POTENTIALITY OF BIOGENERATION OF ELECTRICITY FROM ABATTOIR WASTE WATER THROUGH MICROBIAL FUEL CELL TECHNOLOGY

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ABSTRACT
The potential of generating electricity from waste water obtained from an abattoir through microbial fuel cell technology was evaluated. Results obtained revealed that the consortium of bacteria indigenous to the waste water had the ability to produce electricity. The amount of current generated increased withincrease in incubation duration such that at 48 hof incubation, a current of 17.45mA was generated by the bacterial consortium. The bacteria isolated from the waste water were *Pseudomonasaeruginosa*, *Klebsiella* sp., *Bacillus* sp., *Escherichiacoli* and *Proteus* sp. The maximum electrical current generated by each of this bacterium was0.3, 0.01, 0.01, 0.9 and 0.05 mArespectively. Generally, the amount of current generated in set up that contained the consortium of bacteria was significantly higher (at $p < 0.05$) than that which contained individual pure bacterial isolate. Also, there was a significant difference in the amount of current produced by each pure isolate. Conclusively, this study demonstrates that abattoir waste water has enough strength for the generation of electric current and its utilization in microbial fuel cells hold promise towards sustained energy generation and could be an attractive alternative to reduce the cost of generating electricity.

Key words: Microbial fuel cell, Abattoir, Wastewater and Electricity.

INTRODUCTION

It is well recognized that alternative sources of energy are urgently needed (Franks and Nevin, 2010). Current reliance on fossil fuels is unsustainable due to pollution and finite supplies. While much research is being conducted into a wide range of solutions, it appears that no one solution would be able to replace fossil fuel in its entirety. As such, it is likely that a number of different alternatives will be required. The discovery that bacteria can be used to produce electricity from waste and renewable biomass, has gained much attention (Bond et al., 2002). Electricity is energy created by moving charged particles. It is a fundamental form of kinetic or potential energy created by free or controlled movement of charged particles such as electrons, protons and ions. Electricity is an extremely versatile form of energy. It can be generated in many ways and from different sources. Its versatility enables electricity play a part in nearly every aspect of modern technology. Electricity provides light, heat and mechanical power. Recently, the increased interest in microbial fuel cell technology was highlighted by the discovery that microbial metabolism could provide energy in the form of electrical current.Microbial fuel cell is a device that uses microorganisms to generate electric current through the oxidation of organic matter. It is a device that convert chemical energy to electrical energy during substrate oxidation with the help of microorganism (Bond and Lovely, 2003; Gill et al., 2003). Microbial fuel cell is made up of two compartments (anode and cathode), separated with proton/cation exchange membrane. Microorganisms produce electrons and protons in the anode chamber of microbial fuel cell. Electrons collected on the anode are transported to cathode by external circuit and protons are transferred through the membrane internally (Das and Mangwani, 2010). Thus, potential difference is produced between anode and cathode chamber. The amount of energy produced in microbial fuel cells varies depending on the type of reactor and the specific source of organic matter (Min et al., 2005). Thus, this study focused on the analysis of the suitability of producing electricity from abattoir waste water through microbial fuel cell technology and hence turning waste into wealth by utilizing the effluent that would otherwise

be regarded as a menace to public health

MATERIALS AND METHODS

Source/Collection of samples

The effluent used in this study was obtained from an abattoir located at Abraka, Delta State. Waste water was collected from a reservoir into which effluent from the abattoir drained;a 15 L container which had been previously sterilized with 95% ethanol and rinsed with the waste water was used for the sample collection. Sample was then transported to the laboratory for further analysis within 30 minutes of collection.

Construction of microbial fuel cell chambers

Each experiment was conducted with two chambers. A chamber comprised 1000ml of waste water and an electrode (either cathode or anode as the case may be). Graphite rods extracted from dry cells were utilized as electrodes.Both chambers were connected by a plastic tube with length of 8 cm and diameter of 1.3cm. The tube contained a proton exchanger membrane salt bridge. The electrodes were connected via an external circuit containing a single resistor (1000Ω). The salt bridge was prepared by boiling a solution consisting of water, 1.3% NaCl and 1.5% agar for 3 minutes. The boiled solution was then packed in sectioned plastic pipe that was 8cm long and 1.3cm in diameter. This was allowed to cool and salt bridge was ready for use.

Determination of current generation ability

This initial experiment established the capability of current generation from the effluent as well as the determination of the effect of incubation period on current generation. The set up obtained as described in the section above was allowed to stand for 48 h. At intervals of 0, 3, 6, 12, 24 and 48 h, current generated was read using an ammeter(Nafion^{TM}). Also at the same periods samples were withdrawn from each chamber for determination of total heterotrophic bacteria count (THBC), biochemical oxygen demand (BOD), chemical oxygen demand (COD), pH and phosphate. All the physico-chemical parameters were analyzed using the methods as described by AOAC, 1990 while THBC was determined by the standard plate count method as described by APHA (1998).

Isolation and Identification of Pure bacterial Isolates from effluent

The effluent sample was diluted using the ten-fold serial dilution technique and 1ml was inoculated into nutrient agar plates using the pour plate method. Plates were then incubated at 37°C for 24 h. At the end of which well separated colonies were sub-cultured for identification which was by observation of cellular morphologies and biochemical characterization. The criteria in Bergey,s manual of determinative bacteriology (1994) were utilized.

Evaluation of current generation potential of various bacterial isolates

The effluent was sterilized by autoclaving and distributed in 1000ml amounts into each of anode and cathode chamber. Subsequently, standardized bacterial inoculum was inoculated into both electrode chambers. Chambers containing only sterile waste water served as control.All set-ups were allowed to stand at room temperature for 48 h. Current generated were measured at intervals of 0, 3, 6, 12, 24 and 48 h.

RESULTS

Preliminary experiment conducted using microbial fuel cells demonstrated that current could be generated using abattoir waste water and the bacteria needed were indigenous to the effluent. The effect of contact time on current generation is presented in Figure 1. Results obtained revealed that the amount of current generated increased with increase in incubation duration. Within the first 3 h, current generated was 0.09mA. This increased steadily up to 24 h, thereafter, there was no noticeable increase. Maximum current generated by the bacterial consortium was 17.45mA. In control, no current was generated throughout the study period. At the end of the incubation duration, BOD values obtained in the preliminary set-up decreased from 94.1 to 32.4 mg/l while CODvalues decreased from 1163 to 984 mg/l. Additionally, quantity of phosphate reduced from 7.48 to 3.10g/l and log of total heterotrophic bacteria count declined from 7.24 to 6.6. However, in control, there was no bacterium in the control from 0 h to 48 h. Also,

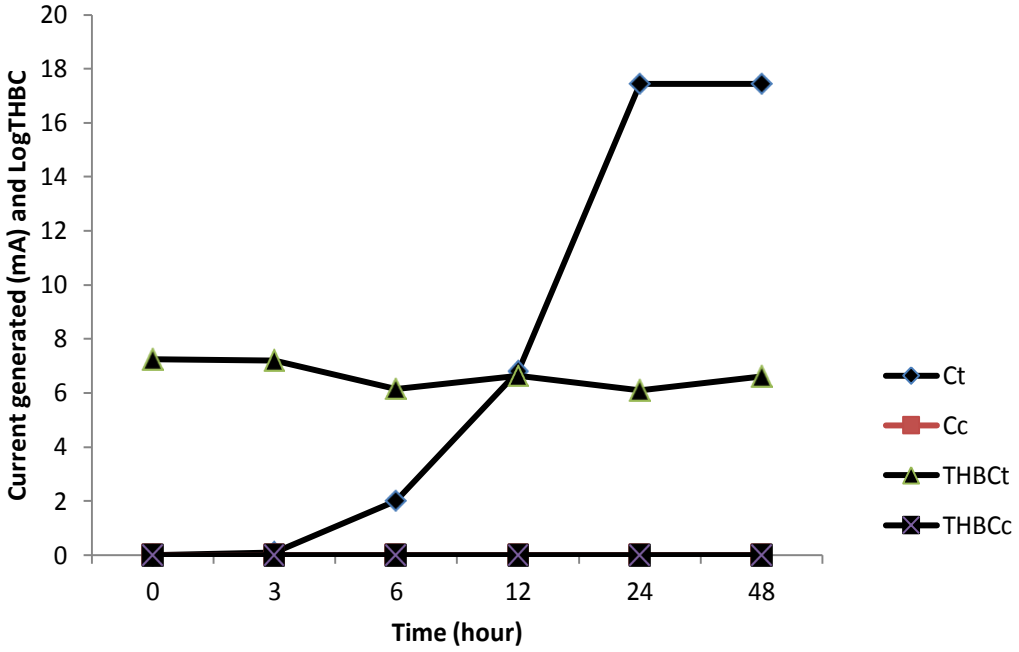

Figure 1. Changes in current generated and total heterotrophic bacteria count in preliminary set-up.Ct= Current generated in test MFC; Cc = Current generated in control MFC, THBC = total heterotrophic bacteria count, THBCt = total heterotrophic bacteria count in test MFC, THBCc = total heterotrophic bacteria count in control MFC.

there were no changes in pH, BOD and COD values of c values of control.

Twenty-six bacterial isolates belonging to five genera were obtained from the effluent. These isolates were; *Pseudomonasaeruginosa*, *Klebsiella* sp., *Bacillus* sp., *Escherichiacoli* and *Proteus* sp. Results obtained from experiments that utilized each axenic bacterial isolate in current generation indicated that each isolate had the capability of generating electrical current although to varying degree as presented in Figure 2. *P. aeruginosa* generated a current of 0.001mA at 3 hof incubation, after which a steady increase in current generation was observed. At 48 h, current recorded was 0.3mA. In set-up containing *Bacillus* sp., current generated was only noticed at 12 and 24 hof incubation, amount of current generated was 0.01mA. The maximum current recorded in set-up containing *Klebsiella* sp., *E. coli* and *Proteus* sp. were 0.01, 0.9 and 0.05mArespectively and detection of each was at 6, 3 and 12h of incubation. Generally, the amount of current generated in set up that contained the consortium of bacteria was significantly higher (at $p < 0.05$) than that which contained individual pure bacterial isolate Figure 3. Also, there was a significant difference in the amount of current produced by each pure isolate. The trend in production was *E. coli* >*Pseudomonas* sp.>*Proteus* sp.>*Klebsiella* sp.≥ *Bacillus* sp.

DISCUSSION

Experiments conducted using MFC demonstrated that electric current could be generated from abattoir waste water and that the bacteria required are indigenous to the effluent. The generation of current is largely due to bacterial activity as no current was generated in MFC that contained sterile effluent. Probably, the circuit voltage generated was as a result of the potential difference between the two chambers that was created by the bacteria activities.

The bacteria population concentration was directly proportional to the amount of current generated. This explains the observation made that increase in total heterotrophic bacteria count corresponded to increase in current generation. This was likely, due to increased metabolic activities and therefore, more electrons were transferred to the anode and subsequently to the cathode, ultimately leading to increase in the circuit output (current). Similar result was reported by Baran and Deka, (2010) and

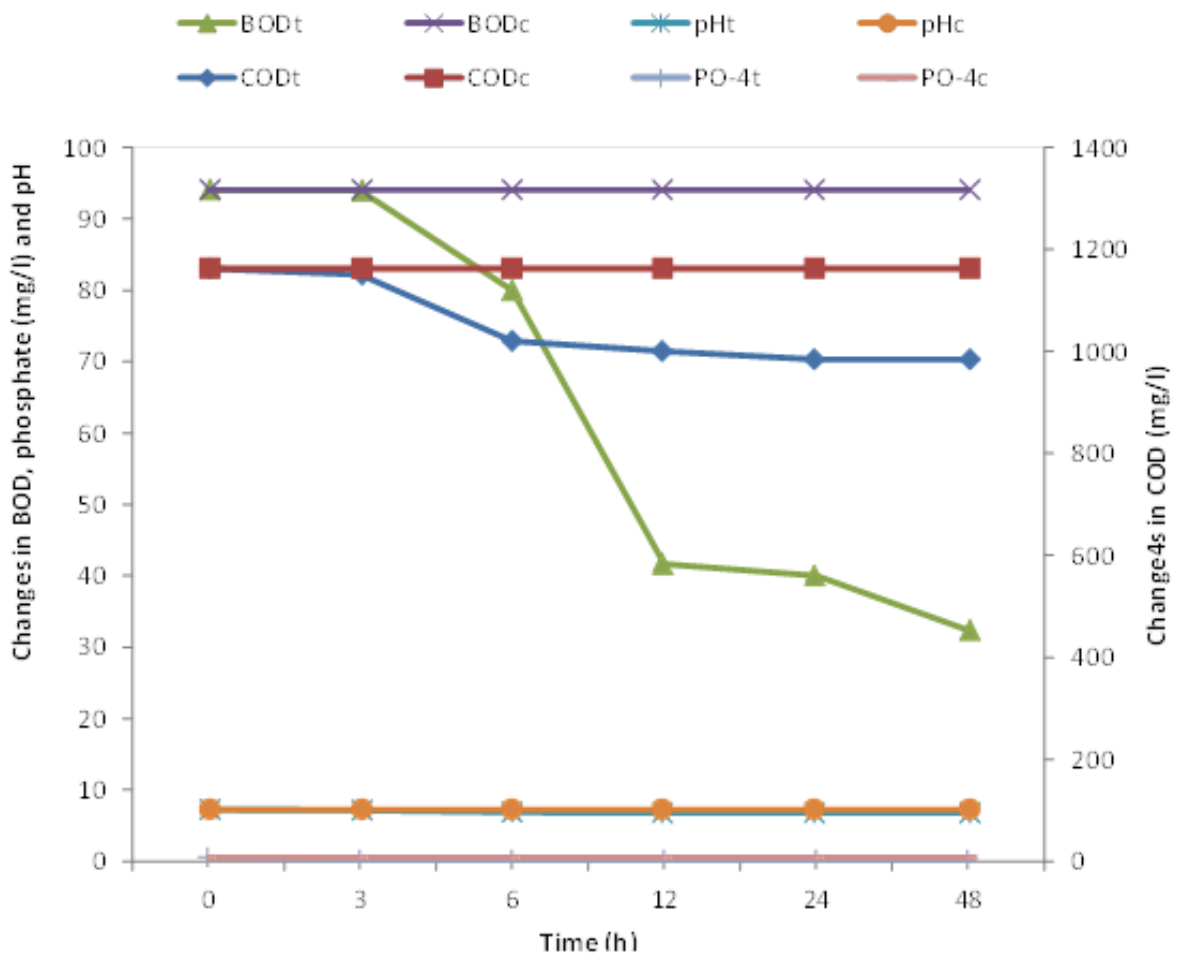

Figure 2. Changes in various physico-chemical parmeters in each MFC. t= test; c = control.

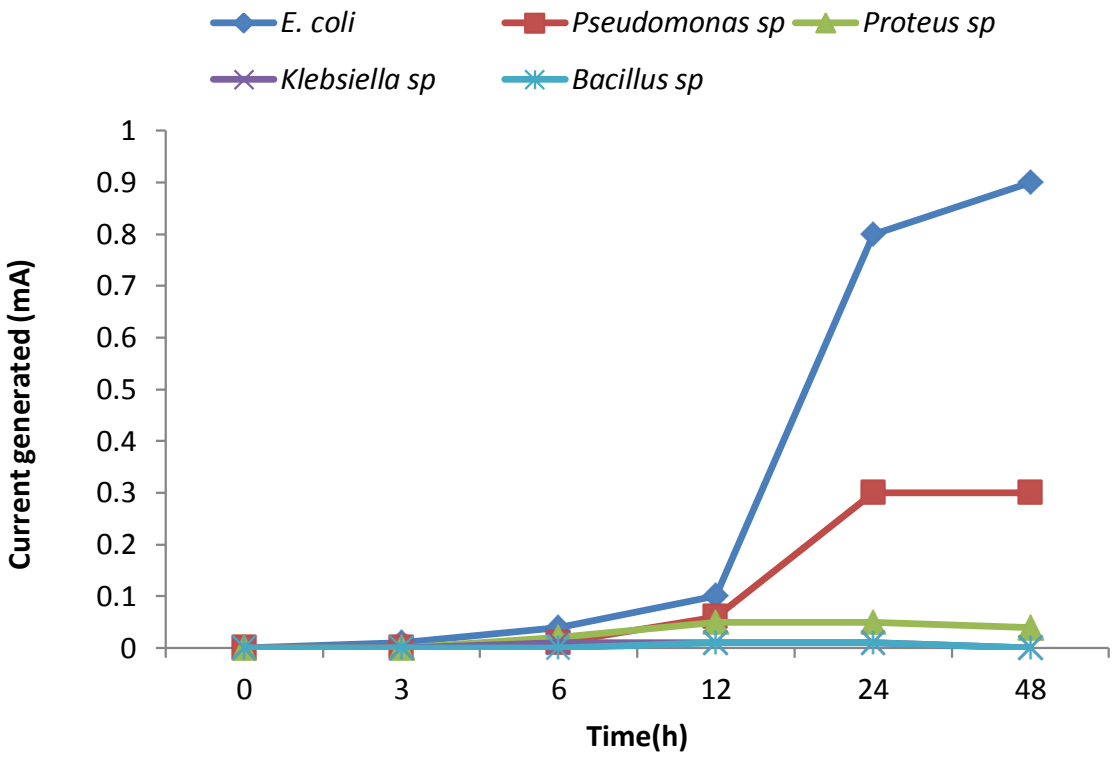

Figure 3. Current generated by various pure bacterial culture.

Raebeyand Verstraete (2005).

The five genera of bacteria (*P. aeruginosa*, *Klebsiella* sp., *Bacillus* sp., *E. coli* and *Proteus* sp.) obtained in this study showed the potential of generating current although to varying degree. The difference in the amount of current generated by each isolate may be due to the varying extent to which each isolate was able to produce electrochemically active substances that may either be metabolic intermediates or end product of respiration. Testing of each inoculum for current generation indicated that axenic bacterial cultures had a lower capability of electriccurrent generation than the mixed bacteria. This result is similar to that obtained by Kim et al. (2002). The limitation in the amount of current generated in this study may be consequent upon the kind of organisms involved. The work of Rabaeyet al. (2003), revealed that, metal producing bacteria such as *Shewanellaputrifaciens*, *Geobactersulfurreduces* and *Desulfuromonasacetoxidans* are the most excellent tool in microbial fuel cells because they transfer electrons directly to the anode without a mediator.

Nevertheless, this study demonstrates that abattoir waste water has enough strength for the generation of electric current and that microbial fuel cells hold promise towards sustained energy generation and could be an attractive alternative to reduce the cost of generating electricity.

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