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Decentralised wastewater treatment: A case study of Nehru garden, Alwar, Rajasthan

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Abstract
Wastewater is one of the biggest menaces in the world. Around the world wastewater is produced on a large scale while a comprehensive solution to the problem has been difficult to find. Therefore, this study has been conducted on decentralised wastewater treatment. Here, the water has been purified by the use of special plants such as Cana Indica, Typha angustifolia. The study work has been conducted around six wastewater treatment plants and the procedures adopted in each of them. The procedure makes it possible to treat wastewater without use of any chemicals. The treated water so obtained can be used to water plants in plantations, farms, etc.

Keywords: wastewater, natural process, decentralised waste water treatment

1. Introduction
Wastewater is the water that is affected by human use, from any combination of domestic, industrial, commercial activities. The types of wastewater includes domestic wastewater occurs from households, municipal wastewater from communities and industrial wastewater from industries. The wastewater contains chemical and biological pollutants.
Households may produce grey wastewater from sinks, dishwashers, washing machines, bath tubs, and showers as well as black waste water from flush toilets.
Generally there are two types of waste water flows over the surface in our cities or colonies. One of them is foul sewer and another one is surface water sewer. The foul sewer water contains, commonly known as black waste water, have to be send for treatment to treatment plants but many times flows in rivers without treatment. The surface water sewer carries uncontaminated rainwater as well open drains contaminated water directly to a local river, stream or soak away.
The wastewater contains various pollutants few of them listed below.

Chemical or physical pollutants
- Heavy metals, including mercury, lead, and chromium
- Organic matter such as feces, hairs, food, paper fibers, plant material, humus, etc;
- Soluble organic material such as urea, fruit sugars, soluble proteins, drugs, etc;
- Inorganic matter such as sand, grit, metal particles, ceramics, etc;

Biological pollutants
If the wastewater contains human faces, as is the case for sewage, then it may also contains pathogens of one of the four types
- Bacteria
- Viruses
- Protozoa
- Parasites

2. Decentralised Waste Water Technologies
DWWT technologies that is commonly used for small communities based on natural systems. In natural systems, wastewater constituents are removed or transformed by natural processes at natural rates. Thus, most natural systems for wastewater treatment require substantial land area, which often makes them infeasible for large populations. The main types of natural treatment systems can be divided into soil-based and aquatic-based processes (WEF, 2001).

Soil-based natural treatment systems are as below
- Subsurface (soil absorption system, or leachfield),
- Slow rate, surface (irrigation),
- Rapid infiltration (groundwater recharge), and
- Overland flow.

Aquatic-based natural treatment systems are as follows:
- Waste water stabilization ponds,
- Wet-lands (surface, subsurface, and vertical flow)
- Floating aquatic plants (e.g., duckweed or hyacinth)
- Aquatic animals - Aquatic animals such as clams, snails and other filter-feeding shellfish.

In decentralized treatment, the process adopted or the treatment of wastewater undergoes the natural process without adding any organic matter or chemicals.
Decentralized wastewater treatment consists of a variety of approaches for collection, treatment and dispersal/re-use of wastewater for individual dwellings, industrial or institutional facilities, clusters of homes or businesses, and entire communities. These process consists of biological tress which

helps to make wastewater usable by treating it. The basic fundamental behind the cleaning of wastewater in decentralized wastewater treatment is that the roots of the specific plants make the wastewater purified by depreciating the quantity of BOD and COD of water as well as other parameters of water such as pH, TDS, oil and grease.

The general methods adopted for the treatment of wastewater are

1. Aquatic plants - Plants with strong tolerance for pollutants can mitigate or fix water pollutants through adsorption, absorption, accumulation, and degradation. There are five types of plants present to perform such operations that are –
   - Cana Indica
   - Typssha angustifolia
   - Eichornia crassipes
   - Salvinia molesta
   - Reed grass
   - Micro-organisms - Microorganism based technologies are used to decompose, transform, and absorb water pollutants. Results to date generally confirm the existence of the appropriate microbial functional groups responsible for removing specific pollutants from wastewater.
2. Microbial dosing - Microbial dosing uses specific and efficient microorganisms to remove pollutants present in the water. Commercial products, such as FLO-1200, could achieve remarkable results in the river pollution control under the conditions of river aeration.

3. Literature Review

Decentralised wastewater treatment system is mainly used for treating its BOD & COD and reducing it to the optimum level so that it become useful for various purposes, mainly for horticulture. Organic compound in wastewater are converted to the useful minerals and organic matter by the means of special kinds of plants.

Here are some projects where this water treatment system is adopted given below:-

3.1 Decentralised wastewater treatment system at Adarsh College, Distt Thane [1]

This Decentralised waste water treatment system developed at Kualhaon, Badlapur.

The capital cost of plant is about Rs.4 Lakhs and operation and maintainance cost of about Rs. 60000 – Rs. 80000 per year. This whole treatment plant is spread in area about 57 sqm having treatment capacity of 2-3 KLD of waste water.

Technology used- Collected black water and grey water from the collection tank send to the biogas settler. The waste water then flows to the anaerobic baffled reactor (6 chambered having gravels as filter media) and then to the next four chambers equipped with anaerobic up-flow filters (with gravel filter media). After the anaerobic treatment, the wastewater is directed to the horizontal planted filter having fine gravel as the filter media. The treated wastewater then flows to the polishing pond where it is stored and reused for horticulture purpose. The biogas collected is used to provide energy to gas stoves and lamps present in the Ecosan exhibition hall.

3.2 Constructed wetland for wastewater treatment at Indian Agriculture Research Institute, Pusa, New Delhi [2]

This DWWT system has capacity of 2.2 MLD and is spread in area of about 1.42 Ha, implemented at Institutional level. Total capital cost of this system is 1.2 Crores.

Technology used- preliminary/ primary treatment takes place in 2-sewage wells and 1-grit chamber. Secondary and tertiary treatments of the wastewater done in 3-treatment cells (each of 80 meter by 40 meter), where organic, nutrient and metal pollutant reduces. Typha latifolia – a hyper-accumulating emergent vegetation is planted in each treatment cell with a bed of gravels of varying sizes/ grades. The whole system designed for gravity flow of the wastewater, from the grit chamber to the treated water-collector sump. The flow of the wastewater in each treatment cell is so regulated that there is complete sub-surface flow, thereby leading to no ponding, foul smell, mosquito breeding or any direct contact with wastewater. The treated water is finally collected in an treated water-collection tank(80 meter by 40 meter by 2 meter), from where it is finally pumped into the irrigation network of the institution.

This system is capable of removing turbidity (99%), BOD (87%), Nitrate (95%), Phosphate (90%) and heavy metals (81-99%)

3.3 Decentralised wastewater treatment system at Aravind Eye Hospital, Pondicherr y [3]

This system is designed for capacity of about 320 KLD in 2690 sq. m area, with capital cost of 1.12 crore & operation and maintenance cost of 2.5-3 Lakhs per annum.

Technology used- The grey water and the black water, first enter into separate two chambered settlers. The settlers for black water treatment are integrated with the anaerobic baffled reactors. The partially treated black water then undergoes secondary anaerobic treatment through baffled reactors. The black water and grey water is collectively passed through anaerobic filter and then to the series of horizontal gravel filters planted with Canna indica. Final treatment is done through polishing ponds where the water is stored also for further reuse.

In this system BOD reduction to 98%, COD reduction to 96% and TDS reduction to 96%.

3.4 Decentralised Wastewater Treatment System at Kachpura village in Agra [4].

It has capacity of about 50 KLD and is made with capital investment of Rs. 10-11 Lakhs. Operation and maintenance cost of this plant is about Rs.70,000 – 80,000 per year.

The system treats approximately 50 KLD of the total wastewater which it receives from 5 slums through a common drain. The remaining untreated wastewater flows through parallel drain into the major drain that connects to the River Yamuna.

Technology used- The system consists of screen chamber for removal of the solid waste. The wastewater then enters into

three chambered septic tank for primary treatment. After primary treatment, it goes to nine chambered baffled anaerobic reactor which is filled with gravels, act as filter media. After secondary treatment the wastewater goes to *canna indica* planted filter bed, filled with three different types of filter media (white river pebbles, red stones and gravels). The treated wastewater is reused for horticulture and irrigation purpose.

This system has achieved reduction potential for BOD by 61%, COD by 64% & TDS by 94%.

3.5 Decentralised wastewater treatment system at Bankers Colony, Bhuj [5]

This system designed in 300 Sq.m. area to treat 30 KLD waste water with capital investment of around Rs. 15 lakhs with operation and maintenance cost of about 1-1.5 lakhs per year.

The Bankers colony is below the level of the main sewer line. it was decided to for DWWT. The treated wastewater is reused for horticulture purpose in order to develop the green belt in the region.

Technology used- The sewage first goes into a two chambered settler. After the primary treatment the wastewater goes to the Anaerobic Baffled Reactor (nine chambered) system with the anaerobic filter in the last two chambers. Then the wastewater flows to the planted filter and finally to the polishing pond. The excess of treated wastewater goes to the storm water Lake. Percentage reduction in BOD, COD and TDS are 91%,81% and 98% respectively.

3.6 Case Study of Dwwt, Alwar

This project is implemented at Nehru Garden, Alwar, Rajasthan in area of about 730 m^2 by UIT, Alwar. This project is operational in this 4 hectare garden since 2016. Capital cost being invested in this project is approx. Rs. 32 Lakhs with operation and maintenance cost of about Rs. 2.4 Lakhs per annum. This treatment system is designed with capacity of about 100 KLD.

Project Background:- Runnel having flow of about 5 MLD out of which 50,000 liters is diverted to the inlet of decentralised waste water treatment system, treated for horticulture use.

Treatment Technology:- The Decentralised waste water treatment system implemented at Nehru Garden consists of 2 sewage collecting tanks followed by 3 chamber settling tanks, then it leads to planted gravel bed having special type of plant species known as CANNA INDICA and then two chambers of treated water collection tank. Inlet in this is controlled by a sluice valve at inlet which involves input rate of about 1 MLD. This water is then filled up in 3 chambered settling tanks which allows saperation of settable solids for about 24 hrs. This water is then entered in PGF (planted gravel bed) bed which is filled with crushed up stones and planted CANNA INDICA, which reduces significant amount of BOD, COD, TKN and Phosphates in treated water. This treated water is then used for horticulture purposes.

This system demands water of about 0.08 MLD – 0.1 MLD during summer season. This system treats water without any use of chemicals. [6]

Construction

The construction of the decentralized wastewater treatment plant, which adopted(figure-1), is the surface wastewater flowing through a nearby runnel is pumped into the plant by the help of the motor and a rotating valve for treatment. Now this wastewater is passed through a screening chamber where the solid waste(like leaves, clothes, papers, stones, polyethens, etc.) is collected by passing it from screens. Further this wastewater after screening is passed through a de-silting chamber constructed so that the wastewater overflows through one partition to another so that the fine sand particles settles down by the help of gravity. After passing from screening and desulting chamber the wastewater is passed through the main body of this system that is the planted bed area.

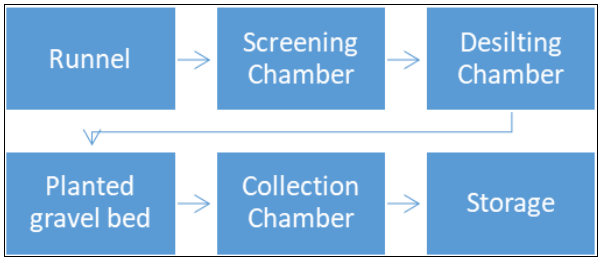

Fig 1

This area or part of the system contains 800mm depth from the top. This plantation area is inclined 150mm from bottom to continue the flow of water without the use of any electrical energy. The 300mm layer from bottom of this plantation area is covered by 50-100mm aggregate and the another layer of 500mm above first layer is covered with 20-50mm aggregate. The plants (canna indica) are placed over these two layers of gravels having 200mm distance from centre to centre between each plant in both the directions. The total area of this plantation area is 10m*30m and the total number of plants used is 8500 of cana indica.(figure–2) After filtering or treating between the roots of cana indica there is a collecting chamber to collect the water. From here it is sorted in storage tanks.

Fig 2

Working

As we have seen the construction above.The flowing runnel containing waste water from commercial and domestic

communities. As we know the wastewater is used water from domestic household, municipal, communities or commercial region. A pipe is connected for the supply of wastewater from the runnel(figure-3).

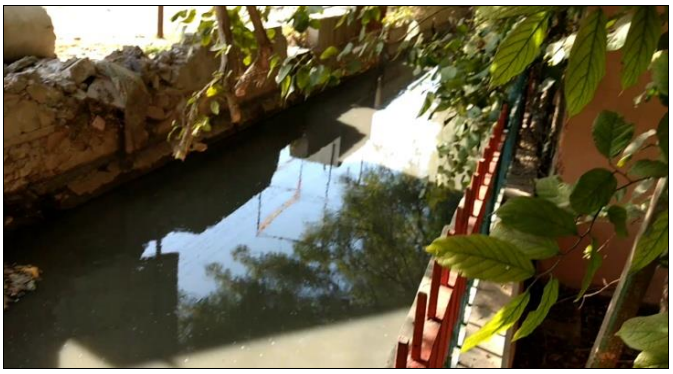

Fig 3

A motor having a rotating valve to control the flow of water such that the supply of wastewater can be allowed as per the need. This wastewater now pumped towards the screening tanks to remove the impurities present in the wastewater like dead animals or their carcass, vegetable waste, food remains and solid waste. Here the most of the impurities or coarse impurities gets collected as a waste (figure- 4)

Fig 4

Now this water pumped into the de silting tanks at vary constant speed because as per the construction a partition wall is provided in the middle of the tank, so that wastewater over flows above this partition wall. Due to constant speed of wastewater, the wastewater overflows such that the fine sand particles of fine impurities get settle down at the bottom of the tank(figure-5).

Fig 5

Now after collecting the basic fine and coarse impurities the wastewater remains, only containing organic impurities which we will treat in this system naturally by the help of *canna indica*. From this de-silting chamber eight pipes of ten inches each in diameter and having equal distance between them so the flow of wastewater should be equal at the outlet of each pipe and that is why the reason behind increasing this outlet area by the help of ten pipe is only that the flow wastewater should be uniform(figure-6)

Fig 6

From here the wastewater enters into the main body of this system. After entering in this body the wastewater gets filtered by the two layers of aggregates and from the roots of *canna indica*. The roots of *canna indica* makes the wastewater purified because the tissues of roots of *canna indica* decreases the BOD and COD of wastewater (figure-7).

Fig 7

In this portion of treatment the wastewater flows without any pumping due to the inclination provided at the earth surface during construction. From here, the treated water is collected into the collecting chamber and from where it is pumped inside the storage tanks having capacity of 50000 lit.(figure-8)

Fig 8

4. Results

Results as shown in table no.-1 indicates the successful implementation of DWWT.

Table 1

S.no.	Parameters	Inlet	Outlet on
1	pH	6.6	7.4
2	TSA in mg/lit.	105	34
3	COD in mg/lit	598	121
4	BOD in mg/lit (3 days at 27^0c)	340	20

5. Conclusion

With ever increasing population of cities and towns, it is becoming increasingly difficult to treat used water. Thus, decentralised waste water treatment plants can be beneficial for conservation of water as well since it can be reused as water for irrigation and horticulture etc.

6. Acknowledgment

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