# Computer Aided Design Of Conventional Activated Sludge Treatment Plant

S.A. Raji, K.J Olaleye, M.O Adebisi, D.N Nwadike

**Abstract**: Carrying out a design on a conventional Activated Sludge Plant under several conditions and various criteria is becoming complex, tedious and cumbersome. The era of Computer has resulted in a faster, accurate, and more advanced method of obtaining data, storage, processing and analysis. Several tools are being developed to design and solve various engineering problems and environmental engineering field is no exception. Some packages have been developed in this area in basic, C - language, visual basic etc. This research focuses on the full design of a conventional Activated Sludge Plant. Some of the components developed include: Daily Sewage Flow, BOD of Sewage entering the aeration, BOD left in Effluent, BOD removed in Activated Plant, Efficiency required in Activated Plant, Rate of air supply, secondary sedimentation tank and Sludge drying beds. Design for the checks was also developed. Some of the checks include: Aeration Period, Sludge Retention Time, Volumetric Loading and Return Sludge Ratio. Visual Basic Package was adopted for the design.

**Index Terms**: Conventional Activated Sludge, BOD, Sewage, Aeration period, Sludge Retention Time and Return Sludge Ratio.

## 1 INTRODUCTION

Wastewater is a turbid Liquid, mainly water; containing a diversity of organic and inorganic matter in the form of suspended solids, colloidal particles, dissolved compounds, and diverse microorganism. Wastewaters are usually classified as municipal or industrial. This paper however focuses on municipal otherwise known as domestic wastewater, whose most significant constituents are usually suspended solids, biodegradable organic matter, and .pathogens (Oswaldo, 1987). Hence, the treatment of this wastewater to reduce the polluting components to levels whereby effluent discharge will not cause serious impact on the receiving water bodies is an issue which cannot be overemphasized. Worldwide, the activated sludge process is one of the most widely used for biological wastewater treatment. Activated sludge is a biochemical process for treating sewage and industrial wastewater that uses air (or oxygen) and microorganisms to biologically oxidize organic pollutants, producing a waste sludge (or floc) containing the oxidized material. It is hence an aerobic, suspended growth process that involves the growth of microorganisms in an aeration tank. A typical activated sludge system consists of a reactor or aeration tank, a settling tank, and a sludge recycle system (Oswaldo, 1987). The first component is usually preliminary treatment, typically consisting of screening, flow measurement, and perhaps grit removal.


- *SA Raji is currently a senior lecturer in Civil Engineering Department in University of Ilorin, Nigeria, E-mail: saraji12000@gmail.com*
- *J.K Olaleye is currently pursuing masters degree program in Civil Engineering in University of Ilorin, Nigeria. E-mail: olaleyekunle253@yahoo.com*
- *M.O Adebisi is currently pursuing masters degree program in Civil Engineering in University of Ilorin, Nigeria. E-mail: debisimarkus@gmail.com*
- *D.N Nwadike is currently pursuing masters degree program in Civil Engineering in University of Ilorin, Nigeria. E-mail: gistdan2000@yahoo.com*


The second component, the primary clarifier, is used to remove settle-able suspended matter. The underflow goes to sludge treatment and disposal and the overflow goes to an aeration tank. Although four variations of the activated sludge process are common;

- Conventional Activated Sludge
- Extended Aeration
- Completely mixed activated sludge
- The contact stabilization process

This paper designs the conventional activated sludge process, as it can be used over a wide range of wastewater flowrates, from small to very large plants. The aeration tank in a conventional activated sludge process is typically designed with a long, narrow configuration, thus giving approximately 'Plug Flow' through the tank (Harlon, 2011).

## 2 AIMS AND OBJECTIVES

The aim of this research is to produce a comprehensive design of an activated sludge treatment plant using computer soft-wares packages and manual calculations. The specific objectives to achieve this aim include;

1. To develop a comprehensive design software for the design of conventional activated Sludge plant using Visual Basic.
2. To incorporate some checks such as Aeration Period, Sludge Retention Time, Volumetric Loading and Return Sludge Ratio.
3. To validate the developed computer software by checking the design of an existing conventional activated Sludge plant.

## 3.0 MATERIALS AND METHOD

The major steps adopted to develop this software for design of conventional activated sludge plant are:

1. Algorithm development for the programming of conventional activated sludge plant.
2. Development of software.
3. Verification of the designed Software.

### 3.1 Design of Conventional Activated Sludge Treatment Plant

#### 3.1.1 Biochemical Oxygen Demand

Biochemical oxygen demand (BOD) is an indirect measure of the concentration of biodegradable organic matter in water or wastewater. Organic matter (as measured by BOD) is one of the major constituents removed from wastewater in domestic wastewater treatment plants. The reason for being concerned about organic matter in water is its effect on dissolved oxygen in the receiving stream. Dissolved oxygen in water is essential for much of aquatic life, so organic contaminants that affect dissolved oxygen level in water are of concern. Biological Oxidation in wastewater is represented by the equation; waste organic matter (primarily C, H & O) + O2 →CO2 + H2O + energy. The process takes place as aerobic microorganisms utilize the waste organic matter as their food (energy) source. The process uses oxygen, so if it is taking place in a water body, dissolved oxygen is consumed. A large supply of organic matter in the water will result in multiplication of microorganisms and rapid removal of dissolved oxygen, leading to oxygen depletion below the level needed by aquatic life (Harlon, 2011).

#### 3.1.2 Aeration

The aeration tank is the heart of an activated sludge treatment process. It is here that biological oxidation of dissolved and fine suspended organic matter takes place. Under the process of aeration, water is brought in intimate contact with air, so as to absorb oxygen and to remove carbon dioxide gas. It may also help in killing bacteria as well as in removing $H_2S$ gas, iron and manganese to a certain extent. The organic matter comes in with the primary effluent. The dissolved oxygen level is maintained by blowing air into the aeration tank through diffusers. This also serves to keep the aeration tank contents mixed. A suitable concentration of microorganisms is maintained in the aeration tank by settling out the 'activated sludge' (microorganisms) in the secondary clarifier and recycling them back into the aeration tank (Harlon, 2011).

#### 3.1.3 Sludge Retention Time

Biological solids retention time (BSRT) also known as the Sludge Age or Cell Residence Time (CRT) may be defined as the average length of time in days that an organism remains in the secondary treatment system (synder and Wyner, 2000). It can also be defined as the total active microbial mass in the treatment system divided by the total quantity of active microbial mass withdrawn daily, including both the bio-solids purposely wasted those lost in the effluent (Oswaldo 1987).

#### 3.1.4 Return Sludge Ratio

Return Activated Sludge (RAS) refers to the biological solids (mixed liquor solids) that settle in the secondary clarifier and are continuously returned back to the aeration tank. This proportion of the floc is used to re-seed the process. It is the settled biomass is returned to the treatment process to provide organisms which will continue removing pollutants.

### 3.2 The Computer Software

The software developed for the design of conventional Activated Sludge treatment plant is formulated using the Visual Basic.

## 4 RESULTS AND DISCUSSION

The design was done using Visual Basic for coding and the program was run with available parameters and validated manually. The available data were obtained by estimation.

### 4.1 VALIDATION OF SOFTWARE

The design of a conventional activated sludge plant, using developed software is validated by comparing with the outcome with a manual design of a proposed conventional activated sludge. Some Manual equations adopted in the computer aided design are displayed below.

- Daily Sewage Flow
  Q =$P * A/1000$

Where P is Population and A is the Average Sewage Flow.

P = 60000
A = 180 lpcd
Q= $60000 * 180/1000$
Q= 10800m$^3$/s

- BOD of Sewage Coming into Aeration (Yo)
  Yo = (100-Y)/100*X

Where X is the BOD of Sewage, Y is the BOD removed in Primary treatment.

X=220mg/l
Y=30%
Yo= (100-30)/100*220
Yo=154mg/l

- BOD Left in Effluent (Ye)
  Ye = (100-H)/100*X

Where H is the BOD reduction desired

Ye= (100-85)/100*220
Ye=33mg/l

- BOD removed in Activated Plant (D)
  D = Yo-Ye
  D = 154-33
  D = 121mg/l
- Volume
  V= (Q*Yo)/ (Xt*(f/m) )

Where V is the Volume, Xt is the MLSS

V= (10800*154)/(2000*0.35)
V=2376m3

- Efficiency Required in Activated Plant
  E=D/Yo*100

Where E is the Efficiency required in activated plant

E=121/154*100
E=78.5714%

- Check for Aeration Period
  T=V/Q*24
  T=2376/10800*24
  T=5.28h (Within the limits of 4 to 6h) O.K
- Check for Sludge Retention Time (θc)
  V.Xt=α_y. (Q (Yo-Y_e) θ_c)/(1+K_e.θ_c )

Where Ke is Endogeneous respiration constant = 0.06d-1, θc is the sludge age and αy is the yield coefficient = 1.0

2376*2000=1.0*(10800(154-33) θ_c)/(1+0.06* θ_c )
Θc =1/0.215
Θc =4.65 days

- Check for Volumetric Loading
  Volumetric Loading = Q*Yo/V
  VL = 10800*154/2376
  VL = 0.7Kg/m3 (within the permissible range of 0.3-0.7Kg/m3); O.K
- Check for Return Sludge Ratio

$RSR = X_t / (10^6/100 - X_t)$

Where RSR is Return Sludge Ratio

$RSR = 2000 / (10^6/100 - 2000)$

RSR = 0.25 (Within the range of 25-50%); O.K

- Tank Dimension

  $TL = V / (B*D)$

Where TL is the Total Length of the Aeration Channel,

B is the breadth and D is the depth

$TL = 2376 / (4.5*3)$

TL=176m

- Rate of Air Supply Required

  $BC = 100*(D*Q)/1000$

Where BC is the blower Capacity i.e Air Required

$BC = 100*(121*10800)/1000$

BC=90.75m3/min

- First Surface Area Required

  $SA1 = Q/F$

Where SA1 is the first surface area required and F is the Surface Loading rate

$SA1 = 10800/20$

SA1= 540m2

- Second Surface Area Required

  $SA2 = (Q*X_t)/1000*(1/K)$

Where K is the Solids loading

$SA2 = (10800*2000)/1000*(1/125)$

SA2=172.8m2

The higher surface area of 172.8m2 is adopted

- Diameter of Tank

  $Diameter = \sqrt{(SA2*4)/\pi}$

  $Diameter = \sqrt{540*4/3.142}$

  Diameter = 26.219m

- Weir Loading

  $WL = Q/(D*\pi)$

  $WL = 10800/(26.219*3.142)$

  WL = 131.097m3/day/m

  131.097<150; O.K.

- Design of Sludge Drying bed

  $QWXR = (Q*X_t)/\theta c$

  $QWXR = (10800*2000)/4.5$

  QWXR=4645.161Kg/d

The Output from the design software is shown in the figures.

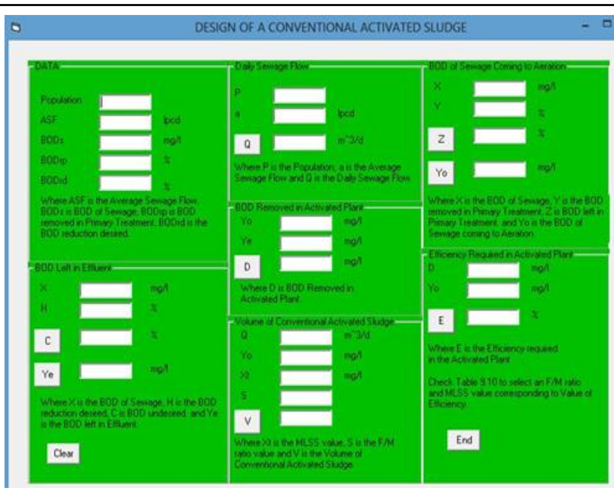


***Fig 1:*** *Computerized Design of a conventional Activated Sludge*

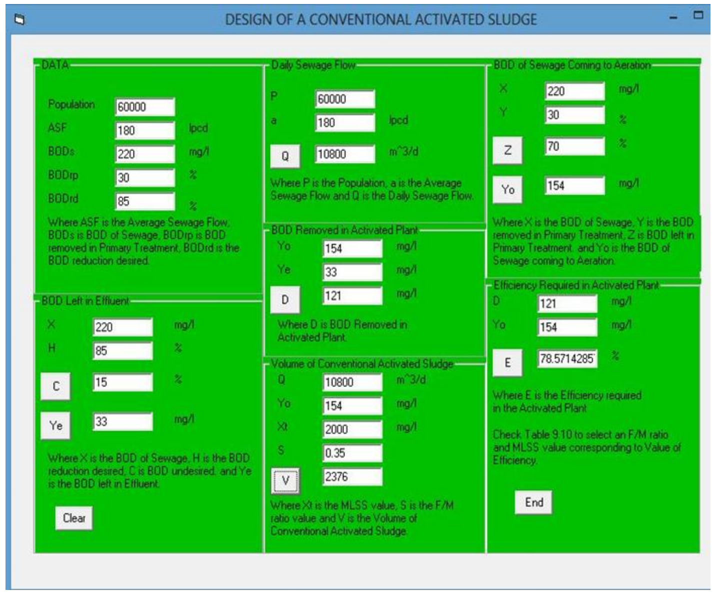


***Fig 2:*** *Validated output of Conventional Activated Sludge Plant*

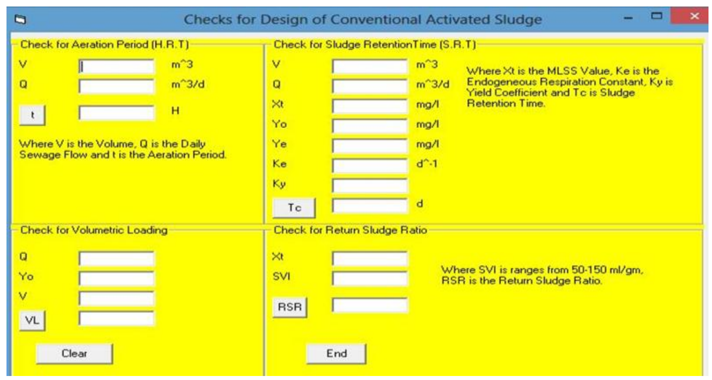


***Fig 3:*** *Computerised design for Checks*

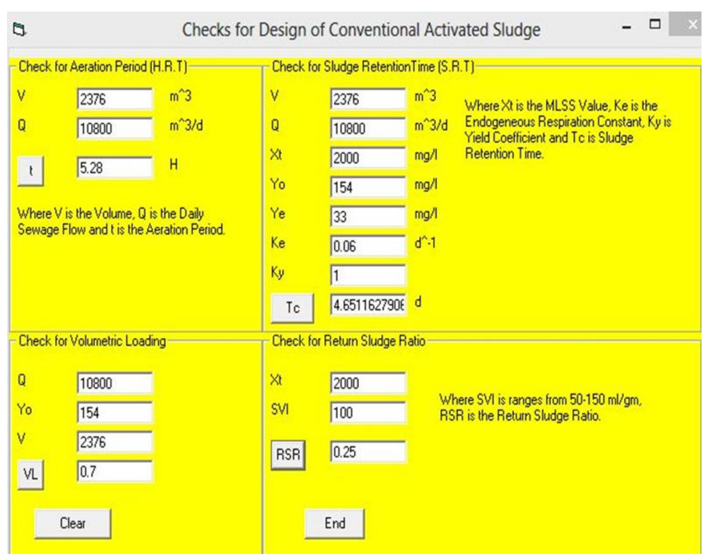


***Fig 4:*** *Validated Output for Checks*

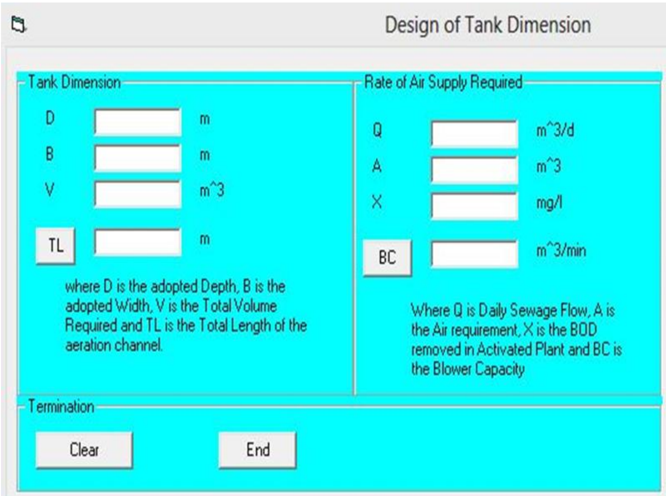


***Fig 5:*** *Computerized design of Tank Dimension*

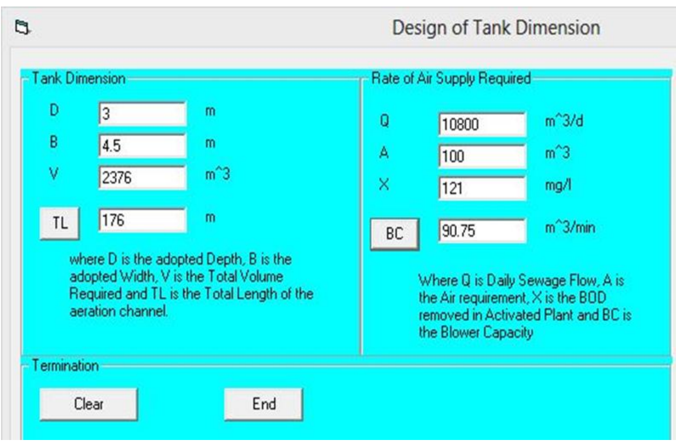


***Fig 6:*** *Validated Output for Design of Tank Dimension*

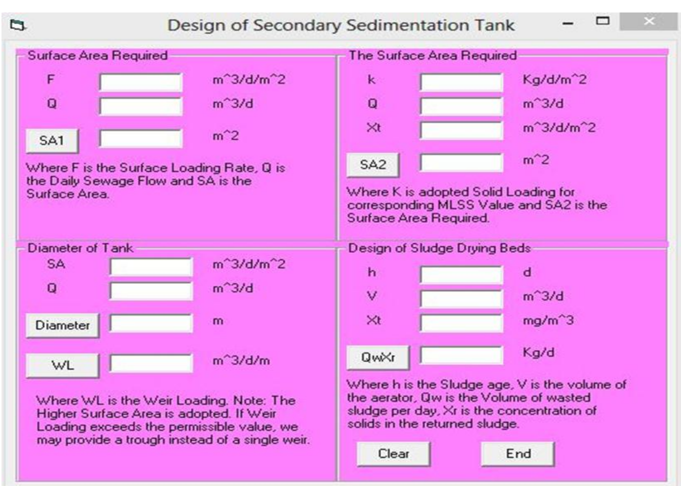


***Fig 7:*** *Computerised Design of Secondary Sedimentation Tank*

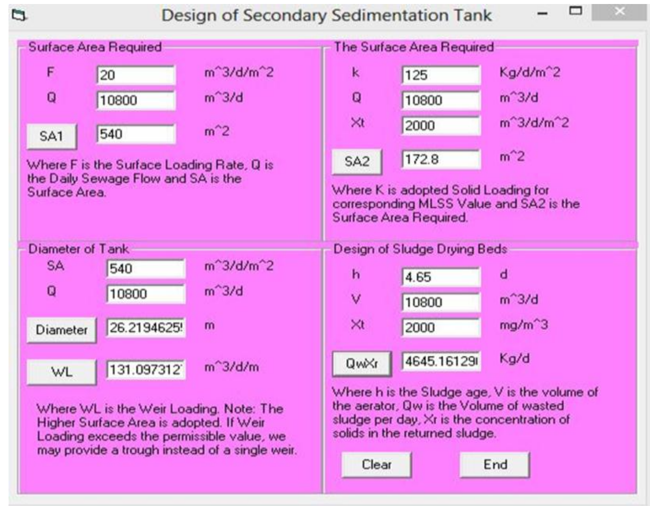


***Fig 8:*** *Validated Output for Design of Secondary Sedimentation Tank*

## 5 CONCLUSION

The activated sludge wastewater treatment process is capable of producing an excellent effluent quality when properly designed, constructed and operated. It may be employed to accomplish varied degrees of removal of suspended solids and reduction of BOD and ammonia. Conventional activated sludge are a variation of the widely used activated sludge process for biological wastewater treatment. Parameters and equations used for designing conventional activated sludge plant and operational calculations in S.I. units. Present software is developed in latest version of Visual Basic.

## REFERENCES

[1] G.S. Bajwa, Practical handbook on public health engineering, 2nd Edn., Surabh publisher, New Delhi, 3, (2003).

[2] J. P. Ganote, and D. Dohare, (2015) "Computer Aided Hydraulic Process Design of Conventional Water Treatment Plant without and with Upgradation". Department of Environment Engineering, Shri Govindram Seksaria Institute of Technology and Science, Indore (INDIA).

[3] S.K.Garg, Water supply Engineering, 11th Eds., Khanna Publishers, New Delhi, 129-135, (1999).

[4] H.B. Harlon, (2011) "Activated Sludge Calculations with Excel". PDH Enterprises, LLC. Morrisville.

[5] IS-10500:1991, drinking water Specifications, Bureau of Indian Standard Institutions, New Delhi, (1991).

[6] M. Oswaldo (1987) "Design of The-Step-Feed activated Sludge Process". M.Eng Thesis, Department of Civil Engineering and Applied Mechanics. McGill Univeràity. Montreal, Canada.

[7] R. Snyder, and D. Wynner, (2009) "Activated Sludge Process Control; Training Manual for Wastewater Treatment Plant Operators". State of Michigan Department of Environmental Quality. 800-662-9278 Environmental Assistance Center.