

Simulation and Evaluation Factors Effecting Sizing of Different Types of Wastewater Treatment Plant

Ass. Prof. Dr. Mohammad A.M. Al-Tufaily

Prof. Dr. Mohammad A. Alanbari

Nawras Shaker Jawad

Babylon University/Engineering College/Civil Department

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Abstract:

a computer program is designed using Visual Basic Software 6.0 for designing different types of wastewater treatment plants. This program deals with different environmental factors that affecting the design of wastewater steps.

The verification between the results of the program and that obtained from hand calculations showed a good agreement

The relationships between independent and dependent variables are found by multiple non - linear regression analysis. The statistical program "Data Fit version 8.0" is used in the present study.

The population was found to be the most significant variable affecting design of all wastewater units.

Keywords: Wastewater treatment plants, Biological wastewater treatment.

Introduction:

The biological treatment unit is considered to be the most important unit in the wastewater treatment plant, and because of its important, the wastewater treatment plants were named after the biological treatment method employed (AL- Turaihy T. A, 1993).

The Studied Wastewater Treatment Plants:

1- Activated Sludge Process: In this process, wastewater is mixed with a concentrated bacterial biomass suspension (the activated sludge) which degrades the pollutants.

2- Extended aeration: It consists of an aeration with a longer detention time than the conventional activated-sludge process (AL- layla, 1981).

3- Oxidation ditch: It is an earthen tank of special shape with arrangements for a sufficient supply of oxygen. Raw wastewater is aerated for an extended period of time.

4- Aerated lagoon: The aerated lagoons are suspended growth reactors in earthen basins with no sludge recycle. (Metcalf and Eddy, 1979).

5- Anaerobic ponds: Anaerobic ponds are commonly 2 – 5 m deep and receive wastewater with high organic loads. They normally do not contain dissolved oxygen or algae.

6- Facultative ponds: Facultative ponds (1-2 m deep) are of two types: Primary and secondary facultative ponds. The process of oxidation of organic matter by aerobic bacteria is usually dominant in primary facultative ponds or secondary facultative ponds.

7- Aerobic Ponds: Aerobic ponds also referred to as high-rate aerobic ponds, are relatively shallow with usual depths ranging from 0.3 to 0.6 m allowing light to penetrate the full depth.. (ASCE, 1992)

The Studied Environmental Factors:

1) Population: The wastewater generated depends upon the population and per capita contribution of wastewater. (Masten and Davis, 2004).

2) Average and Maximum Per Capita Sewage Contribution: New wastewater systems should be designed on the basis of an average daily per capita (lpcd) flow of wastewater of not less than (270 liters) nor greater than (350 liters) (WEF manual of Practice No.8 and ASCE Manual, 1992).

3) Organic Loadings and Total Solids Concentrations: The strength of a wastewater is usually measured as 5-days biochemical oxygen demand (BOD₅), and total suspended solids. In middle Euphrates regions wastewater systems designed on the basis (70 l/d.c) for BOD production and for TSS production of wastewater of (90 l/d.c).

4) Variation in Temperature: The temperature of the sewage is very important in assessing the overall efficiency of a biological treatment process, the fermentation in the sludge layer in oxidation ponds depends very much on temperature (AL- Turaihy T. A, 1993). Temperature decreasing may result in a significant decreasing in the soluble (BOD) removing rate (Davis, L.F., 1976).

5) Infiltration / Inflow (In/Iw):In/Iw is a part of every collection system and must be taken into account in the determination of an appropriate design flow.

6) Variation in Raw Waste Load: S. Davies (2005), stated that the increasing in the concentration of substrate, the growth rate increases exponentially and then levels off. Therefore, with further increase in concentration of substrate in the medium, there is no further increase in growth. The bacteria are at their maximum growth rate.

7) Design Period: Qasim Syed (1985), declared that the selection of design period depends on useful life of treatment units, future growth in population, service area, water demand and wastewater characteristics and performance of treatment facility during the initial year when it's oversized this choice lies between (10-25) years.

Description of Computer Program:

The program is written using Visual Basic 6.0 language. The steps of the program are as follows:

1. Choose the type of wastewater treatment plant.
2. The run of the computer program required the inputs data. These data are found in every type of treatment and assumed as follows (initial population,=100000 capita, specific sewage production= 270 l/c. day, design period= 25 year, growth rate= 3.8 %, the specific domestic BOD₅ in raw sewage flow= 70g/c.day, the specific domestic TSS in raw sewage flow= 90 g/c.day, the temperature= 20 °C, the area served by network= 400 hectare, and the infiltration rate= 0.1 l/s.ha).
3. The effluent standards were kept constants values = 40 mg/l, =60mg/l.
4. Determining of future population, peaking factor, total average flow rate, peak flow rate, minimum design flow rate, organic load and solids concentrations (BOD and TSS), then design preliminary treatments (screening and grit chamber).

Note: the steps from(1 to 4) are found in every types of wastewater treatment.

4. Design primary sedimentation tanks (rectangular and circular basins)

Note: this step is found only for the type of treatment that need this treatment like (conventional activated sludge, and oxidation ponds).

5. Design a biological treatment according to it's type as follows:

- Design an aerobic reactors assuming (K_d , Y , θ_c , MLSS, X_r)

- Design an extended aeration assuming (K_d , Y , θ_c , $MLSS$, X_r)
 - Design an oxidation ditch assuming (K_d , Y , θ_c , $MLSS$, X_r)
 - Design an aerated lagoon assuming (K_d , Y , θ_c , X_r)
 - Design an anaerobic pond by assuming (temperature T and hydraulic retention time HRT)
 - Design an facultative pond by assuming (temperature T and dispersion factor D)
 - Design an aerobic pond by assuming (elevation e and energy utilization efficiency E)
6. Design secondary sedimentation tanks (circular basins):
7. Design sludge treatment process

Application of Computer Program for Studying Treatment Plant:

The computer program consists of three main parts, which are (A) The choice of biological treatment type (B) The information base and (C) The design calculation modules which contain design requirement as shown in Figs. (1) and (2).

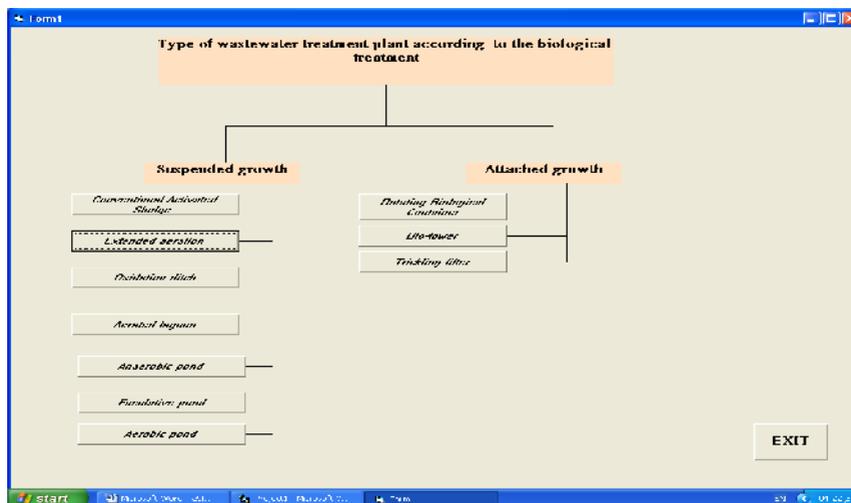


Fig.(1): Different types of Wastewater Treatment Plant of Present Study

Domestic Wastewater			Iraqi Effluent Standard		
Sewage production	270	lit/day	BOD5	20	mg/l
Design Demand	20	year	TSS	30	mg/l
Initial population	100000	people	Other Characteristics		
Growth rate	3.8	%	COD	120	mg/day
BOD5 production	20	mg/day	Total Nitrogen	8	mg/day
TSS production	90	mg/day	Total Phosphorus	2	mg/day
Inhibition Rate	0.1	lit/hr	Suspended Solids	20	mg/l
Area Served	4000	ha	pH	7.2	-
Temperature			Variable Solids	75	%
Summer Temperature	40	°C			
Winter Temperature	10	°C			
Wastewater temperature	20	°C			

Fig.(2): General Information for Wastewater Treatment Plant

The Regression Analysis Technique:

Regression were done by using "Data Fit" program models. The three forms were used for each one of design requirements to investigate which form gives the best fitting of data (i.e. appropriate model). Table (2) show regression models that were proposed and investigated.

Table (2): The Proposed Models

symbol	description
A	$y=b_1x_1+b_2x_2+\dots\dots\dots b_kx_k$
B	$y=\exp(b_1x_1+b_2x_2+\dots\dots\dots+b_kx_k)$
C	$y=b_1x_1+b_2x_2+\dots\dots\dots b_kx_k+G$

Where;

y = dependent variables; x_1, x_2, \dots, x_k = the independent variables, and $b_1, b_2, b_3, \dots, b_k$ = are model coefficients, and G is model constant term.

The Dependent Variables (y):

The volume of each treatment unit, quantity of total air required for aerobic reactors, and volume of gas production were assumed to be the dependent variables (y).

The Independent Variables (x_k):

The independent variables can be seen in table (3).

Table (3): The Independent Variables

Variable	Description
x_1	Population, capita
x_2	Temperature, °C
x_3	Specific sewage production, l/c.d
x_4	Tss production, g/c.d
x_5	BOD ₅ production, g/c.d
x_6	A era served by network, ha
x_7	Infiltration rate, l/s.ha
x_8	Design period, y

Results and Discussions:

The result of present study can be seen in table (4).