

# Design Of Waste Stabilization Pond For Sewage Treatment At Nigerian Defence Academy Staff Quarters, Permanent Site Mando Kaduna

I Abdullahi, I Nasiru, A Saminu, L Sagir, E Charity

**Abstract**— Waste treatment is normally by two main methods which are mechanical and natural. *Mechanical method* of treating wastes comprises of sanitary sewer system, aerated lagoons with mechanical aerator, this poses problem due to non availability of electricity to power the machine constantly and mechanical defect that hinders smooth operation. There is also cost of chemical to treat the sewage. *Natural method* has proven to be more effective and less expensive. This made the natural method to be adopted as a major method for treating wastes in many countries. This methods involves the use of ponds. These are large shallow basins enclosed by earthen embankment in which raw sewage is treated by entirely natural process involving both algae and bacteria. Wastes are usually treated by supplying them with oxygen so that bacteria can utilize the waste as food.

**Index Terms**— Waste treatment, *Mechanical method* of treating wastes, WSPs.

## I. INTRODUCTION

Waste Stabilization Ponds (WSPs) 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 temperate and tropical climates, and represent one of the most cost-effective, reliable and easily-operated methods for treating domestic and industrial wastewater. Waste stabilization ponds are very effective in the removal of faecal coli form bacteria. Sunlight energy is the only requirement for its operation. Further, it requires minimum supervision for daily operation, by simply cleaning the outlets and inlet works. The temperature and duration of sunlight in tropical countries offer an excellent opportunity for high efficiency and satisfactory performance for this type of water-cleaning system. They are well-suited for low-income tropical countries where conventional wastewater treatment cannot be achieved due to the lack of a reliable energy source. Further, the advantage of these systems, in terms of removal of pathogens, is one of the most important reasons for its use.

**Manuscript received November 15, 2014.**

**I Abdullahi**, Department of Civil Engineering Nigerian Defence Academy, Kaduna

**I Nasiru**, Department of Civil Engineering Nigerian Defence Academy, Kaduna

**A Saminu**, Department of Civil Engineering Nigerian Defence Academy, Kaduna

**L Sagir**, Department of Civil Engineering Nigerian Defence Academy, Kaduna

**E Charity**, Department of Civil Engineering Nigerian Defence Academy, Kaduna

WSP systems comprise a single string of anaerobic, facultative and maturation ponds in series, or several such series in parallel. In essence, anaerobic and facultative ponds 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 (UNEP). 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 weak sewage is to be treated prior to its discharge to surface waters. 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 coli form bacteria/100 ml. The WSP 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 coli form bacteria.

### A. Processes in Waste Stabilization Ponds

#### B. Anaerobic ponds

Anaerobic ponds are commonly 2 – 5 m deep and receive wastewater with high organic loads (i.e., usually greater than 100 g BOD/m<sup>3</sup>.day, equivalent to more than 3000 kg/ha.day for a depth of 3 m). They normally do not contain dissolved oxygen or algae. In anaerobic ponds, BOD removal is achieved by sedimentation of solids, and subsequent anaerobic digestion in the resulting sludge. The process of anaerobic digestion is more intense at temperatures above 15 C. The anaerobic bacteria are usually sensitive to pH <6.2. Thus, acidic wastewater must be neutralized prior to its treatment in anaerobic ponds. A properly-designed anaerobic pond will achieve about a 40% removal of BOD at 10 C, and more than 60% at 20 C. A shorter retention time of 1.0 - 1.5 days is commonly used.

#### C. Facultative ponds

Facultative ponds (1-2 m deep) are of two types: Primary facultative ponds that receive raw wastewater, and secondary facultative ponds that receive particle-free wastewater (usually from anaerobic ponds, septic tanks, primary facultative ponds, and shallow sewerage systems). The process of oxidation of organic matter by aerobic bacteria is usually dominant in primary facultative ponds or secondary facultative ponds.

The processes in anaerobic and secondary facultative ponds occur simultaneously in primary facultative ponds. It is estimated that about 30% of the influent BOD leaves the

## Design Of Waste Stabilization Pond For Sewage Treatment At Nigerian Defence Academy Staff Quarters, Permanent Site Mando Kaduna

primary facultative pond in the form of methane (UNEP). A high proportion of the BOD that does not leave the pond as methane ends up in algae. This process requires more time, more land area, and possibly 2 -3 weeks water retention time, rather than 2 -3 days in the anaerobic pond. 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 WSPs is related to the algae they contain.

### D. The study area

The permanent site staff quarters for Nigerian Defence Academy is the study area which comprises of

- a. Officers quarters
- b. Soldiers quarters

Estimated population obtained is 312 persons.

The British code of practice 302:1972 recommends a central waste plant for population above three

Hundred (300) people. This necessitates the need for sewage treatment plant in Nigerian Defence

Academy permanent site since there is no provision for it in the NDA master plan.

### E. Effluent Disposal

1. The Maturation pond effluent could be discharged safely into the receiving river, which is being used for various purposes by the community.
2. Surface water discharge is the most common method of effluent disposal; there are other disposal methods such as land disposal which result into ground water recharge and sometimes crops irrigation or recirculation for industrial cooling system and on rare occasion's consumptions which follows a thorough treatment.
3. The ponds effluent will be discharge into the existing stream which is a tributary to river Rigasa.

#### a) Pond Dislodging

1. Sludge is the concentration of settle able and suspended solid contents of the sewage which settle down to the bottom of the pond. It is the undesirable product of the sedimentation process in either water or sewage treatment. Dislodging is required whenever the pond is half-full of sludge. Sludge accumulation rate is greater in the first pond that receives the sewage than the subsequent ponds. In this case the sludge in the facultative ponds is greater than in the maturation ponds. This is because a considerable amount of the settle able and suspended solids settle down in the preceding facultative pond before coming into the maturation pond which in turn removes the remaining solids.

That is the reason why the number of years required before dislodging maturation pond is longer than facultative pond.

The rate of sludge accumulation is approximately 0.003 – 0.04m<sup>3</sup>/hd year and dislodging is required when the pond is half-full of sludge. This occurs every n-year where n is given by:

$$n = \frac{\frac{1}{2} (\text{pond volume, m}^3)}{(\text{Sludge accumulation rate m}^3/\text{hd.yr}) \times \text{population (p)}}$$

For design purpose the rate of sludge accumulation may be estimated as 0.0m<sup>3</sup>/hd.yr

$$Q = 179.\text{m}^3/\text{d}$$

$$P = 468$$

$$t = 1 \text{ d}$$

$$\therefore n = \frac{\frac{1}{2} (179.71 - 1)}{0.04 \times 468}$$

$$= 4.79$$

$$= 5 \text{ years}$$

Operational result have shown that dislodging intervals in years (n) for anaerobic ponds is usually 7 – 10 years, and maturation ponds take a very long time before dislodging if there will be any

As anaerobic ponds are exempted in the treatment the facultative pond should be dislodged as five (5) years interval while for the maturation pond 7 – 10 years if there will be any.

### F. Sludge Handling

Sludge treatment and disposal is important in waste water treatment work, because it comprises of solids with water and also harbor pathogenic organism which render it hygienically unsafe. Sludge decomposes rapidly because it serves as food for the living organisms in it. However, the problems encountered in sludge handling may be overcomes with the use of adequate treatment and disposal methods. For this project the sludge treatment method adopted will be sludge digester and sludge drying beds.

Sludge digestion is an anaerobic fermentation process which enables the sludge drying bed area to be used to reduced by as much as two-third (2/3) and also has the additional benefits of producing combustible gases which can be used for power. While in sludge drying bed process a layer of wet sludge 20 to 25cm thick is spread over a drainage layer of aches. Water is removed partly by evaporation and partly by drainage when the sludge has dried well it is expected to be use on the polytechnic farm as manure.

## II. LITERATURE

### A. Design Tools and Rapidly-Developing Technology

Waste Stabilization Ponds (WSP) and Constructed Wetlands (CW) have proven to be effective alternatives for treating wastewater, and the construction of low energy-consuming ecosystems that use natural processes, in contrast to complex high-maintenance treatment systems, will hopefully lead to more ecologically-sustainable wastewater treatment in the future. CWs and WSPs also have the capability of meeting the demand for a high percentage removal of pathogenic organisms, compared to conventional technologies. CWs and WSPs combined, and joined with other technologies, may be important for even more improved performance of water cleaning systems. WSP's and CW's are now well-established methods for wastewater treatment in tropical climates. Their many advantages include: simplicity, low cost, low maintenance, low energy consumption, robustness, and sustainability. While WSPs are most commonly used for treating domestic wastewaters, they are also successfully used for treating industrial wastewater, including water that contains agro-industrial wastes. One of the potential advantages of using constructed wetlands is that

they do not allow mosquitoes to breed (sub-surface flow wetland). The process of designing WSPs and wetlands, and predicting their performance, is improving rapidly as we gain more experience with these systems.

Many countries in tropical climates use WSPs for wastewater treatment (e.g., Tanzania, Kenya, Malawi, Uganda, Zambia, Botswana, and Zimbabwe). Many of these systems have been performing below the required standards, due to lack of proper operation and maintenance (Design manual, 1998). Constructed wetlands have not yet received the deserved attention as an alternative method for wastewater treatment. Waste stabilization Ponds(WSP) designers come from many different backgrounds or disciplines, including civil engineering, environmental engineering, microbiology, chemical engineering, soil science, or natural resources management. Many of the WSP design tools and models have been adopted from countries with temperate climates. Thus, not all models can be transferred and used in tropical climate countries. For example, the hydrology and climate in tropical African is significantly different to that of most States in the United States or Europe. Nutrient removal in these countries has a high priority, whereas the removal of pathogenic organisms has a high priority in tropical countries. Most empirical model or design tools developed and used on-site or regionally-specific WSPs or Constructed Wetlands (CWs) data. Different characteristics, in terms of climate and hydrology, can lead to problems when models are transferred without appropriate modification for local conditions. Further, using simple tools or “rule of thumb” methods, in lieu of appropriate design techniques, often results in malfunctions or a reduced efficiency in the effect of WSP's and CW's.

The objectives of this waste stabilization and constructed wetland manual are as follows:

- To provide WSP and CW designers, builders and operators with appropriate information to develop, implement and operate WSP and CW for a range of applications and design objectives;
- To provide standard systems approach that can be adopted universally, and which can accommodate a development technology, with changes in information concepts and ideas with time;
- Provide theoretical background on the biological, chemical and physical processes of WSPs and CWs, the current state of the technology and technical knowledge on how to design, operate and maintain the systems; and
- Provide theoretical knowledge on how the models can be used in the best manner to describe the systems.

### III. METHODOLOGY

The basic design criteria for waste stabilization pond are:-

1. **Sewage flow rate**
2. **Temperature**
3. **Retention time**
4. **Influent**
5. **Effluent standard required**

When these criteria are properly established the size types and number of ponds required can be determined.

**Sewage flow rate:** This is based on eighty percent of 120L/C/d water consumption as stipulated by the National subcommittee on water supply and sanitation for urban areas.

**Temperature:** The mean monthly ambient air temperature of the coldest month is 0°C. 23°C is the design temperature suitable for tropical countries.

**Retention time:** This is the time required for the sewage BOD<sub>5</sub> strength to reduce to the desired strength. It is usually minimum seven (7) days.

**Influent concentration:** this is determined in the laboratory analysis. The result of the test shows that the BOD<sub>5</sub> is 400mg/L which is medium strength. This is as a result that only domestic waste is being discharge and waste stabilization pond can handle sewage of this strength. Therefore the use of anaerobic pond is not necessary since they are meant to receive very high strength organic sewage.

**Effluent standard required:** Effluent standard adopted by (D Mara, 1972) is 50 – 70 mg/l BOD<sub>5</sub> for facultative pond and less than 25mg/L for maturation pond.

Field experience in Africa has shown that an average of 60mg/L is adopted for facultative pond effluent.

#### A. DESIGN CONSIDERATION

**Health:** pathogenic organisms should not be spread either by direct contact with the night soil or sewage or indirectly or indirectly via soil, water or food. The treatment chosen should achieve a high degree of pathogen destruction.

**Re-use:** The treatment process should yield a safe product for re-use preferably aqua culture and agro forestry.

**Ecological:** In this case (which is exceptional) when the wastes cannot be re-used the discharge of effluent into surface water should not exceed the self purification capacity of the recipient water.

**Nuisance:** The degree of odor released must be below the nuisance threshold. No part of the system should become anesthetically offensive.

**Cultural:** the methods choose for waste collection, treatment and re-use should be compatible with local habits, social and religious practice.

**Operation:** the skills required for the routine operation and maintenance of the system components must be available locally or are such that they can be acquired with only minimum training.

**Costs:** Capital and running costs must not exceed the commodity's ability to pay. The financial return from re-use schemes is an important factor in this regard.

#### B. DESIGN PRELIMIRIES

1. Population = 312 persons
2. Add 1.3 factor of safety = 156 persons
3. Design population = 468 persons
4. Water consumption = 120L/c/d = 56, 160 L/d
5. Sewage (80% of water consumption) = 44, 928.00L/d
6. DWF = 44.928m<sup>3</sup>/d
7. Peak DWF (4 DWF) = 179.712m<sup>3</sup>/d
8. Li = 400mg/L
9. Le = 60mg/L
10. T = 23 °C
11. t\*<sub>mat</sub> (Minimum of) = 7 days
12. Pond depth facultative = 1.5m
13. Pond depth maturation = 1.5m

# Design Of Waste Stabilization Pond For Sewage Treatment At Nigerian Defence Academy Staff Quarters, Permanent Site Mando Kaduna

## C. MINIMUM EFFLUENT STANDARDS ADOPTED

(MARA D.B. 1972)

1. Final BOD5 to achieve < 25mg/L
2. FC < 5000FC/100ml (Restricted Agriculture)
3. Algal < 10<sup>5</sup> cell/ml
4. SS < 30mg/l
5. PV < 15MG/L
6. PH 5.5- 8.5
7. Ni 4x10<sup>7</sup> FC/100ml
8. Ne 500FC/100ml

## D. DESIGN EQUATIONS

The method adopted for project is first order kinetics and McGarry and pescod formulae for check.

$$A = \frac{Q(Li - Le)}{18D(1.05)^{t-20}} \quad \text{Eqtn. 3.4.1}$$

$$A = \frac{LiQ}{2T-12} \quad \text{Eqtn. 3.4.2}$$

$$A = \frac{Qt}{D} \quad \text{Eqtn. 3.4.3}$$

$$A_{sp} = 20T - 120 \quad \text{Eqtn. 3.4.4}$$

$$P.E = \frac{(Li - Le) \times 100\%}{Li} \quad \text{Eqtn. 3.4.5}$$

$$Ne = \frac{Ni}{(a + Kb t_{FAC})(1 + Kb_{mat})^2} \quad \text{Eqtn. 3.4.6}$$

$$Kb = 2.6(1.9)^{T-20} \quad \text{Eqtn. 3.4.7}$$

$$t_{FAC} = AD/Q \quad \text{Eqtn. 3.4.8}$$

## E. DESIGN OF FACULTATIVE PONDS

1. The sewage is domestic wholly with strength of 400mg/l BOD5 and the flow rate is less than 10,000m<sup>3</sup>/d, therefore preliminary treatment (Anaerobic) is not required (Mara, D.D. 1980). The pond receives raw sewage from the residential building. In order to maintain the pond content predominantly aerobic (rather than predominantly anaerobic) Le for the pond is 60mg/dpond depth is 1.5m.

2. The Surface Area of the facultative pond is given by eqn.3.4.1

$$A = \frac{Q(Li - Le)}{18D(1.05)^{T-20}}$$

$$= \frac{179.712(4 \times 10^{-4} - 6 \times 10^{-5})}{18 \times 1.5(1.05)^{23-20}}$$

$$= 1.9546 \times 10^{-3} \text{ h. a or } 1954.6 \text{ m}^2$$

Check from McGarry and pescod procedure eqn. 3.4.2

$$\frac{Li Q}{2T-12}$$

$$= \frac{4 \times 10^{-4} \times 179.712}{2(23) - 12}$$

$$= 2.114 \times 10^{-3} \text{ h.a or } 2114.23 \text{ m}^2$$

Thus 1954.6m<sup>2</sup> < 2114.23m<sup>2</sup>

Hence the Design is satisfactory.

Applying the length to breadth ratio 2:1  
Length twice width If width = w then length = 2w  
Area = L x width = 2w x w = 2w<sup>2</sup>  
: 2w<sup>2</sup> = 1954.6m<sup>2</sup>

$$W^2 = \frac{1954.36}{2} = 977.18$$

$$W = \sqrt{977.18} = 31.26 \approx 32\text{m}$$

$$\text{But } L = 2w = 2 \times 31.26 = 62.52 \approx 63\text{m}$$

The surface to bottom ratio using 1:3



$$\text{Surface } L = 63 + 3 \times 1.5 = 67.5 \approx 68\text{m}$$

$$W = 32 + 3 \times 1.5 = 36.5 \approx 37\text{m}$$

$$\text{Bottom } L = 63 - 3 \times 1.5 = 58.5 \approx 59\text{m}$$

$$W = 32 - 3 \times 1.5 = 27.5 \approx 25\text{m}$$

Depth is 1.5m allow 0.5m for free board.

## 3. Surface BOD

The loading rate of the pond is given in kg BOD/ha.d by eqn. 3.4.4

$$A_{sp} = 20T - 120$$

$$20(23) - 120$$

$$= 340\text{kg BOD/ha.d}$$

Detention time facultative pond is obtained from eqn.3. 4.8 as

$$T_{fac} = \frac{AD}{Q} = \frac{1954.6 \times 1.5}{179.712} = 16.31 \text{ days}$$

## 5. Pond Efficiency

The pond BOD removal efficiency (P.E.) is obtained from eqn.3.4.5

$$P.E. = \frac{Li - Le}{Li} \times 100$$

$$= \frac{4 \times 10^{-4} - 6 \times 10^{-5}}{4 \times 10^{-4}} \times 100$$

$$= 85\%$$

## F. DESIGN OF MATURATION POND

1. It has been established that in order to produced an effluent with BOD 25mg/l or less and FC less than 5000 FC/100ml, a maturation pond have to be constructed to receive effluent from facultative pond. For the maturation to effectively behave as aerobic pond the Li (i.e. the facultative pond Le) has to be in the range of 50 – 70mg/l (Mara, D.D. 1980). This 60mg/l le of facultative pond is suitable for the maturation pond.

The pond area is from eqn.3.4.3

$$A = \frac{Qt}{D} = \frac{179.712 \times 7}{1.5} = 838.66\text{m}^2 = 840\text{m}^2$$

Applying length to width ratio 2:1

Length = 40.95m, width = 20.49m

Surface to bottom ratio 1:3 surface, L = 45.46 and width = 24.98 and bottom L = 36.36, width = 15.98.

For easy construction used:

Surface L = 46m and width = 25m

Bottom: L = 36m and width = 16

Depth is 1.5 allow 0.5 for free board

2. Detention Time Maturation Pond from Eqn 3.4.8

$$T_{mat} = \frac{AD}{Q} = \frac{840 \times 1.5}{179.712} = 7 \text{ days}$$

3. Faecal Bacteria Die Off in stabilization Ponds

In a similar way to BOD reduction that is by first-order kinetic formula spelt-out in eqn. 3.4.7

$$K_b = 2.6 (1.19)^{T-20} = 2.6 (1.19)^{23-20} = 4.38$$

Therefore to check whether two maturation pond with a retention time of 7 days each can achieve the desire degree of bacteria removal; from eqn. 3.4.6

Where

$$N_1 = 4 \times 10^7 \text{ Fc/ml}$$

$$N_e = \frac{N}{(1 + kbt_{fac})(1 + kbt_{mat})^2} \quad 4.$$

$$= \frac{4 \times 10^7}{(1 + 4.38 \times 16.31)(1 + 4.38 \times 14)}$$

$$= 134.51\text{FC} / 100\text{ml}$$

∴ 134.51 < 5000 FC/100ml effluent standard aimed at which implies that the design is satisfactory.

The facultative pond will be provided with two maturation ponds of the calculated dimensions in series

The ponds are to trapezoidal in section and rectangular in plan. The length to breath ration of 2:1 is adopted for stability purpose.

#### G. POND FACILITY DESIGN

4. Pond Geometry

The hydraulic characteristics of rectangular and trapezoidal section ponds have been found to be superior to those of square, circular ponds and those with irregular geometry. Length to breath ration of 2:1 is adopted for stability.

The ponds are to be trapezoidal in section and rectangular in plan.

#### 5. Pond Base and Embankment

The bottom of the pond should be impermeable, although the sludge layer is expected to seal up small pores in the soil. Sealing of the base is necessary to prevent ground water pollution. Therefore plain in-situ concrete is adopted for the ponds base, sides and on top of embankment to protect it from erosion.

An embankment slope of 1:3 is usually satisfactory in most soil conditions. If steeper slopes are used, their stability should be established by standard soil mechanics procedures. The plain-in-situ concrete stop vegetation growth down the banks and so prevent the breeding of mosquitoes and makes maintenance easier.

#### IV. CONCLUSION

Sewage is a friend as well as an enemy. It is friend if properly handled, and an enemy if not handled properly. Looking at the used of the effluent from the treatment plan it's worth handling properly. As a matter of fact sewage is expensive but it is worth having, as helps in reducing water borne, water washed, water bases and water related diseases.

More so, the choice of waste stabilization pond for the treatment of the sewage from the staff quarters is not unconnected with its advantage over other biological treatment processes. The good deal to be said in it favour from the view point of the factors affecting the choice of treatment method and the satisfactory climatic conditions of the area of the location of the staff quarters is suitable for its adoptability.

Also, the comparatively low constructional and operating cost, simplicity and high treatment efficiency, of the stabilization pond, have render it undoubtedly the most widely applicable and advantageous method of sewage treatment especially in hot climate where the ambient temperature is an advantage. The most disadvantages are that they require large area of land than other treatment methods.

To make the environment a better place to live in, high sanitary conditions should be maintained. This help immensely in keeping the enemies - the mentioned diseases in 1 away from the inhabitants.

#### REFERENCES

1. Environmental Health Engineering in the Tropics Sandy Cairn across and Richard G. Feachem. Published by John Wiley & Sons Chic ester – New York – Toronto – Singapore. FEB 1990 page 159 - 165

2. Sewage treatment in Hot climate john Wiley, MADA, B. D (1980) (pg.3 – 7; 30 – 31; 35; – 67 – 93 ; 142 – 151 )

3. Public Health Engineering Practice Fourth Edition Vol. II Sewage and Sewage Disposal ( L. B Escritt published by Mac Donald and Evans – 1972.

4. Waste –water treatment and disposal HND Lecture note Kaduna Polytechnic.

5. Waste –water treatment and disposal PGDCE Lecture note Bayero University Kano.

6. Design Manual on Waste Stabilization Ponds and Constructed Wetlands.

7. Joint publication by UNEP-IETC with the Danish International Development Agency (Danida).

**Design Of Waste Stabilization Pond For Sewage Treatment At Nigerian Defence Academy Staff Quarters, Permanent Site Mando Kaduna**

APPENDIX 1

BILL NR. 1; CONSTRUCTION OF FACULTATIVE POND  
DIMENSIONS;

- Surface Length 68m and width 37m
- Bottom: Length 59m and width 28m
- Depth 1.5m

Location: Nigerian Defence Academy Kaduna

Items	Description	Unit	Qty	Rate	Amount N k
1.01	<b><u>EXCAVATION AND EARTHWORK</u></b> Clear site of all bush, shrub grasses and all trees, roots, anthills and cart to spoil. Ave. 015m deep	M <sup>3</sup>	9000	40	360,000:00
1.02	Excavate any material in cutting of pond pit to form trapezoidal shape and keep for re-use as embankment filling materials	M <sup>3</sup>	3315	350	1,160,250
1.03	Heap, shape and compact excavated material around pond to form an embankment, slop 1:3.	M <sup>3</sup>	1650	250	416,250:00
1.04	Remove surplus excavated materials away from site	M <sup>3</sup>	1650	170	280,500:00
1.05	<b><u>CONCRETE WORK</u></b> Provide, mix, spread, shape and compact plain in-situ concrete, B.S. 5328, ordinary mix C15P, 40mm aggregate on internal surfaces of pond and embankment shoulder	M <sup>3</sup>	193	15,000	2,895,000:00 <b>5,112,000:00</b>

APPENDIX 2

BILL NR2; CONSTRUCTION OF 2 NUMBER MATURATION POND  
DIMENSIONS

- Surface: Length 46m and width 25m
- Bottom: Length 36m and width 16m
- Depth 1;5m

Location: Nigerian Defence Academy new site Mondo Kaduna

Items	Description	Unit	Qty	Rate	Amount N k
2.01	<b><u>EXCAVATION AND EARTHWORK</u></b> Excavate any material in cutting of pond pit to form trapezoidal shape and keep for re-use as embankment filling materials	M <sup>3</sup>	1415	355	495,250:00
2.02	Heap, shape and compact excavated materials around pond to form an embankment, slope 1:3	M <sup>3</sup>	1155	250	288,750:00
	Remove surplus excavated materials away from site	M <sup>3</sup>	260	170	44,200:00
3.03	<b><u>CONCRETE WORK</u></b> Provide, mix, spread, shape and compact plain in-situ concrete, B.S. 5328, ordinary prescribed mix C15P, 40mm aggregate on internal surfaces of pond and embankment shoulder	M <sup>3</sup>	89	15,000	1,335,000:00
2.04	Cost of construction of 2 Nr Maturation ponds to summary				<b>2,163,200:00</b> <b>4,326,400:00</b>
2.05					

APPENDIX 3  
BILL NR 3; CONSTRUCTION OF BLOCKWORK FENCE AND PIPE WORKS  
DIMENSIONS:

-Surface: Length 455m

Location: Nigerian Defence Academy New site Mondo Kaduna

Items	Description	Unit	Qty	Rate	Amount N k
3.01	<u>EXCAVATION AND EARTHWORK</u> Excav. Fence fdn, standing from strip level a.v.d.n.e. 1m	M <sup>3</sup>	1415	350	495,250:00
3.02	Back-filling of excavated material Around fence foundation	M <sup>3</sup>	15	150	2,250:00
3.03	Remove surplus excavated materials away from site.	M <sup>3</sup>	167	170	28390:00
3.04	<u>CONCRETE WORK</u> Provide, mix cast and compact plain in-situ concrete, 1:3:6 (C.S.G.) for fdn Footing	M <sup>3</sup>	55	15000	825,000:00
3.05	<u>BLOCKWORK</u> Built hollow sandcrete block work, bedded and jointed in cement and sand mortar (1:6). Laid in stretcher bond in 225mm wall	M <sup>3</sup>	1,365	2,200	3,003,000:00
3.06	Supply and fix, double swing iron entrance gate, to 230mm x 230mm	No	1	70,000	70,000:00
	Reinforced concrete column to the treatment plan	No	5	2,175	10,875:00
3.07	<u>PIPE WORKS</u> Supply and install 150mm Asbestos cement (A.C.) pipe to connect ponds including disposal to stream				3,994,115:00

**SUMMARY OF PROPOSED WORKS FOR THE CONSTRUCTION OF FACULTATIVE AND MATURATION  
PONDS, BLOCKWORK FENCE AND PIPEWORKS AT NIGERIAN DEFENCE ACADEMY NEW SITE MONDO  
KADUNA**

ITEM	DESCRIPTION	PAGE	AMOUNT ₦	K
1	Preliminaries and preamble (2%)	27	268,650:00	
2	Bill Nr. 1 – construction facultative ponds	28	5,112,000	
3.	Bill Nr. 2 – Construction of two maturation ponds		4,326,400	
4	Bill Nr 3 Construction Block wall fence and pipe work <b>Subtotal</b> Add 5% Contingencies Builders work Add 5% VAT Estimated total cost for the construction of facultative/maturation ponds, wall fence and pipe works	29	4,326,400  13,701.165 685,058 14,386,223 719,311 <b>15, 105,537</b>	

(Fifteen Million, One Hundred and Five Thousand, Five Hundred and thirty Four Naira Seventy Five Kobo only.