

# Wastewater Treatment by Construction of Wetlands

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**Abstract:** The water quality on earth is depleted due to over-increasing human development activities that over-exploit and affect the quality and quantity of water resources. The rapid growth of development activities has resulted in the pollution of freshwater bodies due to the mixing of domestic waste, sewage, industrial waste, etc. There are many conventional methods to treat wastewater. Despite using conventional methods, there is a way to treat wastewater naturally by using constructed wetlands. The main principle of constructed wetland is Root Zone Technology. It is one of the low-cost and eco-friendly methods to treat wastewater. This treatment system is a natural method to treat domestic and industrial effluents effectively. The construction of a wetland is developed by placing a substrate of soil, sand, aggregate and additionally, a layer of coal, respectively. On the top layer, canna indica plants are planted. When the wastewater passes through the top and intermediate layers, all the suspended solids, pollutants and other nutrients will get trapped in the soil and sand and the remaining pollutants will be removed with the help of bacteria. Some physico-chemical parameters, namely Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), Total Dissolved Solids (TDS), Phosphates, Nitrate, Odour and Colour were analyzed using standard methods. The results obtained indicate that the root zone system works effectively in treating domestic wastewater and can be used for other purposes. There are many advantages to using this technology owing to its easy installation, low maintenance, economical and benefits as compared to costly conventional treatment systems. The raw waste water and treated water were collected and tested for their physico-chemical parameters.

## 1. INTRODUCTION

Water is one of the most important resources in the world. Earth is covered with 97% of salt water, 2% of water is in the form of icebergs and ice caps and less than 1% of water is available as fresh water .We are using fresh water for drinking and also for other purposes. The important water bodies on the earth are polluted due to releasing of wastewater (sewage, domestic, industrial) directly into the water bodies. To reduce the pollution of water bodies we have to take some precautionary measures.

Water treatment processes are best enough to treat the wastewater, but conventional treatment plants are very costly. Constructed wetlands are one of the best techniques to treat wastewater. This process is very effective in treating domestic wastewater, industrial waste and also agricultural wastewater. The treated water is further used for other purposes like toilet flushing, horticulture and agriculture.

### 1.1 Objectives

- The main objective of wetland construction is to remove the impurities from the wastewater (suspended solids, organic matter, pathogens, nutrients).
- To reduce the effects of wastewater into groundwater.
- To test the quality of treated water by using constructed wetlands for other beneficial uses.
- Provide a cost-effective and environment friendly alternative to conventional wastewater.
- Wetlands helps to mitigate floods by absorbing and slowing down excess water during heavy rainfall or storms, reducing the risk of downstream flooding.
- Wetlands stabilize shorelines and prevent soil erosion by trapping sediments, reducing the impacts of waves and currents.
- Wetlands contribute to groundwater recharge by allowing water to percolate into the ground.

## 2. MATERIALS

### 2.1.MATERIALS USED IN CONSTRUCTION OF WETLANDS

The construction of wetlands typically involves a combination of natural and engineered materials. Common materials include clay liners, gravel, sand and native vegetation. These elements help to create the necessary conditions for water filtration, habitat development and overall wetland functionality.

### 2.2 PLANTS

Vegetation plays an important role in wastewater treatment in wetlands. Plants provide a substrate for micro-organisms, which are the most important processors of wastewater contaminants. The most commonly used plants in Constructed Wetlands are natural wetland plants, including *Cyperus papyrus*, *phragmites Australis*, *Typha* and *Scirpus*.

### 2.3 SUBSTRATES

Substrates used for CWs include soil, sand, gravel crushed rock, other natural materials, as well as organic materials. They act as the growing medium of macrophyte plants, support biochemical and chemical transformation, provide sites for removed pollutants and allow the movement of wastewater. Instead of natural material substrates, there are industrial by-product substrates such as slag, fly ash, coal cinder, alum sludge and artificial product substrates such as activated carbon, lightweight aggregates and compost. Coarse sand is considered the most suitable substrate.

#### 2.3.1 Sand

Sand substrate is commonly used in the construction of wetlands due to its permeability and ability to support vegetation. The sand provides a stable foundation for wetland plants, allowing their roots to anchor securely while facilitating water filtration drainage. Additionally, sand substrates contribute to nutrient cycling within the wetland ecosystem. They play a crucial role in creating diverse microhabitats that support a variety of organisms. The permeable nature of sand also helps maintain proper water levels and promotes oxygen exchange, fostering a healthy wetland environment.

#### 2.3.2. Coarse aggregate

In the construction of wetlands, coarse aggregates may also be used in addition to sands, especially in certain types of wetland construction such as constructed wetland cells or engineered wetland systems. Coarse aggregates serve various purposes in wetland construction and are typically chosen based on factors such as porosity, stability and compatibility with the wetland ecosystem.

#### 2.3.3. Coal

Coal is one of the best known carbonaceous raw materials that can act as a potentially low-cost adsorbent material for toxic water contaminant. From its chemical composition, coal is made of carbon in addition to other elements as hydrogen, oxygen, Sulphur and nitrogen. Surface modification of coal can lead to the production of various modified forms

of higher Water sample before treatment adsorption capacity.

In this study, Coal slag was selected as the supporting material in CWs because it has high porosity thereby preventing water clogging in CWs and large amounts of Fe, Al and Ca, suggesting a high potential for sorption. Recycling of CS, an industrial by-product, in wastewater treatment helps reduce its environmental concern.

Because of high content of carbon of this project it has high resistance to various chemicals and high physical strength so that it is widely used for city and industrial water purification. In the process of constructed wetlands coal makes the water cleaner by acting like a sponge that traps particles.

### 2.4. METHODOLOGY OF CONSTRUCTED WETLAND

#### 2.4.1 Construction of tanks

The construction of tanks was done by following works such as site selection, site clearance, layout marking and excavation as shown in the fig 2.1 below.



Fig 2.1: Site selection, layout marking, excavation

#### Inlet tank

##### 1. Details of feed tank:

No. of units -1

Volume of the tank =  $L \times B \times H = 0.88 \times 0.68 \times 0.4 = 0.293 \text{ m}^3$

Area of feed tank =  $L \times B = 0.88 \times 0.68 = 0.598 \text{ m}^2$

##### 2. Details of influent pipe:

No. of units - 2

Pipe size of the feed tank = 0.025 m in dia

A valve is provided to regulate the flow in the



Fig 2.2: Construction of inlet tank

**Wetland tank**

Details of the wetland tank

No. of units -1

Volume of wetland =  $L \times B \times H = 1.24 \times 1.04 \times 0.7 = 0.90 \text{m}^3$

Area of wetland tank =  $L \times B = 1.24 \times 1.04 = 1.28 \text{m}^2$

Distance between plant to plant = 0.15m



Fig 2.3: Construction of wetland tank

**Outlet tank or Effluent tank**

No. of units - 1

Volume of effluent tank =  $L \times B \times H = 0.48 \times 0.38 \times 0.9 = 0.164 \text{m}^3$

Area of effluent tank =  $L \times B = 0.48 \times 0.38 = 0.18 \text{m}^2$

Size of the outlet pipe = 0.06 m in dia.



Fig 2.4 Construction of outlet tank

**2.4.2 Placing of substrates**



Fig 2.5: Placing a layer of coarse aggregate, sand and coal as a substrate

**Soil**

Place a layer of soil at 20cm depth for the growth of plants and also helps to trap large particles present in the wastewater.

**Canna indica**

Canna indica plays a valuable role in constructed wetlands. Its dense root system helps stabilize soil,

preventing erosion. It is often used in phytoremediation, which is the process of using plants to remove pollutants and nutrients like nitrogen and phosphorous aiding in water purification. The plant's ability to thrive in wet conditions makes it suitable for wetland environments, contributing to overall ecosystem balance.



Fig 2.6: Plantation of Canna indica

**3. RESULTS AND DISCUSSION**

**3.1. TREATMENT PROCESS RESULTS**

After undergoing the treatment process, the water has effectively purified. The treatment process follows several processes such as sedimentation, filtration, phytoremediation and nitrification. We are using different materials to treat the domestic wastewater. The treated water can be tested to check the effectiveness of the purification by wetland treatment and found to meet the required environmental standards for discharge, ensuring that it will not harm the surrounding ecosystem. The performance of the plants and materials used in the treatment process can vary based on the influent wastewater. We are using canna indica as a plant and materials such as sand, coal and coarse aggregate. Specific measurements have been used while choosing the materials.

After the treatment process, the water was tested to check the parameters of the water. Finally, the wetland treatment process succeeded in removing pollutants from the domestic wastewater. It is one of the cost-effective and natural treatment processes of wastewater and also sustainable treatment method. We have observed that the colour and odour of the water is changed which is shown in the below figure 3.1 and 3.2.

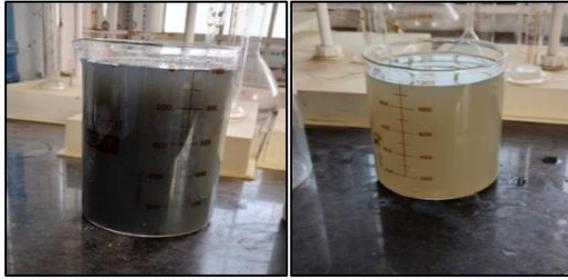


Fig 3.1: Water sample before treatment



Fig 3.2: Water sample After treatment

The quality of the water after the treatment process can be obtained by analyzing the parameters of the treated water such as pH, Turbidity, Total suspended solids (TSS), Total dissolved solids (TDS), chemical oxygen demand (COD), Biochemical oxygen demand (BOD) and nutrients such as phosphates, nitrates. We have investigated the effectiveness of the wetland treatment process to treat the wastewater. This treated water can reduce the problems faced by directly releasing the wastewater into the environment. This treatment process can easily remove the pollutants from the wastewater without using any chemicals and also produce clean water which can further be used for other purposes like toilet flushing, agriculture, horticulture, street cleaning, etc

### 3.2 Test results

Table 3.1: Water sample 1 before and after the treatment

S. No	Parameter	Before treatment	After treatment	Permissible Limits
1	pH	6.76	6.78	6.5 to 8.5
2	Turbidity (NTU)	128	11.75	1 to 5 NTU
3	Total suspended solids (mg/l)	203	120	5 to 10 mg/l
4	Total dissolved solids(mg/l)	1568	1270	5 mg/l
5	Chemical oxygen demand (mg/l)	476	210	30 mg/l
6	Biochemical oxygen demand (mg/l)	376	120	Less than 5mg/l
7	Nitrate (mg/l)	44.88	3.4	10 mg/l
8	Phosphate (mg/l)	32.76	12.5	5 mg/l
9	Coliform bacteria	144	26	<10 per 100ml

Table 3.2: Water sample 2 before and after the treatment

S. No	Parameter	Before treatment	After treatment	Permissible limits
1	pH	6.83	6.9	6.5 to 8.5
2	Turbidity (NTU)	132	10.9	1 to 5 NTU
3	Total suspended solids (mg/l)	210	122	5 to 10 mg/l
4	Total dissolved solids(mg/l)	1777	1106	5 mg/l
5	Chemical oxygen demand (mg/l)	485	210	30 mg/l
6	Biochemical oxygen demand (mg/l)	384	123	Less than 5mg/l
7	Nitrate (mg/l)	44.78	4.5	10 mg/l
8	Phosphate (mg/l)	34.56	12.3	5 mg/l
9	Coliform bacteria	147	33	<10 per 100ml

Table 3.3: Water sample 3 before and after the treatment

S. No	Parameter	Before treatment	After treatment	Permissible limits
1	pH	6.74	6.94	6.5 to 8.5

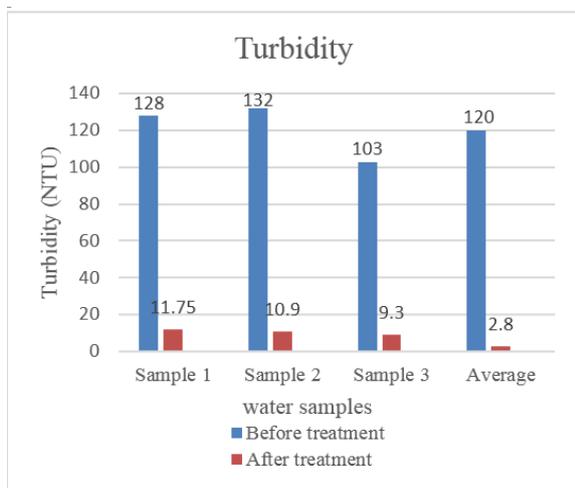
2	Turbidity (NTU)	103	9.3	1 to 5 NTU
3	Total suspended solids (mg/l)	225	135	5 to 10 mg/l
4	Total dissolved solids(mg/l)	1683	1257	5 mg/l
5	Chemical oxygen demand (mg/l)	492	212	30 mg/l
6	Biochemical oxygen demand (mg/l)	378	125	Less than 5mg/l
7	Nitrate (mg/l)	53.40	14.4	10 mg/l
8	Phosphate (mg/l)	37.5	12.3	5 mg/l
9	Coliform bacteria	145	34	<10 per 100ml

Table 3.4: Average of parameters of the water samples before and after the treatment

S. No	Parameter	Before treatment	After treatment	Permissible Limits
1	pH	6.7	6.87	6.5 to 8.5
2	Turbidity (NTU)	120	10.6	1 to 5 NTU
3	Total suspended solids (mg/l)	213	126	5 to 10 mg/l
4	Total dissolved solids(mg/l)	1676	1222	5 mg/l
5	Chemical oxygen demand (mg/l)	484	208	30 mg/l
6	Biochemical oxygen demand (mg/l)	379	122	Less than 5mg/l
7	Nitrate (mg/l)	47.68	7.4	10 mg/l
8	Phosphate (mg/l)	34.9	12.7	5 mg/l
9	Coliform bacteria	145	31	<10 per 100ml

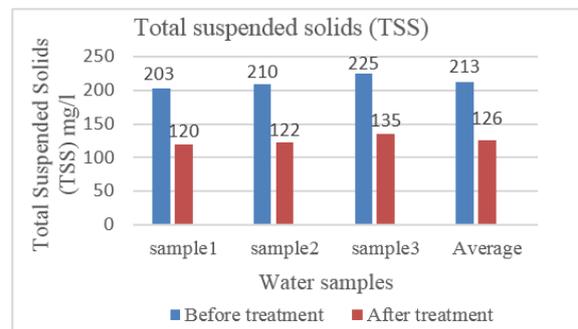
### 3.3 GRAPHICAL REPRESENTATION OF PARAMETERS

Graph 3.1 represents the value of turbidity. Before the treatment, treatment values of three are 128 mg/l, 132 mg/l and 103 mg/l. After the treatment processes the turbidity of three samples was observed 11.75 mg/l, 10.9 mg/l, 9.3 mg/l. The average value of domestic wastewater is 120 mg/l and treated water is 31.95 mg/l. The removal efficiency of water after the treatment in percentage was observed to be 90.82%, 91.74%, 90.97%. The average percentage removal efficiency turbidity was found to be 73%



Graph 3.1 Comparison of turbidity before and after treatment

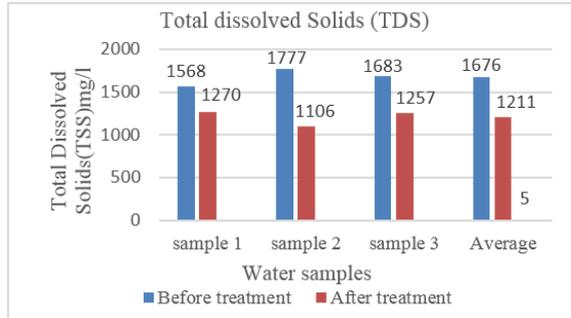
Graph 3.2 represents the values of total suspended solids. Before the treatment values of the three samples are 203 mg/l, 210 mg/l and 225 mg/l. After the treatment processes the total suspended solids of three samples was observed 120 mg/l, 122 mg/l, 135 mg/l. The average value of domestic wastewater is 213 mg/l and treated water is 126 mg/l. The removal efficiency of water after the treatment in percentage was observed to be 40.88%, 41.90%, 40%. The average removal efficiency of total suspended solids in percentage was found to be 27.7%



Graph 3.2 Comparison of total suspended solids before and after the treatment

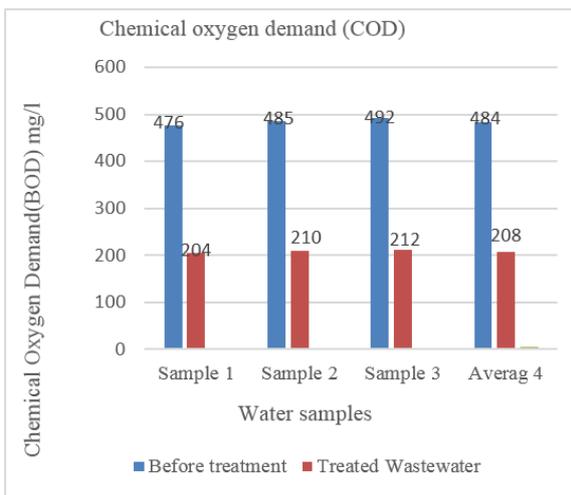
Graph 3.3 represents the value of total dissolved solids. Before the treatment process the values of three samples are 1568 mg/l, 1777 mg/l, and 1683 mg/l. After the treatment process, the total dissolved solids of three samples were observed 1270 mg/l, 1106 mg/

1, and 1257 mg/l. The average value of domestic wastewater is 1676 mg/l and treated water is 1211 mg/l. The removal efficiency of water after the treatment in percentage was observed to be 19%, 37.76%, 25.321%. The average removal efficiency of total dissolved solids in percentage was found to be 27.36%



Graph 3.3 Comparison of total dissolved solids before and after the treatment

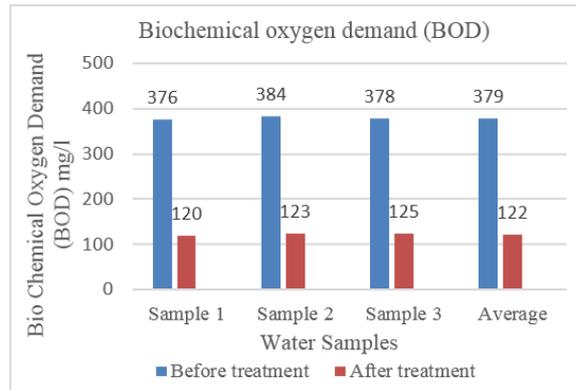
Graph 3.4 represents the value of Chemical oxygen demand (COD). Before the treatment values of the three samples are 476mg/l, 485mg/l and 492 mg/l. After the treatment process, the chemical oxygen demand was observed 204 mg/l, 210 mg/l and 212 mg/l. The average of domestic wastewater is 484 mg/l and treated water is 208 mg/l. The removal efficiency of water after the treatment in percentage was observed to be 55.80%, 37.76%, 56.91%. The removal efficiency of chemical oxygen demand in percentage was found to be 57%.



Graph 3.4: comparison of chemical oxygen demand before and after the treatment

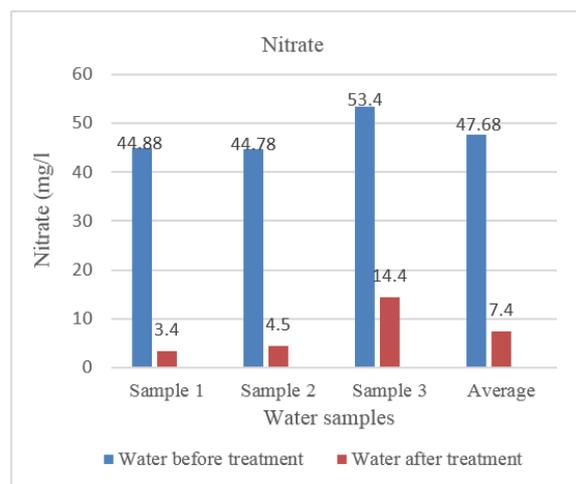
Graph 3.5 represents the value of biochemical oxygen demand (BOD). Before the treatment, the values of three samples are 376mg/l, 384mg/l, 378mg/l. After the treatment process, the biochemical oxygen demand was observed 120 mg/l, 123 mg/l and 125 mg/l. The

average of domestic wastewater is 37 mg/l and treated water is 122 mg/l. The removal efficiency of water after the treatment in percentage was observed to be 68%, 67.96%, 66.93%. The removal efficiency of biochemical oxygen demand in percentage was found to be 68%.



Graph 3.5: Comparison of biochemical oxygen demand before and after the treatment

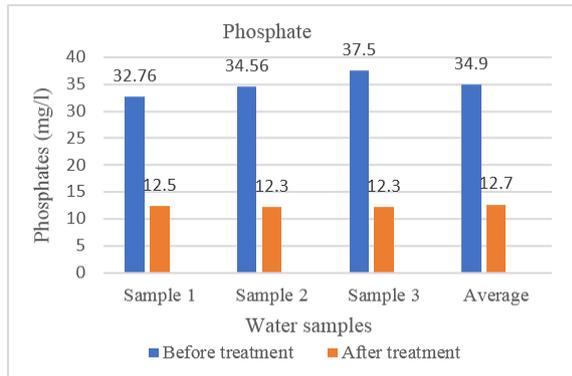
Graph 3.6 represents the value of nitrate. Before the treatment the values of three samples are 44.88mg/l, 44.78 mg/l, 53.40 mg/l. After the treatment process, the Biochemical oxygen demand was observed 3.4 mg/l, 4.5 mg/l, 14.4 mg/l. The average of domestic wastewater is 47.68 mg/l and treated water is 7.4 mg/l. The removal efficiency of water after the treatment in percentage was observed to be 92.42%, 89.95%, 73.03%. The average removal efficiency of nitrate in percentage was found to be 84%.



Graph 3.6: Comparison of nitrate before and after the treatment

Graph 3.7 Represents the value of phosphates. Before the treatment, the values of the three samples are 32.76 mg/l, 34.56 mg/l and 37.25 mg/l. After the treatment process, the phosphates were observed at 12.5 mg/l, 12.3 mg/l and 13.4 mg/l. The removal efficiency of

water after the treatment in percentage was observed to be 61.84%, 64.40%, 67.2%. The average of Domestic wastewater is 34.94 mg/l and treated water is 12.7 mg/l.



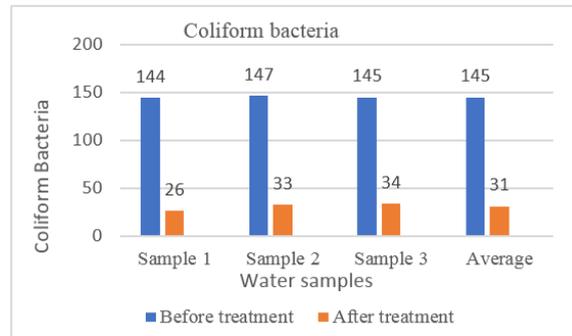
Graph 3.7: Comparison of phosphate before and after the treatment

The average removal efficiency of phosphate in percentage was found to be 79%.

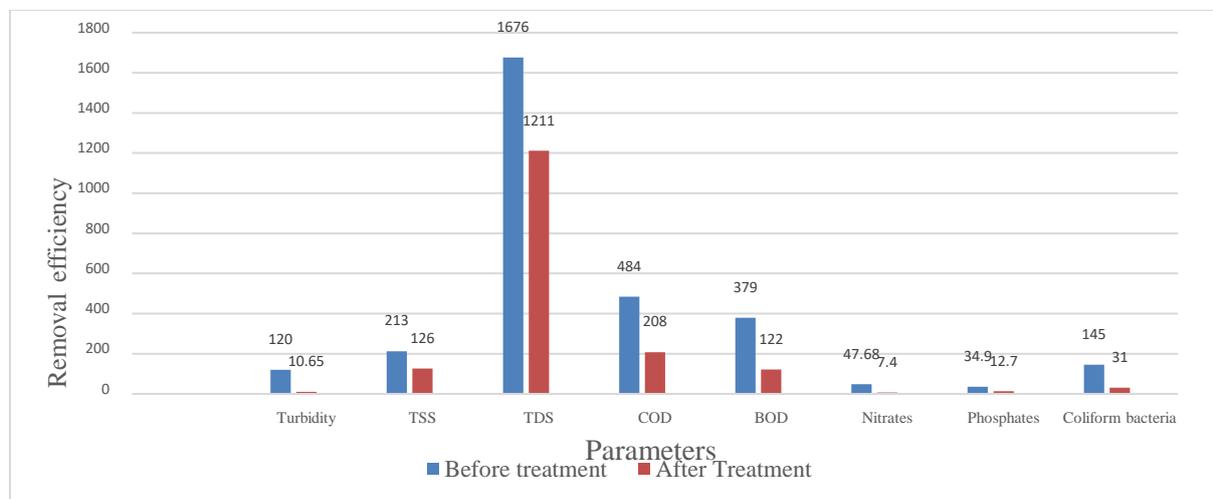
Graph 3.8 represents the value of coliform bacteria. Before the treatment, the values of three samples are

144 mg/l, 147 mg/l and 145 mg/l. After the treatment process, the coliform bacteria were observed at 26 mg/l, 33 mg/l and 34 mg/l. The average of domestic wastewater is 145 mg/l and treated water is 31 mg/l. The removal efficiency of water after the treatment in percentage was observed to be 81.94%, 77.55%, 76.55%.

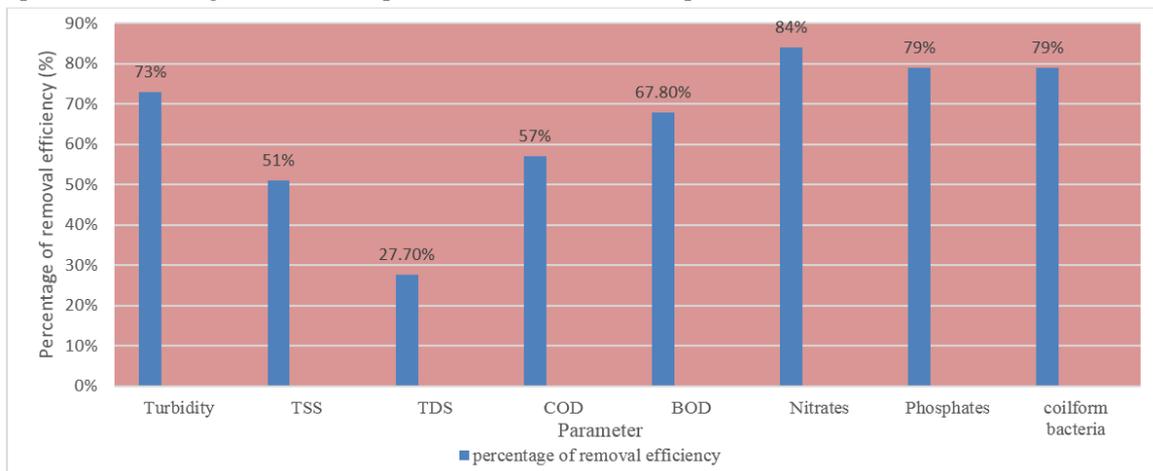
The average removal efficiency of coliform bacteria in percentage was found to be 78%



Graph 3.8: Comparison of coliform bacteria before and after the treatment



Graph 3.9: The average values of the parameters of the water samples before and after the treatment



Graph 3.10: The average removal efficiency of parameters of the water samples after the treatment in percentage

The results of the experiment showed that the methodology used for the treatment of domestic wastewater was effective in removing pollutants from the water. The total removal efficiencies are more than 60%. The removal of TDS can be slightly lower than other parameters. The treated water can be reused for various purposes like toilet flushing, agriculture and horticulture.

The comparison between the domestic wastewater before and after the treatment shows a significant reduction in the concentration of pollutants. This shows that treated water is better than the raw water

#### 4. CONCLUSION

The wastewater discharged from university girl's hostel were analyzed significantly to check the various parameters. It is observed that after the treatment pollutants such as TSS, TDS, COD, BOD, Nitrate, Phosphate and coliform bacteria were removed significantly. It is economical alternative over conventional methods. Application of constructed wetland for wastewater signifies a step towards "Green Technology". We have many other processes to treat wastewater but, it is one of the cheapest processes to treat wastewater to produce a clean water. This method undergoes several processes like sedimentation, screening, filtration, nitrification, phytoremediation. This helps to achieve the results maximum above 70%. The removal efficiency of various parameters of the water samples after the treatment resulted to be turbidity (73%), TSS (51%), TDS (27.70%), COD (57%), BOD (67.80%), Nitrate (84%), Phosphate (79%). Coliform bacteria (79%). This water can be suitable for non-potable uses

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