58TH IEB CONVENTION KHULNA 2018

Sustainable Development for Human and Nature

Digital Technology for Transforming Bangladesh Into Middle Income Country

THE INSTITUTION OF ENGINEERS, BANGLADESH
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National Seminar Session-1

National Seminar Session-2

Unification of ETP (Effluent Treatment Plant)& MFC (Microbial Fuel Cell): Sustainable Development, Environmental Safety, &Renewable Energy

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ABSTRACT

Environment, Energy, and Engineering can make the Earth Elegant together by dint of sustainable development. Sustainable development ensures the environmental safety to sustain the renewable energy. The world is on the verge of energy crisis, pollution, and environmental instability. Renewable energy source as alternative fuel is to be emerged and harnessed for the stability of climate and environment to deal with the descending level of existing sources. Production of electrical energy utilizing of microorganisms through MFC is one such renewable and sustainable technology that is considered to be one of the most efficientand carbon neutral energy sources. Unification of ETP (Effluent Treatment Plant) and MFC (Microbial Fuel Cell) can give a design with eminent efficacy. The unit can utilize the metabolism of the microorganisms in the collection tank of ETP by means of a designed MFC as an integrated system. Efficiency of the unit is being studied on the basis of electricity generation, percentage COD removal, and recovery-removal of heavy metals via treatment of waste water collected from the ETP of Pran Industrial Park (PIP), Narsingdi, Dhaka, Bangladesh. The continuous studies, experiments, and reviews has shown that the unification of ETP and MFC is amply promising to open the greener threshold for generating renewable energy with a view to gleaning sustainable development and environmental safety.

Introduction

Sustainable development can be sailed by the valiant voyage of environmental safety and renewable energy. In the perspective of industrial contribution to environment ETP reflects an urge to ensure the safety. Effluent Treatment Plant (ETP) is set to integrate the processes used for treating wastewater that is

produced by industries as an undesirable by-product having substance like heavy metals.The constituents of effluents from many industries (e.g. electroplating, tanning, dye manufacturing, textile,food industry, and industry for processing of wood products) [1] contains heavy metals. Heavy metals are generally more persistent in the environment than organic contaminants such as pesticides or petroleum by-products. As a result, they reflect a region of concern since heavy metals triggers serious problems to the environment as well as public health due to toxicity, bioaccumulation, and non-biodegradability. Heavy metals containing water is considered as highly toxic to the agricultural lands, aquatic environment and human health. Microbial Fuel Cell designs a promising pathway for simultaneous effluent treatment i.e. wastewater treatment, electricity production as a renewable energy, and metal removal by means of bioelectrocatalysis, because metal ions can be reduced and deposited by bacteria, algae, yeasts, and fungi. Bioremediation method of microbial fuel cell uses the of driving force of biological entities in the removal & recovery of toxic metals from the environment, which is considered more cost effective and environmentally friendly when compared to the existing physical and chemical methods. The conventional physical, chemical, and biological methodologies to treat industrial effluent e.g.: wastewater, containing heavy metals are energy-intensive and become ineffective if metals concentrations are below 1-100 mg/L [2]. Microbial fuel cell is an innate system which is potential enough to deal efficiently with the lower concentration of metalsto be integrated with Effluent Treatment Plant for sustaining the development of renewable energy and ensuring the environmental safety simultaneously.

Effluent Treatment Plant: Elevation of Environmental Safety

Industrial wastewater treatment denotes the processes used for treating wastewater that is produced by industries as an undesirable by-product. After treatment, the treated industrial wastewater (or effluent) may be reused or released to a sanitary sewer or to a surface water in the environment. Most industries produce some wastewater. According to industrial acquisition, PIP follows the recent trends which have been to minimize such production or to recycle treated wastewater within the production process.Many other existing industries which have not taken step yet to implement ETP as an urge, should be concerned about the important issues regarding environmental safety for the sustainable development on the

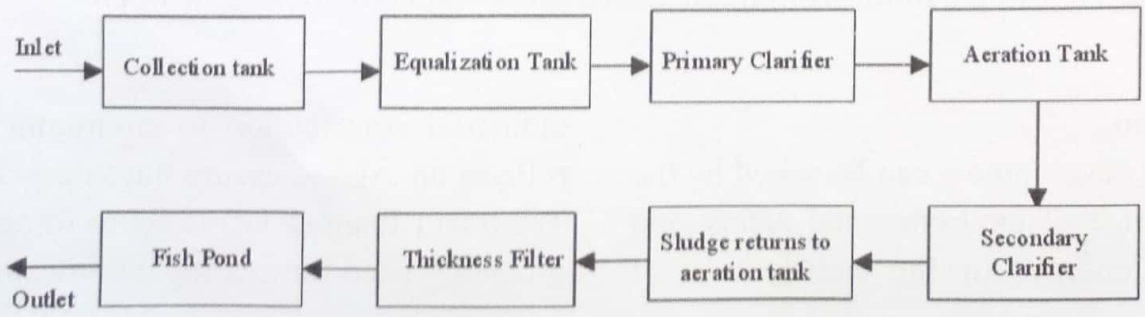

Figure 1: Process Block Diagram of a general biological ETP; Reference: Pran Industrial Park

basis of ETP. It isan alarming concern that if the waste stream i.e. inlet of ETP from the process plants is directly discharged to environment then environment, soil, plant, water, aquatic life in the ecosystem are to be framed under threat.

Figure 1 represents, a general biological Effluent Treatment Plant. Generally, the inlet in the ETP is the waste stream come from the process plants which is to be treated. In the collection tank the effluent i.e. wastewater is to be collected to follow the path towards the equalization tank for cooling and mixing where source of nitrogen and phosphorous e.g. DAP as nutrients are to be added for the growth for microorganisms. Unlike chemical treatment which uses chemicals to react and stabilize contaminants in the wastewater stream, biological treatment uses microorganisms that occur naturally in wastewater to degrade wastewater contaminants.There may be mixture of species of them. The stream out of equalization tank goes to the primary clarifier for neutralization for maintaining pH to provide the microorganisms a healthy and survivable ambiance. The equalization tank needs to go anaerobic condition in where the respiratory and metabolic activity of microorganisms get aided by means of neutralization and protonic balance. The outlet stream from the primary clarifier goes to aeration tank after neutralization in where blowers are set to supply air after filtration whereaeration is an activated sludge process based on pumping air into a tank, which promotes the microbial growth in the wastewater. The microbes feed on the organic material, forming flocs which can easily settle out. After settling in a separate settling tank, bacteria forming the "activated sludge" flocs are continually recirculated back to the aeration basin to increase the rate of decomposition.Oxygen is needed by the bacteria to allow biodegradation to occur. The supplied oxygen is utilized by bacteria in the wastewater to break down the organic matter containing carbon to form carbon dioxide and water. Without the presence of sufficient oxygen, bacteria are not able to biodegrade the incoming organic matter in a reasonable time. In the absence of dissolved oxygen, degradation must occur under septic conditions which are slow, odorous, and yield incomplete conversions of pollutants. Under septic conditions, some of the biological process convert hydrogen and sulphur to form hydrogen sulphide and transform carbon into methane. Other carbon will be converted to organic acids that create low pH conditions in the basin and make the water more difficult to treat and promote odour formation. Biodegradation of organic matter in the absence of oxygen is a very slow biological process. The secondary clarifier gives an outlet stream from where the sludge returns for further aeration and goes for thickness filter from where the final outlet stream is to be collected in a fish pond. The fish pond ensures the quality of treated effluent i.e. clearer water to be discharged in where aquatic life can be sustained at an standard and healthy manner without being jeopardized.

Microbial Fuel Cell: Sustainable Step for Environmental Safety & Renewable Energy

Microbial fuel cell (MFC) is a bio-

electrochemical device that harnesses the power of microbes during respiration to convert organic substrates directly into electrical energy. MFC is a fuel cell which transforms chemical energy into electricity using oxidation and reduction reactions. Microbial fuel cells rely on living biocatalysts to facilitate the movement of electrons throughout their systems instead of the traditional chemically catalyzed oxidation of a fuel at the anode and reduction at the cathode. The special aspect behind MFC can be focused down to two words: cellular respiration [3]. Cellular respiration is a collection of metabolic reactions that cells use to convert nutrients into adenosine triphosphate (ATP) which fuels cellular activity. Bacterial respiration is basically one big redox reaction in which electrons are being moved around. Whenever there are moving electrons, the potential exists for harnessing an electromotive force to perform useful work. A MFC consists of an anode and a cathode separated by a cation specific membrane or salt bridges. Microbes at the anode where electrons are released oxidize the organic fuel generating protons which pass to the cathode, and electrons which move from the anode to an external circuit to generate a current. The principle, of course, is collecting the electrons released by bacteria as they respire.The fact that bacteria can directly supply electrons or oxidize the substrates to produce electricity makes MFCs an ideal solution for wastewater treatment and domestic energy production. When an organic "fuel" enters the anode chamber, the bacteria set to work oxidizing and reducing the organic matter to generate the life sustaining ATP that fuels their cellular machinery. When bacteria consume an organic substrate like sugar under aerobic conditions, the products of cellular respiration are carbon dioxide and water.

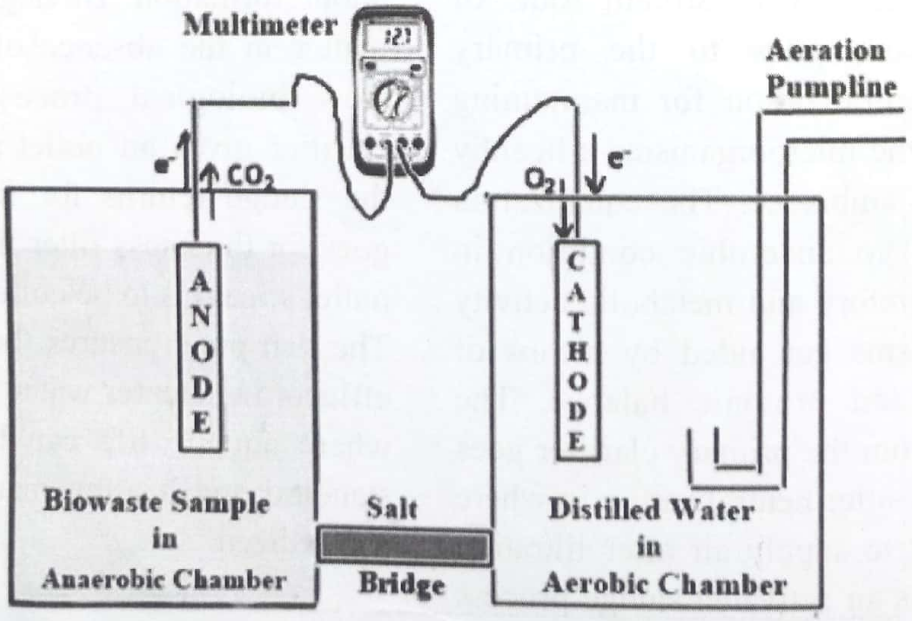

Figure 1: Schematic Diagram of a general Microbial Fuel Cell

However, when placed in an environment void of oxygen, cellular respiration will produce protons and electrons instead of carbon dioxide. It is therefore necessary to impart an anaerobic environment in the anode chamber of the MFC.The aeration of cathodic chamber maintains the pH by protonic balance. Thus, MFC reflects the path to step for sustainable development both for the production of renewable i.e. greener energy as electricity and protection of environment ensuring the urge of safety.

Experimental Motivation: A threshold of optimism for Sustainable Development

The motivation that has originated the idea of unification is the experiments and researches generated gradually and regularly.

The experimental motivation opens a threshold of optimism to go onward with firm and fervent enthusiasms for sustainable development. The motivation from experiments can be remarked as:

(i) Cr (VI) as a target metal having an original amount of 200 mg/L in domestic wastewater showed a complete removal within 150 h generating a MFC performance of 150 mW/m2 [4].

(ii) Cu2+ containing wastewater is treated having an amount of 1000 mg/L of target metals where the source of inoculum is the excess sludge as anolyte and CuSO4solution as catholyte and the run time is 288 h. The metal reducing efficiency was 97.8% and the MFC performance in the two chambered microbial fuel cell was 536 mW/m3 at Cu2+ concentration of 6400 mg/L [5].

(iii) COD is the Chemical Oxygen Demand which measures the amount of oxygen needed to decompose the organic substrates. When there are many microorganisms in the wastewater, the COD becomes higher. Due to the presence of enormous microorganisms just after collecting the wastewater in collection tank the COD values higher. In the MFC, the microorganisms metabolize the organic substrates resulting in a lower COD [6].

(iv) The COD removal efficiency is 58% without any sludge addition. In addition of 100 ml sludge the efficiency becomes 63% while 200 ml addition removes 74% of COD. Without the aeration in the cathode chamber, the efficiency is 47% while vise-versa gives 58% [7]. The significant contributions and changes of percentage COD removal are being gleaned and verified .

Proposal of Unified ETP & MFC on Bangladesh Perspective: Integrated Sustainability, Energy Renewability, & Environmental Stability

The unified ETP and MFC is being proposed by means of perpetual experiments, studies and research which is specifically generated by the our thesis project under the Department of Chemical Engineering, Bangladesh University of Engineering & Technology (BUET) corroborated by Pran Industrial Park, Bangladesh.

According to the industrial perspective of Bangladesh, the environment does not get the shield of safety at many junctures due to the concerns of cost, vacillating condition of engineering ethics, poor networking system among proper authorities, insufficient skilled labors. The absence of the shield of safety always results in environmental instability. The proposal of unified ETP and MFC can confirm an integrated sustainability, energy renewability, and environmental stability together. The remarks to be elucidated are:

(i) The collection tank of ETP is to follow a type of MFC system in where the anodic chamber contains the same wastewater batch-wise to treat the effluent biologically and to produce electricity simultaneously.

(ii) The produced electricity in the proposed unification is environment friendly as a renewable energy in comparison with the existing systems. The plan is to increase the production rate at a sustainable manner with desirable efficacy.

(iii) The MFC system has the potential to remove and recover heavy metals to protect the environment and to collect important heavy metals by means of biological segregation.

(iv) The output of the MFC i.e. the treated water can follow the path of neutralization and a clarification steps to reach fish pond. The cathode may aid the unified system supporting by means of aeration and the anode bolsters with the mixing steps regarding the nutrients. It will be really cost-effective on the sense of construction issues.

(v) The path of treatment is being concerned about the contamination e.g. removal or recover of heavy metals in anode of the integrated system. The path of the systems also ensures the production of electricity in a simultaneous manner which can be utilized as a greener source of energy.

(vi) Until now this promising technology is not commercially practiced and still under development. Scale-up and materials issues are the challenges in the application of MFCs for wastewater treatment through ETP.

(vii) The objective of this project is to develop an efficient and cost effective system& design for integration to maintain the standard of Environment Conservation Rules (ECR) to achieve the sustainability and to glean the renewable energy efficiently.

Conclusion

Unification of ETP and MFC is a proposal to be implemented by dint of perpetual, perceptive and promising experiments, technologies, and research by which the industrial effluent i.e. wastewater of countries like Bangladesh can be recycled as Bio-electricity i.e. renewable energy generation with simultaneous treatment of waste to protect the environment from contamination and considering the

environmental-economic aspect of heavy metals. The gradual studies on the proposal is aspiring to inspire with a view to developing the sustainability on the basis of the driving force of renewable energy and the shield of environmental safety.

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