DESIGN OF WASTE STABILIZATION POND

(CASE STUDY FEDERAL UNIVERSITY OF TECHNOLOGY MINNA GIDANKWANO CAMPUS)

BY

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PGD/CE/08/029

A THESIS SUBMITTED TO POSTGRADUATE SCHOOL IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF POST GRADUATE DIPLOMA (PGD) DEGREE IN CIVIL ENGINEERING

SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY, FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGERIA

FEBUARY, 2011

DECLARATION

I hereby declare that this project titled **"Design of waste stabilization pond(case study Federal University of Technology Gidankwano Campus Minna.)"** was written by me under the supervision of Prof O.D Jimoh, which is a research project in accordance with the requirement of the Civil Engineering Department, Federal University of Technology,Minna.

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CERTIFICATION

This is to certify that this project work titled **'Design of waste stabilization pond(case study Federal University of TechnologyGidankwano, Minna.)'** was fully carried out by me under the supervision of Prof O.D Jimoh and submitted to the Department of Civil Engineering Federal University of Technology, Minna, to meet the requirement governing the award of Postgraduate Diploma(PGD) in the Department of Civil Engineering, Federal University of Technology, Minna, Niger State, Nigeria.

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DEDICATION

This thesis is dedicated to Almighty God, the giver of all wisdom and the creator of heaven and the earth.To my parents, Mr. and Mrs. J.A Atuegbu and my siblingsfor financial, and moral support given to me.

ACKNOWLEDGEMENT

I give glory and honour to the Almighty Lord for granting me the wisdom, knowledge and understanding to see this project through. My heartfelt gratitude goes to my project supervisor Prof. O.D Jimoh, for his thorough guidance and supervision, Engr. Prof.S.Sadiku, the HOD, Civil Engineering, Dr. O.A. Ehigiator, Dr. J. A. Otun, Dr. T. C .Ogwueleka, Dr. A. Mohammend, Engr.(Dr).P. N. Ndoke, Engr. S.F. Oritola, Dr. S Auta, Dr. J.I. Aguwa, Dr. A.A. Amadi, Engr. Musa Alhassan, Engr. M. Muazu, Dr. T.Y. Tsado, Engr. J. Olayemi, Engr. M.A. Mustapha, Engr. S.S. Kolo, Engr. M. Kudu, Engr. A.O. Busari, Engr. A. O. Ibrahim, Mrs. A. O. Gbadebo, Engr. O. I. Jimoh, Engr. BallaAlhaji for their impartations. I am particularly grateful to all the technical staff in the Department of civil engineering for their moral and intellectual support and also to my fellow students for their mutual co-operation.

Finally, in a very special way, I will like to express my gratitude to my parents, Mr. and Mrs. J.A Atuegbu, my siblings, Engr. Richard Adesijiand my friends FunkeFolarin and MrsEbodaghefor their support, incentive and encouragement, they are the best. To all, I say God's blessing.

ABSTRACT

This project work presents the design of waste stabilization pond for the Federal University of Technology MinnaGidankwano campus. Thus waste stabilization ponds which are the most important method of wastewater treatment in hot climates (or at least potentially so) is been designed to treat the wastewater of the University. Ponds have considerable advantages particularly as regarding cost and maintenance and the removal of feacal bacteria. They are highly recommended for wastewater treatment in developing countries with hot climates where there is sufficient land available and where the temperature is most favourable for their operation. However, their use is not restricted to hot climates only.

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CHAPTER ONE

1.0 INTRODUCTION

Wastewater may be defined as a combination of the liquid or water-carried wastes removed from residences, institutions, commercial and industrial establishments, together with such groundwater, surface water and storm water as may be present.

If untreated wastewater is allowed to accumulate, the decomposition of the organic materials it contains can lead to the production of large quantities of malodourous gases. In addition, untreated wastewater usually contains numerous pathogenic, or diseases-causing, microorganisms that dwell in the human intestinal or that may be present in certain industrial waste. Wastewater also contains nutrients, which can stimulate the growth of aquatic plants and it may contain toxic compounds. If wastewater is not properly treated, then the environment, drinking water sources and human health can be negatively impacted.

1.1 Design of Waste Stabilization Ponds

Waste stabilization ponds are relatively shallow body of water contained in an earthen basin of controlled shape, designed for the purpose of treating waste water. They are undoubtedly the most widely applicable and advantageous methods of waste treatment in hot climate. Raw sewage is aerated by entirely natural and biological process involving both algae and bacteria, and no machinery or energy input is required except the sun. Ponds are the cheapest and simplest of all treatment technologies and are capable of providing a very high quality affluent.

It has proven to be effective alternatives for treating waste water and the construction of low energy consuming ecosystem that use natural process in contrast to complex high maintenance treatment process or system and it would hopefully lead to more ecologically sustainable waste water treatment in the future. Waste stabilization ponds also have the capability to meet the demand for a high percentage removal of pathogenic organisms compare to conventional technologies. Waste stabilization ponds combined with other technologies may be important for even more improved performance of water cleaning systems. There are many advantages which include simplicity, low cost, low maintenance, low energy consumptions, robustness and sustainability. Waste stabilization ponds are most commonly used for treating waste waters; they are also successfully used for treating industrial waste water including that which contains agro-industrial waste. The process of designing waste stabilization ponds and predicting its performance is improving rapidly as we gain more experience with these system. Many countries use waste stabilization ponds for waste water treatment. Many of these systems have been performing below their required standard, due to lack of proper operation and maintenance. In any case the design of waste stabilization ponds system for the school provides sufficient or effective treatment of the school sewage and provides opportunity for waste water re-use.

1.2 Aim and Objectives of the Study

The main aim of the study is to design waste stabilization pond system for the treatment of sewage from Federal University of Technology Minna. The specific objectives are:-

i. To estimate the wastewater flow

ii. To design a facultative and maturation ponds

iii. To design a treatment plant capable of degrading the waste water from Federal University of Technology Minna.

1.3 Scope of the Study

The project covers only the design that is no construction was carried out. It also shows the development of operational guidelines in physical facilities design.

1.4 Importance of the Study.

This study has enormous significant to the school in the sense that it can effectively treat the sewage from the school and also provide opportunity for waste re-use it can achieve a large degree of purification at the lowest cost. It has extreme simplicity of operation and maintenance which the school can afford.

The rate of removal of pathogens in WSPS is considerably greater than that in any other methods of sewage treatment. Thus, waste stabilization ponds should always be regarded as the most preferred method of sewage treatment especially in this our type of climate

CHAPTER TWO

LITERATURE REVIEW

2.1 Application of Waste Stabilization Pond System.

Waste stabilization ponds are large, shallow basins in which raw sewage is treated entirely by natural processes involving both algae and bacteria. They are used for sewage treatment in temperature and tropical climates and represents one of the most cost effective, reliable and easily operated methods for treating domestic and industrial waste water. Waste stabilization ponds are very effective in the removal of faecal coliform bacteria. Sunlight energy is the only requirement for its operation. Further, it required minimum supervision for daily operation, by simply cleaning the outlets and inlet works, the temperature and duration of sunlight is tropical countries is efficient and satisfactory performance for this type of water cleaning system. They are well suited for low income tropical countries where conventional waste treatment cannot be achieved due to the lack of reliable energy sources.

Waste stabilization pond system have a considerably advantages (particularly regarding costs and maintenance requirements and the removal of faecal bacteria) oval all other methods of sewage treatment.

Treatment is required principally to reduce the organic loads and pathogen organisms in the sewage and to ensure that it is suitable for whatever re-use process is selected for it. Under these circumstances a waste water treatment system such as, waste stabilization pond provides a cheap alternative to conventional processes.

2.2 Type of Waste Stabilization Ponds and their Specific uses.

Waste stabilization ponds consists of facultative and maturation ponds. But, waste stabilization ponds systems comprises a single string of anaerobic and facultative ponds which are designed for removal of Biochemical Oxygen Demand (BOD) and maturation ponds for pathogen removal, although, some BOD removal also occurs in maturation ponds and some pathogen removal in anaerobic and facultative ponds. In most cases, only anaerobic and facultative ponds will be needed for BOD removal when the effluent is to be used for restricted crop irrigation and fish pond fertilization as well as when sewage is to be treated prior to its discharge to surface water. Maturation ponds are only required when the effluent is to be used for unrestricted irrigation thereby having to comply with the WHO guideline of < 1000 faecal coliform bacteria / 100ml. Waste stabilization pond does not require mechanical mixing needing only sunlight to supply most of its oxygenation. Its performance may be measured in terms of its removal of BOD and faecal coliform bacteria.

2.3 Facultative Ponds

Depths of facultative ponds range between 1 to 2m deep. There are of two types of facultative ponds; Primary facultative ponds that receive raw waste water and secondary facultative ponds that receive particle free waste water (usually from anaerobic ponds, septic tanks, primary facultative ponds and shallow sewage system). The process of oxidation of organic matter by anaerobic bacteria is usually dominant in primary facultative ponds of secondary facultative ponds.

The process in anaerobic and secondary facultative pond occurs simultaneously in primary facultative ponds. It is estimated that 30% of the influent BOD leaves the primary facultative pond in the form of methane. A high proportion of the BOD that does not leave the pond as methane ends up in algae. This process require more time, more land, and possibly 2 – 3 weeks water retention time, rather than 2-3 days in the anaerobic ponds, in the secondary facultative pond (and the upper layers of primary facultative ponds), sewage BOD is converted into "Algal BOD" and has implications for effluent quality requirements. About 70 – 90% of the BOD of the final effluent from a series of well designed waste stabilization ponds is related to the algae they contain.

Pathways of BOD removal in primary facultative ponds in – secondary facultative ponds that receive particle free sewage (anaerobic effluent) this remaining non-settle able BOD is oxidized by heterotrophic bacteria. The oxygen required for oxidation of BOD is obtained from photosynthetic activity for the micro algae that grows naturally and profusely in facultative ponds.

Facultative ponds are designed for BOD removal on the basis of a relatively low surface loading (100-400kg BOD/ha day). In order to allow for the development of a healthy algae population, since the oxygen for BOD removal by the pond bacteria is generated primarily through algal photosynthesis the facultative ponds relies on naturally growing dark green in colour because of the algae they contain. Motile algae (chlanrydonoma and Euglena) tend to pre-dominate the turbid water in facultative ponds, compared to none- motile algae (chlorella). The algae concentration in the pond depends on nutrient loading temperature and sunlight but is usually in the range of 500-2000Ng chlorophyll. Because of the photosynthetic activities, to a maximum level in the pond algae, there is a diurnal variation in the dissolved oxygen concentration. The dissolved oxygen concentration in the water gradually rises after sun shine or sun rise in response to photosynthetic activity, to a maximum level in the afternoon after which it falls to a minimum during the light, when photosynthesis ceases and respiratory activities consume oxygen. At peak algal activity, carbonate and bicarbonate ions react to provide more carbon dioxide for the algae, leaving an excess of hydroxyl ions. As a result, the PH of the water can rise to above 9, which can kill faecal coliform, Good water mixing, which is usually facilitated by 8 winds within the upper water layer, ensures a uniform distribution of BOD, dissolved oxygen, bacteria and algae and algae, thereby leading to a better degree of waste stabilization.

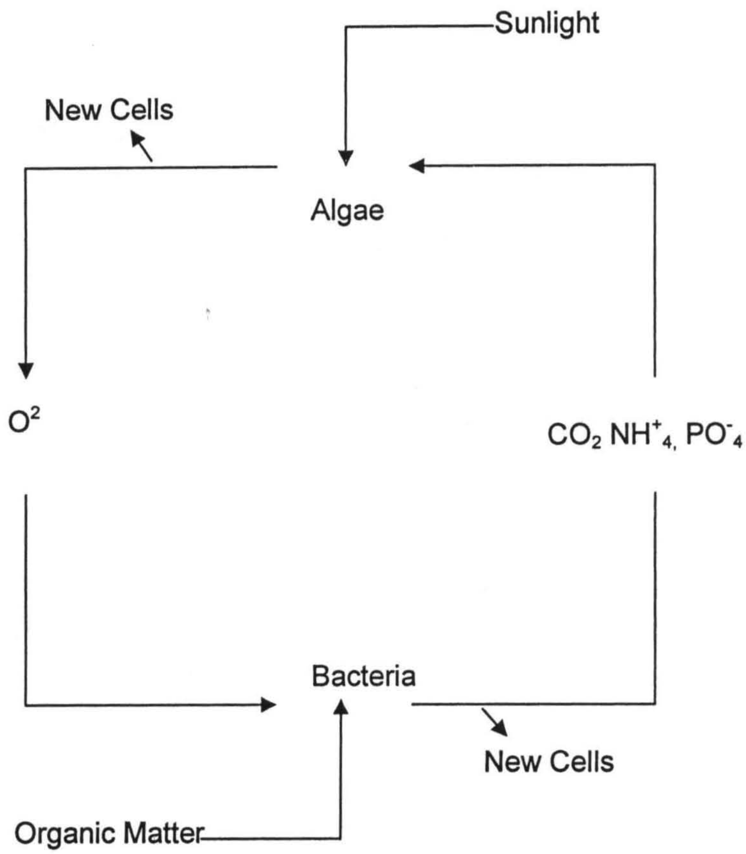


Fig 1 ***Symbiosis of algae and bacteria***

As the sewage enters the pond most of the solids settle to the bottom to form a sludge layer. At a temperature greater than 15^{0}C intense anaerobic digestion of the solid occurs, as a result the thickness of the sludge layer is rarely more than about 250mm and often less. Desludging is only rarely required, once every 10-20 years.

Depth less than 1m do not prevent emergence of vegetation. This must be avoided as otherwise the pond becomes an ideal breeding ground for mosquitoes and midges. With depth greater than 1.5m the oxygen is to near the surface with the result that the pond is predominantly aerobic, this is undesirable. Hence, a depth between 1m and 1.5m is acceptable (Mara, 1979).

2.4 Kinetic Process in Facultative Ponds

The growth of mixed culture was studied at concentration ranging between 200-800mg COD/l, in a series of batch chemostat reactors. From laboratory data, the specific growth rate (N) was determined. There is several growth models in the literature used to evaluate growth parameters. Most of these models describe the number of microorganisms without the consumption of substrate.

Zwietering et al, (1990) derived a modified mathematical relationship for the increase in biomass over time, which relate the population size over time to the specific growth rate, lag time and asymptotic level of organisms.

2.5 Effects of pH on the Growth Rate of Heterotrophic Bacteria and Algae in Secondary Facultative Ponds

Knowledge of the effects of pH on the growth rate of algae and heterotrophic bacteria and its subsequent impact on the degradation of organic matter is useful for better operation and design of secondary facultative ponds. The kinetic of microbial growth and product formation are influenced by diurnal variation in the pH in the pond resulting diurnal variation in the carbon dioxide. Algae required large quantities of dissolved carbon dioxide during photosynthesis, causing a depletion of carbon dioxide (Co_2) and leading to a shift in the carbon bicarbonate (Co_{3-2} – Hco_3) equilibrium, resulting in an increase in pH due to the formation of hydroxyl (OH) ions. The effects of Ph on the growth rate of heterotrophic bacteria and algae in secondary facultative ponds were investigated, using batch growth at a pH value between 5 and 11. The optimum pH and pH constant for algae and heterotrophic bacteria was determined using the pH model. For a pH value higher than 8, the chlorophyll causes a content decreases. However, the specific growth rate of hetrophic bacteria and algae was high with a pH value between pH 7 to 8. At a pH value above 9, the specific growth rate of both biomasses started to decrease. The specific growth rate of microorganism in the secondary facultative pond was increasing from a pH value of 5, reaching a maximum value at a pH between 6.5 and 8. The observed optimum pH for heterotrophic bacteria was 8.5 and the pH constant was 200. The parameters were obtained at a maximum growth rate of 3.6 day and 3.45 day for 13 heterotrophic bacteria and algae biomass. The observed optimum pH for algae was 6.8 and the pH constant was 1.79. the region of pH insensitivity for heterotrophic bacteria and algal biomass was between 7 and 9 and also 6.5 and 8. The range between the optimum pH for algae and heterotrophic bacteria was 1.7 pH units. It was conclude that the pH simultaneously affects algae and heterotrophic processes in facultative ponds with an almost equal magnitude. The model was found to stimulate well the influence of pH and algae and heterotrophic bacteria biomasses.

2.6 Diurnal Variation of Dissolved Oxygen in Facultative Stabilization Ponds.

Oxygen tension in waste stabilization ponds is an operational parameter with a great deal of daily and hourly variation. The rate of oxygen production is a function of the algal concentration. Since algal growth is both light and temperature dependent, the rate of oxygen production (photosynthetic) follows the same pattern.

Temperature is also an important parameter exhibiting marked. Seasonal and daily variation in waste stabilization ponds, it influences photosynthesis, the growth of microorganism and the bio-decomposition of organic carbon in the system. The fluctuation in pH influences the kinetics of microbial growth, species competition and product formation in the pond.

Microbial species can grow within specific pH range, which typically extends over 3 to 4 pH units, with an optimum growth rate near the mid-point of the range. Values of pH to 11 are not common in waste stabilization ponds with the highest levels being reached late afternoon, thus, the combined effects of changes in temperature, pH and high intensity may have a marked effect on microbial activities in the pond than when only one factor is considered. In reality, changes in these forcing function and processes occur. Simultaneously, thus their influences on the processes should be determined at this level. The objective of the work reported therein was to use the long-term data collected from the ponds to determine the manner in which pH, temperature and light utilization of dissolved oxygen in the secondary facultative waste stabilization pond. The influence of this forcing function on the model was determined for their combined effect, rather than their effect at the individual level. The dissolved oxygen sub-model was developed in order to depict the combined influences of light, pH, temperature and carbon dioxide on the processes of dissolved oxygen production and utilization in secondary facultative waste stabilization pond

2.7 Maturation Pond

The maturation ponds usually 1-1.5m deep, receive the effluent from the facultative ponds. The primary function is to remove exerted pathogens. Although maturation ponds achieve only a small degree of BOD removal, their contribution to nutrient removal also can be significant. Maturation ponds usually show less vertical biological and physicochemical stratification and are well-oxygenated throughout the day. The algal population in maturation ponds is much more diverse than that of the facultative ponds. With non-motile algal tending to be more common, the algal diversity generally increases from pond to pond along the series. Although faecal bacteria are partially removed in the facultative ponds, the size and numbers of the maturation ponds especially determine the numbers of faecal bacteria in the final effluent. There is some removal of solids associated bacteria in anaerobic ponds, principally by sedimentation. The principal mechanism for faecal bacteria removal in facultative and maturation ponds is now known to be

a. Time and temperature
b. High pH (>9)
c. High light intensity, combined with high dissolved oxygen concentration.

Time and temperature are the two principal parameters used in designing maturation ponds, faecal bacteria die-off ponds increase with both time and temperature High pH values (above 9) occur in ponds, due to rapid photosynthesis by pond algae, which consumes Co_2 faster than it can be replaced by bacteria respiration. As a result, carbonate and bicarbonate ions dissociate as follows

$$2HCO_3 \rightarrow CO_{32} + CO_2$$

$$CO_{32} + H_2 0_2 \rightarrow 20H + CO_2$$

The result Co_2 is fixed by the algae, and the hydroxyl ions accumulate, often raising the pH to values above 10. Faecal bacteria (with the notable exception of vibrio cholerae) die very quickly at pH value higher than 9 the role of high light intensity and high dissolved oxygen concentration as recently has been elucidated. Light of wave lengths between 425 – 900mm can damage faecal bacteria by being absorbed by the humic substance ubiquitous in waste water. They remain in an excited state sufficiently long to damage the cell. Light mediated die-off is completely dependant on the presence of oxygen, as well as being enhanced at high oxygen, as well as being enhanced and at high pH values. Thus, the sun plays a three fold role in directly promoting faecal bacteria removal waste stabilization pond and increasing the pond temperature and more directly by providing the energy for rapid algal photosynthesis. This not above 9 but also result in high dissolved oxygen concentration; which are necessary for its third role, namely promoting photo-oxidative damage. (Metcalf and Eddy 1979) control the design process because sunlight and photosynthesis are less then, but not in tropical continents like ours, while the mass rate of organic input remains relatively constant. In some cases, shout term anaerobic conditions can occur in the summer months, during and early morning hours. Algae respire during the light but cannot produce oxygen without sunlight during the summer months, algae population become very great and algal respiration combined with that of bacteria can deplete oxygen stored during day light hours. Conversely, photosynthesis by the large algae populations' may results in super saturation with oxygen during daylight hours.

The principal advantages in WSPS relates to their case of construction and management. Each wall is rip rapped to prevent damage from waves, and a day liner is needed to prevent leakage to the ground H_2O. Most ponds are rectangular, but other shapes are used at particular sites(Mara, 1976)

2.10 Waste Stabilization Ponds Maintenance

Waste stabilization pond systems are most often used in small communities and consequently should be designed with the objective of minimizing management requirement. Unless regular maintenance is performed, both structural and performance failures can occur, however the principal maintenance problem is controlling plant growth in shallow area as and on dikes. Plant roots break up dikes, which results in gradual structural break down. Aquatic plants provide a protected area for mosquito larva and a place where debris accumulates. Regular removal of growth is required in all installations.

2.12 Pond Shape

The shape of the pond affects the performance of the pond, the narrower the pond, the better the performance of hydraulic characteristics. Rectangular ponds are generally preferable to avoid dead zone, and it has been show that the performance of these pond is superior to those of square and circular pond and those with irregular geometry. Length to breath ratios are commonly 2-3 to 1. Provided rounded hydraulic characteristic; rounded comers is preferred to sharp corners.

2.13 Pond Base

The pond bottom should be kept flat\\\. Level beds are the best. Preferably ponds should be built on impermeable soil. The seepage of the inflow, the base should be sealed with polythene sheeting, puddle day, bitumen or asphalt, whichever are is the cheapest. Seepage looses in unlined ponds decreases with time of the soil is not permeable as the sludge larger itself which acts as a sealant

2.14 Embankment of the Pond

These are usually made with slopes 1 in 2-3. They should be protected from wave erosion by pre-cast concrete slabs or stores ri-rap laid at top water level. This also prevents vegetation growing down the embankment end so forming suitable habitat for snails and mosquitoes the slabs also makes maintenance work easier.

2.15. Inlet and Outlet Structures

All pond system in exception of the very smallest ones should have a venture or par shall glumes to measure the inflow and a vee-notch to measure the final outflow (effluent) this enables the performance of the pond to be checked in meaningful manner and skill show when the hydraulic design capacity h2as been reached screens night be useful too.

2.16 Pond Layouts

The acceptable pond layouts are one facultative plus two (or more) maturation pond or one anaerobic plus one facultative plus two (or more) maturation ponds. It has been recognized (both in theory and practice) that a series of ponds produces a better effluent that a single large pond of the same overall volumes

2.17 Location of Site

Lower elevation site is the best place to consider for waste stabilization ponds to save the cost of pumping and reduce the use of pressure pipes. Zoning of distance restriction from inhabitant necessary the site of WSPS; should be about 500 meters from the nearest residence in the environment and it should be fenced to avoid hydrogen sulphide smell and also prevent falling into the ponds.

2.18 Direction of Prevailing Wind

Short circuiting affects and performance of the pond. Wind causes erosion in the pond as well. Therefore, pond should not be sited greater than 50m/h anything that would cause obstruction in the direction of wind should be disallowed. Bing building and trees causes the mixing by the wind to be insufficient. The clear distance should be greater than 5m to 8m multiply by the height of the obstructing element. Mixing minimizes hydraulic short circuiting and the formation of stagnant regions and it ensures a reasonable uniform vertical distribution of BOD algae and oxygen. Mixing is the only means by which the large members of non-motile algae can be carried up into the zone of effective light penetration. Mixing also helps in the transportation of the oxygen produced in photic zone to the bottom layers of the pond.

CHAPTER THREE

METHODOLOGY

3.1 Design Criteria

The design of the waste stabilization pond for FUT is based on the fact that the waste water is wholly facultative. The waste stabilization pond in series is an ideal treatment method for the wastewater. It would involve a wastewater treatment plant, as shown below:

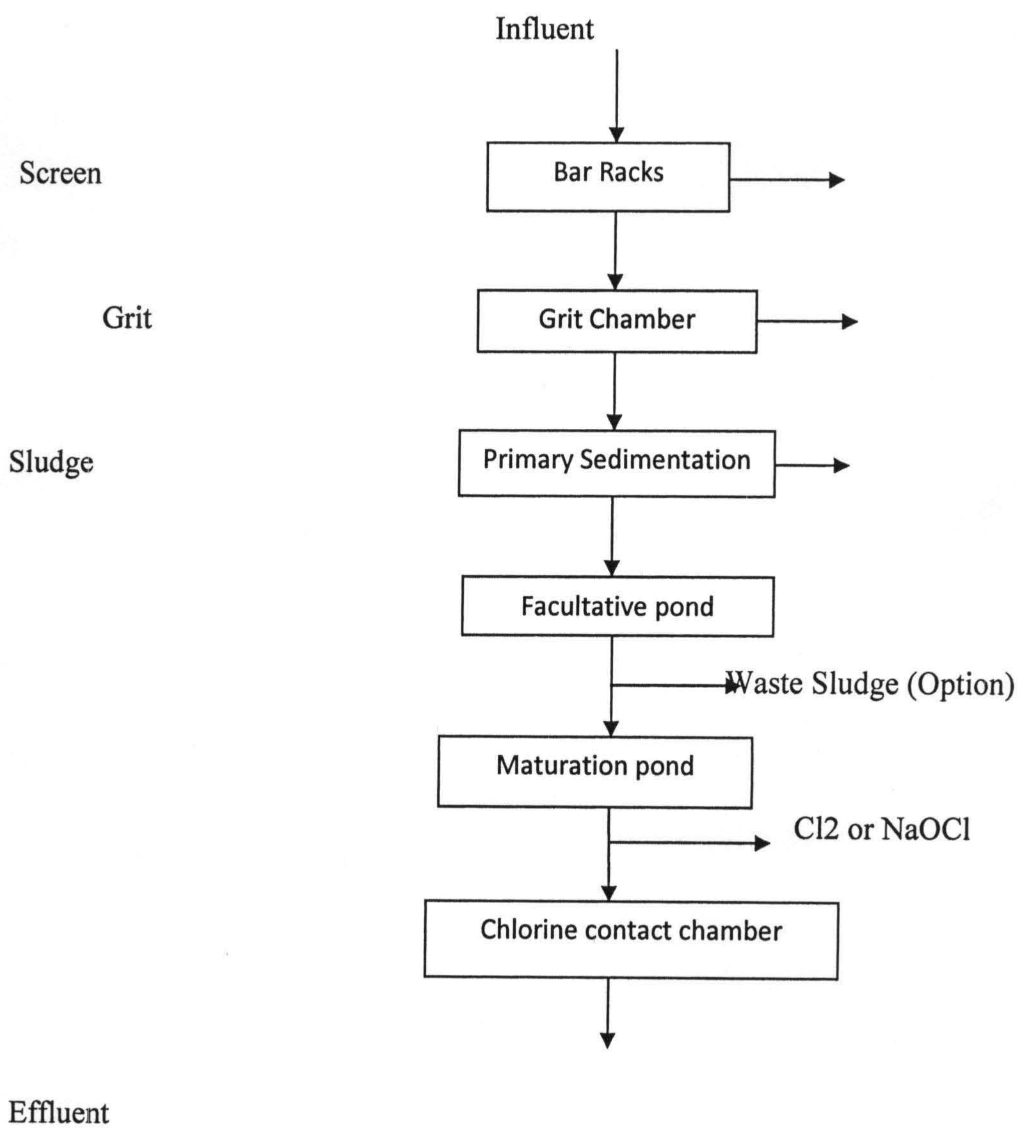


Fig. 2

The treatment process plant is restricted to facultative and maturation pond.

The most accurate method of obtaining the per capita consumption of water is to obtain water consumption figures for the design area from the authorities and divide it by the population of the area. Since the figures are unavailable and considering the design area to be a University, a value of 250l/cd is adopted according to National University Commission (NUC) guidelines (Mara. 1976).

3.2 Design Criteria for Facultative Pond

The standard range of dept for a facultative pond is between 1m and 1.5m length to breath ratio is usually 2-3 to 1 (Mara 1979), the area of the pond A is given by

$$A = \frac{Qt}{D} \qquad \text{..................} (1)$$

Where

Q = Volumetric flow rate, m^3/d

t = retention time, d

D = assumed pond depth, m

Assuming a completely mix reactor in which the BOD removal follows the first order kinetics which is how below

$$S = \frac{S_O}{1 + K_r} \qquad \text{........................} (2)$$

S = Effluent Concentration or Biochemical oxygen demand in effluent

S_o = Influent Concentration or BOD oxygen demand in influent

K = Temperature

K can be found from Arrhenius equation, thus

$$K_r = K_{20}O^{r-20}$$

Since K is temperature dependent, the pond can be estimated as follows

$$\frac{t}{d} = \frac{T_1 - T_p}{F\,(T_p - T)} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

t = retention time

d = depth of pond

T_1 = influent temperature

T_p = Pond temperature

T = ambient air temperature

F = exchange coefficient = 0.40 for waste stabilization pond (Arevala. 1986)

Taking t = 5d, and d = 1.2m

3.3 Design Criteria for Maturation Pond

The depth of the maturation pond is selected between 1m to 1.5m

Length to breadth ratio is usually from 2-3 to 1

The mid depth area is given as

$$A = \frac{Qt}{D} \qquad \text{..............................} (4)$$

Where

Q = volumetric flow rate, m^3/d

t = retention time, d

D = assumed pond depth, m

For maturation pond it has been found that two ponds in series, each with a retention time of 7 day area required for effective BOD_5 removal of about 60%. The removal of faecal coliform bacteria from any pond follows the first order kinetics of the form.

$$N = \frac{N_1}{1 + K_{bt}} \text{............................} (5)$$

Where

N = number of faecal coliform in effluent, /100ml

N_1 = number of faecal coliform in influent / 100ml

K_o = first order rate constant for faecal coliform removal d^{-1}

For n number of ponds in series

$$N = \frac{N_1}{(1 + K_{bt})(1 + K_{bt2})....(1 + k_{btn})} \qquad \text{.......................} (6)$$

Where

T = retention time in the nth pond

The value of K_b is extremely sensitive is given as:

$$K_{b(T)} = 2.6(1.19)^{T-20}$$

Where

$K_b(T)$ = value of K_b at T.C

It can hence be deduce that a waste stabilization pond in series starting with a facultative pond and two maturation ponds (having the same size) is an ideal design for both BOD and faecal coliform. The two maturation pond effectively remove nitrogen, suspended solids and phosphorous. (Mara 1976)

CHAPTER FOUR

RESULTS

4.1 Sewage Production

The first step in the estimation of wastewater flow rate and quantity is to access the quantity of water consumed. This will enable an estimate of sewage flow to be made after water losses have been subtracted from the total water supply.

A considerable portion of the water does not reach the sewers because not all the water supplied results in waste water. About 60 – 80% of the water consumed reaches the sewers (Metcalf, 1979) due to leakages from water mains, service pipes and water consumed by those not connected to the sewers. Considering the design area, 70% of the water consumed will be assumed to become waste.

Therefore, per capital water consumption is assumed to be 250l/cd according to NUC guidelines.

Considering project area 70% of H_20 consumed is assumed as waste

Per capita sewage production = 70 x 250

= 175l/cd

Present population of the university is 5500, in the next 30 years estimated population is

$P_2 = P_1 (1 + {}^{r}/_{100})^{n}$

$P_2 = 5500 (1 + {}^{5}/_{100})^{3}$

= 6,367

∴In 30 years the expectedpopulation will be 6,367.

4.2 Design Preliminaries

Design Population	=	6,367
Per Capita Sewage	=	175l/cd
Influent BOD	=	250mg/l
Influent tem	=	32^{o}c
Minimum Ambient Temp	=	27^{o}c
Retention Time	=	10 days
Effluent BOD	=	25mg/l

4.3 Pond Design

Facultative Pond; Chosen depth d,	=	1.2m
Retention Time	=	10 days
Sewage Quantity	=	175/cdx 6,367

⟹ 1,114,225 = 1114.225

Area of Pond A = $\frac{Qt}{d} = \frac{1114.225 \times 10}{1.2} = 9285.21$

70% BOD reduction in facultative Pond is given by

Influent BOD5 = 0.3 x 250mg/l = 75mg/l

N Years = 1/2 (Pond volume M^3) sludge accumulation rate M^3/hdyr x (population)

$$\frac{1114.225}{2 \times 0.04 \times 6367} = 2.2$$

∴Desludging frequency every 2 yrs

Assuming a completely mix reactor in which BOD removal follows 1st order kinetics

$$S_e = \frac{S_o}{1 + K_T}$$

K_T can be found from Arrhenius equation:

K_T is Temperature dependent, therefore the pond can be estimated by

$$\frac{t}{d} = \frac{T_i - T_p}{F\,(T_p - T_a)}$$

t	=	retention time		
d	=	depth of pond		
Ti	=	influent temperature		
Tp	=	Pond Temperature		
Ta	=	ambient air temperature		
F	=	exchange coefficient	=	0.04

$$\frac{5}{1.2} = \frac{32 - T_p}{0.4\,(T_p - 27)} = \frac{32 - T_p}{0.4\,T_p - 10.8}$$

$5\,(0.4\,T_p - 10.8) = 1.2\,(32 - T_p)$

$2T_p - 54 = 38.4 - 1.2\,T_p$

$2\,T_p + 1.2\,T_p = 38.4 + 54$

$3.2\ T_p = 92.4$

$T_p = 28.9^0C$

$K_{28.9} = K_{20}\theta^{28.9-20}$

$K_{20} = 0.3d^{-1}$ θ for WSP ranges from 1.05 – 1.09 (Mara1979)

$K_{28.9} = 0.3 \text{ x } 1.05^{8.9}\ d^{-1}$

$= 0.46\ d^{-1}$

To find the number of ponds to reduce BOD_5 to 25mg/l

From Equation; $S_e = \frac{S_o}{1 + K_T}$

For n series ponds

$$S_e = \frac{S_o}{(1 + K_T)^n}$$

Thus,

$$\frac{1.05}{2.0} = \frac{1}{(1 + 0.46 \text{ x } 5)^n}$$

$$n = \frac{\log 2}{\log 3.3} = 0.58$$

n = 1 pond

Check if the required number of pond is satisfactory

1. Effluent after first pond

$$S_{e1} = \frac{1.05}{1 + 0.46\,x10} = 18.8\ mg/l$$

Effluent after the first pond is satisfactory because it does exceed the required minimum of 25 mg/l.

Area of pond for facultative $= A = \frac{Qt}{D}$

$$A = \frac{1114.225\ x\ 10}{1.2} = 9285\ m^2$$

Surface loading rate in kg / had is

$$S = \frac{10^3 \times Li \times Q}{10^4 A} = \frac{10 \times 1.05 \times 1114.225}{9285}$$

$$S = 126kg/had$$

The maximum permissible surface loading per pond is 126 kg/had

Check:

2T – 120 = (20 x 32) – 120 = 520kg/had

Where T = mean annual temp

Surface loading is satisfactory, because the maximum permissible loading per pond must not exceed 20T – 120

For a rectangular pond

Taking length to be twice its breadth

$A = 9285m^2$

$L \times B = 9285$

$2B \times B = 9285$

$2B^2 = 9285$

$B^2 = 4642$

$B = 68m$

$L = 2B$

$L = 2 \times 68$

$= 136m$

:- B = 68m; L = 136m ; D = 1.2m

4.4 Design preliminaries for Maturation pond

There was no laboratory test carried out, therefore no exact parameters to carry out the calculation. However, the design criteria are as shown below:

Maturation Pond depth ranges from 1m – 1.5m

Length to breadth ratio is usually 2 – 3 to 1

Mid depth area $$A = \frac{Qt}{D}$$

$$A = \frac{1114.225 \times 7}{1.2} = 6499.65 \text{ m}^2$$

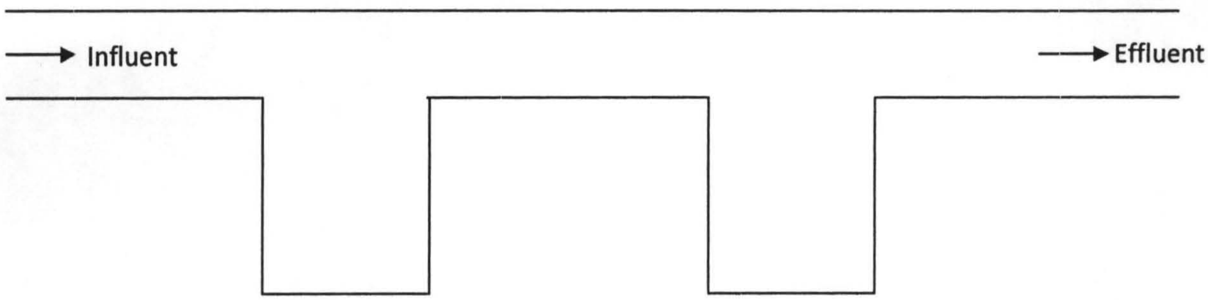
$$N_e = \frac{N_2}{(1 + k_{bt} \text{ facultative})(1 + k_{bt} \text{ maturation})^2}$$

The value of K_b= 2.6 at 20°c and N_2= 4×10^7 (Mara, 1975)

$$N_e = \frac{4 \times 10^7}{((1 + (2.6\text{x}10))\,((1 + (2.6 \times 7))^2}$$

$= \frac{4 \times 10^7}{(27)\,(368.64)} = 4019\text{FC}/100\text{ml}$ Satisfactory

In maturation ponds it is found that 2 ponds in series with a retention time of 7 days are required for effective pathogen removal. If the pond does not satisfy the effluent standard of < 5000 FC / 100ml, then 3 or more ponds with a retention time of 5 days are chosen. It can hence be deduced that a waste stabilization pond in series starting with a facultative &a maturation pond having same size is ideal for both BOD &faecal coliform removal.



Facultative pond *maturation pond*

B = 68m

L = 136m

D = 1.2m

Fig 3*Diagrammatic representation of the ponds*

4.5 DISCUSSION

Waste stabilization pond is very essential for the University because the effluent produced from this design can be discharged into the environment with considerable low risks. Waste stabilization pond is better than the septic tank which is commonly used in the University because the effluents from septic tanks are often polluted and also contain pathogenic organisms. Effluents from septic tanks if not properly disposed can contaminate the ground water which is the primary source of water for the University. This design is economical and can achieve any required degree of purification at the lowest cost and does not require skilled labour for its operation and maintenance. The method of construction is such that, should at some future date the land is required for some other purpose, it is easily reclaimed. The algae produced in the pond are a potential source of high-protein food which can be conveniently exploited by fish farming. Fish have been successfully grown in maturation ponds. The sale of fish can bring in substantial revenue and so reduce the running costs of the treatment works.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

1. The design method and the treatment process used, allows for the provision of a WSP in the school to treat waste water and make it available for reuse or direct discharge into the environment. The pond has been arranged in rectangular shapes to maximize efficiency.
2. Design flow is reached in 30 years and the series of ponds can be desludged easily by channeling the flow through another series of ponds.
3. The use of facultative and maturation ponds in this design favours the analysis of WSP design.

5.2 RECOMMENDATION

As a result of strong odour that emanates from WSPs the ponds should be located far from residential and academic areas. These ponds should be located at the outskirts of the school in other for easy acquisition of land in case of insufficient land area.

The following factors should be considered in the construction of WPS.

i. Pond bottom should be well compacted to avoid excessive seepage. Where excessive percolation may result in pollution of groundwater, a pond sealer or linear is required.

ii. Inlet and outlet structures should achieve better hydraulic distribution and pond performance.

iii. Embankment should have inside and outside slope three horizontal to one vertical.

iv. Surface runoff should be minimized around the ponds.

v. Pond depth should not be shallow to reduce the emergence of vegetation and mosque breeding

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