WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

The Exact Behaviour of Polyester Mesh Fabric Membrane When thoruoghly Mixed in Activated Sludge Process.

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ABSTRACT

The work covers the treatment efficiency of the submerged polyester mesh fabric membrane in activated sludge process, which was assessed under different operating conditions such as; mixed liquor suspended solids, organic loading rates, sludge retention time. New bio-kinetic model were generated. The constants in the equation were determined from the experimental data. The data were split into two groups, one group was used for calibration, while the other group was used for verification. The extent of fit of the equation were determined by regressing the predicted values against the measured values hence, the coefficient of correlation were determined.

Finally, the application of the model coefficient system design was done and a minimum room size of experimental model system treatment plant was determined . The coefficient used for this design is the average coefficient of the first group of the set of all the experiment carried out when the Chemical Oxygen Demand (COD) was maintained at 1000, 1500, 2000 and 2500 and the coefficient obtained were the biomass decay coefficient (day^{-1}), K_D, slope as 4.2132 day^{-1}/ 0.178hr^{-1}, yield coefficient, (day^{-1}),Yc, the intercept as – 0.9436l/day/ 0.023m^3/hr^{-1}/ 81.5227m^3/s, maximum specific growth (h^{-1}), μ_{max}, slope 159.65day^{-1}/ 6.652hr^{-1} and half saturation coefficient for substrate, Ks, the intercept of 1.96799mgCOD/L, slope and intercept for the Specific Substrate Utilization Rate, SSUR, U and Mixed Liquor Suspended Solids, MLSS, M respectively. After which the principle steady state equation was generated and the coefficient values were substituted. The derived models were compared with the existing models. Studies on fixing of existing wastewater treatment plants with Submerged Polyester Mesh Fabric Membrane in Activated Sludge Process should be seriously investigated. The scope of applying submerged polyester mesh fabric membrane in activated sludge systems for treating combined wastewaters should be investigated, since the results of toxic loading showed positive ability of submerged polyester mesh fabric membrane in activated sludge process when toxic pollutants are high.

Symbols and Meanings

FM Env. Std -Federal Ministry of Environment Standard

mg/l- Milligram per Litre, **NS**- Not Stated

NTU- Nephelometry Turbidity Unit**, ND**- None Detected

Cfu- Colony Forming Unit per Millilitre **NG**- No Growth

1.1 Introduction

Most works on activated sludge process from previous works in literature were based on theories and sludge properties. Hence, the need for easier and more accurate approach to development of model comes in. Thus, this research seeks to offer a helping approach through the application of the new model in designing the sludge treatment system which would be used to solve problems.

This study seeks to address many sludge disposal issues amongst which are the following;

Firstly, On site disposal of untreated sewage:-On site disposed systems have caused random development of bacteria and high rate of pollution to groundwater and environment.

Secondly, inadequate and expensive sludge treatment systems. As a result of this, there is need to set up an experiment, assess the treatment efficiency of the submerged Polyester Mesh Fabric membrane activated sludge process under different operating conditions. Also, derive a new kinetic model, calibrate, verify the model and compare the derived model with the existing models. Hence, apply the model in the design of the system.

1.2 METHODS

Setting up an experiment for collection of data and determination of relevant parameters. The initial stage of the research was laboratory testing after which was the fabrication process. Later in the process was the preparation of the sample influent Substrate Feed. The entire stages are as detailed in the subsequent sections.

1.3 Sample Laboratory Testing

The fabrication work and part of the feed preparation were done at the waste-water treatment laboratory, located at Imo State Polytechnic, Umuagwo-Ohaji . The sample was later taken to the New Concept Laboratory, Obinze along FUTO road where the activation process was carried out, including the chemical and the microbial analysis.

Fabrication: At the initial stage, two 0.95cm hose of length 137.2cm were positioned up and down of the dosing pump. Also, 0.64cm hose was attached adjacent to 0.95cm hose. The first 0.95cm hose was the inlet hose while the second 0.95cm hose was the outlet hose. The 0.64cm hose was used to send out the left over. 30 x 20 polyester mesh fabric was attached directly to the PVC pipe held by 8.07cm socket, coupled with an inner socket of size 3.03cm PVC socket.

The bushing of size 3.03cm was used to reduce the PVC socket to 1.27cm size. The rectangular plexi glass stand were perforated which enabled the 0.95cm inlet hose that was attached to 1.27cm PVC pipe which was used to fix the filter and it was connected to the dosing pump. The dosing pump was set at 60 stokes and was powered.

To assess the treatment efficiency of the submerged polyester mesh fabric membrane in activated sludge process under different operating conditions (such as mixed liquor suspended solids- MLSS, organic loading rates, sludge retention time).

The experimental flow diagram is as shown in Figure 1.

1.4 Experimental Set-Up

The experimental set-up is as follows;

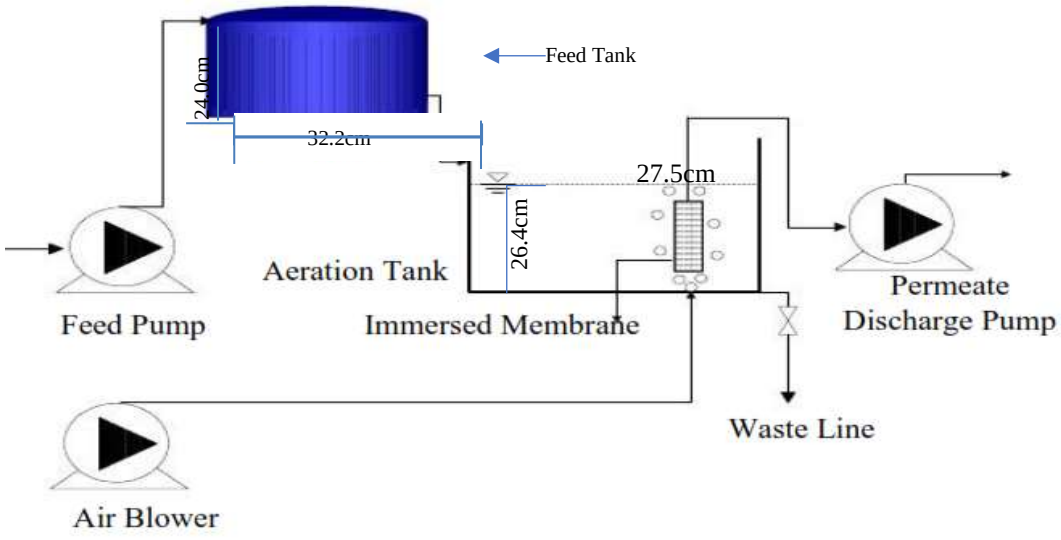

Figure 3.1: Experimental Flow Diagram

(i.) Feed Tank: The feed tank was a graduated, rectangular plexi glass tank of dimensions 46cm × 32.2cm × 24cm. The over flow outlet was positioned in a way that the capacity of the feed tank was twenty litres. The concentrated synthetic wastewater was diluted with tap water as influent concentration requirements in the feed tank.

(ii.) Aeration Tank: The aeration tank was a rectangular tank with dimensions of 39.2cm × 27.5cm × 26.4cm. The wastewater was fed to the aeration tank from the feed tank through a float to control the level of the wastewater inside the aeration tank to eightee ste drain on the aeration tank.

Fig. 1 Experimental flow diagram

(iii.) Diffusers: The reactor contents were kept under aerobic conditions using two cylindrical stone diffusers. These diffusers were connected to the air-injection line through tygon tubes.

(iv.) Suction Pump: The peristaltic pump of variable speed was used at intermittent operation to extract the permeate through membranes. The master flex tubes were used to connect the pump to the microfiltration membranes.

(v.) Permeate Tank: The permeate was collected using polyethylene container. The container was graduated on the outside in order to facilitate the measurement of the permeate volume.

1.5 Methodology

Waste Characterization: Influent Substrate Feed Preparation

The synthetic substrate that made of glucose, peptone and yeast extract (organic source) was used as substrate throughout the research period to ensure a consistent influent to the membrane bioreactor. The sewage wastewater was made up of in-organics, micronutrients, nitrogen and phosphorous for the development of the biomass. The concentrated feed solution was prepared and stored in the refrigerator at 4 ^{0}C for a maximum period of seven days. The influent feed concentration of required strength in terms of Chemical Oxygen Demand (COD) was later prepared by diluting the concentrated feed with tap water.

The influent substrate concentration was varied for the bio-kinetic studies. The influent was supplied to the reactor continuously in order to match with the permeate flow rate by keeping the water level constant in the reactor using a mechanical float. The seeding micro-organisms were obtained from the return sludge.

Section A

1.6 Experimental Procedure

The first peristaltic pump was used to pump in twenty - litres (20 litres) of sample into the feed tank and the total of eighteen litres (18 litres) were pumped into the aeration tank.

The initial seeding of the bioreactor was accomplished by charging the bio-reactor with eighteen litres (18 litres) of the returned activated sludge. The biomass was allowed to acclimatize to the synthetic substrate at the first four weeks of the operation. The pumping was carried out intermittently with the schedule. The intermittent suction method was applied because intermittent suction showed higher performance than continuous suction with regard to the maintenance of stable flux. The stopped watch was used to achieve the intermittent schedule. The experimental processes were carried out for almost a year, with continuous monitoring to establish bio-kinetic coefficients and to assess the ability and suitability of the membrane bioreactor to provide the required Chemical Oxygen Demand (COD) removal and to absorb the shock loadings. The experimental investigation was made up of two phases. In the first phase, the bio-kinetic coefficients were determined by operating the system at different sludge retention time (SRT) and by allowing a steady state condition at each adopted stage of sludge retention time. The Mixed Liquor Suspended Solids (MLSS) concentration was attained and maintained under steady state conditions at the beginning of the study. A steady state condition was achieved when fairly constant biomass growth and filtrate Chemical Oxygen Demand (COD) were obtained. Sludge was wasted daily to maintain steady state conditions. The accurate measurement of the biomass and effluent substrate concentrations were recorded.

The Sludge Retention Time (SRT) was controlled and the Organic loading rate (OLR, kg COD/ kg MLSS day) was increased, hence the second steady state condition for the same Mixed Liquor Suspended Solid (MLSS) concentration was achieved. The biomass and effluent substrate concentration were recorded. Then, third steady state condition was established by further increasing the Organic Loading Rate (OLR). The kinetic coefficients were determined by plotting these parameters at steady state conditions.

Next, the biomass concentration was increased and similar analysis was carried out after attaining steady state conditions at each of the specified substrate concentrations. The organic loading rate ranged from 0.40 kg COD/ kg MLSS day to 5 kg COD/ kg MLSS day in the above experimental runs. Flux was also monitored to assess the performance of the submerged polyester mesh fabric membrane under different MLSS concentrations and different organic loading rates.

In the second phase, at the 500mg/l MLSS concentration, the reactor was subjected to a shock loading of high influent substrate concentration of 1000 mg/l COD and effluent quality was monitored to study the ability of the submerged polyester mesh fabric membrane in activated sludge process to with-stand shock loadings. After this, the reactor was fed with synthetic substrate contaminated with phenol. The effect of phenolic toxic loading on the performance of the submerged polyester mesh fabric membrane in activated sludge process was studied without acclimatization as well as with acclimatization. For the acclimatization experiments, the bacteria were acclimatized to the phenol for over a month and then effluent quality for the bacterial populations in the reactor was monitored to study the effect of organic toxic pollutant to the submerged polyester mesh fabric membrane in activated sludge process. Then the reactor was fed with synthetic substrate contaminated with chromium. The effluent quality as well as for the bacterial populations in the reactor was monitored to study the effect of inorganic toxic pollutant to the submerged polyester mesh fabric membrane in activated sludge process. The pumping was carried out intermittently with the schedule as shown in Table 1.

Table 1: Pumping Schedule

S/No.	On Time	Off Time
1.00	07:00 am	08:10 am
2.00	08:15 am	09:25 am
3.00	09:30 am	10:40 am
4.00	10:45 am	11:55 am
5.00	12:00 pm	01:10 pm
6.00	01:15 pm	02:25 pm
7.00	02:30 pm	03:40 pm
8.00	03:45p m	04:55 pm

1.7 ANALYTICAL PROCEDURES

The sampling from the reactor and permeate were carried out periodically and analyzed for the following Physio-chemical parameters, by the methods described in the Standard Methods for the examination of wastewater for the continuous reactor experiments (APHA.AWWA.WPCF, 1985). Under the analytical process, several test were conducted.

Turbidity: This was carried out according to Standard Methods for the Examination of Water and Waste-Water 16th Edition. APHA. AWWA. WPCF, 1985. Part 200; Pages 133-136.

Temperature and pH: Similarly the Temperature and pH tests were carried out according to Standard Methods for the Examination of Water and Waste-Water 16th Edition. APHA. AWWA. WPCF, 1985. Part 400; Pages 429 – 436 and Part 200; Pages 126-127.

Suspended Solids: The Suspended Solids were evaluated according to Standard Methods for the Examination of Water and Waste-Water 16th Edition. APHA. AWWA. WPCF, 1985. Part 200; Pages 97-100.

Dissolved Oxygen (DO): The dissolved oxygen was carried out according to Standard Methods for the Examination of Water and Waste-Water 16th Edition. APHA. AWWA. WPCF, 1985. Part 400; Pages 413-42.

Chemical Oxygen Demand (COD): The chemical oxygen demand (COD) was out according to Standard Methods for the Examination of Water and Waste-Water 16th Edition. APHA. AWWA. WPCF, 1985. Part 500; Pages 535-537.

Biochemical Oxygen Demand: The biochemical oxygen demand was carried out according to Standard Methods for the Examination of Water and Waste-Water 16th Edition. APHA. AWWA. WPCF, 1985. Part 500; Pages 525-531.

Total Organic Carbon: This was out according to Standard Methods for the Examination of Water and Waste-Water 16th Edition. APHA. AWWA. WPCF, 1985. Part 500; Pages 507-513.

Phenol: This was carried out according to Standard Methods for the Examination of Water and Waste-Water 16th Edition. APHA. AWWA. WPCF, 1985. Part 500; Pages 556-558.

Chromium: This was carried out according to Standard Methods for the Examination of Water and Waste-Water 16th Edition. APHA. AWWA. WPCF, 1985. Part 600; Pages 657-665.

1.8 MICROBIOLOGICAL ANALYSIS

Serial dilution (spread plate/pour plate method)

Inoculation

One millilitre (1ml) of each waste-water samples was pipette into a test tube containing nine millilitres (9ml) of sterile distilled water.

i). Ten (10) fold serial dilution of the waste-water sample were prepared using sterile distilled water as the diluents.

ii) Aliquots (0.1ml) of each (10^{-2}, 10^{-3}, 10^{-4} , 10^{-5}) of the test tube were inoculated in a Nutrient agar plate, Macconkey agar plate, salmonella shigella agar plate and Eoesin methylene blue plate by spread plate technique and incubated at thirty-seven degrees centigrade (37^{o}c) for

twenty-four hours (24 hrs) for bacteria and twenty-five degrees centigrade (25^{o}c) for seventy eight hours to ninety-six hours (78hrs – 96 hrs) for fungi on the incubator.

iii) After incubation, colonies were observed on different plate and were counted and recorded.

Media Preparation

i) **Nutrient agar**

This is a basic media mostly used for culturing, sub-culturing and for total viable bacterial count.

Procedure

(i) Twenty-eight grams (28.0 g) of the nutrient agar were dissolved in one hundred millilitres (100ml) of distilled water and were gently heated to completely dissolve the medium.

(ii) The prepared media was sterilized by autoclaving at fifteen pressure square index or one hundred and twenty-one degrees centigrade (15psi or 121^{0}c) for fifteen minutes (15 minutes). The medium was dispensed as desired in the plate.

ii) **Salmonella Shigella Agar**

The salmonella shigella agar was carried out according to Standard Methods for the Examination of Water and Waste-Water 16th Edition. APHA. AWWA. WPCF, 1985. Part 900; Pages 926-928.

iii) **Eosin Methylene Blue (EMB) Agar**

It is used for differential isolation of gram – negative ereteric bacterial and total faecal count.

Procedure

(i) Thirty-six grams (36grms) of the agar were suspended in one thousand milliliters (1000ml) of distilled water.

(ii) The medium was completely dissolved by heating.

(iii) The medium was dispensed and sterilized by autoclaving at fifteen 15 pressure square index (121^{0}c) for fifteen minutes (15 minutes).

(iv) The medium was poured into the petri dishes (plates).

1.8.1 Identification of Isolates

The isolates were identified using their colonial appearance, the following test were carried out, gram staining, catalase test, citrate test, methyl red test, oxidase test and coagulase test.

1.8.2 Bacterial Identification

A) Gram Staining

Procedure

(i) Smears of the isolates were prepared and heat was fixed on clean grease freeslides.

(ii) The smears were stained for one minute with crystal violent. This was flooded with dilute gram's iodine solution. This was washed off with water and the smear decolourized with ninety-five percent (95%) alcohol till the blue colour was more dripped out (about 30 seconds).

(iii) The smears were then counter stained with saffranin solution for about ten seconds (10 seconds).

(iv) Finally, the slides were washed with tap water, air dried and observed under oil immersion objection.

B) **Methyl Red Test**

Bacteria produce acid by fermentation of glucose, which changes $_{P}$H of the medium. It falls and is maintained below 4.5. This test detects the production of acid.

Procedure

(i) The test organism was inoculated into peptone water broth and it was incubated at thirty-seven degrees centigrade for 5 days.

(ii) Five drops of 0.04% solution of alcoholic methyl red solution were added into the mixture and were well mixed and the result was read immediately.

C) **Urease test**

The test detected an ability of an organism on the agar slant of urea ager.

Procedure

(i) The test organism was inoculated on the ager slant of urea ager and was incubated at thirty-seven degrees centigrade.

It was observed after four hours and after overnight incubation and the result was recorded.

1.8.2 Bio-Kinetic Equation for the Submerged Polyester Mesh Fabric

Membrane in Activated Sludge Process (SM-ASP).

Activated Wastewater Sludge Kinetic Experiments

The experiments were carried out in four different operations of maintaining the influent substrate of Chemical Oxygen Demand (COD) at 1000, 1500, 2000 and 2500 with variation of the wastewater flow rate and permeate volume of each operation and other parameters were also measured and recorded.

1.8.3 Bio-Kinetic Data Computation for the Submerged Polyester Mesh Fabric

Membrane

Tables 4.14 to 4.18 showed the computed specific substrate utilization rate, SSUR, U, organic loading rate, sludge retention time and mixed liquor suspended solid, MLSS, M values, with the variation of the wastewater flow rate and permeate volume for each operation, including the other parameters.

1.8.4 Activated Bio-kinetic Model Prediction: Determination of Bio-Kinetic Model

Coefficients

The experimental results were used in computation of the time inverse 1/SRT and the gram inverse 1/S of each operation and the operation was renumbered as MLSS10001, MLSS15001 and so on. The specific substrate utilization rate SSUR, U and Mixed Liquor Suspended Solid MLSS, M valueswould be used in graph plotting.

1.8.5 To derive a new bio-kinetic equation for the submerged polyester mesh fabric

membrane in activated sludge process (SM-ASP).

1.9 Model Development

1.9.1 Design Study

Based on the limitations from earlier research (as stated on Table 2.13 to 2.31 of literature review), the study shall be designed in line with the specific objectives as follows;

a. Derivation of the bio-kinetic model

b. Calibration and verification of the model

c. Comparative analysis of the new equation with the existing ones

1.9.2 Development of Bio-Kinetic Model

The new model is derived based on the enzymeticprinciples high-lighted by Monod (Agunwamba, 2001) and first order kinetics as stated below;

The rate of growth of bacterial cells in continuous and batch culture systems is given as;

$$\gamma_G = \mu T \quad (1)$$

Where; γ_G = rate of bacterial growth, mass / unit volume time

μ = specific growth rate, time^{-1}

T = concentration of micro-organisms, mass PER unit volume

Note: For the batch culture; $\frac{dC}{dt} = \gamma_G$ (2)

Furthermore,

Therefore; $\frac{dC}{dt} = \mu T$ 2b

By applying Monod equation to the effect of a limiting substrate or nutrient;

$$\mu = \mu_m \frac{S}{K_s + S} \quad 3$$

where; μ = specific growth rate, day^{-1}

μ_m = maximum specific growth rate, time^{-1} or day^{-1}

S = concentration of growth limiting substrate in solution (mg/l) surrounding the biomass, mass / unit volume

Ks = half velocity constant, substrate concentration at one-half the maximum growth rate (mg/l) or saturation constant which is numerically equal to the substrate concentration at $\mu = 0.5\mu_m$, Mass / unit volume.

Substituting Equation

$$\gamma_G = \frac{\mu_m TS}{K_s + S} \quad 4$$

By converting a portion of the substrate to new cells and some portion is oxidized to organic and inorganic end products. The relationship between the mass of bacteria produced and the mass of organic substrate removed is defined by a coefficient, Yc which is mathematically stated as;

$$Y_c = \frac{(dc/dt)}{(ds/dt)} \quad 5$$

Where; Yc = yield coefficient

S = concentration of growth limiting substrate in solution.

Note that: The yield coefficient is assumed to be constant for a given biological process, treating specific waste. The relationship between the rate of substrate utilization and the rate of growth is given as; $\gamma_G = -Ycr_{su}$ 6

Where; γ_G = rate of bacterial growth, mass / unit volume time^{-1}

Yc = yield coefficient

r_{su} = rate of substrate utilization, mass / unit volume time

The decrease in cell mass known as endogenous decay, R_d as a result of all the cells not being in the same growth phase, caused by death and predation is proportional to the concentration of organism present in the bacterial systems used for the sludge treatment.

This endogenous decay, $R_d = -K_D$*T 7

considering, K_D = endogenous decay coefficient, time^{-1}

Rd = rate of decay, mass / unit volume

Note that: The growth of the biomass in the process is expressed as;

$\frac{dC}{dT} = \mu C - K_D$*T 8

Further substituting gives

$\frac{dS}{dt} = \frac{\mu T}{Yc}$ 8b

Further rearrangement gives

$\frac{dC}{dt} = Yc(\frac{dS}{dt}) - K_D$*T 9

and also $\mu = U * Yc - K_D$ 10

Taking U as the rate of specific substrate utilization, time^{-1}

That is $U = \frac{Q*(S_o - S)}{VC}$ 11

Taking Q = Flow rate, l/s; V = Reactor volume, L

S_o = Influent substrate concentration; S = reactor substrate concentration

C = effluent biomass concentration (mg total dry solids/ litre, MLSS)

Assumptions for the Model Development are;

(1.) A completely mixed reactor was used (mixing was carried out by the stone aerators provided at the bottom of the filtration unit, near the end of the tank).

(2.) The concentration of influent substrate remained constant (this was done by using the synthetic influent as substrate).

(3.) There was no microbial solids in the influent substrate.

(4.) The volume of the reactor was constant (that is; the rate of inflow was equal to the permeate flux), this was achieved by the use of mechanical float.

(5.) There was complete rejection of the mixed liquor suspended solids (no biomass was allowed to come out with the permeate).

(6.) The substrate was not rejected (since the membrane has a high molecular weight-cut-off, the glucose has a low molecular weight) and steady state conditions were carried out throughout the system.

Note that; The rate equations describing the performance of the system are the mass balance equations of both the biomass and substrate. These are stated as follows;

Biomass balance; [Rate of change of biomass in the reactor] = [Rate of increase due to growth] – [Rate of loss due to endogenous respiration] – [Deliberate wastage]

The above statement is symbolically represented as;

$$V\frac{dC}{dt} = \mu TV - K_D TV - Q_w T \qquad 12$$

Where; V = reactor volume, L

T = Biomass concentration in the reactor, mg/l

μ = Specific growth rate, day^{-1}

K_D = Biomass decay coefficient, day^{-1}

Q_w = Wastage flow rate, l/s

But at steady state conditions, $\frac{dC}{dt} = 0$;

∴ Equation (12) becomes;

$$\mu = K_D + \frac{Q_w}{V} \qquad 12b$$

The sludge retention time is defined as,

$$SRT = \frac{Total\ mass\ of\ organisms\ in\ the\ reactor}{Total\ mass\ of\ organisms\ leaving\ the\ system\ per\ day}$$

$$\therefore \quad SRT = \frac{VC}{Q_W C} = \frac{V}{Q_W} \qquad 13$$

By putting Equation (11) into Equation (10);

$$\mu = K_D + \frac{1}{SRT} \qquad 13a$$

The reaction kinetics of submerged polyester mesh fabric membrane in activated sludge process.

From Equation (12) gives the steady state for substrate concentration in the reactor,

$$S = \frac{K_s\left(\frac{1}{SRT} + K_D\right)}{\mu_m - \left(\frac{1}{SRT} + K_D\right)} \qquad 13b$$

Where; S = Reactor substrate concentration (mg/l)

K_S = Half velocity constant, substrate concentration at one-half the maximum growth rate (mg/l)

μ_m = Maximum specific growth rate, day^{-1}

K_D = Endogenous decay coefficient, $time^{-1}$

SRT = Sludge retention time

Therefore, Substrate Balance, [The rate of change of substrate in the reactor] = [Rate of input of the feed substrate] – [Rate of removal due to biomass utilization] – [Rate of removal due to washout] – [Substrate lost during deliberate wastage of biomass]

The above statement can be mathematically stated as;

$$V\frac{ds}{dt} = QSo - \mu\frac{CV}{Yc} - S(Q - Qw) - QwS \quad 14$$

At steady state conditions; $\frac{dS}{dt} = 0$;

Hence, Equation (14) becomes

$$\frac{Q}{V}(So - S) = \mu\frac{T}{Y_C} \quad 15$$

Putting Equation (12) into Equation (15) gives the biomass concentration, T at steady state conditions;

$$T = Y_C * \frac{Q}{V} * \frac{S_o - S}{K_D + \frac{1}{SRT}} \quad 16$$

Where; T = Biomass concentration; Y_C = Yield coefficient; Q = Flow rate, l/s;

V = Reactor volume,L; S_O = Influent substrate concentration;

S = Reactor substrate concentration; K_D = Biomass decay coefficient, day^{-1}

SRT = Sludge retention time

The parameters which are thehalf velocity constant, substrate concentration at one-half the maximum growth rate (K_S) in milligram per litre, specific growth rate (μ) in per day, yield coefficient (Yc) and the biomass decay coefficient (K_D) in per day were determined through linearization of Equations (13) and (15) as follows:

Determining the bio-kinetic coefficients, biomass decay coefficient (K_D) and the yield coefficient (Yc) and rearranging Equations (16) gives:

$$\frac{Q}{VC}(So - S) = \frac{1}{Y_c}\frac{1}{SRT} + \frac{K_D}{Y_c} \quad 16b$$

Also determining the bio-kinetic coefficients, the maximum specific growth rate (μ_{max}) in per day and half velocity constant, substrate concentration at one-half the maximum growth rate (K_S)in milligram per litre, Equation (13) can be re-arranged as:

$$\frac{SRT}{1+(SRTK_D)} = \frac{Ks}{\mu_{max}}\left(\frac{1}{S}\right) + \frac{1}{\mu_{max}} \quad 17$$

Plotting Equation (16) as Q(So-S)/Vc versus 1/SRT, from the slope and the intercept, the bio-kinetic coefficients, biomass decay coefficient (K_D) and the yield coefficient (Yc) were determined. The obtained value of biomass decay coefficient (K_D) wouldbesubstituted into Equation (17); plotting SRT/[1+(SRT K_D)] versus 1/S, the bio-kinetic coefficients, the maximum specific growth rate (μ_{max}) in per day and half velocity constant, substrate concentration at one-half the maximum growth rate (K_S)in milligram per litre were determined from the slope and intercept.

Calibration and Verification

The constants in the equation were determined from the experimental data. The data were split into two: one set was used for calibration, while the other was used for verification.

1.10 Statistical Analysis

Curve Fitting

The method adopted for curve fitting has been detailed on pages 79 to 80 of the literature. The extent of fit of the equation were determined by regressing the predicted values against the measured values. The coefficients of correlation were determined. The fittings of the measured Specific Substrate Utilization Rate, SSUR$\mathbf{U_{measured}}$ and predicted quadratic trendline model value Y_{uc} is calculated as follows;

∴ Correlation Coefficient, $r_{U_m y_{uc}} = \frac{n\sum U_m y_{uc} - \sum U_m \sum y_{uc}}{\sqrt{[n\sum U_m^2 - (\sum U_m)^2][n\sum y_{uc}^2 - (\sum y_{uc})^2]}}$ 15

Where; U = specific substrate utilization rate from first set of experiment

U_m = the measured values of specific substrate utilization rate, SSUR

Y_{mc}= the measured values of graphical regression quadratic equations on calibration

y_{uc} = the predicted values of graphical regression quadratic equations on calibration

2.0 Results

From the various analysis conducted, the results were as detailed in the sections below

2.1 Experimental Bio-Kinetic Data Collection and Relevant Parameters

The results of the pumping are as stated below .

Table 2.1: Data for Flux and Turbidity during a Typical Day

Time (Hours)	Permeate Volume (Litres)	Flux, $L.M^{-2}Hr^{-1}$	Turbidity (NTU)
0:00	0.00	-	-
1:00	1.00	64.94	20
2:00	1.50	48.70	40
3:00	2.00	43.29	60
4:00	2.50	40.58	80
5:00	3.00	38.96	100
6:00	3.50	37.88	120
7:00	4.00	37.11	140
8:00	6.00	48.70	160
9:00	8.00	57.72	180
10:00	10.00	64.94	200
11:00	12.00	70.84	220
12:00	14.00	75.76	240
13:00	16.00	80.00	260
14:00	18.00	83.49	280

Table 2.2: Data for Flux and Turbidity after Back-Washing

Time (Hours)	After Backwashing With Air Alone		After Backwashing With Air And Water		After Backwashing With Water Alone		Permeate Volume(L)
	Flux ($L.m^{-2}hr^{-1}$)	Turbidity (NTU)	Flux ($L.m^{-2}hr^{-1}$)	Turbidity (NTU)	Flux ($L.m^{-2}hr^{-1}$)	Turbidity (NTU)	
0:30	64.94	20	64.94	20	64.94	20	0.50
1:00	77.92	40	77.92	40	77.92	40	1.20
1:30	69.26	60	69.26	60	69.26	60	1.60
2:00	77.92	80	77.92	80	77.92	80	2.40
2:30	65.45	100	65.45	100	65.45	100	2.52
3:00	73.59	120	73.59	120	73.59	120	3.40
3:30	65.31	140	65.31	140	65.31	140	3.52
4:00	68.18	160	66.50	160	67.42	160	4.20
4:30	86.58	180	82.58	180	83.26	180	6.00
5:00	103.89	200	100.05	200	104.80	200	8.00
5:30	118.06	220	110.09	220	115.04	220	10.00
6:00	129.87	240	125.45	240	127.55	240	12.00
6:30	139.86	260	134.80	260	136.82	260	14.00

7:00	148.42	280	140.22	280	145.32	280	16.00
7:30	155.84	300	152.44	300	158.64	300	18.00

Table 2.3: Data for Bio-kinetic Studies

Time(Days)	Influent COD(mg/l)	Effluent COD (mg/l)	Permeate Volume (L)	Tank MLSS (mg/L)		Tank MLVSS (mg/l)
				Before Wasting	After Wasting	
1	20	15.00	42.00	110	99	85
2	20	14.50	42.00	105	95	80
3	20	14.00	36.00	107	94	89
4	20	13.20	36.00	112	80	79
5	20	13.00	30.00	113	82	80
6	20	12.50	30.00	115	84	81
7	20	12.00	34.00	117	100	90
8	20	11.30	36.00	111	85	72
9	20	11.00	38.00	101	92	70
10	20	10.40	40.00	150	91	84
11	20	10.00	32.00	130	86	73
12	20	09.50	34.00	120	93	74
13	20	09.00	34.00	108	87	82
14	20	08.20	38.00	119	84	71
15	20	08.00	30.00	118	83	75
16	20	07.50	32.00	120	81	79
17	20	07.20	34.00	122	88	80
18	20	07.00	36.00	124	89	76
19	20	06.30	38.00	126	90	82
20	20	06.00	40.00	128	93	81

SHOCK LOADING AND TOXIC LOADING

Table 2.4: Data for Shock Loading (High Organic Loading Rate)

Time (Days)	Influent COD(mg/l)	Effluent COD(mg/l)	Permeate Volume (L)	Tank MLSS (mg/l)
1.0	500	52	30	1500
2.0	650	102	28	1800
3.0	650	85	26	1850
4.0	800	180	30	2000
5.0	800	64	28	2250
6.0	1000	200	30	2300
7.0	1000	95	28	2500

8.0	400	08	30	1350
9.0	500	52	30	1500

Table 2.5: Data for Chromium Loading

Time (Days)	Influent COD (mg/l)	Effluent COD (mg/l)	Influent Chromium (mg/l)	Effluent Chromium (mg/l)
1.0	500	250	10	10.5
2.0	500	200	10	10.2
3.0	500	150	20	20.4
4.0	500	300	20	18.6
5.0	500	100	30	25.5
6.0	500	50	-	-
7.0	500	20	-	-

Table 2.6: Data for Microbial Studies

Parameter	FM Env. Std	Mixed Liquor	20 mins	40mins	50mins
Total Bacteria count, cfu/ml	0-30	1.0 x1 0^4	NG	NG	NG
Total E.Coli Count, cfu/ml	0	3.3 x 10^5	2.7 x 10^5	3.2 x 10^5	1.2 x 10^5
Total Coliform Count, cfu/ml	0	3.0 x 10^4	1.0 x 10^4	NG	NG

2.2 Treatment Efficiency of the Submerged Polyester Mesh Fabric Membrane in Activated Sludge Process

Figure 2.1 to Figure 2.5 showed the assessment of the treatment efficiency of the submerged polyester mesh fabric membrane in activated sludge process under different operating conditions.

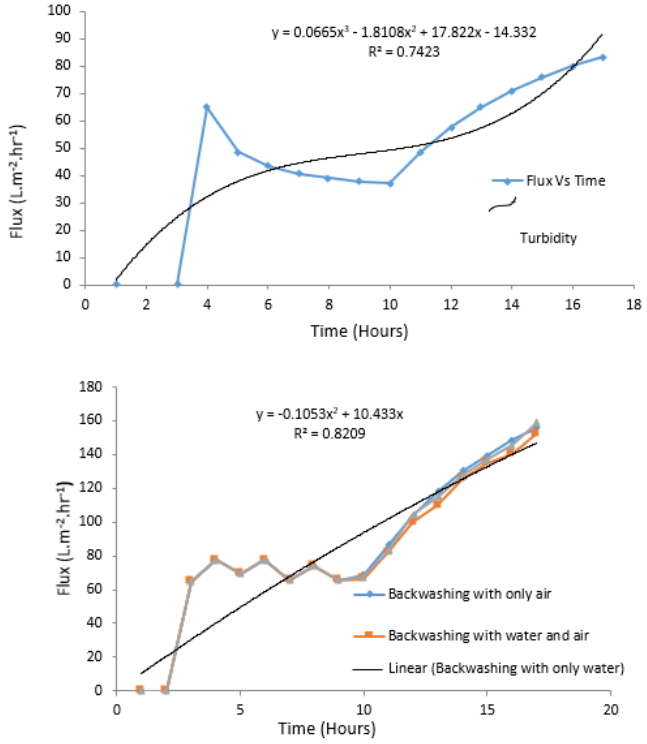

Figure 4.1: Variation of Flux with Time

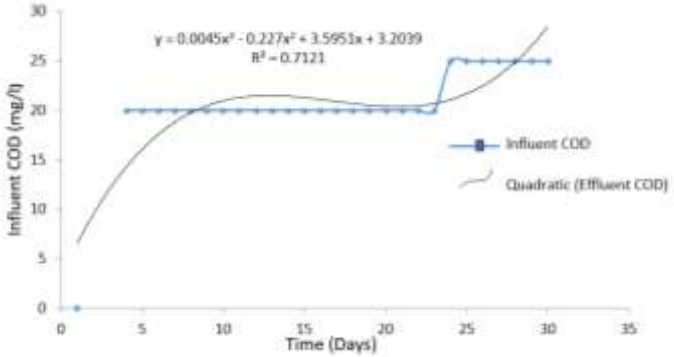

Figure 2.2: Variation of Flux with Time after backwashing

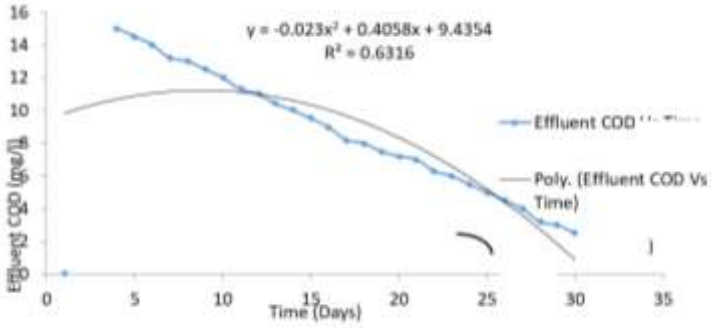

Figure 2.3: Variation of Influent COD with Time

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