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Treatment of Wastewater with Construction of Wetland

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Abstract: Constructed Wetlands are an alternative, promising technology for water/wastewater treatment and pollution mitigation. They belong to the wider category of natural treatment systems.
The main principle is to exploit natural materials (gravel, sand, plants) and naturally occurring processes under controlled conditions for treatment purposes. Constructed Wetlands have been characterized as an environmentally friendly, sustainable technology which provides multiple economic, ecological, technical and societal benefits. It is a rising technology which can be effectively used for domestic, municipal and industrial wastewater treatment, as also for sludge dewatering and drying. This chapter presents an overview of this eco-technology; its different types, main design considerations and various advantages over conventional treatment methods.
The theme of the project was initiated from the concept of the Constructed Wetland mechanism that can be effectively used for the treatment of waste As the constructed wetland mechanism has a wide scope to develop more than other techniques, it will be a perfect model for such kind of experimentations & the application-oriented mechanism in our college hostel in addition to the projects like energy park & the bio-gas plant. Also, it will be an ideal low-cost technology for the educational institutes to treat their waste in better manner.

I. PROJECT OBJECTIVES

A. Cost efficient in terms of construction, operations and maintenance.
B. Effectively treats wastewater from human waste and storm water.
C. Uses technology that is simple to understand and manage.
D. Low energy consumption required for operations.
E. Assists in maintaining groundwater and surface water levels
F. Contributes to environmental protection by providing a habitat for plants and animals.

II. INTRODUCTION

A constructed wetland (CW) is an artificial wetland to treat sewage, greywater, stormwater runoff or industrial wastewater. 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 provide secondary treatment to wastewater. The design of the constructed wetland has to be adjusted according to the type of wastewater to be treated. Constructed wetlands have been used in both centralized and decentralized wastewater systems. Primary treatment is recommended when there is a large amount of suspended solids or soluble organic matter (measured as BOD and COD).

Similarly, to natural wetlands, constructed wetlands also act as a biofilter and/or can remove a range of pollutants (such as organic matter, nutrients, pathogens, heavy metals) from the water. Constructed wetlands are designed to remove water pollutants such as suspended solids, organic matter and nutrients (nitrogen and phosphorus). All types of pathogens (i.e., bacteria, viruses, protozoan and helminths) are expected to be removed to some extent in a constructed wetland. Subsurface wetland provides greater pathogen removal than surface wetlands. 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.

III. LITERATURE REVIEW

A. Paper 1

This paper proposes the Constructed wetlands (CWs) are a low-cost technology that has been used to treat various types of wastewaters for nearly twenty years.

They are an attractive treatment option because they use solar energy, are simple to construct and operate, have low maintenance cost and are inexpensive and sustainable compared to conventional treatment methods . The water quality improvement observed depends on the wetland design, microbial community, and the different plant species involved.

Constructed wetlands are artificial systems that have been designed to operate as natural wetland ecosystems to improve wastewater treatment efficiency. These systems generally fall into two general categories: a) subsurface flow system wetlands, and b) free water surface systems. In recent years, constructed wetland technology has been based on three basic types of CWs: a) free water surface

B. Paper 2

The objective of this paper is to present the state of the research activities on the application of constructed wetlands for the removal of pharmaceutical contaminants from wastewater. The review focuses on the application of constructed wetlands as an alternative secondary wastewater treatment system or as a wastewater polishing treatment system. The design parameters of constructed wetlands Y. Li et al. / Science of the Total Environment 468–469 (2014) 908–932 909 were summarized to provide an understanding about the target pharmaceuticals, configuration, hydraulic mode and vegetation species of the reported constructed wetlands. The removal efficiencies of pharmaceuticals in constructed wetlands were also summarized in this paper in order to evaluate the performance of constructed wetlands in a macroscopic level. In addition, the possible removal mechanisms of pharmaceuticals related to the three important components of constructed wetlands (substrate, plants and microbes) were analyzed. The overall goal of this paper aims to be able to offer help for the further research in future.

C. Paper 3

This paper is intended to provide a quantitative case study review that evaluates the ability of constructed wetlands to treat GW for reuse at the house, school, neighborhood or commercial building scale. Of particular concern is the ability of treated effluent to meet the most advanced standards or guidelines for non-potable reuse, which are mainly driven by pathogen-related human health risk (Beck et al., 2013; NAS, 2016). In order to address the limited availability of specific pathogen removal data, the ability of wetlands to meet physical or chemical criteria that directly influence pathogen removal dynamics was reviewed. In addition, a quantitative review of common disinfection technologies appropriates for treating wetland effluent was performed with an emphasis on studies that disinfected treated GW.

D. Paper 4

This paper discusses the Wetlands have been recognized to be a natural resource throughout human history. Their importance is appreciated in their natural state by such people as the Marsh Arabs around the confluence of the rivers Tigris and Euphrates in southern Iraq, as well as in managed forms, for example rice paddies, particularly in South East Asia . The water purification capability of wetlands is now being recognized as an attractive option in wastewater treatment. For example, the Environment Agency has recently spent more than £1m on a reed bed scheme in South Wales.

This system is designed to clean up mine water from the colliery on which the constructed wetland and associated community park is being built. Reed beds provide a useful complement to traditional sewage treatment systems.

They are often a cheap alternative to expensive wastewater treatment technology such as trickling filters and activated sludge processes . Vertical-flow and horizontal-flow wetlands based on soil, sand and/or gravel are used to treat domestic and industrial wastewater .

They are also applied as passive treatment of diffuse pollution including mine wastewater drainage as well as urban and motorway water runoff . Furthermore, wetlands serve as a wildlife conservation resource and can be seen as natural recreational areas for the local community . The functions of macrophytes within constructed wetlands have been reviewed previously. Phragmites sp., Typha sp. and other swamp plants are widely used in Europe and Northern America . A considerable amount of work on constructed wetlands has already been carried out in the UK by universities, the water authorities and the Natural History Museum. WRc Swindon, Severn Trent Water and Middlesex University, in particular, have made an important textbook contribution to constructed wetland research.

E. Paper 5

This paper proposes the definition of *rural area* differs from country to country (Braga et al., 2016). The term *rural area* is generally used as an expression for non-urban or peripheral regions (Dax, 1996). Ricketts et al. (1998) defines *rural area* as a geographic area located outside towns and cities.

According to the Organization for Economic Co-operation and Development (OECD), the classification of a region as predominantly rural is based on two different characteristics: (i) areas which present a population density below 150 inhabitants per square kilometre; or (ii) areas which have more than 50% of their population living in rural local units (OECD, 2011).

It is estimated that around one-quarter of the population of OECD countries lives in rural regions (OECD, 2018). Inadequate sanitation systems still exist in many parts of the world, especially in rural areas, which are commonly underserved in several low- and middle-income countries (WHO, 2018). It is estimated that only 9% of the rural population worldwide is connected to sewers (WHO-UNICEF, 2017). The WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP) updates have highlighted inequalities between rural and urban areas (WHO-UNICEF, 2017).

IV. METHODOLOGY

A. Vertical Subsurface-Flow Constructed Wetlands (VSSF)

Some constructed wetlands are designed to have vertical water flow. In such a case, it is called vertical subsurface-flow constructed wetlands (VSSF) . Similar to HSSF, the flow of VSSF should be passed through filter beds before entering the CW channels . The flow in VSSF is either by gravity or by pumps. Certain considerations should be taken into account in the design of VSSF. The time required for the wastewater to percolate through the vertical channels should be calculated. In most cases, the flow in VSSF is controlled such that there is a time interval between the loading events, and intermittence loading is adopted .

The plant roots transfer some oxygen to the subsurface, and dryness periods allow oxygen diffusion to subsurface. Thus, the oxygen level in VSSF is high, which promotes the growth of aerobic bacteria. Therefore, VSSF enhances aerobic degradation and is found to be suitable for nitrification and is more aerobic than HSSF. Previous studies found that VSSF promotes a wide range of degradation and decontaminations processes including, biodegradation, adsorption, precipitation, and filtration . It was also found that the VSSF is successful in removing the organic matter and suspended solids. The VSSF capital cost is less than the HSSF capital cost because the VSSF needs a smaller area size compared to HSSF.

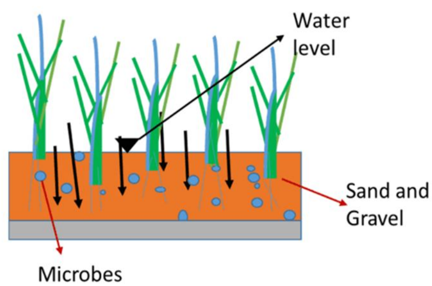

Fig : -Schematic layout of vertical subsurface flow constructed wetlands.

B. Design Of Wetland

1) Preliminary Design Steps

The preliminary design steps are as below :

a) *Selection of Site:* The site is benefited because of naturally sloping ground availability for the constructed wetland as it will be cost effective . The site should be away from human activities .
b) *Pre-treatment:* The pre-treatment in the form of septic tank was already available at the site. However, the pipeline of waste water from septic tank to wetland is broken . We suggested the installation pipe for conveying waste water from septic tank to wetland .
c) *Design of construction wetland*

2) Design Calculation

Data we collected for design of wetland from girls hostel .

Capacity of tank = 1200 lit

The tank is filled 4 times per day .

Number of girls = 83

3) Design of Wetland

Capacity = 1200 x 4 = 4800 lit / day

Take 80% of total water for domestic waste

So, Domestic waste water = 3840 lit / day

Discharge = 3.84 m^3 / day

1. Influent BOD =216 mg/l
2. Effluent BOD = 20 mg/l
3. Discharge Q = 3.84 m^3 / day
4. Vegetation type = Cana indica
5. Minimum water temperature = 6 ° c
6. Basin media = Coarse sand .
7. Assume depth of wetland = 1.2 m .

a) Select values for α , k20 for coarse sand

Porosity (α) = 0.39

K20 = 1.35

b) Determine the values of kT at 6 degree.c

kT = k20 (1.1)rest to (T-20)

= 1.35 (1.1)rest to (6-20)

= 0.36

c) Determine detention time (t) using

t = - In (Ce / Co) * kT

= - In (20 / 216) * 0.36

= 6.6 Days .

d) Area = Discharge / depth

= 3.84 / 1.2

$_2$ ∴ Area = 3.2 m^2

e) Width = Area / depth

= 3.2 / 1.2

∴ Width = 2.67 m

6) Length = Detention time x Discharge /Width x Depth x α

= 6.6 x3.84 / 2.67 x 1.2 x 0.39

∴ Length = 4.44 m .

From lab model =

- Inflow rate =

6 lit = 0.006 m^3

4:30 min = 270 sec

Inflow rate = 0.006 x 270

= 1.62 m^3 / sec

- Outflow rate after 15 days

  2 lit = 0.002 m^3

  1:43 min = 103 sec

Outflow rate = 0.002 x 103

= 0.206 m^3/ sec

C. Model Making

1) Step 1

First we apply layer of polythene on wetland.

Fig:- Polythene Layer

Polyethylene, also known as polythene or polyethene, is one of the most commonly used plastics in the world. Polyethylenes usually have a linear structure and are known to be addition polymers. The primary application of these synthetic polymers is in packaging. Polyethelyne is often used to make plastic bags, bottles, plastic films, containers, and geomembranes.

It can be noted that over 100 million tonnes of polyethene is produced on an annual basis for commercial and industrial purposes.

The general formula of polyethylene can be written as (C2H4)n. Most types of polyethylene are thermoplastic (they can be remoulded by heating). However, some modified polyethylene plastics exhibit thermosetting properties. An example of such a class of polyethylene is cross-linked polyethylene

2) Step 2

After that we provide layer of aggregate of 16-18 mm size.

Fig:- Aggregate 16-18 mm size

3) Step 3

Provide layer of aggregate of 8-10 mm size.

Fig:- Aggregate 8-10 mm size

4) Step 4

After that we provide a layer of coarse sand**.**

Fig:- Coarse Sand Layer

5) Step 5

Then we plant canna indica species on wetland for treatment of wastewater.

Fig:- Canna Indica Plant Species

D. Performance of canna indica in wetland for treatment of wastewater

Constructed wetlands (CWs) have great potential as low-cost natural wastewater treatment in developing countries. The present study appraises the performance of the vertical flow constructed wetland for domestic wastewater treatment. More specifically, the potential of Canna Indica in the removal of carbon, nitrogen, and phosphorus (CNP) from wastewater under tropical conditions. CW cell was fabricated with a vegetative layer of Canna Indica and tested with domestic wastewater. Based on the test results, Canna Indica shows a high Removal Efficiency (RE) of Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD5) on the order of 87% and 91%, respectively.

Similarly, nutrients removal efficiency for total nitrogen (TN), total phosphorus (TP) was found to be 97% and 98%, respectively. The investigation also revealed that there is considerable removal of sulfates with efficiency equal to 78.4%. Overall, the Canna Indica based CWs were found to be suitable for wastewater treatment in the tropical regions, provided a viable medium for treating the wastewater in peri-urban and rural areas of developing countries.

V. EXPERIMENTAL ANALYSIS

A. Tests Performed on Wastewater

Study of materials to be used for wastewater has been done.Various tests have been carried out on the wastewater.The following are the tests carried out on wastewater:

1) pH test
2) Alkalinity
3) COD and BOD
4) Digital pH

a) pH Test

The result which we get after pH testing of treated wastewater are as follows

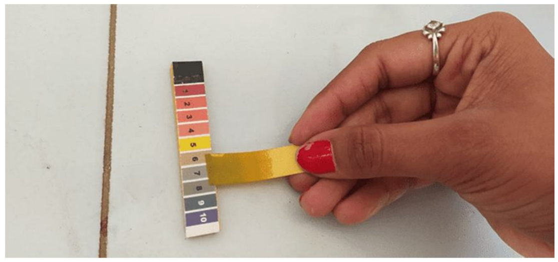

Fig.:- pH test results after 30 days

Result: -pH of treated wastewater after 30 days is 7.2

b) BOD Test

The results which we get after BOD test of treated wastewater are as follows

Result:-

Table no. BOD test results after 30 days of treates

Sr no.	Parameter	Unit	Sample
1	Biological oxygen demand (BOD)	mg/l	165

c) Digital pH

The result which we get after test of treated wastewater are as follows:

Fig.:-Digital pH test results after 30 days

Result:-The Digital pH of treated wastewater is 7.0.

Fig.:-Growth of plant species

VI. CONCLUSION

As we concluded the Constructed Wetland System which we have provided in our Girl's Hostel to treat the wastewater within the Hostel campus, which is generated in the campus, is one of the pioneer plants in this region.

Also according to the references which we referred, such plant, which is based on very innovative concept & though it is not a proved technology, is the only plant which is purposefully executed to treat the waste in a very efficient & responsible manner.

During the course of project, we came out with lot of advantages of this system over the conventional treatment systems. Also few practical limitations during the project are also discussed here honestly. And hence, some suggestions or the degree of extra efforts which we found important so as to make this particular system more efficient are also discussed here. Irrespective of these limitations, we found the system to be the best for the problem with which we started the project.

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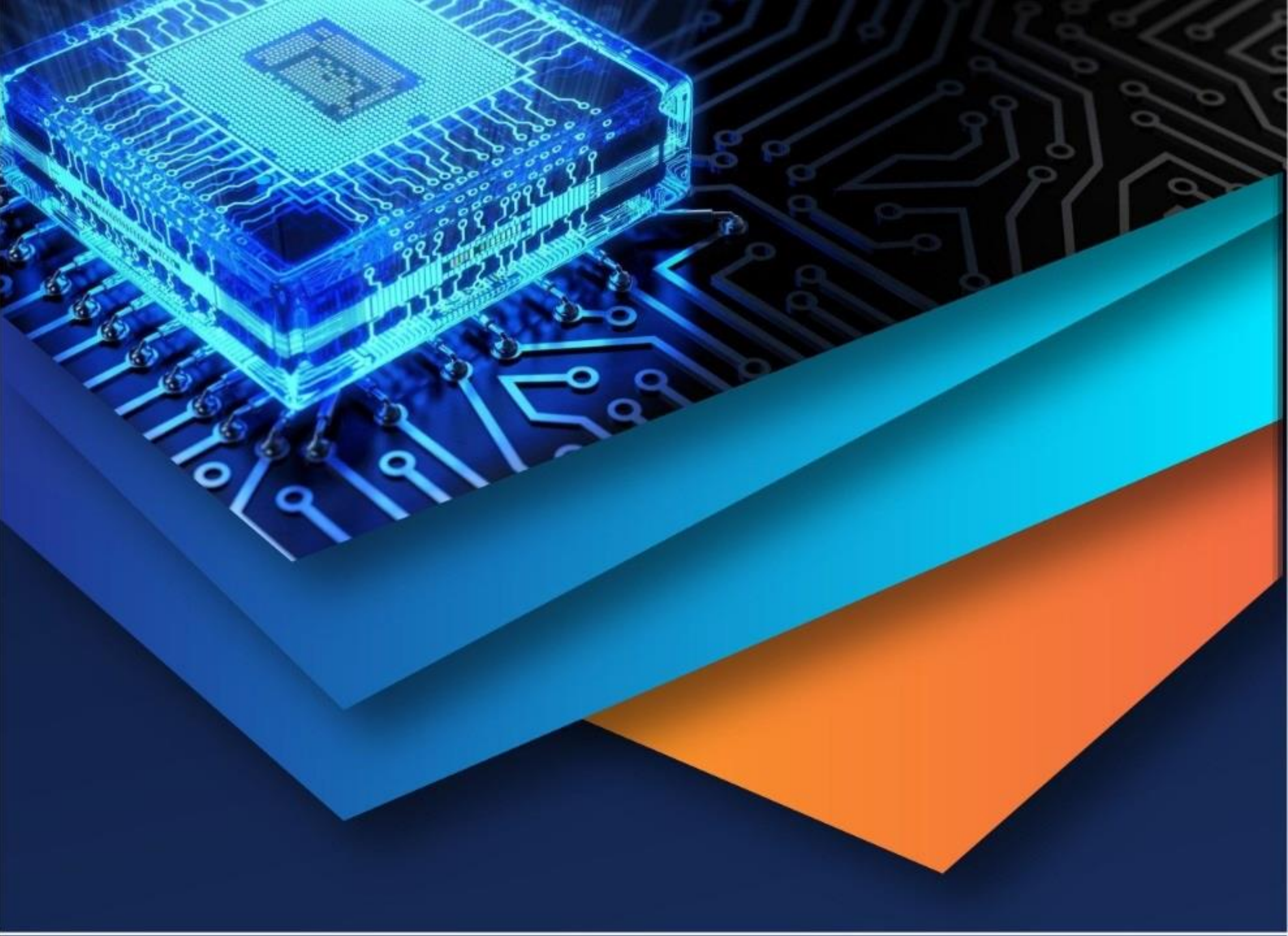

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