Methane Generation Potential from Waste Water Using Anaerobic Rotating Biological Contractor (RBC)

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Abstract: **The history of wastewater treatment is entirely tied to the history of water itself. As industrialization and urbanization have rapidly grown and water has become more contaminated due to discharge of untreated water containing high amount of organic load. In this study we have designed and fabricated an anaerobic rotating biological contractor which can treat synthetic wastewater with the help of bio-film. This reactor was built on small scale to detect the efficiency of this treatment system, this anaerobic rotating biological contractor is made up of two glass tanks, 28 acrylic glass discs, rotating shaft and DC motor. This project is designed to treat approximately 30 liters of wastewater during one cycle process as it is batch. Two holes are provided on the top corner of the tank from which one is utilized for input of wastewater into the main tank and other hole is utilized for gas collection purpose. In this process anaerobic digestion takes place which involve four basic processes like hydrolysis, acidogenesis, gametogenesis and methanogens and then bio-gas is produced which is compound mixture of (CO2+CH4) from which methane is utilized for energy recovery purpose. And the treated water is drained out from the drain valve provided at the bottom of the tank in to the secondary clarifier in which wastewater is retained for certain period of time to allow the formation of flocs. Electrical panel is installed to control the motor and the gas generated can be collected in an acrylic glass collection jar.**

Keywords: **synthetic wastewater, batch, rotating biological contractor, hydrolysis, acidogenesis, gametogenesis and methanogens**

I. INTRODUCTION

The history of waste water treatment is entirely tied to the history of water itself. As industrialization and urbanization have rapidly grown and water has become more contaminated due to discharge of untreated water containing high amount of organic load in it, is being discharge into water bodies. Water treatment has emerged over the centuries to compete to the growing requirement for pure, less hazardous water so that it does not affect aquatic life and to reduce the organic loading of the wastewater so that it can reuse for other miscellaneous activities (such as gardening, washing, flushing and etc) and to discharge it into water bodies without causing significant harm to them. In present days, focus over the water quality remains supreme. Over the decades, scientists have discovered more and more contaminants in fresh water sources. These some scientists have noted a strong correlation between drinking water contamination and many significant health problems. It used to be said that "the solution to pollution is dilution." When small amounts of sewage are discharged into a flowing body of water, a natural process of stream self-purification occurs. Densely populated communities generate such large quantities of sewage; however, that dilution alone does not prevent pollution. This makes it necessary to treat or purify waste water to some degree before disposal.

The use of hazardous chemicals in manufacturing industries and agriculture cause severe water pollution as waste from these industries goes directly into nearby rivers, lakes, ponds and seeps into ground water. The water from that resources is then use for domestic use and drinking purposes, which is highly contaminated by impurities like iron and manganese in addition to turbidity in ground water, and in surface water undesirable chemicals, biological contaminants, suspended solids and dissolve solids are found. If these impurities are not removed before use can cause several severe diseases when consumed by humans or animals. For removal of these contaminants we use several waste water treatment techniques out of which biological techniques are very much important to reduce organic loading and these techniques are very much less expensive as compare to chemical techniques because in this techniques water is treated with the help of micro-organisms which consumes organic load to derive their food and change the complex organic compounds into simpler one. Thus there is no any need of high energy, particular chemicals for treatment which saves our economy. There are many biological wastewater treatment techniques but we are entirely concern about rotating biological contractor (RBC).

In rotating biological contractor (RBC) wastewater's organic loading is very much reduce effectively and efficiently. There are two types of rotating biological contractor

1. Aerobic Rotating Biological Contractor
2. Anaerobic Rotating Biological Contractor

In aerobic treatment of wastewater we need to supply the oxygen for micro organism to carry out their metabolism function to consume the organic load thus in output we get only treated water but in case of anaerobic process no oxygen is supplied to micro organism but the anaerobic micro organism consumes the carbon and nitrogen compounds present in the wastewater to carry out the metabolism activity in output we get methane gas which later used for energy recovery purpose. Higher the C/N ratio in the wastewater higher is the production of biogas (CH4 and CO2)

A. Types of wastewater

Depending upon the source of generation, waste water is broadly classified as domestic wastewater and industrial wastewater.

i. Domestic wastewater

Domestic wastewater also known as municipal wastewater or simple sewage, is the used water, which has been discharged from residential, commercial and institutional zone of city or a town and collected through sewerage system. In general, domestic wastewater contains organic and inorganic solids and microorganisms mainly bacteria.

ii. Industrial wastewater

Normally the wastewater generated by large and medium industries are called industrial wastewater. The waste water varies in quantities and quality from industry to industry and from process to process for the same industry. In general, a majority of manufacturing industries generate a large volume of high strength wastewater.

Concept of Biological Treatment

The colloidal and dissolved solids, mainly organic in nature, still remain in the effluent from primary sedimentation tank because the removal of colloidal solids by simple sedimentation takes longer time, while the reduction of dissolved solids requires their stabilization or conversion into such solids which can then be removed by gravity settling. Fortunately, the mixed population of microorganisms naturally present in the wastewater is able to utilize the colloidal and dissolved biodegradable organic matter as their food for their growth and multiplication. So, to remove the colloidal and dissolved solids from primary effluent, the wastewater is further treated normally using biomass as an agent. This further treatment of wastewater is called secondary treatment and since it usually employs for biological processes it is termed as biological treatment of wastewater.

II. METHODOLOGY

Anaerobic Rotating Biological Contractor is the type of attached growth process which treats the water biologically (by means of bio-films). Our rotating biological contractor comprises of tank which is made up of acrylic glass material which is fully covered from top cover which is also made up of acrylic glass of 4mm thickness to make the system anaerobic. One inlet opening is provided from the top from where the waste water enters into the tank from overhead vessel (tank). Another opening is provided at the top for the gas collection which is produced during the anaerobic digestion by the micro organism. One opening is provided at the base of the tank to drain out the treated water in to the sedimentation tank. Acrylic transparent glass sheet is used so that we can easily analyze all the process going in the tank.

A. Design

Rotating biological contractor's tank is made up of Acrylic glass material of 4mm thickness. Waste water is inserted from the top of the tank where opening is provided. We use over head tank to store the raw water and also to regulate the flow into the RBC tank. Gas kits are provided at the sides of tank where the rod intercepts the tank from both sides to ensure the anaerobic condition inside the tank. Rod is fixed from both ends. One end is fixed with hanger and other end is fixed into the gear box. Gear box is used to control the rotation of the disc with the help of rod. We maintain the depth of the rod in the tank in such a way that the discs are 40% submerged in to the waste water. 20 discs are used in the RBC tank, which are hanged on rod that also helps them to rotate in the tank. Gas is collected from the top opening and is stored in separate chamber for energy recovery purpose. Motor is used to derive out the power to rotate the discs with the help of gear box that converts electric energy of motor in to the mechanical energy.

B. Fabrication

Anaerobic rotating biological contractor following parts are used. Assembling following parts complete RBC. Following table shows the name and quantity of items used in the fabrication of rotating biological contractor.

Table. 1: Item used in Anaerobic Rotating Biological Contractor

S.No	Name Of Items	Quantity Of Items
1	Rotating Biological Contractor Tank	1
2	Top cover of the tank	1
3	Inlet opening	1
4	Outlet valve (for gas and treated waste water)	2
5	DC Motor	1
6	Gear Box	1
7	Transparent Pipe & PVC pipe	3
8	Overhead Tank	1
9	Gas Collector	1
10	Discs	20
11	Rotating shaft	1
12	Typhoon nut	21
13	Washers	21
14	Hangers	1
15	Frame (table)	1
16	Sedimentation tank	1
17	Panels	2

Fig.1: Anaerobic Rotating Biological Contractor

i Rotating Biological Contractor Tank

This tank is made up of acrylic glass material of thickness 4mm. It is designed to treat wastewater upto 30 liters. The dimensions of the tank are 60*40*23 cm. An opening of about half inch is provided at the bottom of the tank to facilitate drainage of treated water and for washing purposes. This is the main tank in which raw waste water enters from top opening upto the level such that discs are 40% submerged into wastewater, during treatment of wastewater this tank will remain close from top so that oxygen will not enter into the tank.

ii Top Cover of RBC Tank

This cover is also made up of an acrylic glass material of thickness 4mm. The dimensions of the top cover are 60*40*20 cm. Two openings are provided in the top cover one opening is for injection of raw wastewater this opening is located at the corner of the top cover so that during injection of wastewater it does not come in contact with rod located at the center of main RBC tank to protect the rod from unwanted reactions. Another opening is provided at adjacent corner to collect the biogas produce during biodegradation of organic matter by methanogenesis bacteria. The boundaries where two tanks will overlap are sealed properly to avoid the oxygen to enter into tank

iii Inlet Opening

This is the opening provided at the corner of the top cover from where the raw waste water enters into main tank from over head tank. Opening diameter is half inch and it is connected with overhead tank with the help of flexible transparent pipe of same diameter.

iv Outlet valve

This is the opening provided at the bottom of the main tank from where the treated wastewater after treatment goes into secondary sedimentation tank, with the help of transparent pipe. The Diameter of this opening is also made about half inch, this also help us in cleaning of tank to remove deposited waste material.

v Over Head Tank

Over head tank is made up of fiber material and have a capacity to store raw wastewater upto 50 liters. This tank is placed on the stand at suitable height so that raw wastewater flows directly into the main tank through pipe, also water regulator tab is provided with over head tank to control the flow of raw wastewater into main tank.

vi Rotating Disc

Disc is made up of material acrylic glass material with a diameter of about 36cm. It plays a major role in treatment of waste water and it is one of the major components of rotating biological contractor. Numbers of discs are rotated together with the help of rotating shaft and they are 35-40% submerged into wastewater. Biofilm formation takes place on the surface of discs which help in degradation of organic waste. We are using at least twenty discs in our designed rotating biological contractor.

vii Rotating Shaft

We are using shaft in our RBC which is 1 meter long and 15 cm in diameter and it is made up of material stainless steel, threads are provided on shaft so that discs get fixed easily. As we are working with wastewater we cannot use any other material like iron which can be easily corroded. Shaft is fixed from both the sides; one side is fixed in hanger while other side is connected with gear box for rotation.

viii DC Motor

It is an electrical devise which converts electrical energy into mechanical energy. It is used in rotating biological contractor to take power from source and convert it into mechanical work to rotate gear box which ultimately connects with shaft.

ix Gear Box Coupled With DC Motor

The transmission box which is also known as the gear box. It is used to change the speed and torque of shaft. As assembly we are using in rotating biological contractor is heavy in weight so we need to provided this gear box so that assembly easily get revolved. Gear box is operated by card which is used to control and regulate the revolution of shaft.

x Transparent Pipe

Transparent pipe is the type of pipe from which we can easily watch the inside of the pipe. We used 3 transparent pipes in our system at different openings, one is used at outlet opening, one is used at biogas collection opening and another one is

used at inlet opening for their respective purposes. Each pipe is 1 meter in length with diameter of half inch is used at each opening.

xi Sedimentation Tank

It is our final tank at which treated wastewater goes after biodegradation in which complex compounds converted into simplest compounds and forms large flocs which are settled down at the bottom of sedimentation tank by the action of gravity which can be later on used for making fertilizer. Treated wastewater collected in sedimentation tank can be used for many of purposes except cooking, drinking etc.

xii Hangers

Hangers act as a support to hang the shaft and help shaft to revolve easily. we have used three hangers to provide support at different points so that overall load of shaft is uniformly distributed over each hanger rather than at a single one. Each hanger is 1 ft high.

xiii Rubber Washers

Each disc is tight with another disc with help of washers and rubber gas kit. We have used gas kits in between discs and washers it acts as a soft material during tightening of discs so that discs will not damaged during fitting on shaft.

xiv Plastic Typhoon nut

These are made up of plastic material having threads on their inside surface. These are used between two discs to ensure that one disc is tight properly with another disc on the shaft.

xv *Frame*

This is type of table made up of iron sheets having dimensions of 5*3*2.5 ft. Every part of rotating biological contractor include tanks, motor, over head tank, hangers, and panels except sedimentation tank will be placed on the table.

xvi Panels

We have used two panels in which cables for dc motor, ampere meter, volt meter, and also card which controls the shaft revolution are installed. Shape of the panel is like box made up of iron material.

C. OPERATING PROCEDURE

STEP 1: Collection of Wastewater

Wastewater from fields such as domestic, industrial wastewater is collected; make sure that the wastewater which you are taken must contain high BOD, COD and carbon to nitrogen ratio. This helps in generating sufficient amount of biogas during treatment.

STEP 2: Characterization of Wastewater

Before filling the wastewater into the tank we will find out its parameters like BOD, COD, TDS, Alkalinity, Acidity, Dissolved Oxygen and etc.

STEP 3: Filling of Rotating biological tank with wastewater

After collection wastewater is inserted into over head tank from which it is transfer to rotating biological tank by mean of inlet opening through pipe connected between over head tank and rotating biological tank.

STEP 4: Checking of valves and leakages

Before inserting wastewater into main tank make sure that outlet valve must be closed and there should be not any leakages around the tank. The wastewater will be filled in such a away that only 40 percent of discs are submerged in it, otherwise it will drain out from opening provided for rotating shaft.

STEP 5: Connecting DC Motor with electricity source

Motor needs electrical power to run, so it is very much necessary to provide proper electricity while operating the project. That is why some panels are required to regulate or operate the motor at particular voltage. And panels are then connected to electrical supply.

STEP 6: Setting of shaft revolution

Motor has high revolutions so to reduce rpm to our requirement some circuits are installed inside the panels which regulate the rpm along with our requirement through regulator provided on the panel from which we can increase or decrease the rpm as per requirement.

STEP 7: Treatment of Wastewater

Wastewater is to be treated in the main tank in which the discs are revolved, which contains the biological media on their surface as they rotate inside the tank bio-media starts to grow by consuming the nutrients and organic matter from the wastewater under the anaerobic condition which reduces the organic load and some impurities.

STEP 8: Generation and Collection of Biogas

Under anaerobic condition when micro organisms utilize the organic matter for their growth purpose they produce biogas through four basic processes (hydrolysis, acidogenesis, acetogenesis and methanogenesis) and it is then collected through the opening provided in the top corner of the tank from which gas is collected into jar.

STEP 9: Turn off the DC Motor

When wastewater is treated as per requirements are achieved then simply turn off the motor by cutting the power or by just simply switching off the motor through panel.

STEP 10: Drain Out Treated Wastewater

Wastewater is drained out after treatment with the help of valve provided at the bottom of the main tank through pipe.

STEP 11: Storage of Treated Wastewater into Secondary Clarifier

After draining out the wastewater it is collected into secondary clarifier (tank) in which water is left for certain period of time for flocks formation, flocks then settle down in the bottom of the tank.

STEP 12: Analysis of Wastewater Parameters

Wastewater sample is collected from secondary clarifier to analyze its parameter after treatment to compare the result before and after treatment to calculate the efficiency

STEP 13: Maintenance & Back Washing Of System

If necessary then maintenance and back washing is required when the main tank gets dirty or clogged with suspended load and bio-film then it is necessary to clean the main tank for proper treatment.

III. CONCLUSIONS

In our present work, we have demonstrated an Anaerobic Rotating Biological Contractor. We have explained briefly designing and fabrication of rotating biological contractor. Wastewater from the different places will be collected and it will be analyzed by doing different physical, chemical and biological test. After analyzed, wastewater will be treated in the Anaerobic Rotating Biological Contractor and then again tests will be performed to analyze the water on same parameters to note down the efficiency of water treatment of the project. It is batch type laboratory scale reactor it will be further expanded into a large scale reactor which can be later use for treating large volume of wastewater. If necessary we can make reactors in series or parallel combination to treat larger volume and to obtain more efficiency. One reactor is called one module and the modules are provided in series so that large volume of wastewater can easily be treated and again same modules are connected in parallel also to treat the water more efficiently. In this project we have designed and fabricated an anaerobic rotating biological contractor which can treat synthetic wastewater with the help of bio-film. This reactor is built on small scale to detect the efficiency of this treatment system, this anaerobic rotating biological contractor is made up of two glass tanks, 28 acrylic glass discs, rotating shaft and DC motor. And this project is designed to treat approximately 30 liters' of wastewater during one batch process as it is batch reactor do not work continuously. Two holes are provided on the top corner of the tank from which one is utilized for input of wastewater into the main tank and other hole is utilized for gas collection purpose.

IV. RECOMMENDATIONS

- It can be used for treatment of any kind of wastewater which contains high organic load in it.
- We can increase its number of reactors as per requirement of treatment.
- We can also make it continuous stirred type reactor.
- We can operate the motor on solar power as solar energy is renewable form of energy.
- We can also implement this project on mass scale.
- We can also use disinfectants in the wastewater present in the secondary clarifier so that the effluent can also be used for recreational purpose without causing any harm to anyone.
- Some pre-treatment units must be installed before can be retained from entering the main tank to avoid the clogging in the outlet.

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