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Modelling of Physico Chemical Parameter for Poultry wastewater in Dual Cell Microbial Fuel Unit with Biomass Electrode

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***Abstract* – This experimental research on the modeling of physiochemical parameter in microbial fuel cell involves physiochemical parameter with a multi- parameter water checker. The parameter analyzed were; Conductivity, Turbidity, Total suspended solid (TSS), Total dissolved solid (TDS) and salinity, standard methods. The raw poultry waste solution which serves as an electrolyte has values of COD 2052mg/l, BOD 493mg/l, pH 6.36, Conductivity 16.36 µs/cm, Turbidity 964 NTU, TSS 1100 mg/l, TDS 9260mg/l and salinity 9.6% as anode electrolyte. The result obtained after 28 days of operating the cell shows poultry waste physiochemical parameter reduction and that using R2 as bases, the model of the physiochemical parameters proposed showed polynomial relationship for all the biomasses apart from the electrode from sawdust that are showed Linear relationship for Salinity and same R2 (0.9877) for TSS and also for The best fit, for is for sawdust with exponential correlation with R2 value of 0.9815 for salinity. The research study has shown that Microbial Fuel Cell has a strong polynomial relationship correlation for different electrode produced of different biomass materials with poultry waste solution as electrolyte.**

***Keywords* – Model, Poultry wastewater, Microbial fuel cell, physiochemical parameter, biomass, electrode.**

I. INTRODUCTION

The complexity problems raised by existing energy demand and supply issues of developed and developing countries makes alternative and renewable sources an important supplementary sources to avert severe energy disaster (Bond and Lovely 2003; Singh et al., 2010).

The fossil fuel having recorded a get number of negative impact as a notorious culprit relating to environmental degradation (Min et al., 2005), and been term non sustainable and non-environmental friendly. As concern for the environment and sustainable energy sources increases, interest is growing a lot as researches aimed at finding a more ecological that is environmentally friendly and cheap with minimal or near to zero use of fossil fuel(Min et al., 2005; Mohan et al., 2008). Alternative energy of the bioenergy source is has the capacity to assuage this existing world energy and environmental issues. There have been an increase in search for a wide range of solution to energy challenges, with scientists and engineers coming to the conclusion that no single energy source will effectively compete with fossil fuel in the short term as no single energy source is capable of delivering on the existing global energy demand achieved from the use of fossil fuels. Furthermore extraordinary source energy for combatting and reduction pollutants in waste streams and effluents to reduce and compete with the requirement in the existing conventional sewage procedure calls for effective and efficient alternative processes as well, aimed at economic advantage and environmental consideration. Foremost exertions is been put in to improve on renewable energy sources in the area of improving the existing type and sourcing for new methods (Du et al., 2007). Researchers are of the opinion that it necessary to search for complementary and renewable energy sources.

The application of MFC using microbial communities for the breaking down of wide range of environmental pollutants is also envisaged for in situ environmental cleanup. Bacteria such as Geobacter species have been reported by (Franks and Nevin, 2010) to show some level of performance in anaerobic degradation of landfill leachate and petroleum spill components in ground water (Lovley et al., 1998; Morris and Jin, 2008).

There is the need for readily available MFC materials (graphite for electrodes and nafion for salt bridge) necessitates the search for alternatives material for MFC electrode from readily available biomass materials (sawdust, sugarcane peel, groundnut peels) which constitutes nuisance when not put in use or well managed but can be channeled to useful ends like the production of

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electrodes in place of conventional graphite or expensive platinum coated electrodes.

The experimental research study is aimedat Modeling of Physiochemical parameter behavior in Dual cell Microbial Fuel unit with Electrode made from selected biomass. While investigating waste water treatment potentials.

II. MATERIALS AND METHODS

- **Electrode Preparation**

The biomass was heated in a furnace at 400oC temperature to obtain the charcoal. The biomass charcoal was ground to power and mixed with cement at ratios (w/w) 1:1. Approximately 100ml of water was added to form paste. The mixture was poured into a PVC trunk cut at length of 24.2cm inserted with low resistance flexible wire. The electrodes were dried at a temperature of 100˚C and allow it to cool for about 48 hours. The electrode was tested with multimeter. A resistance of about 6-10Ω was recorded between the terminal point and the wire at the bottom of the electrode. The method of MFC construction and experimental setup in Oji et al., (2014) was adopted for the experiment. The unit was operated for 28days for each run.

- **The MFC set up are as follows**

MFC-GS – Microbial Fuel Cell with Groundnut shell
MFC-SC – Microbial Fuel Cell with Sugarcane peel
MFC-SD – Microbial Fuel Cell with Sawdust
Operation of the MFC set up.

- **MFC Anolyte**

The substrate (Poultry Wastewater from poultry dropping ratio of 3:1(w/w) properly mixed). Non soluble matters were separated after allowing the mixture to settle. The anode chambers were fed with the wastewater.

- **Cathode Electrolyte Preparation**

The cathode chamber is the oxidant chamber which houses the oxygen, the proton acceptor. The cathode electrolyte preparation involves the dissolving of 10g of salt in 6liters of distilled water. The solution was properly stirred. The prepare solution was poured into the cathode chamber as the catholyte for the MFC set-up.

- **MFC Reactor**

The anode chamber containing the substrate (wastewater) solution was connected to the cathode chamber containing brine with a salt bridge inter-connection and load (Resistor, 880Ω).

- **Data collection**

The MFC cells voltage and current reading was carried out using a digital multi- meter for a period of 28days. While a BOD bottle was used to collect sample from the reactor every 5days for analysis.

- **Wastewater treatment measurement**

Conductivity, turbidity, total suspended solid, total dissolved solid and salinityof water Samples
These parameters were measured in-situ using the Multi-Parameter Water Quality Monitor (model 6000 UPG). The samples were collected in 50ml glass beakers and the equipment used to take the measurements directly.

III. RESULTS AND DISCUSSIONS

Bio treatment Performance of charcoal type
The MFC unit prepared with electrode with best performance in terms of charcoal preparation temperature (400oC) and charcoal-cement ratio (1:1) recorded performance in physiochemical treatment as presented.

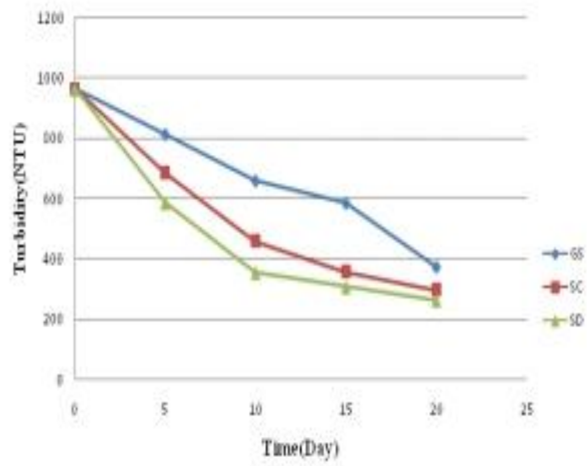

Figure 4.1: Turbidity of Poultry wastewater against time

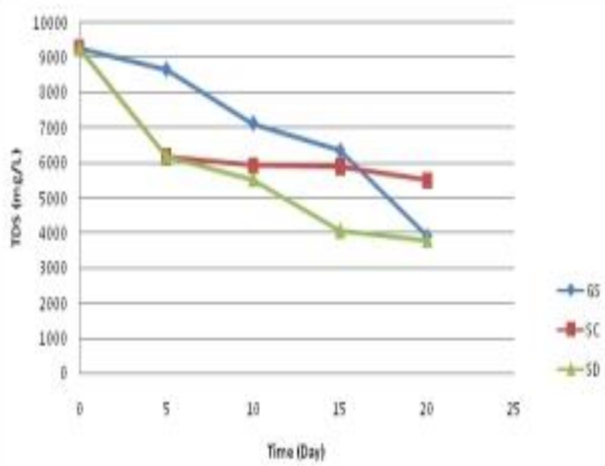

Figure 4.2: TDS of Poultry wastewater against Time

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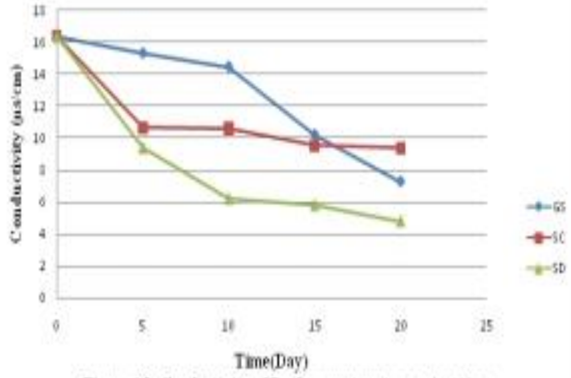

Figure 4.3: Conductivity of Poultry wastewater against time

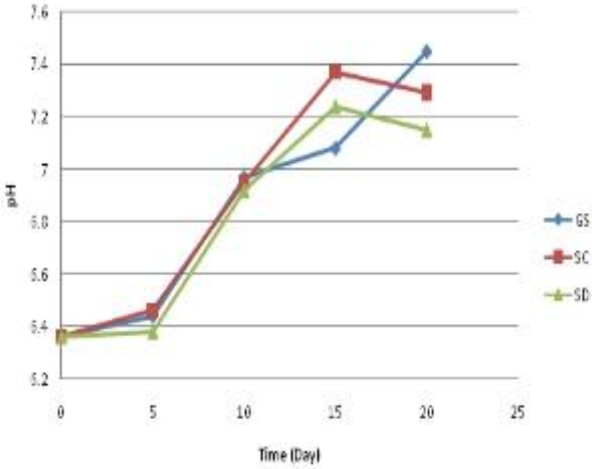

Figure 4.4: pH of Poultry wastewater against time

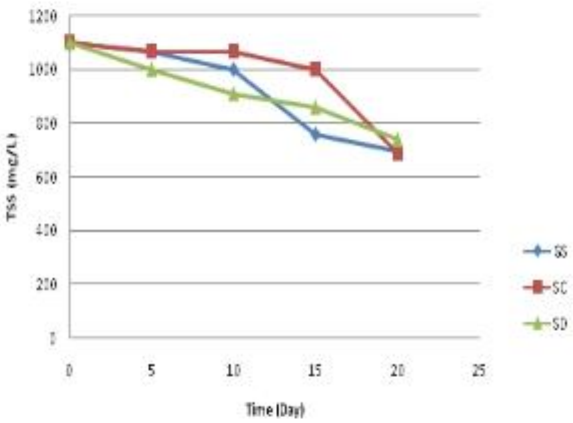

Figure 4.5: TSS of Poultry wastewater against Time

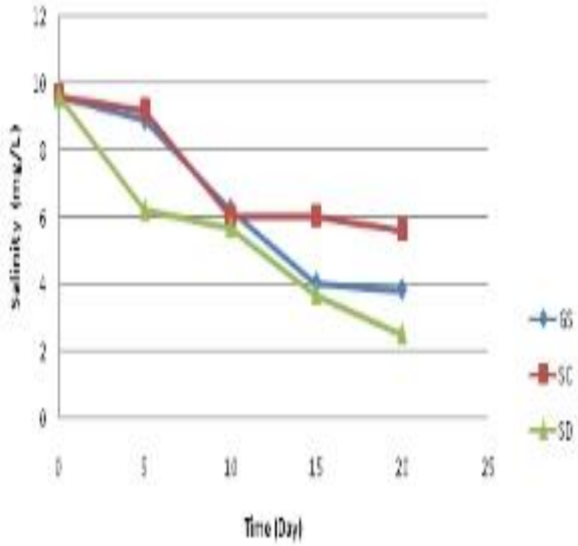

Figure 4.6: Salinity of Poultry wastewater against Time

Table 4.1: Models of the relationships between the Turbidity(YTub) and time(t)

Table 4.1: Models of the relationships between the Turbidity(Y_{Tub}) and time(t)

Biomass type	Trend type	Equation	R^2
Groundnut shell	Linear	$Y_{Tub} = -28.10t + 961.2$	$R^2 = 0.9839$
	Exponential	$Y_{Tub} = 1009.3e^{-0.044t}$	$R^2 = 0.9455$
	Polynomial	$Y_{Tub} = -0.1257t^2 - 25.646t + 954.91$	$R^2 = 0.9846$
Sugarcane Peel	Linear	$Y_{Tub} = -33.18x + 884.8$	$R^2 = 0.9227$
	Exponential	$Y_{Tub} = 916.87e^{-0.06t}$	$R^2 = 0.9796$
	Polynomial	$Y_{Tub} = 1.6086t^2 - 65.351t + 965.23$	$R^2 = 0.9986$
Sawdust	Linear	$Y_{Tub} = -33.68t + 831.2$	$R^2 = 0.8387$
	Exponential	$Y_{Tub} = 838.97e^{-0.06t}$	$R^2 = 0.9254$
	Polynomial	$Y_{Tub} = 2.4343t^2 - 82.366t + 952.91$	$R^2 = 0.9920$

Table 4.2: Models of the relationships between the Total Suspended Solid(YTSS) and time(t)

Biomass type	Trend type	Equation	R^2
Groundnut shell	Linear	$Y_{TSS} = -22.3t + 1147.6$	$R^2 = 0.9136$
	Exponential	$Y_{TSS} = 1168.4e^{-0.02t}$	$R^2 = 0.9022$
	Polynomial	$Y_{TSS} = -0.6714t^2 - 8.8714t + 1114$	$R^2 = 0.9426$
Sugarcane Peel	Linear	$Y_{TSS} = -17.74t + 1162.2$	$R^2 = 0.6906$
	Exponential	$Y_{TSS} = 1185.7e^{-0.02t}$	$R^2 = 0.6594$
	Polynomial	$Y_{TSS} = -1.7743t^2 + 17.746t + 1073.5$	$R^2 = 0.9324$
Sawdust	Linear	$Y_{TSS} = -17.2t + 1094$	$R^2 = 0.9877$
	Exponential	$Y_{TSS} = 1103.6e^{-0.018t}$	$R^2 = 0.9815$
	Polynomial	$Y_{TSS} = -17.2t + 1094$	$R^2 = 0.9877$

Table 4.3: Models of the relationships between the Conductivity(Y_{Con}) and time(t)

Biomass type	Trend type	Equation	R^2
Groundnut shell	Linear	$Y_{Con} = -0.4664t + 17.386$	$R^2 = 0.9181$
	Exponential	$Y_{Con} = 18.293e^{-0.04t}$	$R^2 = 0.8810$
	Polynomial	$Y_{Con} = -0.0206t^2 - 0.0538t + 16.355$	$R^2 = 0.9810$
Sugarcane Peel	Linear	$Y_{Con} = -0.301t + 14.332$	$R^2 = 0.6839$
	Exponential	$Y_{Con} = 14.135e^{-0.02t}$	$R^2 = 0.7292$
	Polynomial	$Y_{Con} = 0.0287t^2 - 0.8753t + 15.768$	$R^2 = 0.9017$

Table 4.4: Models of the relationships between the Salinity(YSal) and time(t)

Biomass type	Trend type	Equation	R^2
Groundnut shell	Linear	$Y_{Sal} = -0.33x + 9.8$	$R^2 = 0.9388$
Sugarcane Peel	Exponential	$Y_{Sal} = 10.272e^{-0.033x}$	$R^2 = 0.9384$
	Polynomial	$Y_{Sal} = 0.0043x2 - 0.4157x + 10.014$	$R^2 = 0.9443$
	Linear	$Y_{Sal} = -0.224x + 9.52$	$R^2 = 0.827$
	Exponential	$Y_{Sal} = 9.5691e^{-0.03x}$	$R^2 = 0.836$
	Polynomial	$Y_{Sal} = 0.0091x2 - 0.4069x + 9.9771$	$R^2 = 0.8752$
Sawdust	Linear	$Y_{Sal} = 9.504e^{-0.034x}$	$R^2 = 0.9703$
	Exponential	$Y_{Sal} = 1103.6e^{-0.018t}$	$R^2 = 0.9815$
	Polynomial	$Y_{Sal} = 0.0083x2 - 0.4997x + 9.2943$	$R^2 = 0.9634$

Table 4.5: Models of the relationships between the TDS(YTDS) and time(t)

Biomass type	Trend type	Equation	R^2
Groundnut shell	Linear	$Y_{TDS} = -260.58x + 9660$	$R^2 = 0.9407$
	Exponential	$Y_{TDS} = 10164e^{-0.04x}$	$R^2 = 0.887$
	Polynomial	$Y_{TDS} = -8.3171x2 - 94.237x + 9244.1$	$R^2 = 0.9836$
Sugarcane Peel	Linear	$Y_{TDS} = -156.36x + 8103.2$	$R^2 = 0.6448$
	Exponential	$Y_{TDS} = 7982.6e^{-0.02x}$	$R^2 = 0.6812$
	Polynomial	$Y_{TDS} = 16.12x2 - 478.76x + 8909.2$	$R^2 = 0.8846$
Sawdust	Linear	$Y_{TDS} = -260.88x + 8377.6$	$R^2 = 0.8857$
	Exponential	$Y_{TDS} = 8496.1^{-0.04x}$	$R^2 = 0.9437$
	Polynomial	$Y_{TDS} = 13.703x2 - 534.94x + 9062.7$	$R^2 = 0.9713$

- **Poultry Wastewater Turbidity and TSS treatment**

The influent waste water turbidity reduces for the various reactors from the influent value of 964 NTU to 374, 298 and 262 NTU for MFC-GS, MFC-SC and MFC-SD units respectively. Also the total suspended solid, TSS of the influent wastewater reduced from feed value of 1100 mg/L for the feed to a reduction of 696, 690 and 740mg/L for the MFC operated with MFC-GS, MFC-SC and MFC-SD units with removal percentages of 36.72, 37.27 and 32.72 for reactor respectively. This TSS reduction is low as compared to that reported by Min et al., (2005), pH adjusted MFC reactor. The plot is presented in Figure 4.1

The polynomial model of best fit for the waste water treatment shows the best fit on the relationship with the turbidity based on the R2 as shown in Table 4.1. The electrode made from thermally treated sugarcane peel biomass had the best R2 value of 0.9986 followed by the sawdust (0.9920) and then the lastly the electrode made from groundnut shell with the least polynomial R2 value of 0.9846.

For the TSS (Table 4.2), the polynomial model of best fit for the waste water treatment is shown in Figure 4.15. The electrode made from thermally treated sawdust biomass had the best R2 value of 0.9877 although the Linear relationship gave the same value. But for the others, the groundnut shell showed an R2 value of 0.9426 while the sugarcane peel electrode with the least polynomial R2 value of 0.9324. The plot is presented in Figure 4.5.

- **Poultry Wastewater Conductivity and pH treatment**

The plot for the Conductivity and pH decline with time are presented in figures 4.3 and 4.4. These results corroborate with the significant influence of divalent compounds bulk substrate on MFCperformance suggested by Argun et al., (2007).

The trend of the waste water treatment shows a best fit based on the R2 values for the conductivity. The R2 value has the polynomial model as best fit for all the biomasses in table 4.3.

\The electrode made from thermally treated groundnut shell biomass had the best R2 value of 0.9810 followed by the sawdust (0.9776) and then the lastly the electrode made from Sugarcane peel with the least polynomial R2 value of 0.9017.

- **Poultry Wastewater TDS and Salinity treatment.**

The Total dissolved solid in the poultry wastewater solution reduced from the first day until the 20th day of the experiment. From the initial value of 9260 mg/l, the MFC unit with Electrode made from Sawdust had the highest reduction in TDS to 3800mg/l followed by the groundnut shell electrode unit with reduction in TDS to 3900mg/l as presented in Figure 4.2.

On the treatment of the Salinity of the wastewater, the best performance occurred using the electrode prepare from thermal treatment for the Sawdust biomass from the initial value of 9.6% to 2.5(Figure 4.6). The next in terms of performance was the Groundnut shell which reduced to 3.8%. The best fit, for is for sawdust with exponential correlation with R2 value of 0.9815

The model for the rate of reduction of the TDS showed a best fit with the Polynomial relationship as shown in Table 4.5. The R2 for the Groundnut shell was the best with a value of 0.9836 while the Sawdust had the second best R2 value of 0.9713 the least was the Sugarcane peel with R2 of 0.8846.

IV. CONCLUSION

The level of treatment of the waste water was monitored using physico-chemical parameters in the raw and treated water. The parameters measured include the Chemical oxygen demand, biochemical oxygen demand, pH, Conductivity, Turbidity, Total suspended solid (TSS), total Dissolved Solid (TDS) and salinity.

All the electrodes were produced using the same dimension of area 2.74 x 10-2 m2. The Poultry waste solution used in this study was produced from poultry dropping in a ratio of 3:1w/w with water. The cells operated at room temperature and all the cells were operated for 28days.

The locally produced electrodes at a biomass conversion temperature of 400 oC and electrode of (1:1) Charcoal-Cement ratio gave the treatment result of chemical oxygen demand (COD) 2052mg/L, Biochemical oxygen demand (BOD) of 493mg/L, pH 6.36, Conductivity 16.36 µs/cm,

Turbidity 964 NTU, total suspended solid (TSS), 110mg/L, total dissolved solid (TSS) 9260mg/l and salinity 9.6%. The Saw dust biomass showed best performance with reduction of COD 84%, BOD 84%, pH 7.15 (second best performance), Conductivity 70%, Turbidity 72%, TSS 30%, TDS 60% and salinity 74% The groundnut shell perform second best.

There are several proposed model for the correlation of the physiochemical parameter behavaior for the different electrode.

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