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**Design of wastewater treatment plant for Public health and sustainable environment in Nigeria**

**ABSTRACT**

PUBLIC HEALTH FACILITYquarters Trans-Ekulu, Ekiti has been upgraded to Health Facility status, the steady

increment in the Facility population results to the increase in domestic sewage generation. Presently

there is no sewage treatment plant, so, it is required to construct a sewage treatment system with

sufficient capacity to treat the increased sewage generation. The project deals with the design of the

sewage treatment plant and its major units such as inlet chamber, grit chamber, comminutor,

primary settling tank, trickling filter, secondary sedimentation tank, sludge digester and sludge

drying bed for the Health Facility. It also involves the sizing of each components of the treatment

plant. The project takes into cognizance the health facility size in land mass, number of health

units, residents’ population and finally it is designed to serve the health facility for the next 30

years as the residents’ population increases. PUBLIC HEALTH FACILITYHealth Facility Ekiti is a residential facility and

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Public Health Facility, Ekiti has been upgraded to Health Facility status, the steady increment in the Facility population results to the increase in domestic sewage generation. Presently there is no sewage treatment plant, so, it is required to construct a sewage treatment system with sufficient capacity to treat the increased sewage generation. The project deals with the design of the sewage treatment plant and its major units such as inlet chamber, grit chamber, comminutor, primary settling tank, trickling filter, secondary sedimentation tank, sludge digester and sludge drying bed for the Health Facility. It also involves the sizing of each components of the treatment plant. The project takes into cognizance the health facility size in land mass, number of health units, residents’ population and finally it is designed to serve the health facility for the next 30 years as the residents’ population increases. Public Health Facility Ekiti is a health facility ands at a distance of 7 km North East of 82 DIV. Ekiti and 5 km south of School of Dentistry, Ekiti. With regards to the health Facility, almost the entire area and environment are plain and the general slope is from West to East. The facility is located at the latitude of N06° 28.669’ (N06.48°) and longitude of E 007° 29.808’ (N007.50°). The soil of the area is gravel and a large proportion of sandy-gravel. All the aspects of the Facility’s climate, and topography, its population growth rate are will all considered while designing the project. By the execution of the project, the entire sewage of the Health Facility can be treated effectively and efficiently.

Keywords: Sewage; treatment; health; tank; analysis; design; wastewater; sludge.

**INTRODUCTION**

The need for adequate sewage treatment system is a global problem and has great impact on individuals, households, families, physical and biological environment. The steady increase in population results in the increase of domestic sewage generation. Thus, no treatment plants for the Health Facility. Proper waste management has been universally accepted as one of the essential human need for a clean and healthy environment. However, many researchers believe that much has to be done in the mechanism of domestic sewage treatment. Since the rapid increase in the population of health facility occupants which result in the increase of sewage generation, the liquid water will require treatment before they are discharged into the water body or otherwise disposed of without endangering the public health or causing offensive conditions. The collection of waste water from occupied areas and conveying them to some point of disposal requires a mechanism for the treatment . stated that the purpose of a sewage collection system is to remove wastewater from points of origin to a treatment facility or place of disposal. The collection system consists of the sewers (pipes and conduits) and plumbing necessary to convey sewage from the point(s) of origin to the treatment system or place of disposal. It is necessary that the collection system be designed so that the sewage will reach the treatment system as soon as possible after entering the sewer. If the length of time in the sewers is too long, the sewage will be anaerobic when it reaches the treatment facilities.

In the past, the trend has been to design the most efficient unit processes, each, at a lowest cost and then combine the units to form an optimum wastewater treatment system. Conducted design studies of the activated sludge subsystem (aeration tank and secondary clarifier). The system provided excellent method of treating either raw sewage or more generally, the settled sewage. It offers secondary treatment with minimum area requirement, and an effluent of high quality is obtained. Though normally, it is found that for towns or small cities or facilitys (like PUBLIC HEALTH FACILITYHealth Facility, Ekiti) with medium sized plants, trickling filters are better; whereas in big cities with large sized plants, the activated sludge plant is better. Analyzed the settling of particles using the ideal basin concept. He assumed that; the direction of flow is horizontal in uniform velocity throughout the settling zone, the concentration of suspended particles is uniform over depth at the inlet of the settling zone, and Particles reaching the bottom remain discrete. His work demonstrated that the efficiency of sedimentation is governed by the surface area measured parallel to the direction of flow. Concluded that the efficiency of primary sedimentation basin is independent of the basin depth but dependent on overflow rate. They have also proposed that for optimum efficiency, settling tanks should be long, narrow (minimize the effect of inlet and outlet disturbances, cross winds, density currents and longitudinal mixing) and relatively shallow. Did not consider flocculation in his analysis. Most wastewater contains both soluble and particulate organic and inorganic matter. Proposed that domestic wastewater contains more organic carbon in colloidal and suspended form than the dissolved form. [6] Also found that particulate fraction is 66% to 83% organic and contributes 58% and 63% of volatile solids for domestic wastewater. He also found that the ratio of Chemical Oxygen Demand (COD) to volatile solids for the particulate fraction is approximately 1.5 : 1.0 while for the soluble fraction varies from 0.6 : 0.8 to 1.0. The aim of this paper is to develop a low cost design procedure for wastewater treatment systems, which will generally allow domestic effluents to be disposed of without danger to human health or unacceptable damage to the natural environment, satisfy a set of specified constraints, and minimize life time costs. Life time cost includes capital, operation and maintenance costs.

To realize this aim, the following specific objectives were pursued: Physical, chemical and biological treatment of the domestic sewage from Public Health Facility health Ekiti Nigeria, Provide treatment at a minimal cost while satisfying specific requirements, to attain a total discounted cost at the lowest possible level while satisfying a set of constraints (these constraints include: a specified effluent quality, and various physical & biological constraints), Design of the sewage treatment plant, and also to set out a model for further subsequent designs of STP for cities and Facilitys. This paper is concerned with the design of a sewage treatment plant for Public Health Facility, Ekiti Nigeria. The scope is limited to the design of the plant and its components, no construction of the plant or production of prototype will be made. The data used in this work were collected from the occupants of the Facility, and local Facility attendants. This study developed a least cost design procedure for wastewater treatment systems, which will generally allow domestic effluents to be disposed of without danger to human health or unacceptable damage to the natural environment.

**2. DESIGN ANALYSIS**

**2.1 Design Elements**

It is common practice to control sewage treatment plant by reference to matters such as waste disposal, site selection, protection of surface waters and impact on neighborhood amenity. Accordingly, sewage treatment plants need to be located in areas remote from residential development with sufficient available land for sustainable wastewater reuse. Proper design and construction will ensure effective wastewater reuse procedures and can be managed on a sustainable basis.

**2.2 Site Analysis**

The research team’s several field visits to the Public Health Facility Ekiti Nigeria availed them the leverage to agree that distance of the sewage water treatment will be 1.5 km away from the residential buildings. The exact location of the site in the facility as measured with the hand held GPS equipment was given as: Latitude; N: 06° 28.668/, Longitude; E: 007° 29.808/; Elevation; 210 m. From the contour map of the facility studied by the team in Fig. 2, observations were made which include the following: The land formation is skewed (sharp slope), There is a running stream at the foot of the slope, and existence of the vegetation along the bank of the stream.

**2.3 Geotechnical Investigation**

**2.3.1 Field work**

Five (5) test borings were dug, to depth ranging from (0.1 - 0.5 m), soil samples were taken intervals. After these, the soil samples were taken to the laboratory for determination of the required parameters with respect to soil properties.

**2.3.2 Laboratory testing**

Laboratory classification tests were carried out on the undisturbed and disturbed samples obtained from the boreholes to improve on field identification and classification tests. The tests carried out include: Moisture Content Determination (MCD), Atterberg Limit Tests (ALT), Particle Size Distribution Tests (PSTD), pH value of W ater in Soils, Sulphate Content of Water in Soils, Bulk density, Specific Gravity; (SG), Undrained Triaxial Compression Test, and Consolidation (Odometer) test.

**2.3.3 Bearing capacity analysis**

The Allowable bearing pressure imposed on a foundation is a function of characteristics of the shear strength of the soil as well as the depth and dimensions of the foundation. The bearing capacities for selected boring locations were based on the SPT N30 value obtained from the Standard Penetration Test field results and the laboratory strength properties of the recovered samples.

**2.4 Designs of the Various Parts That Make Up the Sewage Treatment**

**2.4.1 Design parameters**

Facility Area = 100 hectares, Population = 2500 person, Peak factor = 3.8, Rate of water supply = 300 liters per capital per day. 2.6.2 Design calculation for the discharge in sewer line Time of concentration = 50 minutes, Average impermeability coefficient for the entire area = 0.3, this sewer line will be designed for a flow equivalent to the Wet, Weather flow (W.W.F) plus twice the dry weather flow (D.W.F). Assume that he sewage flow is equal to 80% of rate of water supply. Hence sewage flow (D.W.F.) = 0.8 x 300 = 240 liters

**2.5.3 Hydraulic design of sewers**

The sewage, to be transported through the sewers, is mostly liquid (water), containing hardly (0.1 to 0.2%) of solid matter in the form of organic matter, sediments and materials. Hence, the general approach for the design of sewers is similar to the design of water mains. However, there are things to be considering in this design

1. Pressure of solid matters: This sewage flowing through the sewers contains particles of solid matters (both organic as well as inorganic). These solid particles settle at the bottom and have to be dragged during the sewage transport. In order that the sewers are not clogged, they are to be laid at such a gradient that self-cleansing velocity is achieved, at all value of discharges. Also the inner surfaces of the sewer must be resistant to the abrasive action of the solid particles.

2. Pressure: Sewers may be considered as open channels in most cases, wherein, the sewage runs under gravity. The sewer should run full, and the hydraulic gradient line falls within the sewer. Hence, the sewer must be laid at continuous downward gradient. Sewers run under pressure only when they are designed as force mains and inverted siphons. Hence, consider the design calculations below:

Rugosity coefficient (Asbestos cement for plastic smooth conduit material)

N = 0.011 The sewer is to be laid at a slope,

Design based on a sewer running 0.8 times full at maximum discharge, Water supplied = 2500 x 300 = 750000 liters/day

Assuming that 80% of the water supplied to the Facility appear as sewage, then average discharge in the sewer = 0.8 x (8.68 x10-3) = 6.944 x10-3 m3/s. At a peak factor of 3.8; Maximum discharge = 3.8 x 6.944 x10-3 = 0.0264 cumecs

**2.5.4 Design of the inlet/receiving chamber**

The receiving chamber is where the effluent is received first before pumping it into the grit chamber. This is more or less like the cesspool in its structure. Facility population = 2500, Water supply =300 litres per capital/day. Assuming 80% of water supplied to the facility is converted into sewage. Total sewage flow = 0.8 x 2500 x 300 = 600000 litres/day Assume no detention period; Capacity required =25 m Assume an overflow rate of 30 m3/d/m2, Surface area = 20m2 = B x L =20 m

**2.5.4 Design of the sewage pump**

The centrifugal pumps are most widely used for pumping sewage and storm water, as these can easily be installed in pits and sumps and can easily transport the suspended matter present in the sewage without getting clogged too often. These pumps work on the principle of centrifugal force. They essentially consist of two main parts: (i) The casing and (ii) The impeller rotates with high speed inside the casing. The commonly used horizontal axial flow type pumps are fitted with either open or closed three-vane type impeller. The clearance between the vanes is kept large enough to allow any solid entering the pump to pass out with the liquid, thus preventing the clogging.

**2.5.5 Design of grit chamber**

Grit chambers are provided to protect moving mechanical equipment from abrasion and accompanying abnormal wear. They reduce the formation of heavy deposits in pipelines, channels and conduits. They also reduce the frequency of digester cleaning that may be required as a result of excessive accumulations of grits in such units. High speed equipment such as centrifuges requires that practically, all grits be eliminated to prevent rapid wear and reduce maintenance. The removal of grits is also essential ahead of heat exchanger and high pressure diaphragm pumps. Grit channels, grit chambers or grit basins are intended to remove the grit present in the waste water. There are two general types of grit chambers,

(i). Horizontal flow grit chambers,

(ii). Aerated grit chambers.

To design Grit Chamber having rectangular cross – section and a proportional flow weir as the velocity control device, Max flow: 20 mLd, Diameter of the smallest grit particles to be removed: 0.2 mm, Average temperature: 25°C, Specific gravity of grit particle: 2.65.

**2.5.6 Comminutor**

A comminuting device is a mechanically cleaned screen which incorporates a cutting mechanism that cuts the retained material (larger sewage solids) to about 6 mm in size, enabling it to pass along the sewage. Comminuting devices may be preceded by grit chamber to prolong the life of the equipment. Frequently, they are installed in the wet well of the pumping stations to protect the pump against clogging by rags and large objects. However, provision must be made to bypass comminutors incase flows exceed the capacity of the comminutor or in case there is a power or mechanical failure. The uses of comminutors tend to reduce odours, flies and unsightliness. A communitor consists of a vertical revolving drum-screen with 6mm to 10mm slots. The coarse material is cut by cutting teeth and shear bars on the revolving drum as solids are carried past a stationary comb as shown in the figure. The small sheared particles then pass through the slots of the drum and of a bottom opening through an inverted siphon. The head loss across comminutors depend s upon screen details and flow, the normal value being on the order of 50 to 100 mm. the grid intercepts the large solid particles whereas smaller solids pass through the space between the grid and cutting discs. The capacity of the comminutor for small town sewage treatment is rated between 1 – 2 hp (horsepower).

**2.5.7 Primary settling tanks**

These are usually large tanks in which solids settle out of water by gravity where the settleable solids are pumped away (as sludge), while oil float to the top and are skimmed off. It operates by means of the velocity of flow when reduced by 0.005 m so that the suspended material (organic settleable solids) will settle out. The usual detention time is 3 to 8 hours. Longer periods usually result in depletion of dissolved oxygen and subsequent anaerobic condition. Removal of suspended solid ranges from 50 to 65 percent and a 30 to 40 percent reduction of the five-day biochemical oxygen demand (BOD) can be expected. For rectangular shape tank; Facility population = 2500, Water supply =300 litres per capital/day, Assuming 80% of water supplied to the facility is converted into sewage.

**2.5.8 Trickling filter**

Trickling filter also known as percolating filter or sprinkling filters are similar to contact beds in construction, but their operation is continuous and they allow constant aeration. In this system, sewage is allowed to sprinkle or trickle over a bed of coarse, rough, hard filter media, and it is then collected through the under draining system. Spray nozzles or rotary distributors are used for this purpose. The biological purification is brought about mainly by aerobic bacteria which form a bacterial film known as bio film around the particle of the filtering media. The color of this film is blackish, greenish, and yellowish, and apart from bacteria, it may consist of fungi, algae, lichens, protozoa, etc. For the existence of this film, sufficient oxygen is supplied by providing suitable ventilation facilities in the body of the filter, and also to some extent, by the intermittent functioning of the filter. The straining due to mechanical action of the filter bed is much less. Organic removal occurs by biosorption from rapidly moving parts of the flow, and by progressive removal of soluble constituents from the more slowly moving portion. Type of trickling fitter = Circular, Capacity = 1 million litres of sewage per day, Duration rate of Biochemical Oxygen Demand (BOD) = 5 day BOD of 120 mg. Design the circular trickling fitter, the under drainage system as well as rotary system for the fitter. Suitable design data assumptions are made where necessary.

**3. CONCLUSION**

A successful technical project involves the integration of various fields. This is an attempt to combine several aspects of environmental, biological, chemical, civil and mechanical engineering. Since in Public Health Facility there is no proper treatment plant for sewage, it is necessary to construct a sewage treatment plant for a health estate of such magnitude. The plant is designed perfectly to meet the future expansion for the next 30 years in accordance with Federal Government of Nigeria Codal provisions. This project consists the design of the complete components of sewage Treatment Plant from Receiving Chamber, Grit Chamber, Comminutor, Primary Settling Tank, Trickling Filter, Secondary Settling Tank, Sludge Digester and sludge Drying Beds for sewage. The basic data were first of all worked out and stipulated for the proposed sewage treatment plant on the basis of per capita sewage produced, quality of sewage produced and the standards of effluent specified. The STP was designed using trickling filter instead of activated sludge process due to the population of the occupants and the availability of land area for the construction of the plant. Proper use and maintenance of the sewage treatment system will ensure effective sewage management in the estate.

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