weekly basis for a detention time of 28 days were presented, are as shown in Table 1 and Table 2 below.

The dairy waste water colour is initially thick of white and highly turbid nature gradually changed to clear colourless, odorless effluent after Phytoremediation. The influent dairy waste water had a pungent smell. The smell gets highly reduced after three days of phytoremediation. Almost all the smell is eliminated after 7 days.

The domestic waste water colour is initially brownish and turbid nature gradually changed to clear colourless, odorless effluent after Phytoremediation. The influent domestic waste water had a little smell compared with dairy waste water. The smell gets completely eliminated after three days of phytoremediation.

Dairy waste water-constructed wet land unit					
Parameter	**Detention time**				
	Initial Day	**Day 7**	**Day 14**	**Day 21**	**Day 28**
pH	6.88	7	7.21	7.52	7.6
Turbidity (NTU)	505	175	78	29	2.9
TDS (mg/L)	540	394	221	72	47
TSS (mg/L)	389	90	12	0	0
Chloride (mg/L)	50	29	20	11	8
Sulphate (mg/L)	23.3	16	10.7	6.75	3.1
BOD (mg/L)	736	408	93	41	12
COD (mg/L)	1135	568	125	69	28
DO (mg/L)	0.2	0.6	1.3	1.64	2.36
TN (mg/L)	31.36	19.8	12.6	10.6	7.7
TP (mg/L)	3.73	2.98	2.2	1.5	0.6
Ammoniacal nitrogen (mg/L)	11.8	10.3	8.4	6.3	2.4

TABLE I
EFFLUENT CHARACTERSTICS FOR THE VARIOUS DETENTION TIME (DAIRY WASTE WATER CONSTRUCTED WET LAND UNIT)

Domestic waste water-constructed wet land unit					
Parameter	Detention time				
	Initial Day	Day 7	Day 14	Day 21	Day 28
pH	6.36	6.65	7.12	7.4	7.63
Turbidity (NTU)	79	24.4	9.2	5	1.3
TDS (mg/L)	228	161	103	60	40
TSS (mg/L)	98	22	9	0	0
Chloride (mg/L)	81.10	45.19	30	18.65	9.3
Sulphate (mg/L)	84.20	38	12	8.5	6
BOD (mg/L)	77	62	30	19	8
COD (mg/L)	290	198	124	58	22
DO (mg/L)	1.8	3.05	4.2	4.8	5.6
TN (mg/L)	72	58	46	22	14
TP (mg/L)	45.37	5.34	4.1	3.4	2.3
Ammoniacal nitrogen (mg/L)	67.6	48.4	42.9	18	6

TABLE 2
EFFLUENT CHARACTERSTICS FOR THE VARIOUS DETENTION TIME (DOMESTIC WASTE WATER CONSTRUCTED WET LAND UNIT)

B. Discussions

The pH of dairy waste water was initially 6.88 is very near to neutral temperature. During treatment the pH is increased to 7.6. But in the case of domestic waste water the pH was initialy 6.36 ;its also gradually increased during treatment and the pH after phytoremediation is 7.63. pH rises with photosynthetic activities of azolla plant.

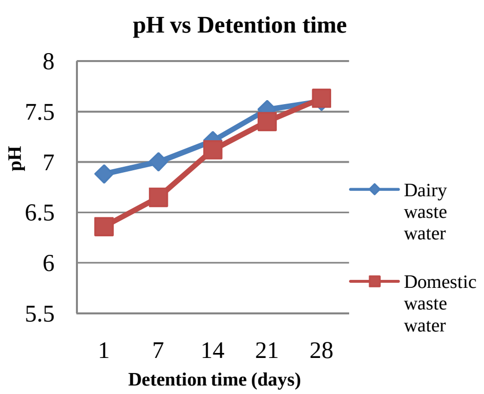

Figure - 6 Comparative graph of pH against detention time

The turbidity of dairy waste water constructed wetland unit and domestic waste water constructed wetland unit are gradualy decreasing. The percentage removal efficiency of turbidity in dairy waste water constructed wetland unit (99.43%) is slightly greater than the domestic waste water constructed wetland unit % removal efficiency of turbidity (98.35%). This turbidity reduction was mainly due to longer the detention period (28days) and reduction in TSS.

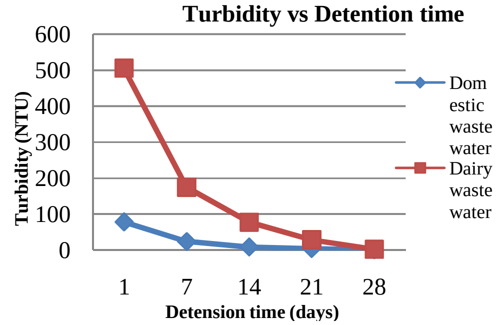

Figure - 7 Comparative graph of Turbidity against detention time

The TDS of dairy waste water is initially 540 mg/L is decreased to 47 mg/L after treatment. The TDS of domestic waste water is also decreased from a value 228 mg/L to 40 mg/L. Even though the TDS removal efficiency is more for dairy waste water CW unit (91.30%) than that of domestic waste water wetland unit (82.46%).

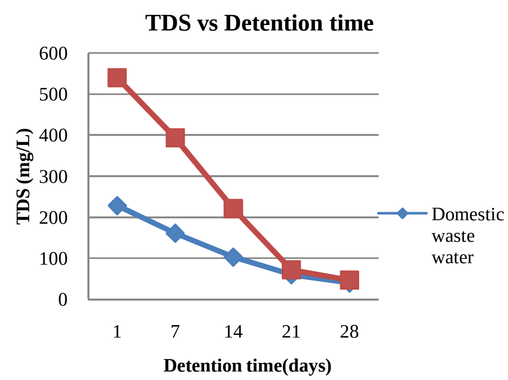

Figure - 8 Comparative graph of TDS against detention time

Initial concentrations of TSS were 389 mg/L in dairy waste water and 98 mg/L in domestic waste water. 100% removal efficiency obtained after treatment. The final TSS concentration of both constructed wet lands was zero. TSS reduced due to substrate media filtration. Longer detention time was also responsible for the TSS removal.

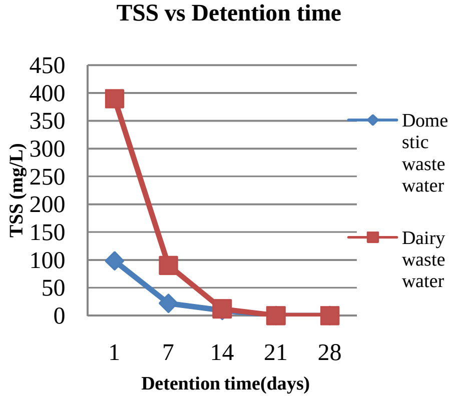

Figure - 9 Comparative graph of TSS against detention time

Chloride values for dairy waste water wet land system and domestic waste water wet land systems reduced with time (during weekly measurements) but the reduction was higher in the domestic waste water- CW unit than in the dairy waste water- CW unit. Chloride initial values in dairy waste water-constructed wetland and domestic waste water-constructed wet land before phytoremediation 50 mg/L and 81.10 mg/L, respectively and these values decreased appreciably to 8 mg/L and 9.3 mg/L. Chloride removal efficiency is greater for domestic waste water CW unit (88.53%) than that of dairy waste water CW unit (84%).

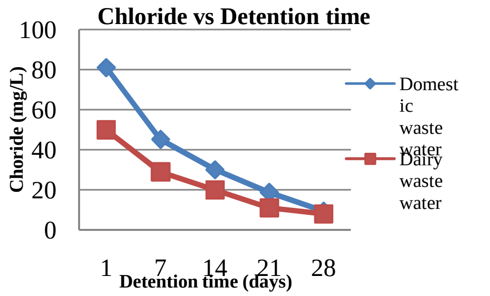

Figure - 10 Comparative graph of Chloride against detention time

Sulphate was removed from 23.3 mg/L to 3.1 mg/L and 84.20 mg/L to 6 mg/L for dairy waste water CW unit and domestic waste water CW unit respectively in the treatment. The result shows sulphate being gradually removed as detention time increases. Domestic waste water CW unit observed with higher Sulphate removal efficiency (92.87%) than dairy waste water CW unit (86.70%).

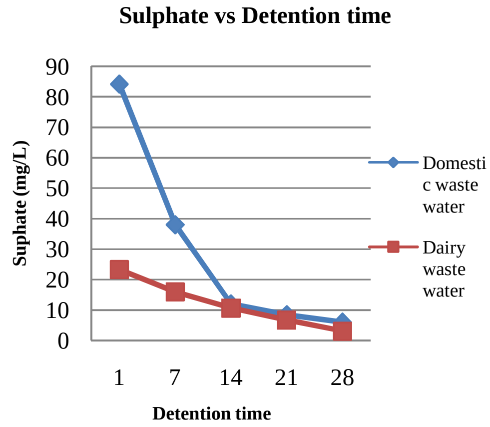

Figure - 11 Comparative graph of Sulphate against detention time

BOD_3 concentration was reduced significantly in both constructed wetlands during the experiments. Initial to final concentration values of dairy waste water is 736mg/L to 12 mg/L. The initial to final concentration values of domestic waste water is 77 mg/L to 8mg/L. BOD removal is observed in constructed wetlands with increase in detention period. From the experiment the BOD removal efficiency is greater for dairy waste water CW unit (98.37%) compared with domestic waste water CW unit (89.61%).

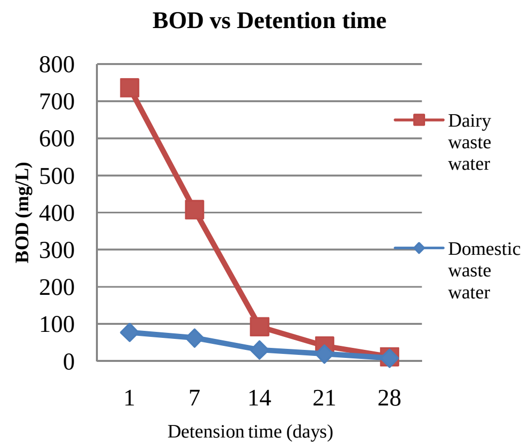

Figure - 12 Comparative graph of BOD against detention time

Similarly COD concentrations reduction observed significantly in dairy waste water constructed wet land unit and domestic waste water constructed wet land unit during the experiments. COD removal efficiency is greater for dairy waste water wetland unit (97.53%) compared with that of domestic waste water wetland unit (92.41). The initial concentration to final concentration values of dairy waste water is from 1135mg/L to 28 mg/L. Where as in domestic waste water is from 290mg/L to 22 mg/L. Azolla pinnata is an aquatic plant. Usually COD removal property observed with aquatic plants activities in the CW. Oxidation of organic compounds was carried out by microorganism's during phytoremediation process is the reason for COD reduction [6].

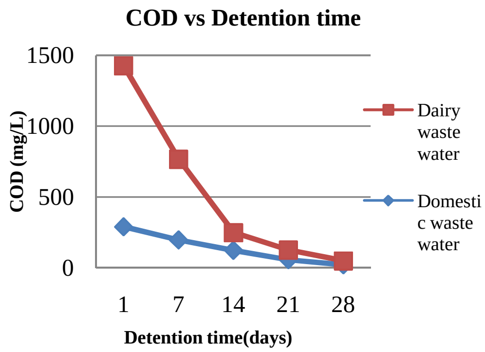

Figure - 13 Comparative graph of COD against detention time

DO gradually increasing in both experimental setup effluents. Initial to final DO concentration values of dairy waste water is 0.2mg/L to 2.36 mg/L The initial to final concentration values of domestic waste water is 1.8 mg/L to 5.6mg/L. This may be due to the photosynthetic activities of azolla pinnata plant.

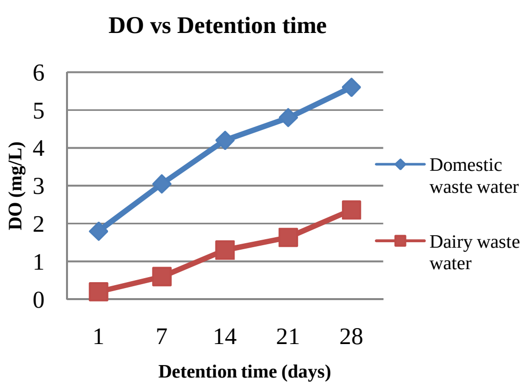

Figure - 14 Comparative graph of DO against detention time

Total nitrogen initial values in dairy waste water-CW and domestic waste water CW land during Phytoremediation 31.36 mg/L and72 mg/L, respectively and these values decreased appreciably to 7.7 mg/L and 14mg/L. TN removal efficiency is greater for domestic waste water wetland unit (80.56%) compared with that of dairy waste water wetland unit (75.45%). The TN removal was also linked with plant- Simply due to bacteria de-nitrification [6].

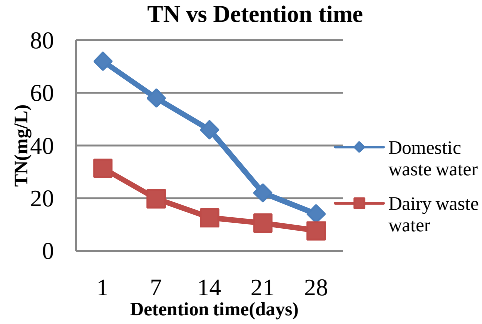

Figure - 15 Comparative graph of TN against detention time

TP was removed from 3.73 mg/L to 0.6 mg/L and 45.37 mg/L to 2.3 mg/L for dairy waste water constructed wet land unit and domestic waste water constructed wetland unit respectively in the treatment. TP reduction during treatment may be due to phosphorous intake by the plant as a nutrient. TP removal efficiency is greater for domestic waste water wetland unit (94.93%) compared with that of dairy waste water wetland unit (83.91%).

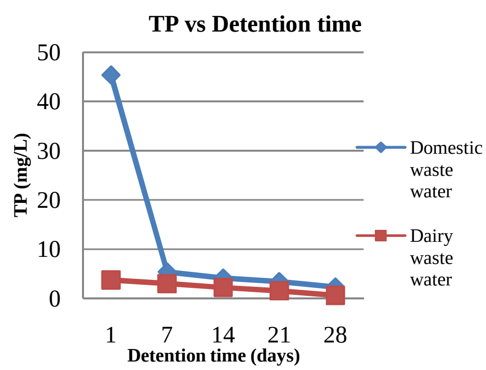

Figure - 16 Comparative graph of TP against detention time

Remarkable decrease is observed in ammonia concentration with detention time of 28 days in dairy waste water and domestic waste water from 11.8 to 2.4 and from 67.6 to 6 respectively. Ammonia nitrogen removal is observed in these CW units. It may be due to plant uptake for performing their biological mechanisms [6]. Ammoniacal nitrogen removal efficiency is greater for domestic waste water wetland unit (91.12%) compared with that of dairy waste water wetland unit (79.66%).

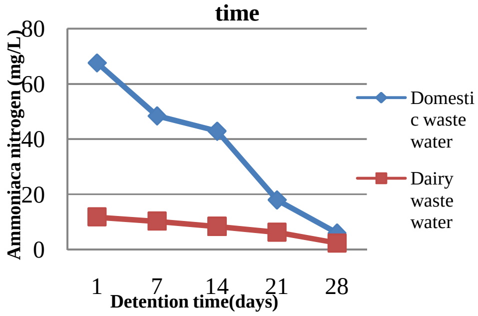

Figure - 17 Comparative graph of Ammoniacal nitrogen against detention time

CONCLUSIONS

The result obtained from the experiment proven that azolla pinnata had great potential in treating dairy wastewater and domestic waste water. Remarkable percentage removal efficiencies were observed in all parameters analyzed; except in pH and DO. TSS removal efficiency is 100% in both dairy waste water and domestic waste water CW system. Turbidity, TDS, BOD and COD removal efficiencies were greater for dairy waste water CW unit compared with that of domestic waste water CW unit. Even though removal efficiency rates over most of the parameters such as chloride, sulphate, TN, TP and ammoniacal nitrogen were slightly greater for domestic waste water CW unit. The overall performance of the azolla pinnata CW units illustrated that this phytoremediation method using CW was efficient in removing tested parameters from the domestic waste water and dairy waste water. These effluents after phytoremediation treatment can be reused and recycled for non- potable purposes like irrigation, domestic uses, cleaning, floor and car washing and sewerage uses. A remarkable yield of azolla pinnata was an additional benefit of the system. This azolla pinnata can be used as feed for cattle and other livestock's. And it can be used as a biofertilizer for vegetable gardens, farm lands. The values obtained for all parameters after a treatment period of 28 days were all within tolerance limits of effluents to be discharged into surface water bodies. From the experiment, it can be concluded that phytoremediation using constructed wetland of azolla pinnata is efficient, eco-friendly and economically reliable method to purify domestic and dairy waste waters.

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