# Treatment of Dairy wastewater by using Vertical subsurface flow Constructed wetland

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***Abstract*: Constructed wetlands are becoming more and more popular for treating all industrial wastewaters in addition to secondary municipal wastewaters in many countries. The effectiveness of a vertical flow engineered wetland system for removing contaminants from dairy effluent was examined in this study. The Vertical Flow Constructed Wetland was built and treated dairy effluent continuously for two months. The two plant species Canna generalis and Hedychium Coronarium were planted in the wetland unit, which also had varied substrate material compositions (such as coarse gravel, fine sized gravel, soil, and sand) with varying substrate thickness and gradations. At the unit's outflow, water samples were taken, and they underwent laboratory analysis to identify various pollutants. It was discovered that the performance was enhanced by the presence of plants; however plant species had no impact on productivity. The removal efficiencies of organic matter ($BOD_5$, COD) from the vertical flow constructed wetland were 91% and 78%, respectively. TDS removal was 67.2% and turbidity removal was 68%. Under conditions of high organic loads and retention time, it was discovered that the systems significantly reduces pollutant concentrations.**

***Keywords*: Vertical flow Constructed wetland, Dairy wastewater treatment, Vegetation, Porous media, BOD, COD, TDS, Turbidity and pH.**

## I. INTRODUCTION :

Constructed wetlands are engineered systems that are designed and built to take use of the natural processes involving wetlands plants, soils, and gravels. They are created to benefit from many of the same processes that take place in natural wetlands, but they do so in an environment that is more controlled. Others have been put in place with multiple use objectives in mind, such as using treated wastewater effluent as a water source for the creation and restoration of wetland habitat for wildlife use, for reuse in agriculture, or for environment enhancement [1]. Some of these systems have been designed and operated with the exclusive purpose of treating wastewater. The effectiveness of pollutant removal varies greatly among the various constructed wetlands employed for wastewater treatment. The removal of organic materials is currently excellent in the most of treatment wetlands after nearly two decades of gradual improvement [2]. Wastewater is treated in VFCWs by flow via surfaces containing rooted emergent aquatic plants. Treatment is carried out using a variety of physical, chemical, and biological processes that function fundamentally as biological reactors. The gravel matrix facilitates the settling of suspended particles and offers surfaces for the development of biofilm and ion exchange and also it provide spaces to bacteria's, wetland plants planted in gravel also assimilate nutrients, transforming them into organic forms that are then returned to the wetland as litter, leachates and secretions [3].

The main sources of dairy wastewater are generally produced from cleaning and washing of milk processing units. Around 2 percent of the entire amount of milk pasteurized is thought to be lost in drains [4]. Dairy wastewaters typically contain lipids, casein, lactose, inorganic salts, cleanser and disinfectants. They also typically have high quantities of other parameters like TDS, Turbidity and pH. Dairy effluents quickly break down and lower the oxygen level of collecting rivers, which instantly causes absence of oxygen state and the emission of potent foul smell which creates nuisance [5]. Receiving water turns into a breeding ground for mosquitoes and flies that spread diseases like cholera, dengue, dysentery, diarrhea and yellow fever. The wastewater that is generated from milk processing in dairy factories is a source of environmental pollution. This requires special water treatment to eliminate potential problems caused by the discharge of milk processing effluent into water bodies [6].

Wetlands were used for hundreds of years to drain sewage. Constructed wetlands technique of filtration is able to take away specific pollutants from dairy wastewater. The existence of vegetation facilitates to remove impurities in wastewater [7]. The current research focuses on the elimination of pollutants. The use of laboratory level vertical flow constructed wetland system packed with substrates and working at different Horizontal retention times for handling of dairy industry wastewater. The constructed wetland system was planted with Canna generalis and Hedychium Coronarium these are used because of its easy accessibility, low cost and aesthetic look [8].

## II. MATERIALS AND METHODOLOGY

- **Experimental Setup:**

The test was carried out in a system of vertical flow constructed wetlands. Two months were spent in conducting the experiment. The Canna generalis and Hedychium Coronarium plants were planted in the constructed wetland unit. The unit consisted of a 0.7m length, 0.42m width and 0.8m depth, each established with a four layer of substrates: 0.25m of 20-30mm gravel in the bottom followed by 0.20m of 6-12mm gravel, 0.15m soil in the middle and 0.20m layer of 1-2 mm sand at the

top. The system was loaded with DWW. The supplied loadings are examined and verified each week. Drains at the bottom of the tanks were used to collect and analyze effluent [9].

- **Effluent analysis**

The dairy wastewater used was collected from the KMF Dairy industry Bathi, Davanagere district. The initial characteristics of the wastewater were tested. The effluent water samples were analysed weekly for BOD, COD, TDS, Turbidity and pH following standard analytical procedures. The temperature of the effluent wastewater ranged between 21 and 27°C [9].

- **Plant Selection**

The Canna generalis and Hedychium Coronarium were used in this study. The wetland plants should be tolerant to water logging anoxic and hyper eutrophication conditions and capable of pollutant absorption [9].

- **Substrate selection**

Substrates used are 20-30mm coarse sized gravel, 6-12mm fine sized gravel, soil and sand. Substrates offer stability for plant and microbial growth. The size of the substrate media affects the root zone's hydraulic permeability and provides site for microbial attachment [10].

- **Dairy effluent treatment**

DWW after passing through the filter media, get filtered through the substrate media and stored in the drain. Then the sample were analysed for BOD, COD, TDS, Turbidity and pH according to standard operation procedure and the removal efficiency of the all the above parameters were taken. Vertical Constructed wetland planted with Canna generalis and Hedychium Coronarium as shown in Figure 1.

**Figure 1** Vertical Constructed wetland planted with Canna generalis and Hedychium Coronarium

## III. RESULTS AND DISCUSSION:

**Initial characteristics of dairy effluents:**

The following table illustrates the initial characteristics of effluents. Different tests were done to the effluent as per method given in the standard procedure [11].

**Table 1** Characteristics of dairy wastewater

| No. | Parameter | Concentration |
|---|---|---|
| 1 | pH | 5.1 |
| 2 | Total dissolved solids (mg/l) | 1250 |
| 3 | Turbidity (NTU) | 930 |
| 4 | BOD (mg/l) | 1380 |
| 5 | COD (mg/l) | 396 |

**Removal efficiency of BOD at different detention period:**

In order to remove BOD of the Effluent we need to dilute effluent more before the process. The Removal efficiency of Biochemical oxygen demand of dairy wastewater at varying Retention periods is represented in Table 2.

**Table 2** Performance of VFCW taking place in Removal of BOD at various detention times.

| Factor | Retention time | Initial | Final |
|---|---|---|---|
| BOD (mg/l) | 7 days | 1380 | 1117.8 |
| | 14 days | 1380 | 814.2 |
| | 21 days | 1380 | 317.4 |
| | 28 days | 1380 | 124.2 |

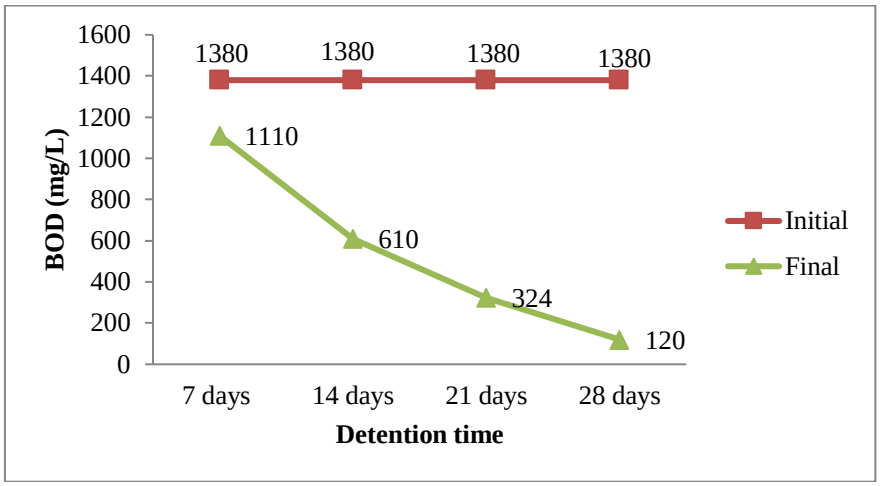


**Figure 2** Reduction of BOD at different suspension time

The Reduction of BOD in Dairy wastewater was 19%, 41%, 77% and 91% at retention period 7, 14, 21, 28 days respectively. The reduction efficiency of BOD at 7 days was not significant. The Removal efficiency increases with increase in Retention period. So the removal efficiency of BOD is very high at 28 days detention period as shown in Figure 2.

**Removal of COD at various Retention time:**
The Removal efficiency of chemical oxygen demand of DWW at various retention periods are shown in Table 3.

**Table 3** Presentation of VFCW on Replacement of COD at different detention time

| Characteristic | Duration (days) | Initial | Final |
|---|---|---|---|
| COD (mg/l) | 7 | 396 | 368.28 |
| | 14 | 396 | 312.84 |
| | 21 | 396 | 201.96 |
| | 28 | 396 | 87.12 |

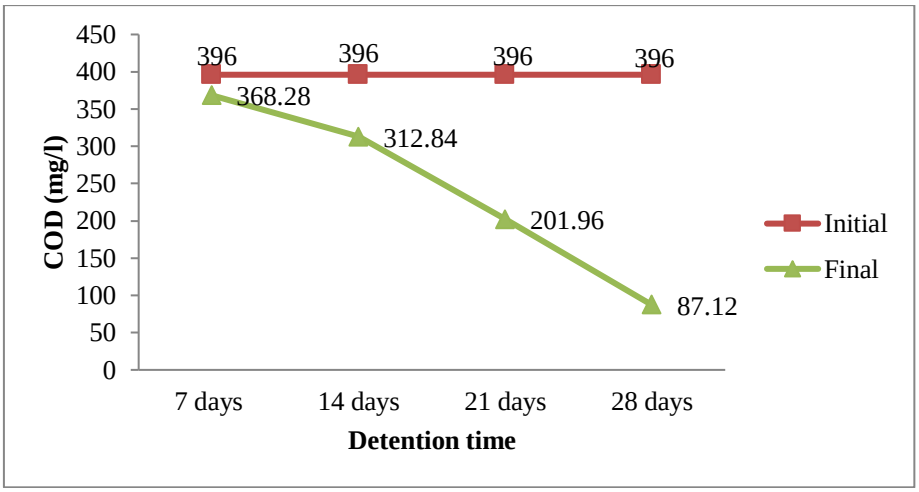


**Figure 3** Reduction of COD at different detention time

The removal efficiency of COD was 7%, 21%, 49% and 78% at various detention times of 7, 14, 21, 28 days. The removal efficiency of COD was less compare to BOD reduction as shown in above Figure 3. The removal of COD is significant at 28 days of retention time. Removal efficiency increases with increase in retention period.

**Removal of Total dissolved solids at different retention time.**

The TDS in effluent was very high initially, the TDS decreased by treating the effluent in vertical constructed wetland with increasing retention time as it is illustrated in Table 4.

**Table 4** Performance of VFCW on removal of TDS at different detention time

| Parameters | Retention time (days) | Initial | Final |
|---|---|---|---|
| T D S (mg/l) | 7 | 1250 | 1175 |
| | 14 | 1250 | 1062.5 |
| | 21 | 1250 | 712.5 |
| | 28 | 1250 | 410 |

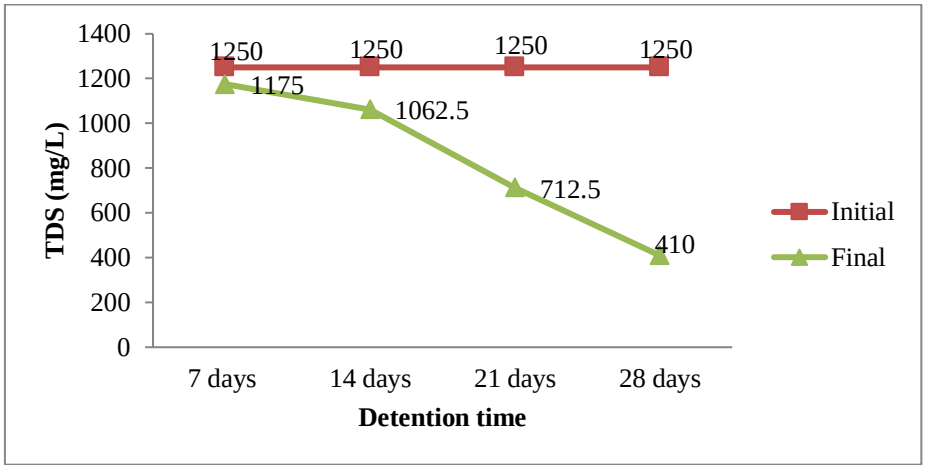


**Figure 4** Reduction of TDS at different detention time

The reduction of TDS in dairy wastewater is 6%, 15%, 43% and 67.2% at 7, 14, 21 and 28 days retention time in that order. On 7 days of DT only 6% TDS was reduced and at last week i.e. 28 days retention time TDS is reduced to 67.2%.

**Removal efficiency of Turbidity by Retention time:**

The turbidity of the effluent reduced up to certain extent in Vertical constructed wetland. The Reduction of turbidity of Diary wastewater at various retention periods was given in below Table 5.

**Table 5** Shows the VFCW's Removal Turbidity in various times

| Parameter | Detention period | Initial | Final |
|---|---|---|---|
| Turbidity (NTU) | 7 days | 930 | 762.6 |
| | 14 days | 930 | 641.7 |
| | 21 days | 930 | 409.2 |
| | 28 days | 930 | 297.6 |

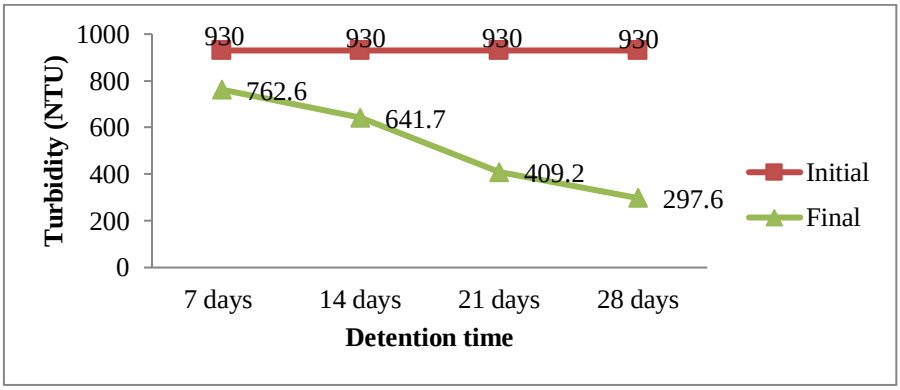

**Figure 5** Removal efficiency of Turbidity at different detention time

The removal efficiency of Turbidity of dairy wastewater was 68% at 28 days Detention period. The reduction in turbidity was not much significant compare to other characteristics of dairy wastewater. At earlier days removal efficiency was not so high. But at greater retention period the removal efficiency was improved.

**Performance of pH at various retention periods**

The initial pH of dairy effluent was 5.1 but by increasing retention periods, the pH also changes as it is shown in Table 6.

**Table 6** Execution of VFCW scheduled exclusion of pH at different DT.

| Parameter | Retention time | Initial | Final |
|---|---|---|---|
| pH | 7 days | 5.1 | 5.5 |
| | 14 days | 5.1 | 6 |
| | 21 days | 5.1 | 6.7 |
| | 28 days | 5.1 | 7.3 |

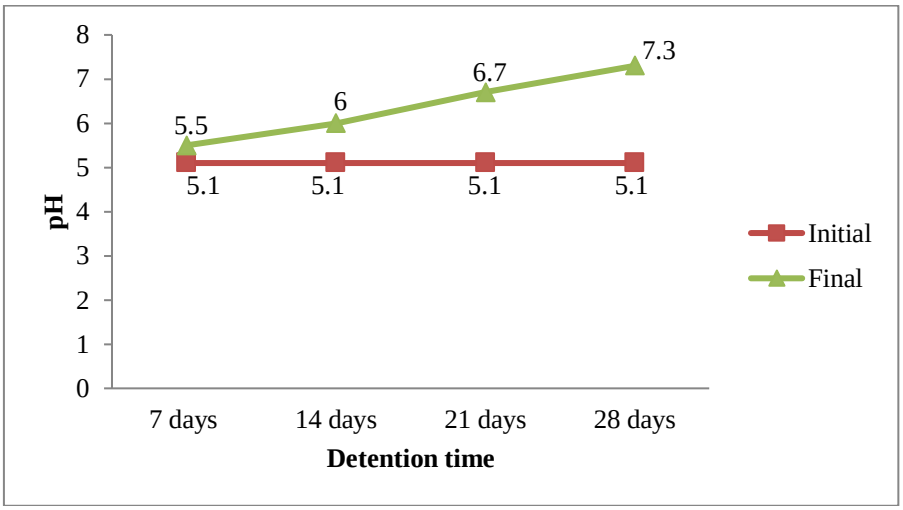


**Figure 6** Removal efficiency of pH by differing retention periods

The initial pH of Dairy wastewater was 5.1 which are acidic in nature. But after treatment the pH of dairy wastewater was changed to 7.3 which were efficient in nature, at 28 days retention period. The treated water with 7.3pH can be used for other uses like non domestic purposes.

**Overall Performance of Constructed wetland :**

The microbial load removal mechanisms in Constructed wetlands include Physical, Chemical and Biological processes [12]. The complete treatment of effluent by Vertical constructed wetland by using aquatic plants is made to remove the contaminants from the effluent. The values of all the parameters are illustrated in below Table 7.

**Table 7** Percentage removal of all the parameters

| Retention period | BOD | COD | TDS | Turbidity | pH |
|---|---|---|---|---|---|
| **7 days** | 19 | 7 | 6 | 18 | 7.27 |
| **14 days** | 41 | 21 | 15 | 31 | 8.33 |
| **21 days** | 77 | 49 | 43 | 56 | 10.44 |
| **28 days** | 91 | 78 | 67.2 | 68 | 8.22 |

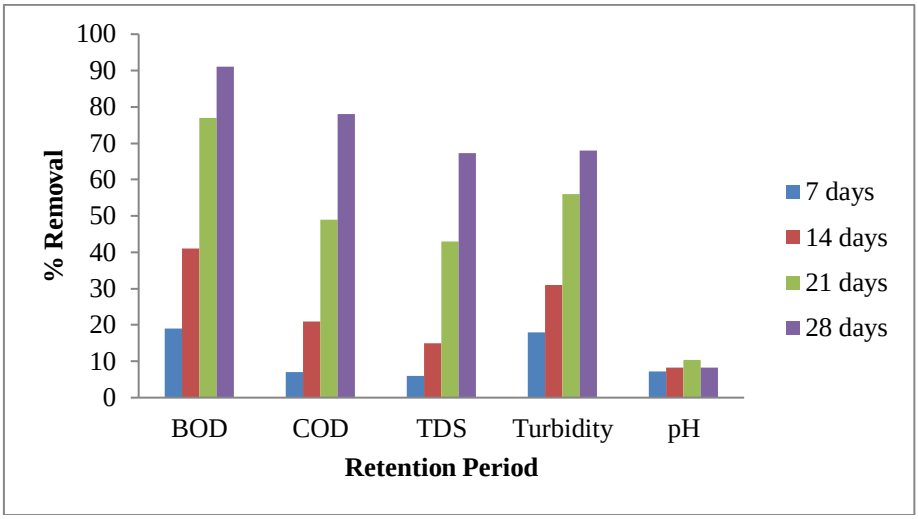


**Figure 7** Comparison of % Removal of parameters at various Retention periods.

The removal efficiency of BOD, COD, TDS and Turbidity was 91%, 78%, 67.2% and 68% respectively and pH was increased to 7.3 at 28 days retention period. By considering the above figure it can conclude that the removal efficiency of BOD and COD were significant compare to other parameters. Reduction efficiency was significant with increase in detention time.

## IV. CONCLUSION:

- This study demonstrates the removal of BOD, COD, TDS, Turbidity and pH of Dairy wastewater to an acceptable rate.
- The properly designed, installed and maintained constructed wetlands are an excellent choice for on-site sewerage treatment.
- Constructed wetland performs better with longer retention time.
- Dairy wastewater needs more dilution to reduce BOD.
- Less supervision is needed in Constructed wetland.

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