Waste Stabilization Pond Design For University Of Ilorin

Raji, S.A., Olusanya, S. O., Olokoba, S. O., Olodo, A. A.

Abstract: This present study includes the use of MATLAB R2012b software for the design and analysis of waste stabilization pond for the university of Ilorin. Kwara State. Contamination and pollution resulting from unlawful and increasing wastewater discharge expose the environment to degradation and the populace to health risks. The forecasted population in 25years time was found to be 93606 people. The total volume of wastewater that will be generated in 2042 was found to be 9372.6m^3/day and the maturation pond had the largest area (43738.80m^2) with its dimension being 296m by 148m by 1.5m while the facultative pond had the least area (11715.75m^2) with dimensions 501m by 167m by 1.5m.

Index Terms: anaerobic, arithmetic progression, facultative, MATLAB, maturation, pollutants, wastewater.

1 INTRODUCTION

THE activities of man gives rise to a wide range of waste products, many of which become water borne and must be carefully treated before release to the environment. Such wastewater may contain excreta, household wastes, industrial discharges, agricultural run-off, and urban storm drainage. All these wastes individually or collectively, can pollute and contaminate the environment [3]. There is an increasing need for low-cost methods of treating wastewater, particularly municipal and industrial effluents. The operations of such methods, and the maintenance of the necessary plants and equipment, must be within the capacity of the developing urban centres and industrial complexes [1]. As migration from rural to urban areas continues, the control of wastewater becomes increasingly difficult. This problem has two aspects: water must be supplied for the carriage of household and industrial wastes, and the water-borne waste from the community that has an adequate water supply must be safely disposed. The protection of water resources against pollution is the development of a sound economy. For both the maintenance of public health and the conservation of water resources, it is essential that water pollution be controlled [14]. Waste stabilization ponds (WSP) system are infrastructures for treating wastewater from individuals, commercial and industrial establishments, ultimately to be returned to the natural environments, they are shallow rectangular lakes in which waste water is retained for between 10 and 100 days, depending on the climate, to allow the removal of BOD, pathogens and nutrients. WSP are usually arranged in series of anaerobic, facultative and maturation ponds to improve the efficiency of the performance [3]. These systems of treatment process are said to be first choice in warm climates wherever land is available at reasonable cost [3].

- *Dr S.A. Raji is a senior lecturer in civil engineering in University of Ilorin, Kwara State, Nigeria, E-mail: saraji12000@googlemail.com*
- *Olusanya Stephen is currently pursuing masters degree program in civil engineering in University of Ilorin, kwara State, Nigeria, PH-07032713959. E-mail: soolusanya@gmail.com*
- *Olokoba, Saheed is currently pursuing masters degree program in civil engineering in University of Ilorin, kwara State, Nigeria, PH-08062641040. E-mail: linksaheed03@gmail.com*
- *Olodo, Abdulrahman is currently pursuing masters degree program in civil engineering in University of Ilorin, kwara State, Nigeria.,*

2 MATERIALS AND METHODS

2.1 Study Area

University of Ilorin, Kwara state, Nigeria was the area taken up for study. The latitude and longitude of the university is Latitude 8.47 °N and 4.68 °E respectively.

2.2 Population forecasting

Arithmetic projection method was adopted for the forecast of the population of the university since the exponential growth rate was not available for the collected data. The population at the end of 25years was forecasted and a population of 93606 was obtained.

2.3 Data Collection

The data used for the study includes population, map, BOD5 measurement, design period and wastewater generated per person per day. The primary source of the data is the works department of the university.

2.4 Design Criteria

Numerous process design methods have been proposed by various researchers for anaerobic, facultative and maturation ponds [8]. The adopted methodology for the design of waste stabilization ponds depends on loading rates, empirical data, field operations and observation. Recently, more attention is given to rational and theoretical design approaches. In addition, attention is being paid to essential pond facilities such as pond geometry, number of parallel and series units of ponds, pond base, embankment, inlet and outlet structures [3]. Loading rates, as a design criterion is a simple approach widely used and recommended in most of wastewater standard design handbooks worldwide.

2.5 Wastewater Generated

The type of wastewater generated is domestic wastewater which is gotten from hostels, departments and laboratories. The quantity of wastewater generated by each category of user differs. The wastewater generated by the laboratories was assumed to be 12000L/day. The present population is 50000 with the volume of total wastewater generated per day about 5012m^3/day. Also the future population was projected for 25years and wastewater generated was estimated.

2.6 Design Period

Before the construction of any project a decision has to be made as to the total life span that the project will use in serving

the purpose for which it is being designed. After this design period, the project is not expected to meet some of the required standard or function expected of it. For this project a design period of 25years was chosen.

2.7 Effluent Limits

Effluent limits represent the maximum amount of pollutants allowed to be discharged from wastewater source to its final destination. These limits vary from one country to another due to geographical location, climatic and socio-economic reasons. They also vary with the characteristics of the wastewater final destination. For example, the effluent limits characterize the required and accepted quantity of the discharged wastewater. Hence, prior to design, the limits must be known [1]. Some of the limits are shown in the result section.

Table -3: *Industrial effluent limits in mg/l*
Source: *(FEPA, 2012)*

PARAMETER	DISCHARGE STANDARDS
Temperature (^{0}C)	<40
Total suspended solids	<200
Grease/oil(total fatty matter)	10 – 220
BOD_5 (mg/L)	30
COD (mg/L)	160
Phosphate	15 -20
Detergents	10 – 15
Sulphate	<250
Toxic/metals/heavy/cyanide	0.1- 0.15
Nitrates mg/L	20
Conductivity	<200FTU
Turbidity (NTU)	<50
Total coliform (MPN/100ML)	400
Alkalinity (mg/L)	100
Total Hardness (mg/L)	200

2.8 Design Parameters

Table 1 below gives the characteristics of the influent used in the design while Table 2 gives the effluent characteristics.

2.9 Pond Design Sizing

Using the loading rate design approach for the design of the pond and also using the characteristic values of the wastewater from the Tables 1 and 2. Average value of BOD_5 was used.

Table -1: *Influent characteristics. [14]*

PARAMETER	INFLUENT RANGE
Flow (m^3/d)	154 – 1148
BOD_5 (mg/L)	16 – 527
COD (mg/L)	56 – 745
Total solids (mg/L)	460 – 1365
Suspended solids (mg/L)	140 – 490
DO (mg/L)	0.3 – 4.5
Ph	5.1 - 7.7
Alkalinity (mg/L as $CaCO_3$)	83 – 310
Acidity (mg/L as $CaCO_3$)	3 – 74
Temperature (^{0}C)	18.5-27.5

Table -2: *Effluent characteristics. [14]*

PARAMETERS	F1	M1	M2
Flow (m^3/d)			0-508
BOD_5 (mg/L)	18 – 60	17 – 32	16 – 38
COD (mg/L)	74 – 143	70 – 258	50 – 141
Total solids (mg/L)	220 – 760	190 – 722	180 – 715
Suspended solid (mg/L)	160 – 240	140 – 290	60 – 270
DO (mg/L)	0.05 -15.9	0.1 – 13.4	0.2 – 15.3
Ph	5.5 – 7.8	5.8 – 8.5	6.2 – 8.6
Alkalinity (mg/L as $CaCO_3$)	90 – 293	72 – 208	68 – 194
Acidity (mg/L as $CaCO_3$)	4 – 34	0 – 26	0 – 20
Temperature (^{0}C)	16.9 – 29	15.8 – 28	15.8 – 29

2.10 MATLAB

MATLAB is a computer program for people doing numerical computation, especially linear algebra (matrices). It began as a "MATrix LABoratory" program, and has since grown well beyond these libraries, to become a powerful tool for visualization, programming, research, engineering, and communication.

3 RESULTS

3.2 Manual Computation and Result

Estimation of quantity of wastewater generated

Present estimation of quantity of wastewater

$$\text{Domestic wastewater generated per person} = 100 l/d$$

$$\text{Assumed laboratory wastewater generated} = 12000 l/d$$

$$\text{Present Population, } P_p = 50000 \text{ people}$$

$$\text{Total wastewater generated} = (50000 \times 100 + 12000)\, l/d = 5012\, m^3/day$$

Future Population Forecast (Projection)

$$P_F = P_p \times (1 + k)^T = 50000(1 + 2.54/100)^{25} = 93606 \text{ people}$$

$$\text{Quantity of wastewater generated in 25years time, } Q = (100 \times 93606$$

Anaerobic Pond Design

$$\text{Retention Time, } t = 5days$$

$$\text{Volume of Pond, } V = 9372.5 \times 5 = 46863m^3$$

$$\text{Influent BOD, } L_I = 272mg/l$$

$$\text{Volumetric BOD loading, } L_V = L_I \times Q/V = 54.4g/m^3/d$$

$$\text{Assumed depth of pond, } d = 4m$$

$$\text{Area of Pond, } A = L_I \times \frac{\quad}{\quad} = 11715.75m^2$$

$$\text{For a rectangular pond with } l:b = 3:1,$$

$$b = \sqrt{(A/3)} = 62m$$

$$l = 3 \times b = 186m$$

Facuktative Pond Design

$$\text{Assumed depth of pond, } d = 1.5m$$

$$L_{IP} = 0.102 * L_I + 60$$

$$\text{Area, } A = Q \times \frac{\quad}{\quad} = 7546.04m^2$$

$$\text{For a rectangular pond with } l:b = 3:1,$$

$$b = \sqrt{(A/3)} = 167m$$

$$l = 3 \times b = 501m$$

Maturation Pond Design

$$\text{Assumed depth of pond, } d = 1.5m$$

$$\text{Detention Time, } t = 7days$$

$$\text{Area of Pond, } A = Q \times t/d = 43738.80m\text{^}2$$

$$\text{For a rectangular pond with } l:b = 2:1,$$

$$b = \sqrt{(A/2)} = 148m$$

$$l = 2 \times b = 196m$$

3.2 Matlab Result

The result of the design was obtained using MATLAB software and inputting the parameters obtained from various concerned authorities. The design reveals that in the year 2042 the population will be 93606 and the wastewater to be generated will be 9372.6m^3/day. The result of the MATLAB program is shown in Figure 1 below.

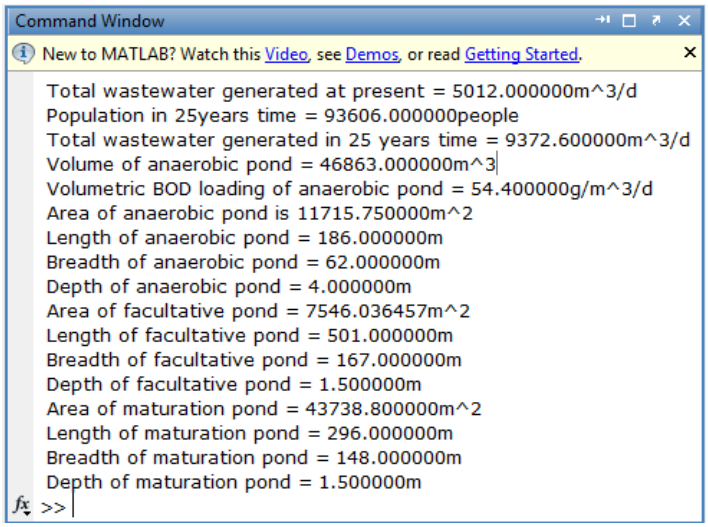

Fig. 1. *MATLAB Result*

4 Conclusion

One of the greatest viability of natural technologies of this nature is their low cost of maintenance, the long life span and their ability to recover variety of resources like treated effluents for irrigation, organic humus for soil remedies and energy from biogas. Based on the projected population the waste stabilization pond was design to receive 9372.6m^3/day. More also, waste stabilization pond shall not depend on mechanical aids such as pumps and distributors as such not affected by corrosion, mechanical faults and power failure. Faecal bacterial viral removal is more efficient in shallow, rather than deep facultative ponds and maturation ponds at least within 1m to 2m for facultative and 0.4m to 1.5m for maturation pond. Finally, from the design values it is observed that the BOD removal of about 89% or more can be achieved. Also, the designed pond will be able to reduce coliform by 95% which make it reusable for irrigation.

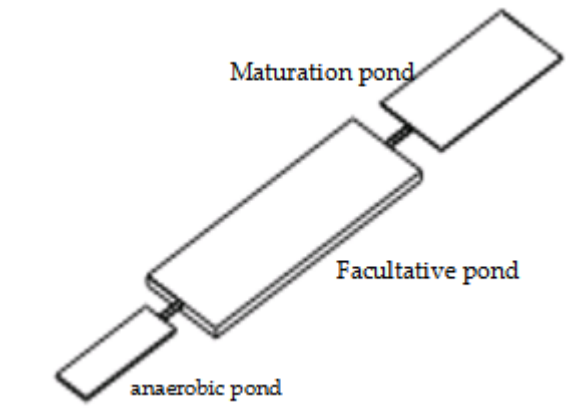

Fig. 2. *AutoCAD schematic drawing of Ponds.*

7 End Sections

7.1 Appendices

```
%% ---------------------------------------------------------------------
% Task 1: Estimation of the quantity of wastewater generated at present
%----------------------------------------------------------------------
Wpp = 100;       % Domestic wastewater generated per person in l/day
Wl = 12000;      % Assumed laboratories wastewater generated in l/day
Pi = 50000;      % Present Population
Wp = Wpp*Pi;     % wastewater generated by population in l/day
Wtl = Wp + Wl;   % total wastewater generated at present in l/day
Wtm = Wtl/1000;  % total wastewater generated at present in cubic metre/day
fprintf(' Total wastewater generated at present = %5fm^3/d\n', round(Wtm))

%% ---------------------------------------------------------------------
% Task 2: Future population forecast
%----------------------------------------------------------------------
T = 25;  % design period in years
k = 2.54;    % average growth rate in  percentage (NPC, 2014)
Pf = round(Pi*(1 + k/100)^T);   % population in 25years
fprintf(' Population in 25years time = %5fpeople\n', Pf)
```

Fig. 3. *MATLAB Code*

Acknowledgment

The authors wish to thank Abolarin John for his support and invaluable contribution.

References

[1] Adetayo A.T. (2005): Design of wastewater treatment plant for slaughter house Zaria, undergraduate project department of water resources ABU Zaria

[2] Arun K. Jain, Ashok K. Jain, B.C. Punmia (1998): Wastewater Engineering (Laxmi publication p. LTD, 22,Golden House Daryaganj,

[3] New Delhi-11002)

[4] Bitrus F.(2014): Design of waste stabilization pond for ABU Zaria phase 2. (Unpublished BSc project, department of water resources and environmental engineering ABU Zaria).

[5] C.Banda Gawasiri (2013): Modern Design of waste stabilization pond in warm climates. Thesis.

[6] Casey I. (1976): unit treatment process in water and wastewater engineering (published by John wiley and son. New York).

[7] Department of conservation and natural resources (division of environmental protection) (1998): Document for design of wastewater treatment plant.

[8] Duncan Mara (1975): Sewage treatment in hot climates (published by English Language Book society/John Wiley and sons Ltd.

[9] Duncan Mara (1998): Design manual for waste stabilization ponds (published by English Language Book society/ John Wiley and sons Ltd.

[10] F.E.P.A (2012): Guidelines and standards for environmental pollution in Nigeria.

[11] Fair G.M. Geyer, J.C and okun,D.A. Element water supply and wastewater disposal second edition, Wiley and sons

Inc, New York 1971.

[12] Gabriel J. B (1980): The treatment of tanney wastewater by waste stabilization pond, unpublished M.Sc Thesis department of water resources and environmental engineering A.B.U Zaria.

[13] Metcalf and Eddy (1981): Third edition wastewater engineering, treatment, disposal and re-use. Published by McGraw-Hill Book co. New York.

[14] Moses S.O (2005): Evaluating the efficiency of a wastewater treatment plant A.B.U Zaria main campus.

[15] Onuoha J. C (1981): Performance study of the wastewater stabilization pond system at A.B.U, Zaria. (Unpublished M.Sc Thesis, department of water resources and environmental engineering, A.B.U Zaria).

[16] Southgate B. A (1949): Treatment and disposal of industrial wastewater (His majesty's, stationary office London).