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"Study on Performance Evaluation of Hybrid Constructed Wetland"

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Abstract- Constructed Wetland are an engineered waste water treatment system that tries to mimic the natural biological physical and chemical processes to teat waste water. It is emerging as cost effective decentralised waste water treatment solution in the community wherethere is availability of cheap land and lack of skilled operaters Different design approaches have been followed and design parameter based on different literature have been chosen to design a subsurface flow constructed wetland .Simplified design approach well suited to climatic needs to be developed to maintain the coat effectiveness of system. The kinetic parameters are involved in the treatment should be selected properly in order to get effective design of system. In Nepal constructed wetland are becoming popular method of water water treatment in decentralised waste water treatment plants as these systems are well suited for small community where land is expensive. Constructed treating domestic, industrial and agricultural wastes. It is an engineered method of purifying wastewater as it passes through artificially constructed wetland area. It is considered as an effective and reliable secondary and tertiary treatment method. The wetland is a natural maintenance free system where the sewage wastewater is purified by the roots of wetland plants. The wetland process functions according to the law of nature, to effectively purify domestic and industrial effluents. The process incorporates the self-regulating dynamics of an eco-system. Application of wetland is finding wider acceptability in developing and developed countries, as it appears to offer more economical and ecologically acceptable solution to water pollution management problems.

CW can be operated as subsurface flow constructed wetland (SSFCW) in which water level remains below the surface of wetland media and free water surface constructed wetland (FWSCW) in which water surface exposed to atmosphere. According to the flow direction, SSFCW further classified as horizontal flow subsurface constructed wetland (HFSSCW) and vertical flow subsurface constructed wetland (VFSSCW).

***Keywords-* Constructed wetland, grey water, organic, Sub surface flow.**

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1. INTRODUCTION

The term wetland encompasses the life interactions of various species of bacteria, the root of the wetland plants, soil, air, sun and of course, water. Wetland is one of the natural and attractive methods of The HFSSCW and VFSSCW have their own advantages and disadvantages. These systems can be operated in two stage or multistage with various combinations to counterbalance the disadvantages of one type with advantages of the other. Such systems with various combinations of HFSSCW and VFSSCW connected in series falls under the category of Subsurface Flow "Hybrid Constructed Wetlands" (SSFHCW).

2. CONCEPT OF CONSTRUTED WETLAND :-

CW is sealed filter beds consisting of a sand / gravel / soil system, occasionally with a cohesive element, planted with vegetation which can grow wetlands. After removal of coarse and floating material the wastewater passes through the filter bed where biodegradation of the wastewater takes place. The Wetlands have been "engineered" and "constructed" for one or more of the following reasons:-

Constructed habitat wetlands:- These are the wetlands that are constructed to compensate for and help offset the rate of conversion of natural wetlands resulting from agriculture and urban development.

Constructed flood control wetlands:-These wetlands are constructed to act as a flood control facility.

Constructed aquaculture wetlands:-Wetlands that are constructed to be used for production of food and fiber.

Constructed treatment wetlands:-Wetlands that are constructed to act mainly as a wastewater treatment system and to improve water quality.

2.1. REVIEW OF PRESENT STUDY :

Though constructed wetlands are already being used in many parts of the world for various functions, it is their wastewater treatment capabilities that has attracted researches for a wide range of applications including treatment of domestic wastewater, industrial/agricultural flows, landfill leachates, etc. Constructed wetlands for other than treatment and water quality improvement functions will be described briefly, before detailing the constructed treatment wetlands

A)I. Machado et al (2016) In this research study, we learned that Conventional wastewater treatment plants commonly require large capital investments as well as operation and maintenance costs. Constructed wetlands appear as a cost-effective treatment, since they can remove the contaminants by the combination of physical, chemical and biological processes with a low cost. Therefore, CWs can be successfully applied for decentralized wastewater treatment in regions with low population density and/or with large land availability as Brazil. The present work provides a review of thirty nine studies developed on CWs implemented in Brazil to remove wastewater contaminants. Brazil current sanitation data is also considered to evaluate the potential role of CWs as decentralized wastewater treatment. Performance of CWs was evaluated according to

(i) type of wetland system, (ii) different support matrix vegetation species and (iv) removal efficiency of chemical oxygen demand (COD), biological oxygen demand (BOD5), nitrogen (N), and phosphorus (P). The reviewed CWs in overall presented good efficiencies, whereas H-CWs achieved the highest removals for P, while the higher results for N were attained on VF-CW and for COD and BOD5 on HF-CW. Therefore, was concluded that CWs are an interesting solution for decentralized wastewater treatment in Brazil since it has warm temperatures, extensive radiation hours and available land. Additionally, the low percentage of population with access to the sewage network in the North and Northeast regions makes these systems especially suitable. Hence, the further implementation of CW is encouraged by the authors in regions with similar characteristics as Brazil. [1]

3. OBJECTIVES

The aim of this small-scale pilot project is to study the effectiveness of the Hybrid Constructed Wetland and also incorporated by planting two different species such as *Cana Indica & Typha* in the treatment of grey water generated in the hostel building

1. To analyze and characterize the waste water.
2. To study the chemical and physical characteristics of the collected waste water.
3. To design and develop laboratory scale multispecies vertical flow constructed wetland system.
4. To carry out performance evaluation of developed system for restaurant wastewater treatment.

4. SCOPE OF WORK

Literature review shows that various studies were carried out for different operational modes, different configurations with varying HRT's and organic loading rates to treat wastewater. The SSFCW are most suitable for oxygenation of support media which improves removal of organic matter and nitrogen. For effective treatment of domestic wastewater, upper 40 cm supporting media layer plays significant role for different organic loading rates and HRT's. The artificial aeration and recirculation of treated wastewater effectively reduce the HRT and surface area of HFSSCW and VFSSCW by compromising the operational and maintenance cost of treatment. The various modified configuration in CW's are responsible for enhancement of nitrification and de-nitrification to remove total nitrogen. Among the various modes of operations the fill and drain operation mode is more suitable for atmospheric reaeration of supporting media and ultimately improve the pollutant removal efficiency of CW.

The present literature review shows that limited work was done on configuration modification to reduce the area requirement for VFSSCW for greywater treatment as the possible contributions to existing work on VFSSCW include use of multispecies, shallow depth, staged units, modifications to system, enhanced aeration, and operational changes. The present study that is Hybrid Constructed Wetland focuses on the modification of configuration of to treat grey water to enhance organic matter removal. In this one-stage pilot model of constructed wetland will be evaluated for batch mode.

5. COMPONENTS OF SSFHCW

Sub-surface Flow Hybrid Constructed Wetland

The important components of constructed wetland systems are vegetation, substrate material, inlet & outlet arrangement and bottom Liner. The two major components of VFSSCW,

i.e. vegetation and substrate material are discussed below.

5.1 .Vegetation in SSFHCW:

Vegetation is the most important components in SSFHCW systems. Wetland vegetation grows in semi-saturated or in fully saturated water conditions. In order to be suitable for use in CWs, the selected macro-phytes should meet the following criteria

1. They should be well adapted to the local ecological conditions.
2. They should be tolerant against a variety of pollutants present in wastewater.
3. They should be easily available in the local area.
4. They should transport efficient oxygen into the constructed wetland
5. They should have maximum absorption capacity of nutrients

The vegetation that are most often used in this constructed wetlands are such as bulrushes (Scarps), spikerush (Efeocharis), and common reed (Paragonites), and Typha. All wetland species are not suitable for wastewater treatment. Plants for treatment wetlands must be able to tolerate the combination of continuous flooding and exposure to wastewater containing relatively high and often variable concentrations of pollutants (USDA-NRCS and US EPA).In VFSSCW or HFSSCW Common reeds (Phragmites Australis) are more often used followed by cattails (Typhalatifolia) (Vymazal et al., 1998).

5.2Role of vegetation in SSFHCW

CW vegetation provides series of benefits and contributes to the creation of the necessary conditions which directly or indirectly affect the system efficiency. Some of the major effects are discussed below (Tanner, 1996):

Physical Effects: The deep, complex, and extended root system within the substrate contributes to the water velocity deceleration, which increases the contact time between the Grey water and the substrate media and the roots, as it moves vertically through the SSFHCW bed.

Hydraulic conductivity: The movement of the stems and the respective crack creation is also beneficial for the vertical permeability of the bed, which improves the hydraulic conductivity.

Bio-film development: The extensive and dense root system of plant species that gradually develops within the substrate layer functions as an attractive attachment area for the microbial population.

Oxygen supply: The presence of plants ensures the enhanced aeration of the bed. These Plants are capable of absorbing oxygen from the atmosphere through their leaves and same time transferring it to the deeper layers of the substrate via release from their roots. This oxygen provided by the roots is then consumed by the aerobic micro-organisms in the bio-film and enables various

Aerobic processes (e.g., nitrification, aerobic degradation of OM).

Direct constituent uptake: Vegetation planted in CW directly uptake various constituents present in wastewater for,e.g.heavymetals.

6.WETLAND MEDIA IN SSFHCW

Sub – surface Flow Hybrid Constructed Wertland

The selection of the substrate predominant part in a SSFHCW system represents a very important design parameter which might significantly affect the performance of the bed. The synergetic effects of sufficient pore volume and gradual development of plant roots manage to maintain the hydraulic conductivity of the bed. Typical range values for the effective sizes (d50) for substrate media found in the literature are: sand 4.5 mm, fine gravel 10 mm, medium gravel 20 mm, and Brickbats 30-45 mm. In the past, soil was almost exclusively used as filter media in SSFCW. This practice, however, often resulted in clogging problems due to the relatively low hydraulic conductivity of this material.

Today, if we see most of the systems contain of different kinds and origins as filter media, usually with a top layer of sand. The presence of gravel offers a series of benefits, which could be summarized as follows as:

1. It supports the growth of the planted macro-phytes.
2. It stabilizes the bed (interaction effects with developed plant roots).
3. It provides filtration effects.
4. It ensures a high permeability, i.e., hydraulic conductivity, for the unhindered downward passage of the wastewater (assuming an appropriate pore volume), thus diminishing the appearance of possible clogging problems.
5. It enhances the treatment efficiency, acting as a sink of various biotic and a biotic elements.
6. It provides an attractive attachment surface area for various microorganisms (bio-film creation) which are involved in the pollutant removal processes.
7. It supports several transformation and removal processes, which can be enhanced by using specialized materials.

The media was tested or proposed for use in CWs in general and, particularly in VFCWs can be classified as (Alexandros, 2014):

1. Natural materials: These are naturally occurring materials that can be used without any or only with a slight pretreatment, e.g., Minerals, rocks, marine sediments, sands, crushed marble, shale etc.
2. Synthetic (man-made) materials: These are materials that are produced in the laboratory or by various treatment processes, e.g., Synthetic zeolites, Vermiculite, Calcite etc.

7. PROCEDURE

- *Inlet zone :*

The primary criterion for design of inlet structure was discharge which was expected to be uniform along the entire width. A 25 liter container was used to provide a continuous flow of greywater through the inlet with natural aeration by allowing grey water to dripping on surface of beds.

Fig 1.Pilot scale Hybrid Constructed Wetland

- *Wetland cell :*

The pilot wetland unit consisted of a PVC container of diameter and depth of 40 cm and 52 cm, respectively (fig1.1)

The media consist of a bed underlain by a permeable layer of filters. Bed was filled to height of 40 cm with sand of size 4.75 mm, aggregates of size 10-20 mm and brickbats of size 30-45 mm and a layer of coalon bed of VSSFCW. The mediacharacteristics are presented in Table fig 2.

Fig 2 Media Characteristics

Table 1..Media Details

SR. NO.	TITLE	EFFECTIVE SIZE (MM)	DEPTH (MM)
1	SAND	4.75	50
2	AGGREGATE	10 -20	100
3	BRICKBATS	30-45	150

- *Vegetation* :

The plants such as "Canna Indica & Typha", are local wetland species, was used in the study. The plants were collected from a nearby lake and planted in the wetland unit. They were used to increase the residence time of water by reducing velocity so as to increase sedimentation of the suspended particles as well as to add oxygen and provide a physical site for microbial bioremediation. The plants had been used to remove suspended solids, nutrients, heavy metals, toxic organic compounds and bacteria from acid mine drainage, agricultural landfill and urban storm water runoff as well as grey water.

8.DESIGN GUIDENCE AND DESIGN PARAMETER:

Hybrid Constructed wetlands are treatment systems that provide for removal of pollutants through a variety of mechanisms. While at first glance, these mechanisms seem simplistic; the interaction between each mechanism can become complex. Models have been developed that try to identify how each mechanism interacts however these models can become complex very quickly. So, the design of constructed wetlands focuses on determining detention time, required surface area, loading rates and medium and water depth. This manual is written under the assumptions of design populations of 25, 150 or 250 people. Given these constraints, Influent wastewater flow and biological load can be determined. This flow rate is acceptable for use when determining sizes of both SF and SSF constructed wetlands.
The following will discuss the steps taken to complete a constructed wetlands design.

8.1 Design Process Overview:

The general process used by this manual to design a constructed Wetland in accordance with the following steps:
1.Determine design requirements:
a.Characterize design flow rates
b.Characterize influent wastewater makeup
c.Determine effluent discharge location and limits
2.Determine Water balance Limitations:
a.Determine Precipitation (SF Wetlands)
b.Determine Evaporation (SF Wetlands)
c.Determine Outfall
3.Size Pretreatment Unit
a.Septic Tank Size, number and layout
4.Surface Flow Wetland Design
a.Select size by loading rate
b.Determine Configuration
c. Apply Safety Factor
d. Determine Water Depth
e. Integrate an Aspect Ratio
f. Determine Hydraulic Retention Time
g. Prepare Hydraulic Design
h. Apply Open Water/Vegetation Ratio
i. Determine Depth of Media and Gradation
j. Layout settling Zone
k. Design Inlet and Outlet Structures
5.Subsurface Flow Constructed Wetland Design
a. Select Size by Loading Rate
b. Determine Configuration
c. Determine Media Depth and Gradation
d. Apply Safety Factor
e. Determine Maximum Water Depth
f. Determine Hydraulic Conductivity
g. Determine Minimum Cell Width
h. Integrate Freezing Concerns
i. Design Inlet and Outlet Structures

8.2 DESIGN PARAMETER

The following important factors are to be considered while designing a SSHCW for domestic sewage treatment such as surface area, OLR, HLR, HRT, Depth of wetland media, Porosity etc. are discussed below.

Surface area :

The surface area requirement for the treatment of wastewater in constructed wetland can be calculated from equation (EPA UNITED STATES, 2000)

$$A_h = \frac{Q_d(\ln C_i - \ln C_e)}{K_{BOD}}$$

Where,

A_h = Surface area of bed (m^2)

Q_d= average daily flow rate of sewage (m^3/d)

C_i= influent BOD5 concentration (mg/l)

C_e= effluent BOD5 concentration (mg/l)

K_{BOD} = rate constant (m/d)

KBOD is determined from the expression KTdn, where,

$$K_T = K_{20}\ (1.06)^{(T-20)}$$

K_{20} = rate constant at 20 °C (d^{-1})

T = operational temperature of system (°C)

d = depth of water column (m)

n = porosity of the substrate medium

KBOD is temperature dependent and the BOD degradation rate generally increasesabout10 % per oC. Thus, the reaction rate constant for BOD degradation is expected to be higher during summer than winter. It has also been reported that the KBOD increases with the age of the system.

Organic and Hydraulic loading rate (OLR and HLR):

Although the parameter of unit area requirement m2/pe (population equivalent) is widely used for the design of CW, it is not fully sufficient. In fact, it only gives a very good indication of the area demands for the system at the preliminary design level.

Hydraulic Retention time (t):

The hydraulic retention time directly affects the organics, nutrients and pathogens removal efficiencies of CW systems. The HRT of CW system can be given as in UN- HABITAT, 2008),

$$t = \frac{nLWd}{Q}$$

Where,

t = Hydraulic retention time (HRT).
n = Effective porosity of media in (%).
L = Length of bed (m).
W = Width of bed (m).
d = Average depth of liquid in bed (m).
Q = Average flow through the bed (m^3/d).

Depth:
The depth of substrate in a SSFCW is strictly restricted to the rooting depth of plants so that the plants are in contact with the flowing water and have an effect on treatment. However, Hydraulic Retention Time (HRT) is to be considered in the selection of the depth of the wetland.

HFSSCW have commonly been designed with beds 30 cm to 45 cm deep as per design consideration and VFSSCW systems are built with larger depths compared to HFSSCW systems. It is recommended to use substrate depth of 70 cm for VFSSCW, which can provide adequate nitrification in addition to the organic pollutants removal.

Porosity:
Porosity of wetland media should be in range between 0.30-0.35 for effective treatment of wastewater so to avoid the clogging problem of wetland media. In early day's sand is used as wetland media in most of CW system having the porosity range between 0.26-0.28, but it has a problem of bed clogging and replacement of such bed is major challenge. The use grit, fine gravel etc. is then explored to avoid such problem. The hydraulic conductivity of wetland media is depending upon the porosity of wetland media. The porosity is also governing by the development of roots planted vegetation over the entire wetland media.

9.DESIGN OF PILOT MODEL OF CONSTRUCTED WETLAND

- *Surface Area:*

$$Ah = \frac{Qd(\ln Ci - \ln Ce)}{KBOD}$$

$$0.1075 = \frac{Qdx(\ln 512 - \ln 200)}{0.123}$$

Qd = 0.014 m3/d

- *Porosity:* n = (volume of void's/total volume) x100 = [volume occupied by water/(0.1075 x0.4)] x 100

= (0.014/0.043) x100
=32.55%

- *Hydraulic Retention Time:*
  t = nLWd/Q Where,

t =Hydraulic retention time (HRT) n=Porosity of Media in % =32.55%
A=LW=Area of bed in m2 =0.1075m2
d =Average depth of liquid in bed in m = 0.4m
Q=Average flow through the bed in cub.m/day
=0.014cub.m/day t = (0.3255x0.1075x0.4)/0.014
t = 0.99days i.e 24 hr

- *Organic Loading Rate:*

O.L.R. = (Q x Ci)/A
= (0.014 x 512)/0.1075
= 66.67 cub.m/day

- *Hydraulic Loading Rate:*

H.L.R = Q/A
= 0.014/0.1075
= 0.130 m/day.

10.OPERATION AND MAINTENANCE INFORMATION

A constructed wetland has a limited number of operational controls compared to mechanical treatment systems. Wetland systems respond to system changes much more slowly than other mecha.nical wastewater treatment systems. In some instances if poor operational decisions kill all of the emergent plants in an SF constructed wetlands, it may take one or more growing seasons (after replanting) to reestablish a plant canopy (WERF,2006).Proper operation and maintenance can dramatically prolong the life of and affect the performance of a constructed wetland system.

10.1Operation and Maintenance Concerns Operation of constructed wetlands is mostly passive and therefore requires little operator input. Operational concerns are similar in nature to a controlled discharge lagoon. The following are the most critical items in which operator input is necessary (US EPA, 2000):

- Adjustment of water levels
- Maintaining uniformity of flow
- Management of Vegetation
- Odor Control
- Control of nuisance pests and insects

1.Water level adjustment
The water level changes will effect hydraulic retention time, atmospheric oxygen diffusion into the water and plant cover. Observed changes in the water level should be investigated as immediately as possible, as they may be due to leaks, clogging or other issues
For SF Type constructed wetlands, the water depth is directly related to the outlet hydraulic control structure, as there are little friction losses through the wetland. A well- designed SF constructed wetland system should provide the operator with the ability to adjust the water level through the entire range of potential water level

2.Uniformity of Flow
Water is introduced into a wetland system through the inlet control device and removed through the outlet control device. Short-circuiting of a wetland system occurs when clogging or other issues create non-uniform preferential flow paths. To help mitigate against this potential, the inlet and outlet control

devices should be inspected routinely. Debris removal and bacterial slime from weir and screen surfaces is necessary. If the inlet and/or outlet manifolds are submerged, they should be flushed regularly. If short-circuiting occurs due to media fowling and solids accumulation in an SSF constructed wetlands, the media must be removed and replaced.

3.Vegetation Management
Establishing vegetation within a constructed wetland involves the planting of suitable vegetative materials at the appropriate time. Species selection for different types of constructed wetlands has been previously established. Planting densities can be anywhere from 1 to 3 feet on center. The higher the density, the more rapid the development of the system, but with an increased construction cost. If planted 3 feet on center, a wetland will take at least 2 growing seasons to approach equilibrium.

4.Odor Control
SF constructed wetlands contain anaerobic zones which release hydrogen sulfide or other compounds. As we decrease the water depth, which will increase the overall amount of dissolved oxygen within the water column may help reduce the anaerobic conditions that lead to these odors. Turbulent flow patterns at the inlet or outlet will generate additional sources of odor. Removal of turbulent flow paths, including splashing, may help to reduce this source of odor.

5.Algae Control
In SF Type constructed wetlands, filamentous algae mats may displace emergent vegetation. Low dissolved oxygen conditions under the algae mat, and lack of access to sunlight, may prevent emergent plants from growing. When this occurs, the water level can be lowered to expose the rooting media and oxidize the algae. Once the algae has been removed, the areas may be replanted

6.Mosquito Habitat
Mosquito control is required in SF constructed wetlands. Very common provisions for mosquito control within an SF constructed wetland include: stocking with mosquito fish, maintenance of aerobic conditions, biological controls and encouragement of predators (Crites and Tchobanoglous, 1998). But also it is not possible to exclude egg-laying mosquitoes from SF constructed wetlands .Therefore the goal of the system is to minimize the number of larvae that survive to become adult mosquitoes.

7.Nuisance Pests
The constructed wetlands are in open environment so there is chances of burrowing animals such as muskrats. These can seriously damage the vegetation and dikes within the constructed wetlands. This also can be avoidwd by the use of a coarse riprap, or wire mesh. The common carp is another nuisance species that can affect treatment performance Carp will uproot vegetation and disturb sediment within the wetland

8.Bed Clogging
Bed clogging within an SSF type constructed wetland is most common cause of failure. High levels of suspended solids, grease or bio-films generation in the bed media result in clogging. Also the Bed clogging can be checked by lowering the outlet structure water level to the minimum, if the water level within the SSF wetlands does not drop accordingly, the wetland is most probably plugged.

9.Recommended Minimum Operational staffing Operational staffing should be sufficient to maintain the resultant discharge and also permit and monitoring requirements established therein. Further, additional monitoring of the system must be performed to assure overall satisfactory operation of the construction wetland system.

11. RESULTS AND DISCUSSION

Range of Parameters of grey water:

Table 2
Range of Parameters

RANGE	pH=	BOD	COD	HARDN	ALKALI	ACIDI	CHLOR
PARA METE R CONC ENTR AT S	7.0-8.5	120-380	260-900	= 200	= 200	=200	= 150

Results of Grey Water Treated By Pilot Model of Hybrid Constructed Wetland.

Table 2
Test Results of Greywater

Sr no.	Retention	pH	BOD	COD	Hardness	Alkalinity	Acidity	Chloride
1	4 Hrs.	8.0	261	350	92	70	120	145
2	8 Hrs.	8.1	257	341	124	76	136	200
3	12 Hrs.	8.1	252	342	43	72	112	170
4	16 Hrs.	8.1	248	331	90	68	112	145
5	20 Hrs.	8.1	246	335	120	72	118	155

- Wastewater Remediation:

Constructed wetland is designed and the prototype model is constructed based on the standard design criteria of EPA and the it is modified as according to Indian conditions. 13 As per the APHA manual. We were analyzed for pH , BOD, COD, Alkalinity, Acidity, Chloride content, and the results were presented and their remediation in Table 7.1

- pH Results :

A hydrogen ion (pH) concentration in the wastewater is depicted in graph. During the study pH values were measured throughout the study period except when equipment failed.

The settling basin pH values fluctuated with pH values that ranged from a low of 5.5 to a high of 9.
Colour Analysis Result :

The colour of waste water at the inlet of pilot scale wetland model which is not clear, when it is taken in opaque glass and after the treatment of waste water at outlet of pilot scale model of wetland it is clearly visible or observed clearly.
The color test result is shown is below given fig. 2

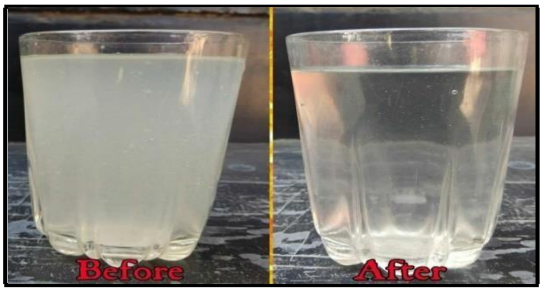

Fig 3 Colour Test

Test results in Graph Format:

1)

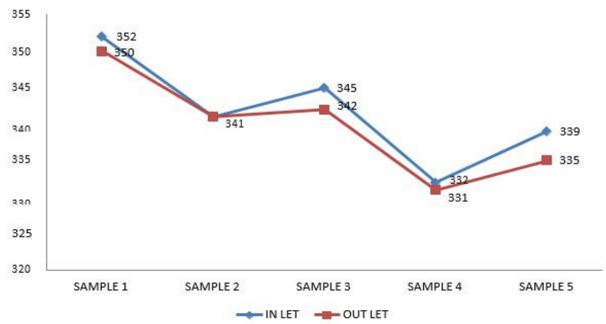

Fig.4 Chemical Oxygen Demand
(all reading in ppm)

2)

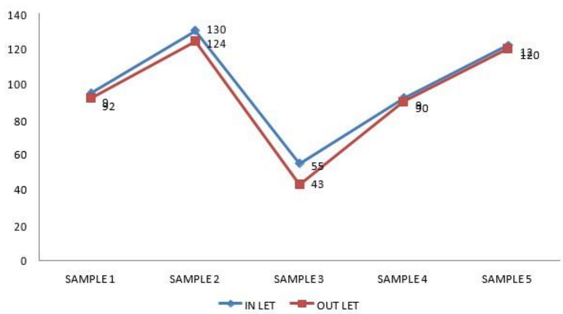

Fig.5 Hardness
(all reading in ppm)

3)

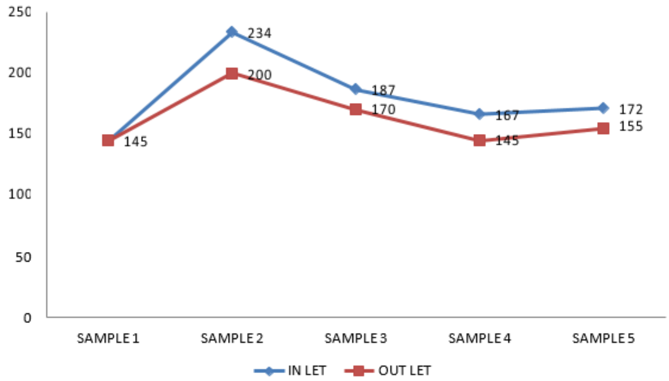

Fig.3. Chlorides
(all reading in ppm)

4)

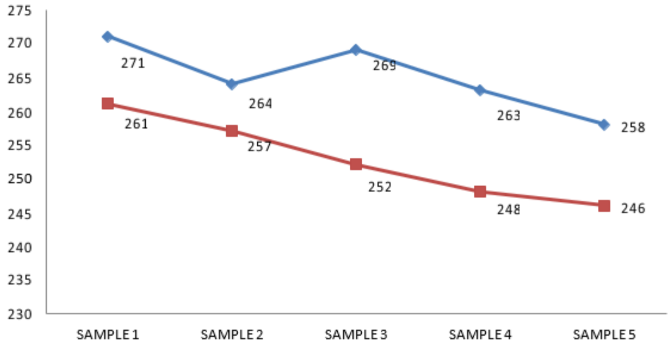

Fig 4.Bio-Chemical Oygen Demand
(all reading in ppm)

5)

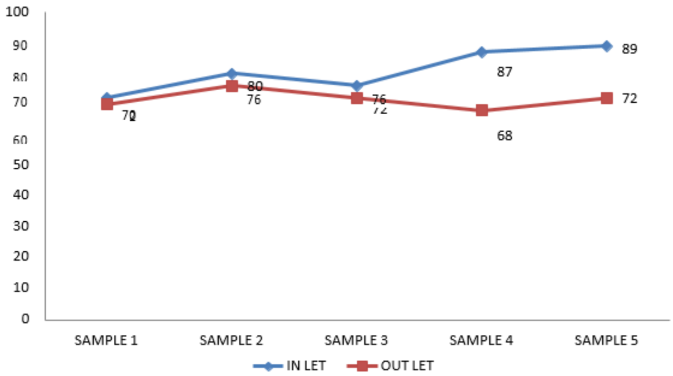

Fig 5.Alkalinity
(all reading in ppm)

6)

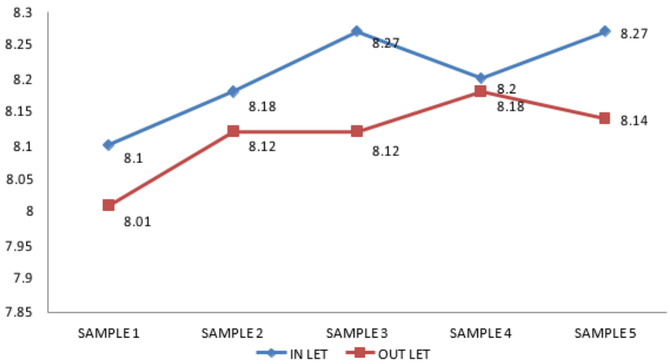

Fig. 9.Ph

7)

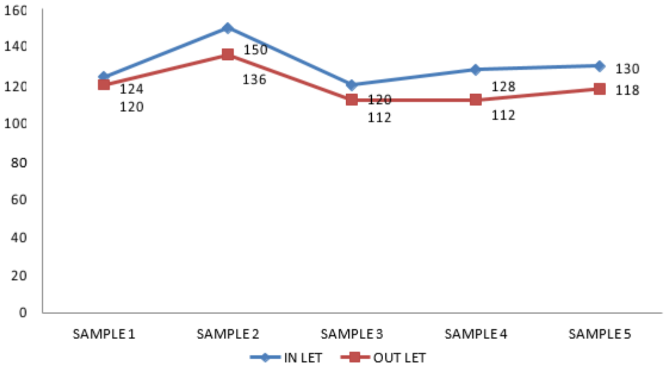

Fig. 7.Acidity
(all reading in ppm)

- ***Results:***

1) BOD Removal Efficiency =58.40%

2) COD Removal Efficiency =59.60%

3) Alkalinity Removal Efficiency=45.12%

4) Acidity Removal Efficiency=53.33%

5) Chloride Removal Efficiency=56.52%

6) Hardness Removal Efficiency=47.32%

12. CONCLUSIONS

Following are the conclusion of project work:
1) From above work we found that BOD, COD removal efficiency 58.40%, 59.60%, 81.61% & 64.02% respectively.
2) It is very economical process such as canna Indica & Typha is naturally available in abundance in nature & very Low cost material is used as it proves economical.
3) Cost Of Construction, Operation, maintenance is less & no skilled labor is required.
4) The treated water after the filtration mechanism can be used gardening, washing, firefighting, Construction, toilet flushing etc.
5) Method is suitable for rural, undeveloped areas, industry (Sugar, Pulp& Paper).
6) The cost of construction and maintenance is low as compare to other type of waste water treatment plant.
7) Constructed wetland can be effectively used for isolated households or apartments as it is compact in size**.**

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