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Domestic Waste Water Treatment by using Constructed Wet Land

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Abstract: *Abstract: A constructed wetland (CW) is an artificial wetland to treat municipal or industrial wastewater, greywater or storm water runoff. It may also be designed for land reclamation after mining, or as a mitigation step for natural areas lost to land development.*

Constructed wetlands are engineered systems that use natural functions vegetation, soil, and organisms to treat wastewater. Depending on the type of wastewater the design of the constructed wetland has to be adjusted accordingly. Constructed wetlands have been used to treat both centralized and on-site wastewater. Primary treatment is recommended when there is a large number of suspended solids or soluble organic matter (measured as BOD and COD).

There are two main types of constructed wetlands: subsurface flow and surface flow constructed wetlands. The planted vegetation plays an important role in contaminant removal. The filter bed, consisting usually of sand and gravel, has an equally important role to play. Some constructed wetlands may also serve as a habitat for native and migratory wildlife although that is not their main purpose. Subsurface flow constructed wetlands are designed to have either horizontal flow or vertical flow of water through the gravel and sand bed. Vertical flow systems have a smaller space requirement than horizontal flow systems.

And with some modifications the constructed wetlands are constructed in acrylic sheets for an experiment purposes. These includes the subsurface horizontal flow constructed wetland, vertical flow constructed wetland and charcoal based horizontal flow constructed wetland. Charcoal is used because it tends to remove the large amount of suspended solids in the wastewater. The results of the parameters chosen came out according to their detention period. The efficiency of the horizontal flow constructed wetlands is efficacious when compared to the other types of experimental setups of wetland.

Keywords: Domestic Waste Water, BOD, COD VFCW, HFCW

1. Introducon

The rapid growth in the population of India effecting the rate of pollution to the natural resources as well as unavailability of good water and air. The water plays a vital role in the hydrological cycle and survivability of humans also. The control of pollution and proper usage of water is the responsibility of every individual.

Globally, the lack of clean water is a growing problem and natural water resources are inadequate to meet their needs, as cities become more and more populous and industrialized and important to improve sanitation and the environment. The number of countries experiencing water shortages in the last forty years is mostly developing countries. Given the global water shortage problems it is important to consider non-standard water sources to meet the growing demand for fresh water.

1.1 Constructed Wetland

Constructed wetlands systems for wastewater treatment technologies were proven effective, low cost and sustainable. The removal of pollutants from these systems is based on a combination of physical, chemical and biological processes.

Wetlands have been developed and constructed that utilize natural processes in the treatment of wastewater. Plants, soil, and small microorganisms were used to remove pollutants from the waste water. Wetlands developed have been used worldwide that have yielded good results.

Wetlands have been constructed using engineering technologies for the following reasons:

●To compensate the transformation of natural wetlands resulting from farming and urban development.

●Serve as a flood control center and produce food and fiber.

●Mainly for treating wastewater in order to improve water quality.

Constructed wetlands contained four major components:

●Vegetation

●Substrate

●Water column

●Living organisms

Large varieties of aquatic plants were used in constructed wetland system for wastewater treatment and cattails were more frequently used macrophyte species. Substrate media also acted as principal storage of all living and nonliving components. Normally the coarse gravel in the size 30-40mm range were used and for upper layer gravel size range 12-15mm are used.

1.2 Types of Constructed Wetlands

According to the flow of water system constructed wetlands can be divided into three main categories which are as discussed below

1.2.1 Surface Flow Constructed Wetlands (SFCW)

Constructed wetlands also referred as free water surface wetlands (FWS). Various activities occur mainly on the topmost layer of the soil and inside the water body. Waterproofing is not always used. As it is at the surface level, there may be chances of mosquitoes and other small insects.

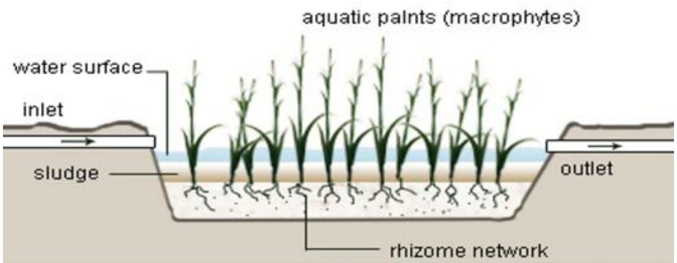

Figure 1.0 Surface Flow Constructed Wetland

1.2.2 Vertical flow constructed wetland

The vertical flow (VF) type consists of layer of sand or gravel bed, planted with prevalent macrophytes. The water filtrates into filter media such as sand and then it moves to the bed by the action of gravity to the outlet. This type of wetlands can be operated in an upstream manner by inactivating inlet conditions and outlet pipe.

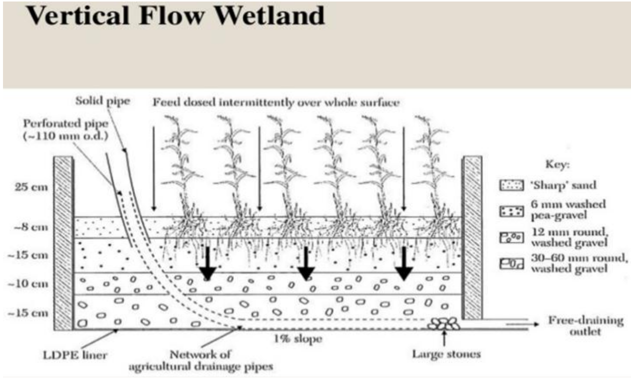

Figure 2.0 Vertical Flow Subsurface Flow Constructed Wetland

2. Need for the study

From the screening of earlier work done by the researcher on various parameters, methods, analysis, case studies and process we can arrive for the following objectives.

- Characterization of domestic waste wastewater.
- Design and fabrication of the constructed wetland unit.
- The optimize variables like flow rate filter media and duration.
- To check the removal efficiency of various

3. Materials

3.1 Coarse Aggregate

They are gravel and crushed stones predominantly retained on the 4.75mm sieve. Size of aggregates used: 20mm to 40mm

Figure 5.0 Coarse aggregates used for VFCW

3.2 Fine Aggregate

They are sand or crushed stones and completely passing through the 9.5mm sieve.Fine aggregate used: River sand.

Figure 6.0 Fine aggregates used for VFCW

3.3 Stainless Steel Wire Mesh

It is a versatile item that have many different customer use for many different application and made up of stainless steel. wire mesh was used as a separator between the filter layers

Sieve openings in mesh :4.76mm

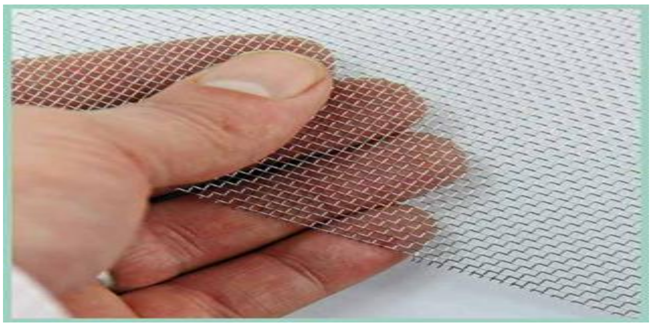

Figure 7.0 Stainless Steel Mesh

3.4 Inlet Pipe and Valve

Pipe is used to inlet the waste water to the constructed wetland and valve is provided to control the flow of the waste water. Diameter of outlet valve used was 6mm.

Figure 9.0 Inlet Pipe Valve used for VFCW

3.5 Materials for HFCW

3.5.1 The container is made up of acrylic sheet. Acrylic sheet refers to the family of synthetic or manmade plastic materials containing one are more derivatives of acrylic acid. It is tough, highly transparent and it can be cut, drilled and formed.

Figure 10.0 Container for HFCW

3.5.2 Fiber Tap

Fiber tap is made up of hard reinforced plastic material. Size of tap: half inch diameter was used.

Figure 8.0 Fiber Tap used for HFCW

3.5.3 Fine Aggregate

They are sand or crushed stones and completely passing through the 9.5mm sieve. Fine aggregate used: River sand.

Figure 9.0 Fine Aggregates used for HFCW

3.5.4 Coarse Aggregate

They are gravel and crushed stones predominantly retained on the 4.75mm sieve.

Size of aggregates used: 20mm to 40mm

Figure 10.0 Coarse Aggregates used for HFCW

3.5.5 River Bed Stone

River bed stone is a sedimentary rock, a form of limestone. It is composed of calcium carbonate, quartz and other materials. Size varies from 4mm to 264mm. River stone can be found in the river bed naturally.

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Figure 11.0 River Bed Stone used for HFCW

3.5.6 Dwarf Bullrush (Typha minima)

●These are also called as pond plants, shallow water plants.

●This species is thought to be native to Eastern Asia, Africa, Indian subcontinent.

●These plants are dwarf can grow up to 3-4m tall.

●These plants are like to be found in a pond

Figure 12.0 Plants in Wetlands (Dwarf Bull Rush)

4. Methodology

4.1 Design of vertical flow constructed wetlands

●The study area is located at environmental engineering lab of civil engineering department, GM institute of technology Davanagere.

●The domestic waste water for the treatment was collected from the sewage treatment plant of the college which receives water from both girls and boys hostel and also from the college. The total occupancy is about 1200.

●The size of VFCW was 1.45x 1.45x 2ft and 5mm thick.

13.0 Design of Vertical Flow Constructed Wetland

●12 inch of free board was left at the top and the filter layer was filled from bottom to top

●First a soil layer of 2 inch was filled at the bottom and mesh was placed as a separating layer

●Second layer of coarse aggregates of 8-inch thickness was placed and final third layer of soil of 8 inches for placed.

4.2 Design of Horizontal Flow Constructed Wetlands

●The study area is located at environmental engineering lab of civil engineering department, GM institute of technology Davanagere.

●The size of HFCW was 2.45*1.45*1.3ft and 5mm thick 1% slope.

●6 inch of free board was left at the top and the filter layer was filled from bottom to top.

●Firstly at bottom 3inch was filled with river stones.

●Secondly 4.3inch of course aggregate was filled.

●Final layer of wetland is filled with 2.3inch of sand (F.A) and the plants were planted till the roots touch the second layer of coarse aggregates.

●The untreated domestic waste water was collected in a can of 20lts capacity having a tap in it and was placed around 3ft above the HFCW.

●A pipe was used to transfer the water to the wetlands which acted as inlet and an outlet valve was fixed at the end of pipe to regulate the flow.

●The water flowed at a constant flow rate of .25m3/day by the action of gravity through the filter layers slowly for a detention time of 6hrs

●The waste water passing the filter media was collected through the tap and was analyzed for different parameters discussed below.

Figure 14.0 Design of Horizontal Flow Constructed Wetland

5. Results and Discussion

The constructed wetlands for the treatment of the domestic waste water treatment was conducted with different operational variables by monitoring various parameters like COD, BOD, turbidity etc… with vertical flow constructed wet land and Horizontal flow constructed wet land and results were tabulated as below.

Variables for different laboratory reveals the following results and discussions.

5.1 pH

It was observed that pH of waste water after the treatment was higher than that of before treatment.

pH values for VFCW

Time in days	pH of waste water before treatment	pH of waste water after treatment
1	8.1	11.8
2	7.4	10.6
3	7.7	11.4
4	8.6	12.8
5	10.2	13.4

Table 1 .pH Values of Wastewater Before and After Treatment

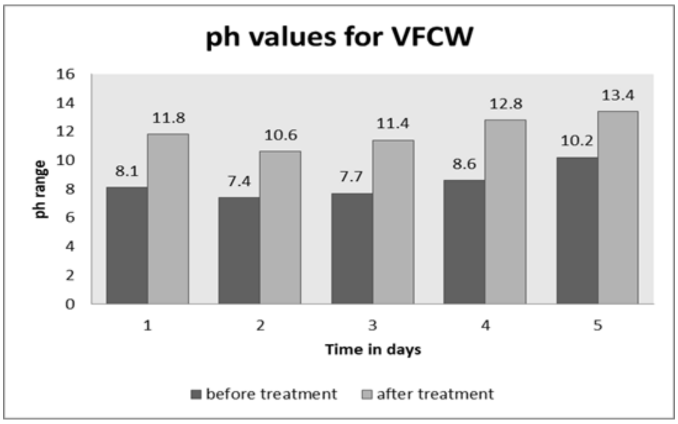

Figure 5.1 Graphical Representation of pH Values for HFCW

The characteristics of the raw wastewater in the inlet and the characteristics of treated wastewater at the outlet were studied for the detention time of 5 days. For the 5 day detention time it was found that ,for VFCW the percentage removal for the pH was 30.12 % and for HFCW percentage removal for the pH was in the range of 7.9%.

Recent researches has shown the potential of wetlands in buffering the acidic waste waters. The increase in pH of VFCW was affected due the presence of substrate i.e, due to the presence of aggregates that neutralised the alkalinity of waste water by increasing the pH level.

pH of the waste water in wetlands is affected by chemical and microbial activities taking place and also by the sand filters. The increase in pH was due to dissolution of mineral ions in sand bed filters during infiltration. The efficiency of neutralising the pH of the waste water was more in VFCW by 22.2%.

5.2 Turbidity

Time in days	% Removal Efficiency for VFCW	% removal Efficiency for HFCW
1	51.04	75.42
2	65.4	78.42
3	68.72	84.72
4	75.77	93.05
5	84.56	93.89

Table 2 .Turbidity Removal Efficiency of VFCW and HFCW

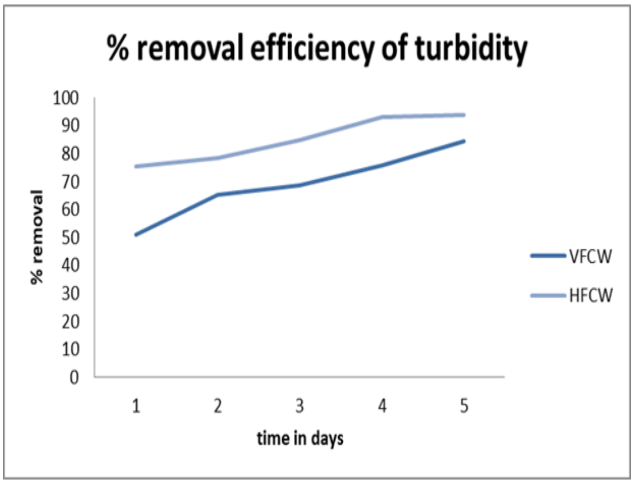

Figure 5.2 Graphical representation of variation in turbidity removal for VFCW and HFCW

The characteristics of the raw wastewater in the inlet and the characteristics of treated wastewater at the outlet were studied for the detention time of 5 days. For the 5-day detention time it was found that, for VFCW the percentage removal for the turbidity was 69.09 % and for HFCW percentage removal for the turbidity was in the range of 85.1%.

Turbidity reflects the inorganic, organic, suspended and colloidal matters present in water that affects water transparency.

The removal mechanism of water turbidity in the wetlands is due to sedimentation and filtration facilitated by plant roots that reduces interspaces between gravel by forming dense filter media that removes suspended particles.

Turbidity removal in sand filters is due to sedimentation and filtration through sand column

5.3 Dissolved Oxygen

Time in days	% Removal Efficiency for VFCW	% Removal Efficiency for HFCW
1	48.83	59.42
2	49.46	60.56
3	40.38	45.38
4	38.46	79.8
5	30.64	55.67

Table 3. DO Removal Efficiency of VFCW and HFCW

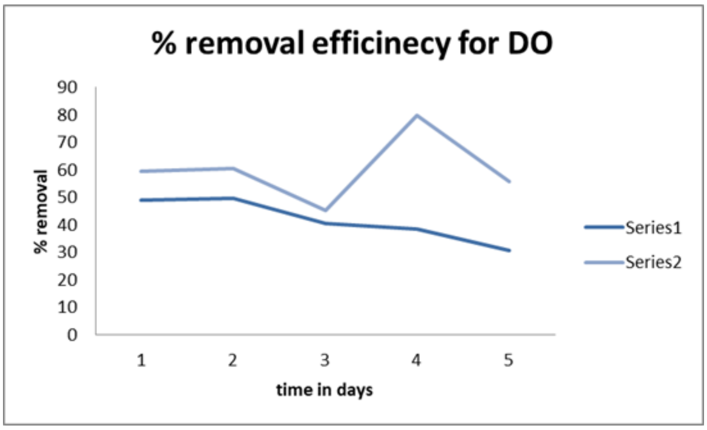

Figure 5.3 Graphical representation of variation in DO removal for VFCW and HFCW

The characteristics of the raw wastewater in the inlet and the characteristics of treated wastewater at the outlet were studied for the detention time of 5 days. For the 5-day detention time it was found that, for VFCW the percentage removal for the DO was 41.54 % and for HFCW percentage removal for the DO was in the range of 60.16%. The % removal efficiency of HFCW was found 18.62% more than VFCW due to the use of carbon dioxide by the plants that was used for the photosynthesis process and also due to the presence of microbial organisms and bacteria

5.4 BOD

Time in Days	% Removal Efficiency for VFCW	% Removal Efficiency For HFCW
1	32.3	59.24
2	45.61	69.84
3	39.73	75.55
4	29.5	79.07
5	39.06	83.78

Table 4. BOD Removal Efficiency of VFCW and HFCW

The characteristics of the raw wastewater in the inlet and the characteristics of treated wastewater at the outlet were studied for the detention time of 5 days. For the 5-day detention time the BOD removal efficiency was found to be 37.24 % for VFCW and 73.49% for HFCW

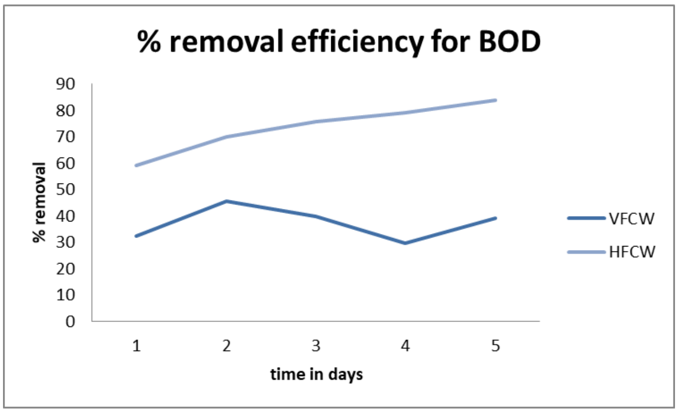

Figure 5.4 Graphical representation of variation in BOD removal for VFCW and HFCW

5.5 COD

Time in days	% Removal Efficiency for VFCW	% Removal Efficiency for HFCW
1	54.83	66.39
2	49.08	69.58
3	61.9	64.82
4	59.8	68.89
5	65.95	76.85

Table 5. COD Removal Efficiency of VFCW and HFCW

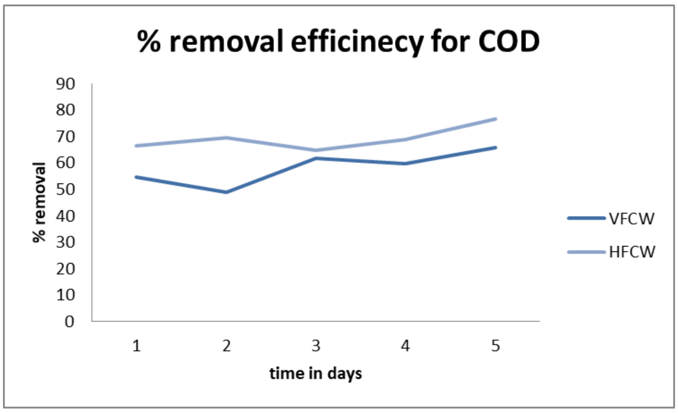

Figure 5.5 Graphical representation of variation in COD removal for VFCW and HFCW

The characteristics of the raw wastewater in the inlet and the characteristics of treated wastewater at the outlet were studied for the detention time of 5 days. For the 5-day detention the COD removal efficiency was found to be 58.31 % for VFCW and 69.30% for HFCW.

Aggregates that affected the removal efficiency, i.e it was due to filtration, sedimentation.

5.6 Comparison of values for all the three constructed wetlands

5.6.1 pH

Time in days	HFCW	VFCW	CBCW
1	8.1	8.6	8.4
3	11.8	11.4	13.4
5	7.7	7.8	8.2

Table 5. pH Values for Alternative Days

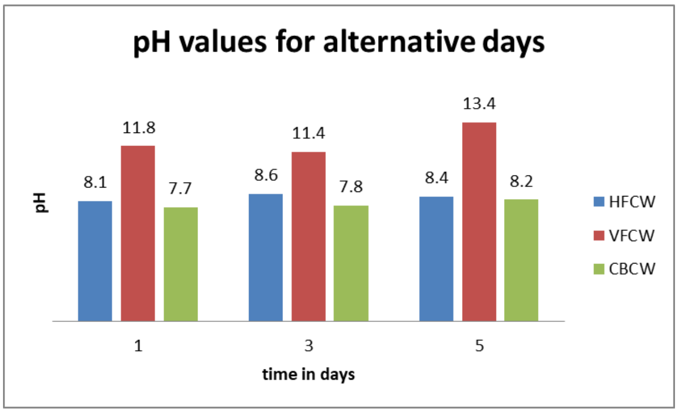

Figure 5.6 Graphical representation of pH values after treatment

5.6.2 DO

Time in days	HFCW	VFCW	CBCW
1	59.42	45.38	55.67
3	48.83	40.38	30.64
5	31.77	22.8	36.04

Table 6. DO Values for Alternative Days

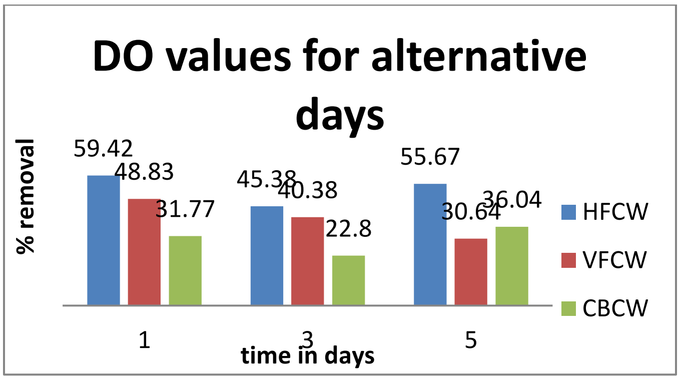

Figure 5.7 Graphical representation of DO values after treatment

5.6.3 BOD

Time in days	HFCW	VFCW	CBCW
1	59.24	75.77	83.78
3	32.3	39.73	39.06
5	30.57	72.21	92.56

Table 7. BOD Values for Alternative Days

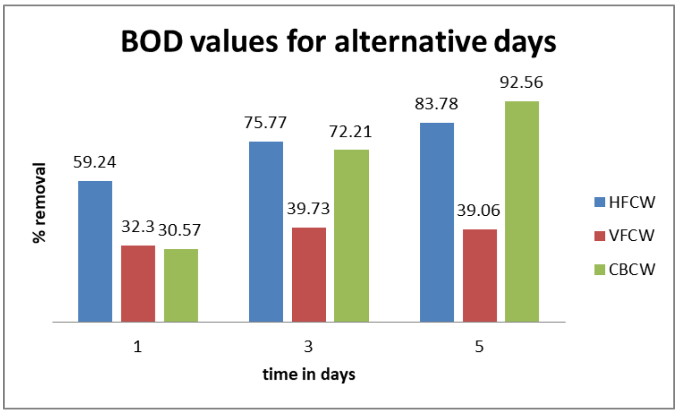

Figure5.8 Graphical representation of BOD values after treatment

5.6.4 COD

Time in days	HFCW	VFCW	CBCW
1	59.24	75.55	18.13
3	32.3	39.73	47.12
5	18.13	39.06	73.91

Table 8. COD Values for Alternative Days

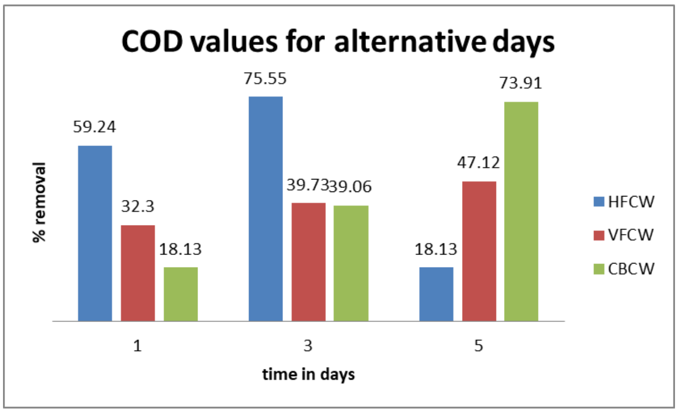

Figure 5.9 Graphical representation of COD values after treatment

6. Conclusions

Constructed wetlands have evolved over the past five decades as a reliable treatment technology applicable to all types of wastewater, including sewage, industrial and agricultural wastewater, landfill leachate and storm water runoff.

Constructed Wetlands require very little or no energy input and, therefore, the cost of operation and maintenance is very low compared to conventional treatment. systems.

Both VFCW and HFCW substantially reduced the parameters like pH, turbidity, DO, BOD and COD for domestic wastewater at reasonable levels.

The entire treatment process is affected by vegetation, sand leveling and surface interactions.

HFCW showed better removal efficiency compared to VFCW.

CBCW has shown good efficacy in treating domestic wastewater but the discharge efficiency has also risen in HFCW.

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