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Production of Hydrogen, Electric Power, and Organic Fertilizer from Sludge Using Anaerobic Sludge Digestion Reactor

Author: B.Perumal[1], M.Shabari[2]
Guide: L.Mekala[1] , N.Veerasekar[2]

- *B.Perumal is currently pursuing M.E. (Final)Environmental Engineering in Erode Sengunthar Engineering College, IndiaPH-9951668959. E-mail: perukrish@gmail.com*
- *M.Shabari is currently pursuing B.E. (Final)Civil Engineering in Erode Sengunthar Engineering College, IndiaPH-9578218284. E-mail: saishabari46@gmail.com*
- *L.Mekala is currently working as a assistant professor in Environmental engineering Dept. under Civil Engineering Department in Erode Sengunthar Engineering College*
- *N.Veerasekar is currently working as a assistant professor in Environmental engineering Dept. under Civil Engineering Department in Erode Sengunthar Engineering College*

Abstract— In current scenario all we are focusing only on the technology development. But we are forgetting to see the impact and pollutants which are destroying our mother earth. It is not only because of technology development, but it may also be the reason for it. My project details how to save our mother earth? Due to bad impact of organic waste. My project also say that how to conventionally produce Hydrogen, Electric Power and Organic Fertilizer from the organic waste.

Index Terms— Fuel in Rockets, eco-friendly, high cod removal efficiency, avoid green house effect, reduction in investment cost, clean energy source, high energy 122 kJ g-1, high economic profitable project to save environment,

1.INTRODUCTION

1.1 GENERAL

Biogas typically refers to a gas produced by the breakdown of organic matter in the absence of oxygen. It is a renewable energy source, like solar and wind energy. Additionally, biogas can be produced from regionally available raw materials such as recycled waste and is environmentally friendly.

Biogas is produced by anaerobic digestion with anaerobic bacteria or fermentation of biodegradable materials such as manure, sewage, municipal waste, green waste, material, and crops. It is primarily methane (CH_4) and carbon dioxide (CO_2) and may have small amounts of hydrogen sulphide (H_2S), moisture and siloxanes.

The gases methane, hydrogen, and carbon monoxide (CO) can be combusted or oxidized with oxygen. This energy release allows biogas to be used as a fuel it can be used for any heating purpose, such as cooking. It can also be used in a gas engine to convert the energy in the gas into electricity and heat.

Biogas can be compressed, the same way natural gas is compressed to CNG, and used to power motor vehicles. In the UK, for example, biogas is estimated to have the potential to replace around 17% of vehicle fuel. It qualifies for renewable energy subsidies in some parts of the world. Biogas can be cleaned and upgraded to natural gas standards when it becomes bio methane and bio hydrogen.

1.2 BIOHYDROGEN

In a compound state, hydrogen is most commonly found on the earth in the form of water, or H_2O. Potentially, as a motor fuel, the main source of hydrogen is natural gas and methanol. Hydrogen fuel may contain low levels of carbon monoxide and carbon dioxide, depending on the source. In order to be useful as a motor fuel, hydrogen must be manufactured from other sources. Pure hydrogen can be extracted from virtually any hydrogen-containing compound.

The worldwide energy need has been increasing expo-nentially and the reserves of fossil fuels have been decreasing. Environmental pollution due to the use of fossil fuels as well as their shortfall makes it necessary to find alternative energy sources that are environmentally friendly and renewable.

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As the depletion of limited fossil fuels is inevitable, there is an urgency to search for replacement source of energy. The extensive use of fossil fuel has also created an environmental issue where emission of carbon dioxide during combustion of fossil fuels has caused a global warming effect. For these reasons, researches are looking at alternative fuels that combat both the mentioned problems. Hydrogen is one of the most abundant elements in the universe in its ionic form. It is an odorless, colorless, tasteless and non-poisonous gas.

Hydrogen can be produced using diverse, domestic resources, including nuclear, natural gas and coal, biomass, and other renewable sources. The latter include solar, wind, hydroelectric, or geothermal energy. This diversity of domestic energy sources makes hydrogen a promising energy carrier and important for energy security.

Hydrogen gas is a clean energy source with a high energy content of 122 kJ g-1. Unlike fossil, fuels hydrogen does not cause any CO_2, CO, SO_x and NO_x emissions producing water as its only by-product when it burns reducing green house effects considerably. Hydrogen is considered to be a major energy carrier of the future and can directly be used in fuel cells for electricity generation.

According to the U.S. Energy Information Administration (USEIA, 2011), the demands of liquid fuels will keep increasing by 2035 and the growth of the transportation sector needs will occupy 85%, despite rising fuel prices.

The annual production of hydrogen is estimated to be about 55 million tons with its consumption increasing by approximately 6% per year. Hydrogen can be produced in many ways from a broad spectrum of initial raw materials.

Nowadays, hydrogen is mainly produced by the steam reforming of natural gas, a process which leads to massive emissions of greenhouse gases. Close to 50% of the global demand for hydrogen is currently generated via steam reforming of natural gas, about 30% from oil reforming from refinery/chemical industrial off-gases, 18% from coal gasification, 3.9% from water electrolysis, and 0.1% from other sources.

1.3 CURRENT USES OF HYDROGEN ENERGY

It is primarily used to create water. Hydrogen gas can be used for metallic ore reduction. Chemical industries also use it for hydrochloric acid production. The same hydrogen gas is required for atomic hydrogen welding (AHW).

Electrical generators use the gas as a rotor coolant. The element is relied upon in many manufacturing plants to check for leaks. Hydrogen can be used on its own or with other elements. Other applications include fossil fuel processing and ammonia production. Ammonia is part of many household cleaning products. It is also a hydrogenating agent used to change unhealthy unsaturated fats to saturated oils and fats.

Hydrogen is also used for methanol production. Tritium is generated in nuclear reactions. It is a radioactive isotope used to make H-bombs. It can also be used as a luminous paint radiation source. Tritium is used in biosciences as an isotopic label.

Other uses of hydrogen are in the fertilizer and paint industries. It is also used in the food and chemical industries. Food industries use the element to make hydrogenated vegetable oils such as margarine and butter. In this procedure, vegetable oils are combined with hydrogen. By using nickel as a catalyst, solid fat substances are produced. In petrochemical industry, hydrogen is required for crude oil refinements.

Welding companies use the element for welding torches. These torches are utilized for steel melting. Hydrogen is required as a reducing agent in chemical industries. Chemical industries use them for metal extraction. For example, hydrogen is needed to treat mined tungsten to make them pure.

- Most used in petroleum refining and petrochemical production (93%)
- Metal processing (2.7%)
- Manufacture of electronic components (1.5%)
- Food processing (0.7%)
- Manufacturing of glass (0.3%)
- Utility power generation (0.2%)

1.4 ADVANTAGES OF HYDROGEN ENERGY

1.4.1 Readily Available

Hydrogen is a great source of energy for a number of reasons, the biggest one being that it is so readily available. While it may take some work to access, there is no element in the universe as abundant as hydrogen.

1.4.2. No Harmful Emissions

Another advantage to using hydrogen energy is that when burned, its leaves almost no harmful byproducts. In fact, when used in NASA's spaceships, the burned hydrogen gas leaves behind clean drinking water for the astronauts.

1.4.3 Environment Friendly

Hydrogen is also non-toxic, which makes it a rarity among fuel sources. Nuclear energy, coal, and gasoline are all either toxic or found in hazardous environments. This makes hydrogen ideal for use in a number of ways other fuel sources can't compete against

1.4.4 Used as Fuel in Rockets

Hydrogen energy is also very powerful and very efficient. It's powerful enough to propel spaceships and safer than using any other similar product to accomplish such an energy-intensive duty. In fact, hydrogen is three times as powerful as gasoline and similar fossil fuels, meaning it takes less of it to accomplish more.

1.4.5 Fuel Efficient

Hydrogen energy is very efficient fuel source than traditional sources of energy and produces more energy per pound of fuel. This clearly means that a car loaded with hydrogen fuel with go much farther than the one using same amount of traditional source of energy.

1.4.6 Renewable

Unlike non-renewable sources of energy which can't be produced again and again as they are limited; hydrogen energy can be produced on demand. Hydrogen is available in plenty. All we need is fossil fuels to break the water molecules to separate it from oxygen.

1.5 DISADVANTAGES OF HYDROGEN ENERGY

Hydrogen energy is not quite the perfect, super clean and cheap energy source that so many companies and governments would love to get their hands on. It's volatile in gas form, and while that makes it able to accomplish huge tasks, it also makes it sometimes hazardous to work around and use.

1.5.1 Expensive:

Hydrogen gas also requires a lot of work to free if from other elements. If it were simple and easy to isolate everyone would be using it. It's already being used to power some hybrid cars, but at the moment it is not a viable source of fuel for everyone. That's simply because it's expensive and time-consuming to produce. That means until technology advances enough to simplify and ease the process; hydrogen energy will continue to be too expensive for most people.

1.5.2 Storage:

Hydrogen is also hard to move around. Whereas oil can be sent through pipelines, and coal can be carried in the back of dump trucks, super-light hydrogen is hard to transport in a reasonable fashion. It is very expensive to move anything more than small amounts of it, making it impractical for most functions.

1.5.3 Not Easy to Replace Existing Infrastructure:

As expensive as hydrogen is to produce and transport, it becomes even more expensive when you consider trying to use it to replace gasoline. There is no existing infrastructure in place to accommodate hydrogen as a fuel source for the average motorist. Gas stations and cars themselves would all have to be refitted at an astronomical cost to taxpayers and governments. It seems insane to even suggest that current fuel sources be replaced when what is already in place is working so well.

1.5.4 Highly Flammable:

Hydrogen in itself is a very powerful source of fuel. We all know the effects of hydrogen bomb that was dropped on Hiroshima and Nagasaki in Japan. It's highly inflammable and always in news for the potential risks associated with it.

1.5.5 Dependency on Fossil Fuels:

Though hydrogen energy is renewable and its environmental impacts are minimal, we still need other non-renewable sources like coal, oil and natural gas to separate it from oxygen. We may reduce our dependency on fossil fuels by using hydrogen but in turn we are actually using them to produce hydrogen fuel

LIST OF ABBREVATIONS

AHW - Atomic Hydrogen Welding

APHA - American Public Health Association

BOD - Biochemical Oxygen Demand

CD - Cyclic Duration

COD - Chemical Oxygen Demand

CNG - Compressed Natural Gas

CSTR - Continuous Stirred Tank Reactor

F/M - Food to Microorganism ratio

HPR - Hydrogen Production Rate

HRT - Hydraulic Retention Time

MLVSS - Mixed Liquor Volatile Suspended Solids

NASA - National Aeronautics and Space Administration

OLR - Organic Loading Rate

PVC - Poly Vinyl Chloride

SRT - Solids Retention Time

SS - Suspended Solids

T-RFLP - Terminal Restriction Fragment Length Polymorphism

TS - Total Solids

TDS - Total Dissolved Solids

TVS - Total Volatile Solids

UASB - Upflow Anaerobic Sludge Blanket

USIEA - United State Energy Information Administration

VFA - Volatile Fatty Acids

VS - Volatile Solids

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2 About Project

2.1 OBJECTIVE OF THE PROJECT

- To produce the hydrogen from organic waste and sludge
- To reduce the electricity problems
- To produce organic fertilizer
- To Minimize COD & BOD and to estimate the removal efficiency

2.2 FEED FOR REACTOR

- Food waste
- Municipal organic waste
- Domestic waste
- Organic waste from treatment plant (such as sludge waste)
- Waste from mill
- And so on… (Any organic waste)

2.3 SLUDGE

Sludge is one of the most important and abundant organic waste from treatment plant. During Secondary treatment of waste water tones of sludge are produced. Ex: CETP [Common Effluent Treatment Plant]. Contains high COD and BOD

3 CURRENT PRACTICE OF SLUDGE

- Collection of sludge
- Thickening of sludge
- Dewatering of sludge
- Evaporation of water from sludge
- Packing of dry sludge
- Dumping or land filling

3.1 DISADVANTAGE OF CURRENT PRACTICE

- Contains high level of COD
- Produce green house gas when decomposed
- Occupies huge are when dumped
- Cost transport charge during disposal of waste water tones of sludge are produced
- Ex: CETP [Common Effluent Treatment Plant]

4 OUR IDEA TO TREAT SLUDGE

- Collection of sludge
- Feed to reactor
- Extraction of H2, electric power
- Drying of digested sludge
- Packing as fertilizer

4.1 WORK REDUCED BY OUR IDEA

NO NEED OF

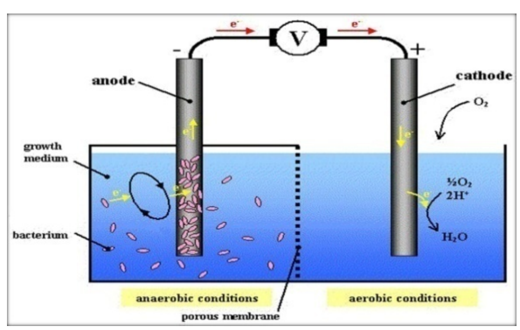
- sludge thickening unit
- sludge de-watering unit
  - Filter press
  - Centrifugal de-watering unit
- Solar evaporation beds
- Packing unit of dry sludge
- Storage place for dumping packages

5 REACTOR SPECIFICATION

PARTS OF REACTOR	SPECIFICATION	USED
ANODE	E^0 VALUE= -0.76	ZINC
CATHODE	E^0 VALUE= +0.34	COPPER
F E E D	BEFORE DE-WATERING	CETP SLUDGE
INOCULUM	NATURAL SOURCE	MIX OF HORSE & COW MA-NURE
MEMBRANE	POROUS	POROUS MEMBRANE
CHAMBER	NON-CONDUCTIVE	PLASTIC
COVER OF CHAMBER	5mm THICK	PLASTER OF PARIS

5.1 REACTOR DESIGN

- Total volume of the reactor = 1+1=2 L
- Height of the reactor = 15 cm
- Diameter of the reactor = 10 cm
- Gas escape = 2.5cm



5.2 REACTOR OPERATION

- Fill
- React (bacteria and organic waste)
- Extraction of Hydrogen gas and electric power
- Settle
- Decant

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5.2 REACTION

In most cases, biomass is made up of large organic polymers. For the bacteria in anaerobic digesters to access the energy potential of the material, these chains must first be broken down into their smaller constituent parts. These constituent parts, or monomers, such as sugars, are readily available to other bacteria. The process of breaking these chains and dissolving the smaller molecules into solution is called hydrolysis. Therefore, hydrolysis of these high-molecular-weight polymeric components is the necessary first step in anaerobic digestion.[21] Through hydrolysis the complex organic molecules are broken down intosimple sugars, amino acids, and fatty acids.

Acetate and hydrogen produced in the first stages can be used directly by methanogens. Other molecules, such as volatile fatty acids (VFAs) with a chain length greater than that of acetate must first be catabolised into compounds that can be directly used by methanogens.

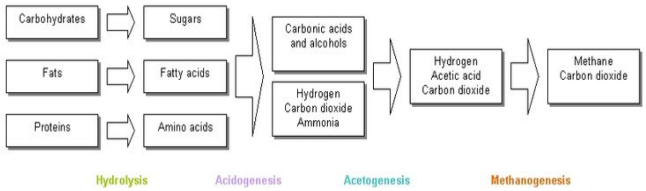
The biological process of acidogenesis results in further breakdown of the remaining components by acidogenic (fermentative) bacteria. Here, VFAs are created, along with ammonia, carbon dioxide, and hydrogen sulfide, as well as other byproducts.[23] The process of acidogenesis is similar to the way milk sours.

The third stage of anaerobic digestion is acetogenesis. Here, simple molecules created through the acidogenesis phase are further digested by acetogens to produce largely acetic acid, as well as carbon dioxide and hydrogen.[24]

The terminal stage of anaerobic digestion is the biological process of methanogenesis. Here, methanogens use the intermediate products of the preceding stages and convert them into methane, carbon dioxide, and water. These components make up the majority of the biogas emitted from the system. Methanogenesis is sensitive to both high and low pHs and occurs between pH 6.5 and pH 8.[25] The remaining, indigestible material the microbes cannot use and any dead bacterial remains constitute the digestate.

A simplified generic chemical equation for the overall processes outlined above is as follows:

$$C_6H_{12}O_6 \rightarrow 3CO_2 + 3CH_4$$



When NaOH is add the following reaction takes place

$$Co_2 + 2NaOH \rightarrow Na_2CO_3 + 2H + [O]$$

$$2H + [O] \rightarrow H_2o$$

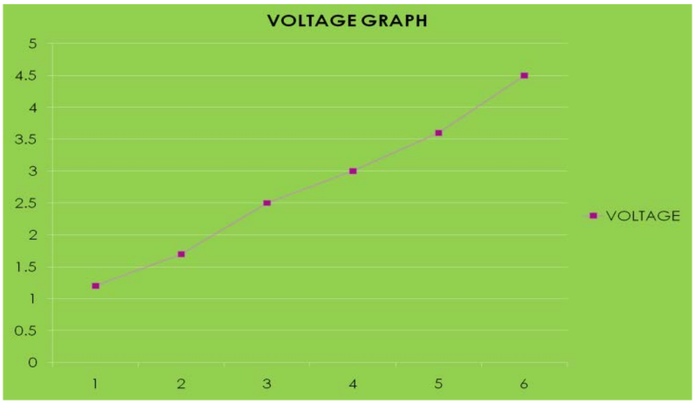
$$Co_2 + 2NaOH + CH_4 \rightarrow 2Na_2CO_3 + 4H$$

5.2 REACTOR EFFICIENCY

- COD removal efficiency 82.32%
- Electric Power Generation 4.5 V(appox.) per liter

6 RESULT

Electrode	E^0 Value	No. of Electrode	Surface Area	No. of days of Incubation	Voltage Produced
Copper, Nickel	+0.34, -O.76	1	62.8cm^2	1 day	1.2volt
Copper, Nickel	+0.34, -O.76	1	62.8cm^2	2 day	1.7 volts
Copper, Nickel	+0.34, -O.76	1	62.8cm^2	3 days	2.5 volts
Copper, Nickel	+0.34, -O.76	1	62.8cm^2	4 days	3.0 volts
Copper, Nickel	+0.34, -O.76	1	62.8cm^2	5 days	3.6 volts
Copper, Nickel	+0.34, -O.76	1	62.8cm^2	6 days	4.5 volts



VOLTAGE GRAPH

7 END SECTIONS

7.1 SUMMARY:

- The experimental study demonstrated the feasibility of H_2 generation from sludge waste by anaerobic fermentation is suspended growth bioreactor using anaerobic inoculums is mix of horse and cow manure.
- The selected reactor operating conditions will find the optimum for effective hydrogen yield.

7.2 SCOPE FOR THE FUTURE STUDY

- To produce the hydrogen from sludge waste
- To optimize the reactor and evaluation of hydrogen yield rate.
- To Minimize COD in dairy wastewater using reactor up to 60%.
- To reduce the fuel and electricity problems

8 CONCLUSION

Although a conclusion may review the main points of the paper, do not replicate the abstract as the conclusion. A conclusion might elaborate on the importance of the work or suggest applications and extensions. Authors are strongly encouraged not to call out multiple figures or tables in the conclusion—these should be referenced in the body of the paper.

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