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Commercial Design of Biodigester for the Biofertilizer Production at Source Level Elimination

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ABSTRACT

The present research work is mainly investigated to design the low cost biodigester to produce high yield biofertilizer products. Further the scope of the work is also examined. The leachate solutions to obtain and determine physio-chemical characteristics and nutrient enrichment. Thus, the process has been employed under anaerobic digestion with the suitable dimensions with suitable selective mode of biological operations. The mesophilic temperature, pH 7.1 TO 7.5 helps to recover high quality of biofertilizer in the range of 85-90% with selective microbial strains. This biodigester is used for domestic purposes of producing biofertilizer in small scale for terrace gardens and also biogas produced as a byproduct is utilized as biofuel for cooking purposes.

INTRODUCTION

Depending upon the substance being digested and the digestor category, anaerobic digestion can be undertaken out as a continuous, batch or semi-batch technique. There are two types of digestion like wet digestion and dry digestion. Wet digestion comprises waste like sewage slush, liquid animal waste. Basically bio-digester operate under three ranges of temperature: mesophilic, thermophilic and psychrophilic. Various types of anaerobic digester technologies namely covered lagoon, plug flow, complete mix, fixed film, Up-flow Anaerobic Slush Blanket (UASB) [1]. The main aim for designing this biodigester is because of its cost efficiency and desired yield is also obtained. The bio-digester consists of following parts namely fermentation chamber, inlet pipe, agitator, gas flexi pipe. The size of the biodigester relies on the desired capacity of the yield required [2].

The anaerobic reaction comprises three stages like hydrolysis, acidogenesis, acetogenesis and methanogenesis. In hydrolysis, sophisticated organic matter like carbohydrates, proteins and lipids are broken down into simpler molecules like sugars, amino acids and fatty acids. In acidogenesis volatile fatty acids are converted acetic acid, hydrogen and carbon dioxide. Methanogenesis in the production of methane and carbon dioxide [3]. The experiment was conducted on a laboratory level with a 50 liters capacity and the working volume of the biodigester is found to be 45 liters, the temperature was around 37℃ (mesophilic temperature). The byproduct (biogas) release was measured by two analytical methods namely cone model and modified Gompertz model. In this study they used peeled cassava tubers with and without inoculum and found that the biogas yield rate is large in peeled cassava tubers with inoculum. The peeled cassava tubers without inoculum have reduced rates of biogas yield after the 21 days of retention time [4].

The B-RADeS (Biodigester Rapid Analysis and Design System) software systems are used in the design of the biodigester. The following procedures are employed in this software, the steps are analyzing the problem, designing of GUI (Graphical User Interface), developing an algorithm, writing a pseudocode on paper, coding over a software named MATLAB. This software helps us to find the biogas yield rate and we could design the biodigester of our desired capacity and model. Through this software any type of biodigester can be designed and valuable output is acquired [5].

The study was conducted in the condominium houses of Ethiopia for the production of biogas for domestic purposes such as cooking by the designing of cylindrical fixed dome bio-digester. By the technique of biomass conversion which results in energy production(biofuel) and nutrient rich biofertilizer which is of high quality obtained as a result of digestion of organic matter. The organic matter utilized in the study is obtained from the food wastes collected from the kitchen of the condos and the fecal wastes collected from the toilets of the condos [6]. For the designing of biodigester, the following parts like inlet chamber, outlet chamber, digester body, gas holder, stirrer has to be in correct dimension and the parameter like pH, temperature, quantity of volatile solids, hydraulic retention time (HRT), digester volume, specific gas production, digester up-loading, gas holder volume to be considered for designing an efficient bio-digester [7].

The methodology used in designing is classified as fabrication, experimentation and evaluation. Under experimentation, implementation, development, observing and monitoring results are employed. Evaluation is further classified as generation of energy and economic feasibility [8]. From the animal waste, the yield of biofertilizer and biogas is comparatively higher than other raw materials used in the biodigester production process. Usage of synthetic fertilizer results in great emission of greenhouse gasses like carbon dioxide, carbon monoxide causing global warming. This research work of biofertilizer produced by the help of a biodigester with wastes provides an efficient way of recycling the unwanted waste thereby eliminating the pollution of land [9]. Thus the work reported in this article states the biofertilizers thus produced from organic waste are both efficient and economic as it is affordable, non-toxic, and does not cause any pollution. This type of biofertilizer is produced by the biodigester within a short duration of time due to the anaerobic reaction at low cost with high yield.

MATERIALS AND METHODS

Material selection for the design and fabrication of biodigester

The biodigester that we design and fabricate is for the production of biofertilizer as the final product. For the fabrication of this biofertilizer we are using a type of polymer named poly vinyl chloride (PVC) which induces us to this type of material due the properties like high impact strength, easier to extrude and mold, low temperature resistant, lower ultimate tensile strength, resistant to corrosion. Therefore, the parts of the biodigester like fermentation chamber, feed inlet pipe, flexi gas and leachate outlet pipe are made up of this poly vinyl chloride material for its properties and resistant various factors. The reaction that takes place in this biodigester is the anaerobic reaction that is the reaction that takes place in the presence of an anaerobic bacteria and in the absence of the oxygen as it happens in the closed environment. In order to increase the rate of the reaction the action of the microorganisms has to be increased so we are using a mechanical device called agitator or stirrer to mix the slurry that is the mixture of solid and liquid fed to the bio-digester which increases the action of the microorganisms. The agitator is made up of stainless steel (SS) or aluminum (Al) due to its characteristics like corrosion resistance, durability, temperature resistance and low maintenance. The agitator runs at the speed of 18 rpm (revolutions per minute) with the aid of a motor. The closing lid is also made up of poly vinyl chloride material.

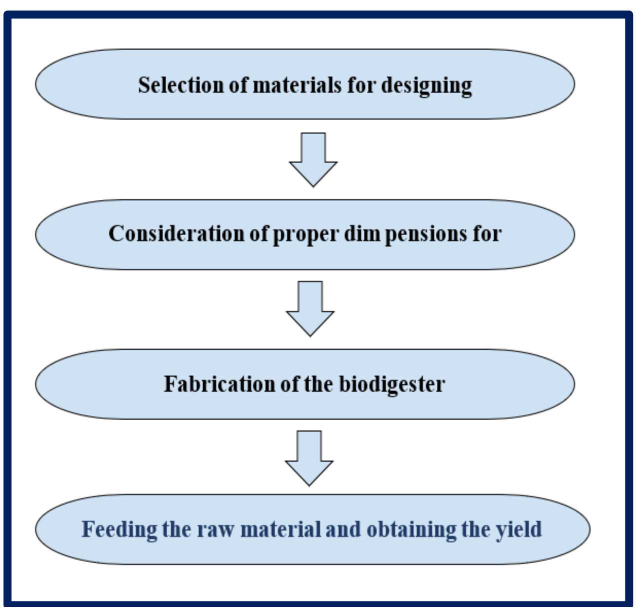

Fig 1: Procedure for Designing a Biodigester for the production of Biofertilizer

Composition of raw materials for the biodigester fabrication

The poly vinyl chloride that is used in the designing of the parts of biodigester like fermentation chamber, inlet and outlet pipe are brought and mold for our desired shape with the composition of ethylene from a colorless gas derived from petroleum and chlorine from the electrolysis of saltwater in which chlorine accounts for 57% of the mass of vinyl chloride monomer, carbon of 38%, hydrogen of 5% respectively. The stainless steel that is used in the agitator which comprises chromium (16-18%), nickel (10-14%), molybdenum (2-3%), carbon (<0.03%). The raw material that is fed into biodigester is the organic wastes like food wastes (vegetables, fruits, leaves) that are collected from various sources like markets, schools, college, office canteens with water at the ratio of 2:1[13-15]. Initially the biodigester was loaded with 3 to 4 kilograms of wastes and periodically with 1 to 1.5 kg of feed. The gas valve was kept open for 70 hours to release any air as it is an anaerobic process.

RESULT & DISCUSSION

Experimental procedure and Measurement

Capacity of the biodigester

The capacity of the fabricated biodigester is 30 liters in volume. In the total capacity, biodigesters cervix where the closing lid is fixed of volume with notation of (V_C), the fermentation chamber of volume denoted by (V_F)[15 − 17]. To fabricate a biodigester we need to use all these volumes as shown in equation 1and 2 for proper structure of an efficient digester with appropriate dimensions.

The parameters that we considered in our calculation:

No. of. Faces	=	10 sides
Length of the chamber	=	40 cm
Length of the inlet pipe	=	4 cm
Length of the semicircular section	=	15 cm
Radius of the inlet	=	20.5 cm
Radius of the outlet pipe	=	1.5 cm

The volume of cervix here considered can be calculated with formula,

$V_C = \boldsymbol{\pi}\,(D/2)^2\ \ l = 5278.34\ cm^3 \quad -------\ eqn\ 1$

Here D/2 = 20.5 cm, l = 4cm

The volume of the semicircular section can be calculated using the formula,

$V_S = 2/3\pi(d/2)^3 = 93653.4\ cm^3$------------------------eqn 2

Here d/2 = 35.5 cm

At last, the volume of the fermentation chamber can be calculated using the formula,

$V_F = \boldsymbol{\pi}R^2\ \ L = 216314.6\ cm^3$

Here R = 41.5 cm

Therefore, the total volume of the biodigester is,

$V_T = V_C + V_S + V_F = 315246.34\ cm^3$

The capacity of the biodigester is chosen to be compact in order to meet with the domestic needs of biofertilizer and later on scaled up to the industrial level depending upon the efficiency.

Outlet pipe design. Since the pipe is cylindrical in shape

The volume of the gas outlet pipe is calculated by the formula as equation 3,

$$V = \boldsymbol{\pi}R_2^2L_2 = 141.3\ cm^3 \text{---------eqn 3}$$

Here R = 1.5 and L = 20 cm

Digester cover plate designing

For the inlet and an outlet pipe the polyvinyl chloride material is used and pressure consideration of bursting pressure is calculated by equation 4,

$P_E = 2\times S_t\times T_M /\ d_m\ -------\ eqn\ 4$

Here P_E is the bursting pressure, S_t is the tensile strength of pipe, d_m the diameter.

Gas valve design through which the gas is collected

The gas valve equation has to be found for the valve and it is represented as in equation 5

$$Q = C_V((P0 - P3)/N)^{\left(\frac{1}{2}\right)} - -eqn\ 5\ ,$$

obtained this by considering the factors like flow rate and expected pressure drop.

Airing detection test for the biodigester fabrication

The airing test was performed to check whether the biodigester is leak proof as the reaction that is being employed here is anaerobic digestion that is the reaction which occurs in the absence of oxygen and there should not be any chance of leakage. From the figure 1 it is clear that how the procedure is carried out in the designing of a biodigester for the production of biofertilizer and biogas as it helps in the waste recycling to the utmost extent as everything, we use in this as feed is converted into the product. Figure 2 demonstrates the designing measurements required for our biodigester which we predicted from the capacity of our feed that we are going to feed to the biodigester based on that volume calculations are made using formulae[17-20].

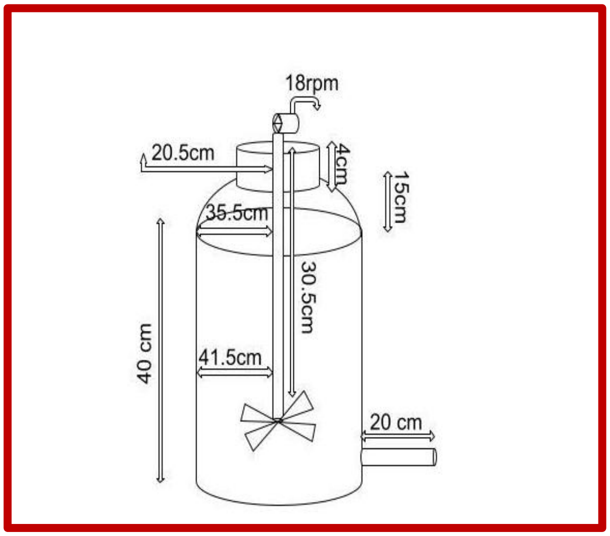

Fig 2: Diagrammatic representation of biodigester model

The biodigester fabricated in this study is used for the production of biofertilizer with rich nutrient content. In this bio-digester operation is of continuous process. It is maintained in a mesophilic temperature (35 - 37℃). The biodigester is connected with an agitator which enhances the population of microorganism as the reaction employed here is anaerobic reaction so the action of microorganisms plays a major role of to increase the rate of reaction which in turn results in the production of nutrient enhanced biofertilizer (slurry) solid fertilizer, leachate obtained can be used as liquid fertilizer. As the reaction proceeds byproduct like biogas is collected which can be used as an efficient alternative for depleting fossil fuels to meet the demands of fuel availability. This results in efficient management as we are converting waste products into useful fertilizer and we are gaining utmost energy efficiency by our designed biodigester.

CONCLUSION

After the completion of our process of producing the biofertilizer using the biodigester we designed we have predicted that experimentally if we give a feed of for example 3 kg of organic matter (food wastes) we got 1.8 kg of nutrient rich biofertilizer, 1.4 kg of liquid biofertilizer and the remaining of the gas called bio-gas contains mainly of hydrocarbon like methane (CH_4). As from this we came to know that we are recycling the waste to the maximum extent as the feed we are feeding is fully converted into either one of the products above mentioned. The biodigester design is useful in the production of biofertilizer at optimum parameters like mesophilic temperature and alkali pH. The biofertilizer is produced at an earlier time than the biofertilizer produced by degradation using landfills. The biofertilizer produced can be used for enhancing the nutrients in the crops as it is natural and it is non toxic in nature as it does not cause any pollution in land. So from this it is clear that it is rich in nutrients and non toxic.

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