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AND UTILISATION OF WASTE WATER TO PRODUCE ELECTRIC ENERGY

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Abstract: Increase in human activities is consuming the natural energy sources which lead to depletion in fossil fuels. Even the sources of fresh water are decreasing at alarming rate. So, we must focus on 3R's-reduce, reuse, recycle. Industrial waste water which can be treated through pollutant free machine (which makes this water toxic free and suitable for reuse to produce electric energy before disposing into environment). This can be made possible by using Microbial fuel cells (MFCs), which converts organic matter into electricity with the help of bacteria present in water. By using pollutant free machine, we can make water suitable for processing, which is adding nitrogen and carbon in suitable amount, which is consumed in 72 hours with 62% voltaic efficiency. The MFCs enriched with iron (III) chloride ($FeCl_3$) produce the most power which is approximately 1.2W/m2 and that can be increased by having it for huge amount of waste water, easily available in industry.

Keywords*:* COD, MFCs, ZERO POLLUTANT,CRSW.

INTRODUCTION

INCREASE IN INDUSTRIALIZATION LEADS TO MORE DEPLETION OF SURROUNDING ENVIRONMENT (SUCH AS AIR POLLUTION, SOUND POLLUTION AND WATER POLLUTION). FROM NATIONAL GEOGRAPHIC REPORTS, 70% OF ALL INDUSTRIAL POLLUTION IS DUMPED DIRECTLY INTO THE WATER TABLE THUS POLLUTING DRINKING WATER. POLLUTANTS FROM INDUSTRIAL SOURCES INCLUDE: LEAD, MERCURY, NITRATES, PHOSPHATES, SULPHUR, OIL, PETROCHEMICALS AND ASBESTOS. FOR EXAMPLE: TEXTILE DYE WASTE WATER PRODUCED BY CLOTHING FACTORIES IS CREATING A MAJOR WATER POLLUTION PROBLEM IN CHINA. FORTUNATELY, FILTRATION SYSTEMS ARE CONTINUOUSLY BEING REFINED TO CLEAN FACTORY WASTE BEFORE IT REACHES THE WATER SUPPLY ACCORDING TO MORE SPECIFIC WATER LAWS (PREVENTION AND CONTROL OF POLLUTION ACT 1974) BY THE SUPREME COURT OF INDIA.

Technology introduction

1. Microbial fuel cell (MFC):MFC is a device which converts chemical energy to electrical energy during substrate oxidation with the help of microorganisms. MFC contains two compartments: cathode and anode separated with proton/cation exchange membrane. Microorganism oxidizes the substrate and produces protons and electrons in the anode chamber of MFC. Electrons collected on the anode are transported to cathode by external circuit and protons are transferred through the membrane internally.

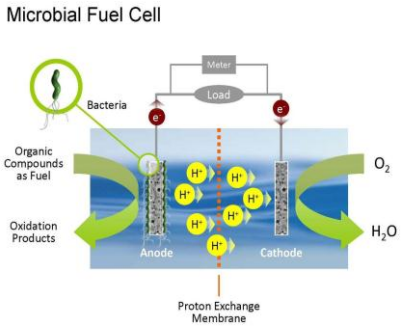

Figure 1: Mediator less Microbial Fuel Cell

Description:
The waste water was fed into the anode compartment from the waste water reservoir.Microorganisms present in the waste water oxidize the substrate and produce electrons and protons in the anode chamber of MFC. Then the metal reducing bacteria present in the waste water directly transfer electrons to electrodes (anode), using electrochemically active redox enzymes.

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Electrons are transferred to the cathode compartment through the external circuit, and the protons through the membrane (Glass wool & Glass bead). The cathode chamber is supplied with oxygen (air) from the air pump. Electrons and protons are consumed in the cathode compartment reducing oxygen to water.
The reactions taking place at the cathode chamber are as follows

$$4H+ + 4e- + O2 \rightarrow 2H2O \text{ or}$$
$$4H+ + 4e- + 2O2 \rightarrow 2H2O2 \text{ (oxygen in excess)}$$

(The above carried process is described in detail in the figure 1.) (1) Oxidation of Fuel, (2) Electron transfer from the microbial cells to the electrode, (3) Electric load in the circuit, (4) Proton supply into the cathode compartment, (5) Oxygen supply and reduction at the cathode.
Due to the potential difference maintained at both anode and cathode chambers, and due to the flow of electrons through the external circuit, electricity is produced which is collected across the load. The effluent and the subsequent waste water from the chambers are being drained out and is sent to the sewage treatment plant for further treatment of waste water. Again fresh waste water (substrate) is supplied to the anode chamber from the reservoir. And, thus the process continues.It was found that a mixed culture of substrates (Industrial waste + Domestic waste) generated a current that was six fold higher than that generated by a pure culture.For calculation of electricity produced through the MFCs the following formula is used:

$$\mathbf{P_{gcr}=V^2/r*q*COD_r}$$

Where,P_{gcr} = power generation per cod removed (W-h/g CODremoved)
V=voltage generated of MFCs (ohm)
COD_r = COD removed (g/L) and
Q = flow through system (L/hr)

Thus maximum power density using various fuels used in power generation reported by different group of scientists can be seen from the table below:

REACTOR TYPE	FUEL USED	POWER (mW/m^2)	REFERENCES
SINGLE CHAMBER	GLUCOSE	766	B
SINGLE CHAMBER	DOMESTIC WASTE WATER	464	C
DOUBLE CHAMBER	GLUCOSE	860	D
DOUBLE CHAMBER	ACETATE	480	B
UP FLOW	SURCOSE	560	E

Number and area of MFC chamber used will depend upon the quantity of liquid discharge waste produced by the industries having suitable condition for proper functioning of process such as suitable amount of carbon and nitrogen which is at 62% voltaic condition for a 72 hour working range and MFCs enriched with iron (III) chloride will produce maximum of its efficiency with minimum consumption of fuel which is $1.2W/m^2$ which will be maximum efficient.

2.ZERO POLLUTANT SCHEME:

Technology introduction: In this process, we use liquid waste to generate suitable gaseous steam which can be used to run the turbine which will produce electric energy and remaining residual will be used in other beneficial form.

Principles for this system: Organic rich waste material available with us as a waste, having COD more than 1lakhmg/l can be concentrated to slop having boiling temperature of 60-65 degree will lead to decrease in the total heat value of the fuel required to convert it into suitable steam.Burning of the slops will leave us with some environmentally friendly residual such as:

a) Potash rich ash which can be used for production of potash fertilizer useful in sugarcane plants.
b) The raw spent is used as fuel for power generation by steam turbine process.
c) Condensates left after passing through turbine can be recycled.
d) With dual production of electricity (MFCs and turbine) we produce electric energy which can be consumed in industries with different applications. For Example: electricity from MFCs can be used for small elements and electricity from turbine can be given to large machines, thus making the industry self-dependent.
e) The boiling and burning must also be kept under check ensuring whether spent wash remains in stable state or not.
f) Because of no coking in furnace and no ash production in the boiler thus clean energy form is produced.
g) We can also add another auxiliary fuel in the same boiler to increase its efficiency.

Estimated Data using various parameters:

5.5 KL of 12 deg. Bx RSW contributes Steam of 1.80 MT upto a pressure of 67 kg/sq. Cm, 510 deg. C temp. Without any support fuel.5.5 KL x 12 Bx RSW generates 160 KWH power on back pressure turbine & 350 KWH with condensing turbine.5.5 KL 12 Bx RSW gives 1000 kilo of 65deg. Bx concentrated spent wash corresponds to (as to pumiao) K=10 kilo. We must mix urea (46% N): 19.1kilo and sources of phosphates (25% as P): 35.2kilo to get a granulated fertilizer of 64 kilo.The spent wash zero discharge system will operate free of cost at the same time provides sufficient surplus power for entire industries. pressure generates its own steam, enough to be used for

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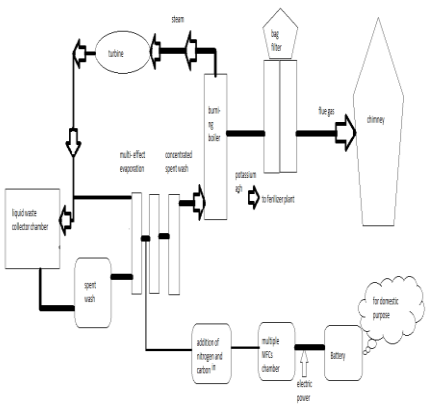
multi effect evaporators to raise initial concentration of raw spent wash from 12 degree Brix to 60-65 degree brix and this concentrated raw spent wash then becomes low heat value fuel which burns all by itself and generates required Steam and Ash, thus leading to zero liquid discharge. No Fuel is required to concentrate raw spent wash of 12 Bx to 60-65 Brix. If one wants to make factory self-sufficient for its power requirements, with If one wants to make factory self-sufficient for its power requirements, with affordable cost, the boiler can be designed and operated for 15 Kg/sq.cm Steam Pressure with suitable Steam Turbine. A 30 KLD Distillery would generate around 250 – 300 kWh from burning only concentrated RSW. This is sufficient to operate the system. The Boiler is lighted up using some 4.00 Tonnes of coal and when furnace temperature is raised and pressure reaches the desired value, this steam is then used to start the concentration system.The Raw Spent Wash of 12 degree Brix is circulated in multi effect evaporators, steam is in the chest and condensate comes out through Steam Traps for re-use.The concentrated Raw Spent Wash (CRSW) of 60-65 degree brix then takes over as FUEL and System becomes SELF-SUFFICIENT.The CRSW generates Steam, it's used in concentrating the Raw Spent Wash, it burn in Boiler and the cycle continues. The entire operation is through control Panel.

Block Representation of the model: This model can be further divided into two subways for concentrated waste.One is for steam turbine.While the remaining amount (according to quality of organic material) can be transmitted to the MFCs chamber. Arrows in the diagram shows flow of the material. While for condensates left after turbine process is reused again in this process.



(Block diagram representation of the process)

CONCLUSION

The three basic R's for renewable energy sources is achieved in this model which are

Reduce: waste water which was earlier directly dumped into the fresh water sources polluting it will reduce in great extent, comforting norms of pollution control board.

Reuse: ash produced after filtering process is rich in potash after adding urea (46% N & 25% P) which will produce granulated fertilizer which has high shelf life which is very popular with sugarcane growers in china.

Recycle: Concentrate spent waste can be used again and again which will lead to production of electrical energy. When we use 5.5kl x 12 RSW generates 160kwh power on back pressure turbine & 350kwh with condensing turbine which will be used in running industrial machinery.

While in case of MFCs cell will produce energy i.e. 1.2W/m^2 which is comparatively very less and used in small energy required application. But this process is very expensive which requires a huge amount of capital not suitable for small scale industries i.e. industry producing pollutant less than 30 kilo liters per day. While for large scale industry would generate around 250 – 300 kWh from burning only concentrated RSW which will be sufficient to operate the system and reaming can be supplied to nearer power station while fertilizer can be sold in open market which will add to economic strength of the industry

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