Modelling of a Small Scale Waste Water Treatment Plant (SSWWTP)

Ogbonnaya, A. Ezenwa[1], Anyanwu Chukwudi. C[2] and NdukweChinedu[2]

[1]Department of Mechanical Engineering / Marine Engineering,Niger Delta University,
P. M. B 071 Wilbforce Island,Bayelsa State, Nigeria. Email: ezenwaogbonnaya@yahoo.com
[2]Department of Mechanical Engineering, Michael Okpara University of Agriculture,
UmudikeUmuahia, Abia State. Tel: +2348037844275. Email:anyanwuchukwudi@ymail.com

Abstract

One of the most important environmental problems faced by the world today is waste handling and management, due to variation in waste water with respect to homes. The two main treatment methods used here are the aerobic and the anaerobic treatment process. The processes are brought together to increase the efficiency of the plant. The plant has the capacity of treating the wastewater with high chemical oxygen demand ***(COD),*** *biological oxygen demand* ***(BOD),*** *settleable and non-settleable solids coupled with some other impurities. It was achieved by introducing some micro-organism in its granular form into the up-flow anaerobic sludge blanket* ***(UASB)*** *tank and aerator at the sequence batch reactor* ***(SBR)*** *tank so that the non-settleable solids could settle at the settling tank. From the analytical result of ten samples used, it was observed that seven out of ten have high COD (red in colour) while the remaining samples had the normal COD range for domestic waste. The average COD removal efficiency at the UASB was 64% while that at the SBR was 14%. Thus, the general performance efficiency of the plant is 78.4% which is the average COD removal efficiency at 100% evaluation.*

Keywords: Influent tank, Equalization tank, UASB, SBR, Settling tank, Biodegradation process.

Every community produces solids, liquids and gaseous wastes; liquid waste commonly comes in the form of waste water, which is 99.99% water and 0.01% of impure substances. Waste water is generated from the discharge of used hazardous liquid waste into the surrounding water. When untreated wastewater accumulates into a septic, the decomposition of its organic composition leads to the production of malodorous gases, poisonous and hazardous substances [7]. In addition, untreated waste water contains numerous pathogens that could survive in a living cell. It also contains nutrient, which can stimulate the growth of aquatic plants, and could contain toxic compounds that potentially be mutagenic or carcinogenic [4].

Despite the fact that wastewater is a major source of pollution it is considered a sustainable and valuable resource that should be collected, treated to acceptable standards. It is not only the preservation of the environment and groundwater aquifers, but also to conserve and augment the water resources (reuse). For these reasons, the immediate and nuisance free removal of waste water from its source of generation followed by treatment, reuse or dispersal into the environment it say to protect public health and the environment [1].

The reuse of treated wastewater, mainly for agricultural irrigation, would promote water conservation through replacement of fresh water reallocated for domestic use from different waste. This would also result in guaranteed regular supplies of fresh water to the citizens. The dispersed pattern in this country makes it economically unfeasible to construct wastewater collection networks and centralized wastewater treatment plants. On-Site small scale wastewater treatment plants, respond to the needs and conditions of rural localities. They can solve the wastewater collection and disposal problems in such communities, along with the benefit of generating a water resource that can be utilized for agricultural purpose. As looking forward it becomes obvious that in the interest of sustainability as well as fundamental economic efficiency, one must view waste water as a raw material to be conserved. Clean water is a scare commodity and should be treated, so it must be conserved and reused. The organic compounds in waste water are the source of energy. Future effort will be focus on improving the efficiency of energy used in the waste water [3].

Aim

The aim of this project is to bring into existence a Small Scale Waste Water Treatment Plant that can convert a waste water with high Chemical Oxygen Demand (COD) and high Biological Oxygen Demand (BOD) to pure water [8].

Objectives

This project is designed to provide a comprehensive study to establish guidelines for their application. The objectives of the project can be summarized as follows:

- To identify appropriate waste water treatment technologies (e.g. treatment by plants, high-loaded treatment lagoons, community septic tanks).
- To identify conditions under which a certain number of waste water can be connected to a single small-scale waste water treatment plant (economic, technical and social viability).
- To design a model for this waste water treatment plant
- Reduce water born disease and high acidic nature of water
- To enhance aquatic lives

Problem Statement

The need for waste water treatment plant increases, due to the scarcity or shortage of water available, high level of industrial and domestic waste discharge into the surrounding water, coupled with lack of compliance to health, safety and environmental policy. These have led to loss of lives and properties including aquatic lives. Hence the waste water treatment plant is needed in order to make the waste water useful to the environment.

Design Criteria

The preliminary criteria of the small-scale wastewater project, given its objectives, will be determined by careful consideration of what is of upmost important when making wastewater technological choices. The Prioritization of criteria was done, after which its assessment for better evaluation is carried out. General assumptions will be made to keep a clear focus on the project objectives, if not, the choice of technology would be restricted. The criteria that would be necessary are as follows:

Topography

Topography or slope of an area has an influence over the type of technology chosen and these conditions change from one site to the next. Some areas have a topography that allows easier implementation of wastewater technologies than others. The type of wastewater technologies chosen with consideration of topographic conditions may work more efficiently as with these technical considerations in mind they become more effective. Topographic conditions are to be considered as a criterion [8].

Materials

The materials that will be used in the construction of the facility will be carefully selected to assure a proper and a reliable unit. The first idea was to use fibre glass but due to the elevation costs of imported fibre materials and to the lack of local sources, it was preceded trying other market available alternatives. Plastic might be an available and appropriate option due to a combination of reasons, including its corrosion control abilities, its light weight, its low cost, its strength-to-weight ratio, and other unique properties but cannot be fabricated [2]

Operation and maintenance

It will be assumed that a certain degree of maintenance is required and also a skilled workforce to perform maintenance and operational duties when needed. Although the operation and maintenance of the system may be reviewed from time to time by the relevant parties, it is most often left to the department themselves in the long run. To overcome this, proper maintenance and operation training is made available to certain people who are responsible for this duty.

Sometimes mechanical equipment is imported and when parts need repair or replacement, they are not available locally so the system becomes non-operational for a period of time. This criterion is placed here because maintenance and operation are important and need to be considered when making a technological choice because the sustainability of chosen technology relies on the proper workings of the two [8].

Materials and Methods

The ***Influent Tank*** consists of a metal sheet welded into a cylindrical drum with height of 63cm, diameter of 52cm and thickness of 5mm. Then the actual diameter is 51cm (i.e. radius of 25.5cm).

Where, $\text{radius} = \frac{\text{diameter}}{2}$, (i)

$\text{Area of the cylinder} = \pi r^2$, (ii)

Area = $\pi \times 25.5^2$

Area = $2042.8\text{cm}^2 = 0.20428\text{m}^2$

$\text{Volume of the cylinder} = \pi r^2 h$, (iii)

$\text{volume} = \pi \times 25.5^2 \times 63$

Volume = $128698\text{cm}^3 = 0.1287\text{m}^3$

The Equalization tank is a metal sheet welded to a cylindrical tank with height of 63.5cm, diameter of 52cm and thickness of 0.5cm. Then the actual diameter of the tank is 51cm (i.e. radius of 25.5cm)

Where, $\text{radius} = \frac{\text{diameter}}{2}$

Therefore, $\text{Area of the cylinder} = \pi r^2$

Area $= \pi \times 25.5^2 = 2042.8\text{cm}^2 = 0.20428\text{m}^2$

The $\text{Volume of the cylinder} = \pi r^2 h$

Volume $= \pi \times 25.5^2 \times 63.5 = 129719\text{cm}^3 = 0.129719\text{m}^3$

The Up flow Anaerobic Sludge Blanket (UASB) tank is a closed cylindrical tank with a hemispherical base welded eccentrically inside an open cylindrical tank with the open cylinder height of 62cm, diameter of 52.5cm and thickness of 0.5cm. Then the actual diameter of the tank is 51.5cm (i.e. radius of 25.75cm)

Where, $\text{radius} = \frac{\text{diameter}}{2}$

Therefore,

$$\text{Area of the cylinder} = \pi r^2$$

$$\text{Area} = \pi \times 25.75^2$$

$$\text{Area} = 2083\text{cm}^2 = 0.2083\text{m}^2$$

$$\text{The Volume of the cylinder} = \pi r^2 h$$

$$\text{Volume} = \pi \times 25.75^2 \times 62$$

$$\text{Volume} = 129150.5\text{cm}^3 = 0.1291505\text{m}^3$$

While the closed cylindrical tank (which has a hemispherical base). The cylinder tank is 40.6cm diameter, height of 52cm and thickness of 0.4cm, therefore the actual diameter of 39.8cm (the radius is 19.9cm). While the hemispherical base diameter is 40.6cm and thickness of 0.4cm. Therefore the actual diameter is 39.8cm (the radius is 19.9cm).

The

$$\text{Volume of the closed tank} =$$

$$\pi r^2 h + \frac{2}{3}\pi r^2 \qquad \text{(iv)}$$

$$(\pi \times 19.9^2 \times 62) + \left(\frac{2}{3}\pi \times 19.9^2\right)$$

Volume

$$= [77134 + 829.4] = 77963.4\text{cm}^3 = 0.0779634\text{m}^3$$

The Sequence Batch Reactor (SBR) system consists of a tank, aeration and mixing equipment and pipes that sequence the different operations. It is possible, however, for an engineer to design an SBR system, as all required tanks, equipment. It is a cylindrical metal tank with a frustum of a conical base.

$$\text{volume of the tank} =$$

$$\text{volume of the cylinder} + \text{volume of the frustrum of the cone} \text{volume} =$$

$$\pi r^2 h + \frac{1}{3}\pi(R^2 + Rr + r^2)h \qquad \text{(v)}$$

Where, $\text{radius} = \frac{\text{diameter}}{2}$

$$\pi \times 25.5^2 \times 47 = 96012.5\text{cm}^3 = 0.0960125\text{m}^3$$

$R = \frac{51}{2}$, where D (bigger diameter) is 51cm

R = 25.5cm

Thus, $r = \frac{d}{2}$

$r = \frac{31}{2}$ where d (smaller diameter) is 31cm

r = 15.5cm

Where, h is 11.5cm. Therefore the volume is

$$\text{volume of the frustrum of the cone} =$$

$$\frac{1}{3}\pi(R^2 + Rr + r^2)h, \qquad \text{(vi)}$$

Settling tank (ST) is a cylindrical metal tank with a frustum of a conical base. Therefore, volume of the tank = volume of the cylinder + volume of the frustrum of the cone

Then,

$$\text{volume} = \pi r^2 h + \frac{1}{3}\pi(R^2 + Rr + r^2)h$$

Weight density and pressure of the wastewater in the influent and equalization Tank

Since it is domestic waste, the density of the wastewater is roughly the same with treated water. Therefore the weight density or specific weight of the wastewater is written as

$$WA = Density \times Volume, \qquad \text{(vii)}$$

Since the volumes of the tanks are already determined and the density is the same as that of clean or treated water at the wastewater temperature (by interpolation) the wastewater has a density equivalent to 990.1 kg/m3 (Metcalf and Eddy, 2001);

W (influent Tank)= $990.1 \times 0.1287 = 127.4\text{kg}$

W (equalization tank)= $990.1 \times 0.1297 = 128.4\text{kg}$

Therefore the pressure is:

$$\text{Pressure} = \frac{\text{weight density}}{\text{surface area}} \qquad \text{(viii)}$$

This is the pressure in Newton per meter square.

The area of the equalization tank is:

$2083\text{cm}^2 = 0.2083\text{m}^2$;

While the weight density by interpolation is 9.7095N,

Therefore the pressure exerted is $= \frac{9.7095}{0.2083}$

Pressure exerted in the equalization tank $= 46.61\text{N/m}^2$.

Where ρ is the density of the wastewater which is the same as the clean or treated water; g is the acceleration due to gravity which is equal to 9.81 m/s2 and h is the height of the wastewater.

Selection of pump

The total head can be gotten as,

$$H_{total} = H_s + H_d \qquad \text{(ix)}$$

$$\text{Or } H = z_2 - z_1 + \frac{KQ^2}{2g} \qquad \text{(x)}$$

The static head H_s is the physical change in elevation between the surface of the reservoir and the point of discharge into the receiving tank.

Where, $K = k_{fittings} + k_{pipe}$ (xi)

$k_{fittings}$, is associated with the fittings used in the pipe works of the system to pump the water from reservoir to the receiving tank. Values can be obtained from standard tables and a total K fittings value can be calculated by adding all the K fittings values for each individual fitting within the system.

Table 1 shows the calculation of K fittings for the system (SSWWTP) under consideration:

Table 1: The calculating $k_{fittings}$ for the system under consideration

Fittings items	No of Items	$K_{Fittings}$ Values	Item Total
Pipe Entrance	1	0.05	0.05
90° Bend (short radius)	5	0.5	3.75
Pipe outlet	1	0.2	0.2
Total $K_{fittings}$ value			4.2

$$K = k_{pipe} + k_{fittings} \qquad [5]$$

Therefore, $K = 4.2 + 12.87$

Then, $K = 17.07$

For 30 liters of waste water:

$$Q = \frac{30 \times 0.001}{90}$$

Then, $Q = 3.33 \times 10^{-4}\ m^3/s$

Since it is 60 liters that is needed;

Then, $Q = 3.33 \times 10^{-4}\ m^3/s \times 2$

Then, $Q = 6.66 \times 10^{-4}\ m^3/s$

The quantity of flow, $Q = A \times V$ (xii)

Where A is the area of the pipe and V is the velocity passing through the pipe

Therefore, $Q = A \times V$

$$V = \frac{Q}{A} \qquad \text{(xiii)}$$

Where $A = \pi\frac{d^2}{4}$ and d is the diameter of the pipe which is 0.0254m

Then $A = \pi\frac{0.0254^2}{4}$

$A = 5.147 \times 10^{-4} m^2$

Therefore $V = \frac{Q}{A}$

$$V = \frac{6.66 \times 10^{-4}}{5.147 \times 10^{-4}}$$

$V = 1.29\ m/s$

Where K_{pipe} is associated with the straight length pipe which is used within the system and is defined as, $K_{pipe} = \frac{fL}{D}$ (xiv)

Where $f =$ frictional coefficient

$L =$ pipe length (m)

$D =$ pipe diameter (m)

Where $R = \frac{VD}{v}$ (xv)

Where V is the velocity which is 1.29 m/s

D is the diameter which is 0.0254 m

And v is the kinematic viscosity which is $0.605 \times 10^{-6} m^2/s$

Therefore, $R = \frac{1.29 \times 0.0254}{0.605 \times 10^{-6}}$

The frictional coefficient,

$$f = \frac{0.25}{\left[\log\left\{\frac{K}{3.7 \times D} + \frac{5.74}{Re^{0.9}}\right\}\right]^2} \qquad \text{(xvi)}$$

The value for k is gotten from the Muddy diagram which is plotted against the diameter of the pipe (0.0254 m) at the cast iron range. Therefore the value for k is 0.01

Then, $f = \frac{0.25}{\left[\log\left\{\frac{0.01}{3.7 \times 0.0254} + \frac{5.74}{54585.12^{0.9}}\right\}\right]^2}$

Therefore, $f = 0.2616$

Then, $K_{pipe} = \frac{fL}{D}$

$$K_{pipe} = \frac{0.2616 \times 1.25}{0.0254}$$

This will give, $K_{pipe} = 12.87$

Then $V = 1.29m/s^2$

Where $H = z_2 - z_1 + \frac{KQ^2}{2g}$

Where, $z_2 - z_1 = 1.2m.$

Then, $H = 1.2 + \frac{(17.07 \times 6.66 \times 10^{-4})^2}{2 \times 9.81}$

And, $H = 1.2 + \frac{7.57 \times 10^{-6}}{19.62}$

$H = 1.2 + 3.86 \times 10^{-7}$

Therefore, $H = 1.2\ m$

Since it is at this head the pump selected is fit for pumping the tank. There will also be a pressure loss in the flow due to leakages in the flow,

Therefore $\Delta P = \frac{K\rho Q^2}{2g}$ (xvii)

Therefore $\Delta P = \frac{17.07 \times 990.2 \times (6.66 \times^{-4})^2}{2 \times 9.81}$

$$\Delta P = \frac{16902.7 \times 4.435 \times 10^{-7}}{19.62}$$

$$\Delta P = \frac{7.496 \times 10^{-3}}{2}$$

Then, $\Delta P = 3.748 \times 10^{-3} N/m^2$

Since the pressure loss is small it can be neglected.

Power requirement to drive the impeller

Under turbulent hydraulic conditions (i.e., when the Reynolds number is greater than 105), the following formula can be used to determine the power requirements of an impeller mixer where P = power requirement, N-m/s,
ρ = density of the fluid, kg/m3,
KT= constant dependent on impeller size and shape,
n = impeller revolutions per second, S^{-1},
D = diameter of impeller, m.
Therefore, $P = \rho K_T n^3 D^5$ (xviii)

Some of the typical KT values for design purposes are given Therefore, the diameter of the Turbine impeller is generally one third of the tank diameter. So the sequencing batch reactor one diameter is 51cm. then the diameter of the impeller

is $\frac{51}{3} = 17cm = 0.17m$

The impeller revolution per minute is assumed to be 450 rpm, therefore the revolutions per seconds is $\frac{450}{60} = 7.5rps$. Then, let the density of the waste water at that temperature is 1000kg/m3. The value for KT Turbine (for six flat blades) is 6.30.
This implies that:

$P = 1000 \times 6.3 \times 7.5^3 \times 0.17^5 = 377.7watts$

Therefore $Power = 377.7watts$

Design of the shaft (Shaft design)

Since the shaft needed is subjected to twisting moment only; therefore

$\frac{T}{J} = \frac{\tau}{r}$ (xix)

T = twisting moment acting upon the shaft. The twisting moment is gotten from the equation below:

$T = \frac{60P}{2\pi n}$ (xx)

Where P is the power generated or used by the prime mover

And n is the speed of the shaft in rpm

J = polar moment of inertia of the shaft about the axis of rotation.

$J = \frac{\pi d^4}{32}$; If it is a solid shaft (xxi)

$J = \pi \frac{[d_o^4 - d_i^4]}{32}$; If it is a hollow shaft (xxii)

Where, d is the diameter of the solid shaft; d_o is the outer diameter of the hollow shaft and d_i is the inner diameter of the shaft. Since the shaft that will be used is a hollow shaft, the equation (xxii) is used

τ = torsional shear stress

r = distance from neutral axis to the outermost fibre and it is gotten from this equation: $r = \frac{d}{2}$

d_i= 0.015m, d_o = 0.023m and the thickness is 0.4cm.

Therefore $J = \frac{\pi(0.023^4 - 0.015^4)}{32}$

Then, $J = \frac{\pi(2.79841 \times 10^{-7} - 5.0625 \times 10^{-8})}{32}$

$$J = \frac{\pi(2.29216 \times 10^{-7})}{32}$$

Finally, $J = 2.25 \times 10^{-8} m^4$

Then the radius, $r = \frac{d_o}{2}$, d_o is 2.3cm

And $r = \frac{2.3}{2}$

$r = 1.15cm$

Then the twisting moment of inertia T is given by

Therefore, $T = \frac{60P}{2\pi n}$ [6]

Where n is 930 rpm, P is 377.37 watts

Then, $T = \frac{60 \times 377.37}{2\pi \times 930}$

By calculation, $T = \frac{22642.2}{5483.36}$

Therefore, $T = 4.12Nm$

Then $\frac{T}{J} = \frac{\tau}{r}$

Where

J is $2.25 \times 10^{-8} m^4$, r is $1.15cm = 0.0115m$ and T is $4.12Nm$

$\tau = \frac{Tr}{J}$ (xxiii)

Then $\tau = \frac{4.12 \times 2.25 \times 10^{-8}}{0.0115}$

$\tau = 8.06 \times 10^{-6} N/m^2$

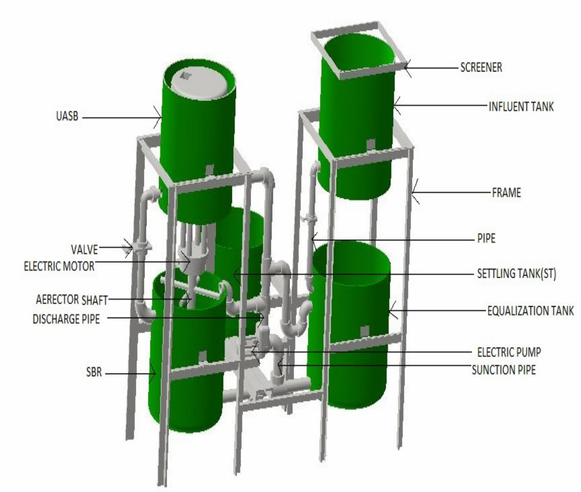

Fig. 1: Detailed view of the Small Scale Waste Water Treatment Plant (SSWWTP)

Operational Procedure

The waste water is allowed to flow into the influent thank through the screening phase. The screener is designed with seaving net of about 0.5mm wide. This is simply to prevent the introduction of solid particles above 0.5mm into the influent tank. As the water enters the influent tank, the effluent tap of the tank is opened and the water is allowed to flow into the equalization tank under gravity. Priming is carried out on the pump before running the pump for the purpose of pH equalization at the equalization tank. In any pumping system, the role of the pump is to provide sufficient pressure to overcome the operating pressure of the system to move fluid at a required flow rate.

In priming, water is filled in the suction pipe, casing and into portion of delivery pipe, this is done for the removal of air. With the presence of air, it is not possible to create pressure because the pressure generated by the impeller is directly proportional to the density of the liquid to be handled. Thus, if the impeller is run in air, negligible pressure will be produced because a very less density of air and hence no liquid will be lifted by the pump.

Thus, it is very essential to prime the pump properly and it should be noted that during priming, delivery valve is kept closed. After priming, the delivery valve is still kept closed and prime mover (electric motor) is powered to rotate the impeller. The rotation of the impeller in the casing filled of liquid produces centrifugal head in the liquid and thus, pressure in the whole liquid is increased. After a short period when pump attains a constant speed, delivery valve is gradually opened thus the liquid is allowed to flow in a radially outward direction though the impeller vanes and attains a higher velocity and pressure at the outer periphery. With the help of special shape of casing (Volute, Vortex or Diffuser), this high velocity energy is converted into pressure energy and reduces high velocity.

Priming is done in any operation that has to do with pumping action with a centrifugal pump.

The equalization process is meant to last for 30minutes or more. After the equalization process, the fluid is transferred to the UASB with the aid of the same pump and proper control of the on/off valves as indicated in the operational manual, alongside with the intermittent dosing of acid or alkali depending on the concentration of the waste water as its reading appears in the pH meter. This process was adopted in order to neutralize the acidity or alkalinity state of the waste water to be treated. Immediately the equalization process is completed, the inlet valve of the Up-flow Anaerobic Sludge Blanket (UASB) is opened as the inlet valve to the equalization tank is closed. This open and close action of the UASB and equalization tank respectively is designed to take maximum of 2seconds.

The equalization tank outlet valve is opened during the priming action, after priming, the pump is powered and allowed to operate for 20seconds in order to raise the pressure in the discharge pipe which is the inlet pipe to the equalization tank through the pump. As the fluid enters into the UASB compartment, the biodegradation process is activated. Biodegradation is chemical dissolution of materials by bacteria or other biological means. With regards to this design, biodegradation is a process by which micro-organisms reacts with the organic content of the waste water in order to reduce the Biological Oxygen Demand (BOD) load of the waste water. This biodegradation action is designed to take place in anaerobic compartments (tank). This process is determined by many factors:

It must be an Up-flow process

It must be at reduced velocity

Strong micro-organisms are used in this process (granular sludge) in the form of sludge bed. The action must be completely anaerobic. The pH level must be at its neutralization state. The temperature at the UASB must not be more than 37℃. The anaerobic process is designed to take not less than 2hours.

Analysis must be conducted at the influent tank, equalization tank, UASB, SBR and Settling Tank (ST)

At the UASB reactor, the biodegradation process is meant to last for 4hours or more, this is simply to enhance proper biodegradation process. At the completion of the anaerobic process at the UASB, the outlet valve of the UASB which is also the inlet valve of the SBR is opened so as to allow the biodegraded waste water to flow into the SBR under gravity.

The SBR with respect to this design is only designed to carry out two operations which are feeding and aerating process, while in some other designs, it is used for four different operations which are feeding, aerating, settling and decanting. The SBR in this design is only used for only two processes in order to increase the operating efficiency of the plant as well as to speed up the flow process.

The feeding process of the SBR is controlled by lowering the discharge valve; hence, the feeding process is designed to take 30 minutes. As the feeding process reaches a certain level, say to the aerator blade level, the aeration process is activated as the feeding continues.

After the feeding action is completed, the aerator is allowed to continue for extra one 1 – 2 hours. At the completion of the aerating action, the fluid is thus allowed to flow to the suction pipe of the pump by opening the outlet valve of the SBR. Before initiating the pumping action, all valves must be closed except the SBR outlet valve and the inlet valve to the Sedimentation Tank (ST), coupled with priming action.

Then the pump is allowed to run, as the fluid flows from the SBR to the ST, then the fluid is allowed to settle for 2 hours or more. This is to allow the non-settleable particles to settle, after which the fluid is discharged for use through the second discharge valve from the ground level. The first discharge valve is designed for the discharge of settled matter and other treated contaminable matter.

At the end of each treatment process, the analytical results for each sample were computed after which the computation for the ten samples was made.

The analytical result is as shown below:

The experimental result for the Small Scale Waste Water Treatment Plant is as shown in Table

Table 2: Two weeks Analytical Result of the SSWWTP with Domestic Waste Water

Day		7-Oct-13	8-Oct-13	9-Oct-13	10-Oct-13	11-Oct-13	14-Oct-13	15-Oct-13	16-Oct-13	17-Oct-13	18-Oct-13
INFLUENT											
Flow (m3/day)	Max 3.084	0.707	1.45	1.5	0.96	0.684	1.25	0.958	1.149	0.946	1.191
CODt influent(<250mg/l)	250	368	348	326	264	218	246	282	237	288	275
pH	2-------12.	8.5	9.0	8.0	5.8	7.0	7.5	7.2	6.5	7.4	7.8
EQUALIZATION											
pH	6.5-----7.5	6.98	6.65	6.95	7.1	7.2	6.85	6.55	6.89	7.25	6.8
Volatile Fatty Acid	15 --- 75mg/l	66.7	47.7	71.3	53.7	51.5	46.6	38.3	27.3	16.9	16.2
Chemical Oxygen Demand	250max (at max hydraulic load)	202.8	302.8	317.2	255.2	218	230.8	282	235.2	263.6	249.9

COD/ VFA ratio	<20% of COD	22%	22%	21%	19%	20%	17%	19%	20%	30%	44%
Organic Load per day (kg COD per day)	Max 3.000	2.603	5.051	4.889	2.537	1.491	3.075	2.705	2.73	2.724	2.724
UASB											
PH BY 10AM lab measurement	6.5-----7.5	6.9	6.7	6.9	7	7	6.8	6.7	6.8	7.1	6.8
COD Into- UASB	Max 250	101.6	110.3	110.3	118.9	195.3	74.6	60.6	64	75.6	74.8
Volatile Fatty acid	<25mg/l (recirculate at value 50mg/l)	41.1	40.2	64	51.9	42.6	36.5	35	24.9	20.4	15
Upflow Velocity	0.001 --- 0.003m/hr	0.002	0.002	0.002	0.001	0.002	0.002	0.002	0.002	0.002	0.002
Total Suspended Solids	<50 mg/l	13.2	12.6	8.9	10.6	9.7	8.9	10	6.8	7.6	7.5
% COD removal UASB	80%	61	62	62	64	69	66	63	67	63	63
%COD removal SBR	20%	13	14	13	15	12	16	15	15	13	14
EFFLUENT											
Ph	6 – 9	7.1	6.8	7.0	7.2	7.0	6.9	6.8	7.1	6.9	7.2
COD (mg/l)	<= 80	78	80	79	77	78	77	76	79	76	78
TSS (mg/l)	<= 30	15	18	20	23	26	22	21	25	23	20
Feeding rate to UASB	M3/HR	0.02	0.02	0.02	0.01	0.01	0.01	0.015	0.015	0.015	0.015

It was observed from the result that seven samples out of ten samples used for the analysis have higher COD (Red coloured) above the COD load for Domestic waste water. While three samples have normal COD influent load range for domestic waste water and for the plant, coupled with other impurities like bad odour, nitrogen and phosphorus contents.

Waste Water Treatment Efficiency:

The performance efficiency of the plant is determined by summing up the total efficiency of the COD removal at UASB and that of SBR. The result is as shown in Table 3**able 3: COD Removal Efficiency**

S/N	Quantity of Waste Water Treated (Liters) (A)	COD removal efficiency at UASB (80%) (B)	COD removal efficiency at SBR (20%) (C)	Performance efficiency of the plant with respect to COD removal efficiency at 100% evaluation (D)
1	60	61	13	74
2	60	62	14	76
3	60	62	13	75
4	60	64	15	79
5	60	69	12	81
6	60	66	16	82
7	60	63	15	78
8	60	67	15	82
9	60	63	13	76
10	60	67	14	81
Average	60	64	14.0	78.4

From Table 3, the performance efficiency of the plant was drawn out from the overall COD removal efficiency, which ranges between 74% to 82% and an average efficiency of 78.4%. The losses encountered includes biogas discharge which was neglected irrespective of its enormous importance, which could be channelled through a gas washer and over an industrial refrigerant like ammonia in order to purify and to convert it to liquid methane that could be stored in a gas storage tank and used as a cooking gas coupled with the excess sludge discharge which could also be used as a raw material in fertilizer industries.

This implies that the potentials of this plant cannot be over emphasized as its efficiency could also be improved by taking care of the biogas discharge and others.

Even as at this stage, the adoption of this plant to domestic level will definitely promote aquatic enhancement, reduce high level of COD discharge in our surroundings which in turn increases soil fertility as it limits such discharge which when discharged into nearby streams tends to destroy aquatic lives. The waste water that is treated at this stage is even good for drinking when passed through the chlorination process, but if it is to be used for aquatic rearing such as fish pond, and even poultry farming, it is advised not to be passed through chlorination process.

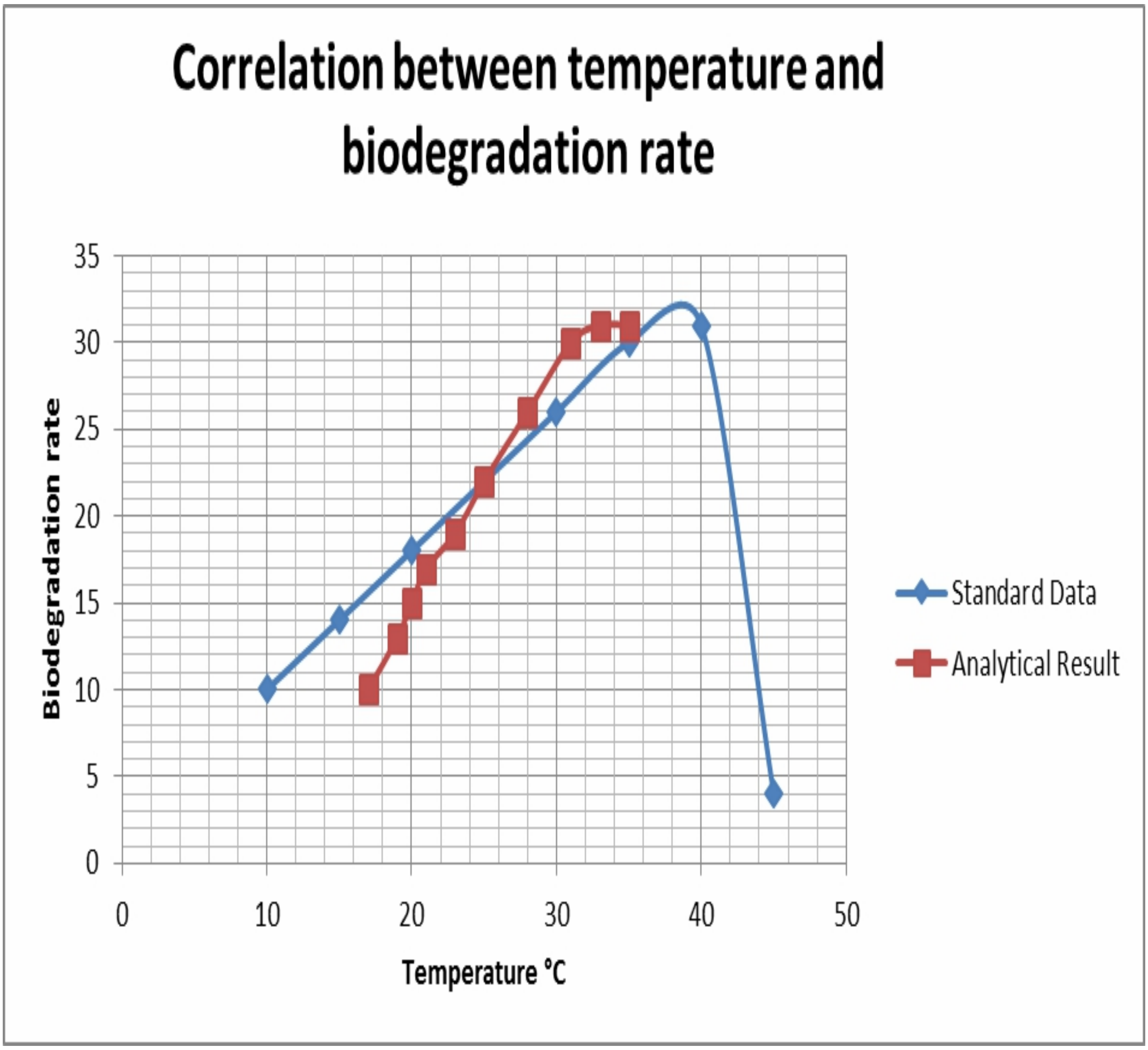

Fig. 2:A graphical illustration of the Correlation between Temperature and Biodegradation Rate (Standard and Analytical Data)

From Fig. 2 above, it is observed that the higher the temperature the higher the biodegradation rate and vice versa. For the standard data, as the temperature exceeds 40°C, the biodegradation rate drops while at the analytical data it was also observed that the temperature did not exceed 35°C [2].

Conclusion

The Small Scale Waste Water Treatment Plant was developed, fabricated and tested in Aba, Abia state. The performance test analysis conducted reveals that the plant performs better when domestic waste water is introduced in the plant. Similarly, when industrial waste samples were introduced into the plant, it was observed that the performance capacity of the plant was drastically reduced which also led to the weakening of some of the micro-organisms used at the Equalization Tank, UASB and SBR, coupled with high level of COD and BOD effluent. This plant is noticed fit for use in places like Root Crop Research Institute. The plant was strictly designed for treating domestic waste at a temperature below 40°C. When the analysis on waste water was conducted, the plant performed efficiently and effectively with greater reduction in the COD, BOD, neutralized pH and so on, thereby making the treated waste water environmental friendly. The granular sludge that was used later was observed to be more efficient than other micro-organisms, spirogyra and fungi that were also used in the process of biodegradation of organic load of the domestic waste water.

Recommendations

It is recommended that:

The plant should be optimized to improve the treatment capacity and the overall efficiency.

The Local Government and other higher Government Agencies should encourage the adoption of the Domestic Waste Water Treatment Plant in several homes.

Agricultural Institutes should take such project up to the next level of implementation and enhancement.

Lastly, the UASB should be strictly Anaerobic at slow flow process.

References

[1] Burks, B.D. and M.M. Minnis. (1994), "Onsite Wastewater Treatment Systems". Madison, WI: Hogarth House, LTD.

[2] Gorissen, K. (2012). "General Principles of a Waste Water Treatment Manual", Lagos Brewery, Nigeria Brewery Plc

[3] Gough I., Langford M., and Gough A. (1999). "The Hybrid Toilet System: General Principles and System Design Drivers", Published by Lanfax Laboratories,Armidale NSW.

[4] Henze M., Harremoës P., Jansen J., Arvin E. (1995). "Wastewater Treatment".Springer-Verlag, Berlin

[5] John Bird (2007), "Basic Engineering Mathematics". Fifth Edition, Elsevier Ltd.

[6] Khurmi, R.S. and Gupta, J.K. (2010): "A Textbook of Machine Design",SeventhMulti-Colour Edition, Eurasia Publishing House Ltd, Ram Nagar, NewDelhi,pages 509-515

[7] Metacalf& Eddy Inc. (2002), "Wastewater Engineering: Treatment Disposal Reuse", 4th ed.,McGraw-Hill, New York

[8] Sasse, L. (1998). "*DEWATS Decentralized Wastewater Treatment in Developing Countries",* Bremen Overseas Research and development Association, Bremen.

APPENDIX I

Picture of the Fabricated Small Scale Waste Water Treatment Plant