International Journal for Multidisciplinary Research (IJFMR)
ISSN: 2582 – 2160, Volume - 1, Issue - 3

Innovative Technologies for Waste Water Treatment

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***Abstract*:Wastewater treatment allows human and industrial effluents to be disposed of without danger to human health or unacceptable damage to the natural environment. Irrigation with wastewater is both disposal and utilization and indeed is an effective form of wastewater disposal (as in slow-rate land treatment). The aim of this paper is to provide a review on the usage of different innovative technologies such as bio-reactor septic tank and immobilising commonly employed photocatalysts for degradation of organic pollutants. The immobilisation of nano-sized photocatalysts can eliminate costly and impractical post-treatment recovery of spent photocatalysts in large scale operations. Some commonly employed immobilisation aids such as glass, carbonaceous substances, zeolites, clay and ceramics, polymers, cellulosic materials and metallic agents that have been previously discussed by various research groups have been reviewed. Another, technology for minimizing waste water is by using bio-reactor septic tank for treating waste water. In India, 70 percent of households are using septic tank systems for the sewage treatment. Investigation deals with plan, design and to develop a low cost new septic tank system namely "Bio-Reactor Septic Tank" to solve the pollution problem of effluents from septic tank and also to fulfill the requirement of water demand. The term "septic" refers to the anaerobic bacterial environment that develops in the tank which decomposes or mineralizes the waste discharged into the tank. In Bio-Reactor Septic tank, instead of soak pit three filter media is used namely Coir filter, Surkhi adsorbent and Sand filter.**

***IndexTerms*:Immobilisation, Photocatalysis, Sewage, Filter Media, Bioreactor septic tank**

INTRODUCTION

In the present situation all over the world, water paucity is the major issue which involves lack of fresh water and hence leads to water crisis. These issues are due to population, pollution and climatic change. Pollution of ground water and surface water are caused due to various human activities **(1).** Pollutants generally enter by direct discharge through a pipe and which further affects the water quality. The level of impact depends upon the import of discharge **(2)**.
The daily pollution entering waste water treatment plants approximates to be:
- 380 tonnes BOD
- 47 tonnes Nitrogen
- 8 tonnes Phosphorous **(2)**

Therefore we require a fresh, innovative and adaptive technique to treat urban waste water. Bioreactor septic tank and photocatalysis are the two innovative and adaptive techniques in the field of waste water treatment which are cost effective.
There are generally two types of waste water produced by the household systems:

Greywater: it is generated form showers, basins and taps.

Blackwater: it is the water that has been mixed with waste of the toilet **(5)**.
Innovative technology for treating urban waste water by the use of bio-reactor septic tank. Accumulation of human bio-waste is constant and unmanaged waste water contaminate the locally available fresh water which further affects health of an ecosystem. Water paucity is the major problem prevailing in developing countries and hence we can reduce the usage of potable water for domestic purpose. The objective is to fulfill the requirement of fresh water **(6)**. The cost of filter media used in bio-reactor septic tank is less as compared to chemical membrane which is used to treat waste water **(7)**.
Another treatment, for treating urban waste water is by the use of photocatalysis. It occurs through water splitting and carbon dioxide reduction and of waste water. In this area researchers are focusing on producing economically viable, non-toxic stable and photo- corrosion resistant catalysts **(3)**.
Photocatalysis is of great interest due to the relative ease of the process. The advantage of the process is that it can completely calcify recalcitrant pollutants into simpler compounds that can be processed by natural mechanisms to harmless constituents. Moreover, this method does not transfer the pollutant from one phase to another but rather eliminates the target compound.
Photocatalyst like zinc oxide, titanium oxide and silver chloride are used for environmental pollution remediation **(4)**.

BIO- REACTOR SEPTIC TANK

In advance, secondary treatment process the suspended solid waste particles are need to be removed. Adequacy of the primary treatment is directly proportional to the tank specification and installation. Bio-reactor septic tank can be made up of plastic, concrete and fiber glass. Advantage of using plastic tank and fiber glass over concrete tanks as they are light weight and hence require anti-flotation devices in high ground water areas **(9)**.

There are two types of waste water treatment:-

1) Centralized **2)** Decentralized

Using centralized treatment system over decentralized is more expensive and complex in construction **(12)**. Manageable and suitable with less cost bio-reactor septic tank design is on-site anaerobic treatment which requires less space **(11)**. The solid waste that encapsulate in the bio-reactor septic tank has to be removed in regular intervals of time. Solid material is carried on with hauling truck and septic pumping which contains liquid contents, scum layer and settled sludge **(8)**.

SUPPLIERS

Manufacturers of concrete septic tanks are available in most areas. Plastic and fiberglass septic tanks are lightweight and may be easier to install in some areas. Because of past failures, it is recommended that plastic tanks will be water tested and inspected carefully for structural integrity **(8)**.

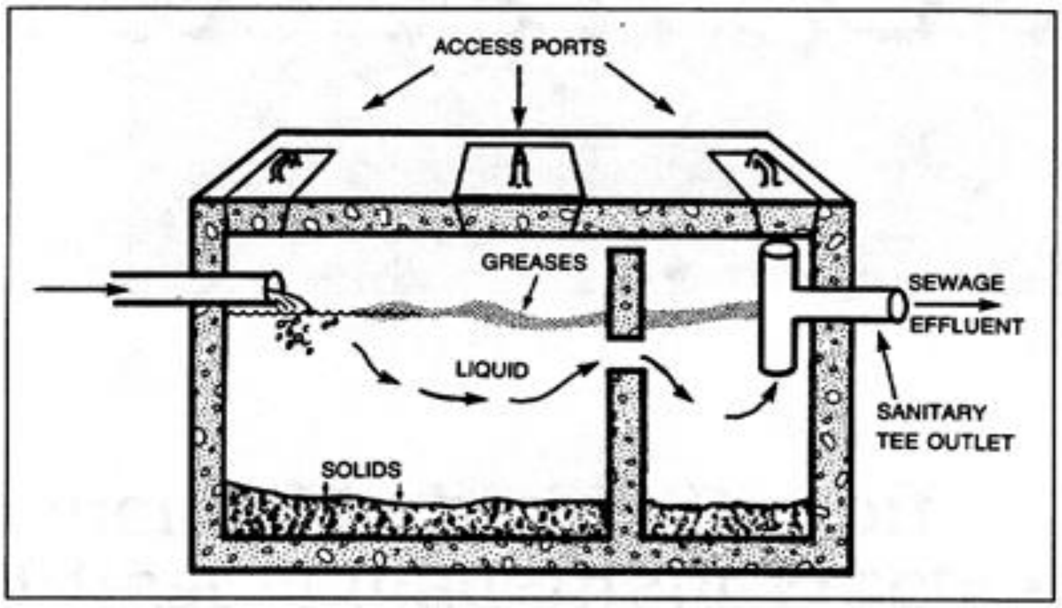

Fig. 1. Inside view of septic tank (14)

METHODOLOGY

The word "septic" is commonly known as for the anaerobic bacterial environment. Bio-reactor septic tank is also considered as a sedimentation tank and it can be either cylindrical or rectangular in its shape. Role of septic tank is to remove very high content of solids which are basically recovered from domestic sources **(5).**

Waste water flows from the inlet pipe of the tank and heavy particles present in it sink due to gravitation and hence forms a layer which is called sludge layer while middle layer remains fairly clear and the top most layer is known to be scum layer which constitutes of floatable particles such as grease and oil. After sometime the settled sludge is degraded anaerobically by the micro-organisms present in the waste water itself. The rate of accumulation is comparatively faster than the rate of decomposition of sludge layer. Due to this settled sludge and the scum layer should be removed in regular intervals of time **(5)**.

The raw sewage from the domestic purposes directly enters into the filter media which comes out as potable water which can be used for toilet flush, Gardening and other domestic purpose **(6)**.

CONSTRUCTION

The minimum mass requirement of the bio-reactor septic tank = of 2000 liters.

Minimum required length = 2 or 3 times pf the width.

Liquid depth for large tank = 1.8m.

Liquid depth for small tank = 1.2m.

An bio-reactor septic tank consists of: (a) inlet pipe (b) outlet pipe (c) baffle wall and (d) manhole. One end is connected to the inlet pipe and the other end is connected to the filter media. A manhole is also required for providing observation and maintainance of inlet and outlet pipes. Position of baffles is about 45cm from the end of bio-reactor septic tank and it should be extended 45cm below and 30cm above the flow line. Elevations of both the pipe- inlet and outlet provide free flow through the tank. Elevation can be maintained by setting the bottom of the inlet pipe 8cm above the water level (9). All the interconnected

International Journal for Multidisciplinary Research (IJFMR)
ISSN: 2582 – 2160, Volume - 1, Issue - 3

pipes used in the bio-reactor septic tank are made up of PVC which promotes waste water to enter and exit without disturbing any crust on the surface **(6)**.

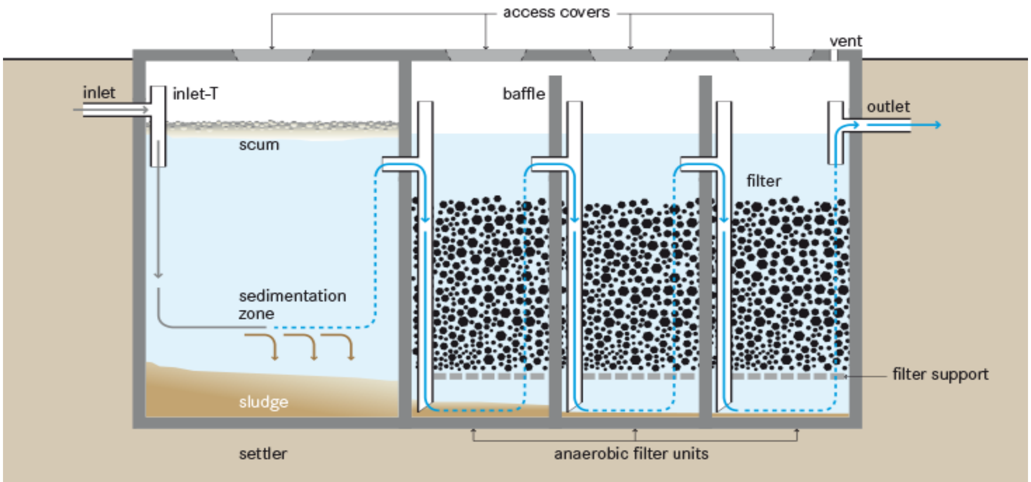

Fig. 2. Inlet and Outlet view of filter media bioreactor septic tank (5)

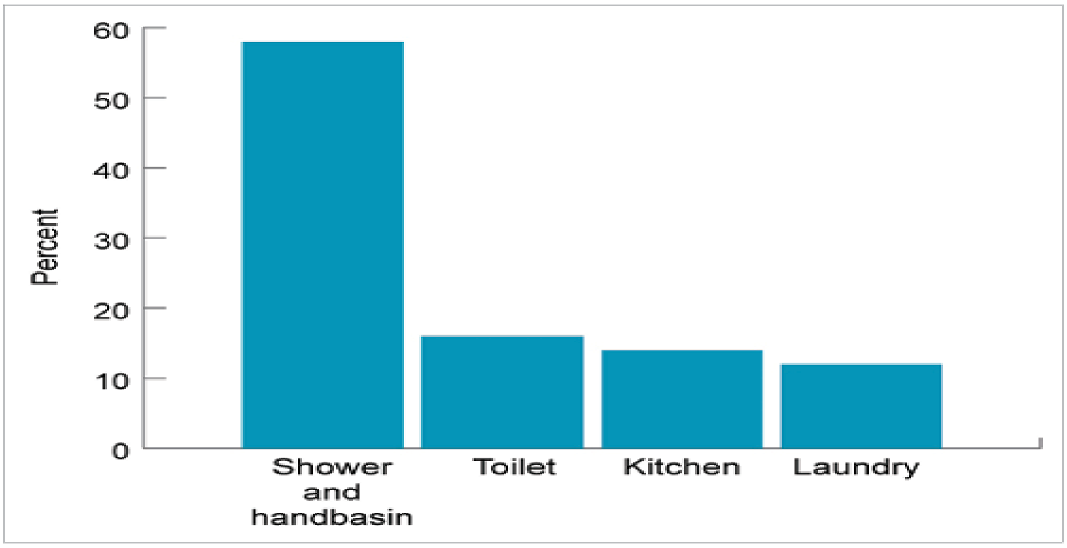

Fig. 3. Majority of household waste water (5)

WORKING

Waste water from various sources enters through the inlet pipe which is made up of PVC and the three layers are formed namely: scum layer, middle layer and sludge layer. Lighter matter floats and form scum layer which mainly constitute of grease and oil. Whereas, denser particles sink and forms sludge layer and the middle layer remains fairly clear. All the three layers formed contains bacteria and chemicals like nitrogen and phosphorus which act as a fertilizer. Breakdown of solid particulate matter is done by anaerobic decomposition and hence which results in the formation of foul gases. Therefore, BOD of water and mass of sludge is decreased. The sewage has to be stored for about five days to determine the BOD. Then after five days the sewage is passed across different filter media **(6)**.In bio-reactor septic tank the following media are used:

1. Coir filter,
2. Surkhi adsorbent and
3. Sandfilter.

- **Coir filter media**

Coir fiber is known to be a natural fiber which is obtained from the husk of coconut and is used in manufacturing of doormats, floor mats, mattresses and brushes. Coconut fiber is known to remove the floating substances suspended in waste water as it is a good adsorbent. Further, it undergoes screening process. Waste water is passed through coir filter media with the help of PVC pipe in a bio-reactor septic tank. Coir is known to be a good adsorbent and hence it absorbs oil readily. Screening process is undergone in coir filter media in which floating solids can be removed. The process of coir filter media requires about an hour and then the filtered water is transferred to the next filter media **(6)**.

Fig. 4. Coir filter media

- **Surkhi Adsorbent**

Surkhi is another name for brick dust and it is used as an substitute for activated carbon **(15)**. Burnt bricks are grinded to form powder which is known as surkhi. Bricks should not be over burnt and should contain less proportion of sand. Surkhi filter absorbs inorganic solid, odour and colour **(16)**. The filtered water from the coir filter media enters into the surkhi adsorbent media through interconnected PVC pipe.

Carbon is activated by the chemical and physical process and hence surface converts into an adsorbent surface. Activated carbon is expensive hence surkhi (moderate burnt brick dust) filter is used as an substitute for it **(17)**. Because Surkhi has similar properties like activated carbon. Also, it is cheaper and easily available.

Fig. 5. Surkhi filter media

- **Sand filter media**

Sand is also used as a filter media. The layers of gravel are present below the fine layers of sand which permits the filtered water to move freely under drains and allows to wash the water and to shift water uniformly upward.

Sand

The fine sand is obtained from devastated waste. And the size of sand is expressed by the term called "effective size". Selected sieve should be of correct size, because very small size leads to very frequent clogging filters, and hence will undergo low filtration rate. On the other hand, large size will allow suspended particles and bacteria to pass through it. The effective size of sand filter varies from 0.35mm to 0.55mm. sand filter is more applicable for purifying waste water with less bacterial content, pathogens and with less turbidity **(18).**

Gravel

The coarse sand is obtained from construction and demolished waste. The layer of gravel which is used below the layers of sand should be durable and tough. It should constitute of density of about 1600 kg/m^3 . The coarse size of gravel 20-60mm are placed in the bottom layer whereas fine size gravel 3-6mm are placed on the topmost layer.

Hence, it is applicable for purifying water with less color, less turbidity, less bacterial content and pathogens **(18)**.

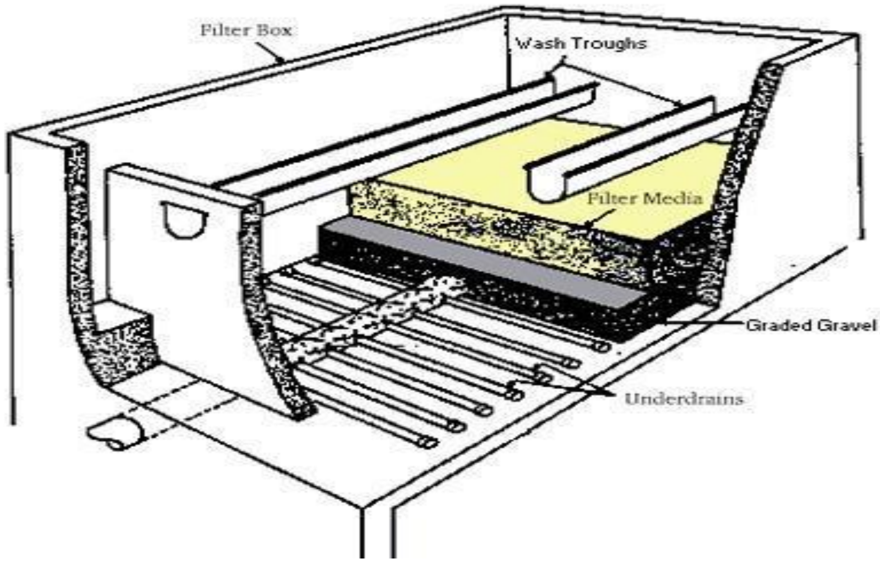

Fig. 6. Sand Filter (13)

PHOTOCATALYSIS

Photocatalysis is a potable technology for waste water treatment. Titanium oxide, Zinc oxide and silver chloride are most commonly used UV responsive semi-conductor for waste detoxification and water splitting of organic compounds. Advantage of using Titanium oxide over silver chloride is the endless lifetime of coating. Titanium oxide during the degradation process remains unchanged and also has high photocatalytic activity, biological immunity and low cost.

Properties of photocatalytic materials

I. It must be strongly, incapacitate permanently in the entrapment medium.
II. It must not show high decrease in its activity upon incapacitation.
III. The catalyst after immobilisation must possess a high surface area.
IV. The immobilising agent must also be able to adsorb pollutants over its surface for an effective photocatalytic degradation process.
V. The material added must have an excellent support for the stability against degradation by strong oxidative radicals generated during the photocatalytic process.
VI. It must provide a considerably large surface area. **(4)**
Two types of reactors are used: (1) TiO2 suspended in the medium (2) TiO2 fixed in a material. TiO2 powder suspended in the water to be treated and another TiO2 attached to a substance which is immersed in waste water **(21)**.
Titanium dioxide, particularly in the anatase form is a photocatalyst under ultraviolet (UV) light. A reactor refers to Titanium oxide powder which is suspended in the water to be treated, while the immobilized catalyst reactor has Titanium oxide powder attached to a substrate which is immersed in the water to be treated **(22)**.

Mechanism of Photocatalysis

The photocatalytic oxidation mechanism includes the following steps:

1. Formation of electron hole with the radiation greater or equal to band gap of the catalyst and it is called photo-excitation state.
2. After that, charge separation occurs.
3. Electron have sufficient energy and crosses the band gap to reach the conduction band (CB) and valence band (VB).
4. Which creates electronic vacancy in the valence band.
5. The holes act as strong oxidising agent and the electrons in conduction band act as strong reducing agent.
6. Hole migrate to the surface and oxidises an electron donor while at the surface the semi-conductor or can donate electrons to reduce an electron acceptor **(4)**.

The photocatalysis occurs in five major steps such as:
(1) transfer of reactants in the fluid phase to the surface;
(2) adsorption of the reactants;
(3) reaction in the adsorbed phase;

International Journal for Multidisciplinary Research (IJFMR)
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(4) desorption of the products; and
(5) removal of products from the interface region **(21)**.
The efficiency of the reaction depends on (a) quantum yield (b) function of number of molecules degraded (c) number of photons absorbed by solution **(4)**.

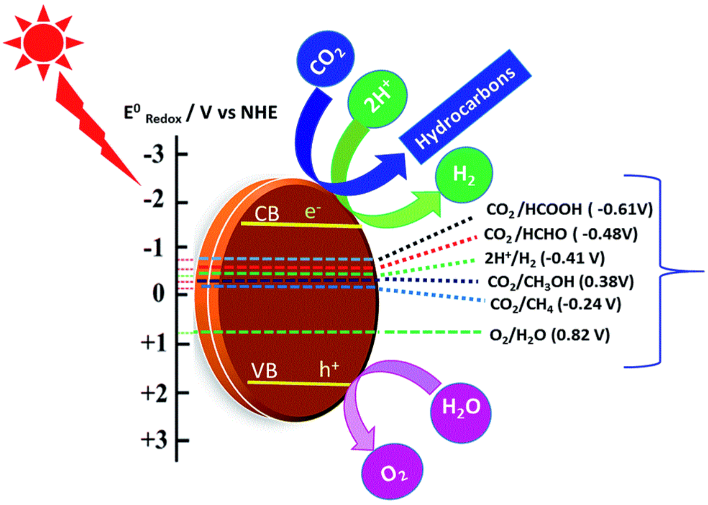

Fig. 7 Semiconductor for photocatalytic water splitting and CO_2 reduction process (22).

APPLICATIONS

1. **Photocatalysis in Treating Pesticide Contaminated Waste Water -** Pesticides causes many immunological disorders, fatal damage, Alzheimer disease, Parkinson disease etc.

The photocatalyst such as Zinc oxide, silver chloride or Titanium oxide intensively efficient as the end products are carbon dioxide, water and inorganic mineral salts. They all have minimum impact on the environment **(23)**.

2. **Photocatalysis in Treating Ethylene dichloride (EDC) in Pharmaceutical Waste Water -** Ethylene dichloride (EDC) are chemicals that have steroid-like structures which affects endocrine functions through steroid hormone receptors even at very low concentration. For example: antibiotics (e.g., sulfamethoxazole, erythromycin, and roxithromycin EDC from industries include "bisphenol A", which leaches from food cans, polycarbonate water jugs, and dental composites; "dioxin". Titanium oxide photocatalyst treatment system is induced as pre or post biological waste water treatment to activate the biotransformation process for pharmaceutical compounds. Its advantages are low chemical input, high energy efficiency and capacity to use renewable and pollution free solar energy. Photocatalytic degradation can efficiently be used in treating EDC contaminated waste water from pharmaceutical industries **(23)**.

3. **Membrane Separation and Photocatalysis in Waste Water Treatment -** Photocatalyst increases the operation performance in terms of good anti-fouling properties. Integration membrane bio-reactor (MBR) with photocatalytic oxidation provides great operation flexibility and superior performance in removing pollutants. Coupling of MBR with photocatalyst is used for treatment of waste water from dye and agricultural land for mineralization of pollutants **(23)**.

CONCLUSION

The review aims to focus on new applications and advancements for bio-reactor septic tank and photocatalysis for revival of its potency of waste water treatment. Use of Bio-rector septic tank can be made in an individual house to fulfill the requirement of water. The construction is easy, consumes less time and cost effective which is most important for developing countries. Photocatalysis plays a prominent role in the treatment of waste water. Large scale implementation of photocatalysis of waste water is required to reduce the pollution and fulfill the demand of fresh water. TiO_2 can be examined as a fresh method of pollution treatment. It helps in degrading dyes, pesticides, pharmaceuticals and herbicides. Photocatalysis proves its ability at many pilot scale application. A large scale implementation of these treatments can help in reducing a great stress on environment due to toxic effluents from industries, harmful organic compounds and pharmaceuticals from domestic sewage etc.

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