International Journal of Multidisciplinary Research and Publications
ISSN (Online): 2581-6187

Design of Wastewater Treatment Plant

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***Abstract*—*Wastewater also known as sewage can be formed in the presence of waste (heavy solid or liquid) or organic matter. The purpose of sewage treatment and its characteristics is to remove contaminants and produce treated wastewater safe enough to be released into the environment. Wastewaters contained contaminants from disposals of waste from households or industrial systems. It includes household waste liquid from baths, toilets, showers, kitchens, and sinks draining into septic tank. Wastewater from households, offices, hotels, restaurants, and hospitals comes in contact with the environment, are major source of pollution and disease-causing bacteria when not collected and treated properly. To provide the public with clean and safe drinking water, many water treatment facilities employ a combination of disinfection, filtration, sedimentation, and coagulation. The development and processing of sewage or wastewater has contributed validly to its utilization from it physical, chemical and biological attributes. The treatment tank for wastewater is designed with primary and secondary treatment modules. The primary treatment unit consists of an primary sedimentation tank for storing the sewage where heavy solids can settle to the bottom while lighter materials float to the surface, the floating materials are removed during the primary treatment, then the heavy liquid are passed to the secondary stage for further treatment. The aeration tank and clarifier, which eliminates the dissolved and suspended biological material, will be part of the secondary treatment. The ultra violet (UV) disinfection unit forms the tertiary treatment in order properly disinfects the water. This search has showcased a wastewater design in handling wastewater and shown that with an effective waste water treatment plant, environmental threat of such water can be minimized before disposing it. There is need to design and fabricates an effective wastewater treatment to handle wastewater from runoff and municipal waste, to prevent environmental pollution and related health challenges*

***Keywords*—** *Wastewater, sedimentation, treatment, disinfection.*

I. INTRODUCTION

Water is a renewable resource essential for sustaining all forms of life, food production, and economic development. The surface water and groundwater play a major role in agriculture, power generation and industrial activities. Surface and groundwater are usually prone to polluted by human activities, which alter the physico-chemical properties of the water (Amadi, 2012). This results to higher concentrations of dissolved or suspended constituents of the pollutant than the maximum admissible concentrations formulated by national or international standards for drinking, industrial or agricultural purposes. The World Health Organization (WHO, 2010) estimates, one-half to two-third of the world's population lack access to adequate quantities of safe drinking water or sanitation. The pollution is especially serious in the urban settlements with greater number of inhabitants, industries, agricultural practices and mining operations. The inadequate sanitary urban infrastructure and the lack of control of the pollution where the majority of the urban and industrial waters are not treated usually results to environmental degradation and pollution.

The wastewater also known as sewage can be formed in the presence of waste (heavy solid or liquid) or organic matter. The purpose of sewage treatment and its characteristics is to remove contaminants and produce treated wastewater safe enough to be released into the environment. Wastewaters contained contaminants from disposals of waste from households or industrial systems. It includes household waste liquid from baths, toilets, showers, kitchens, and sinks draining into septic tank. In many areas, wastewater also includes liquid waste from industry and commerce. Domestic sewage comprises used water from kitchen, bathroom, lavatory, etc. The factors which contribute to variations in characteristics of the domestic sewage are daily per capita use of water, quality of water supply and the type, condition and extent of sewage system, and habits of the people. The composition of municipal sewage, which includes both domestic and industrial wastewater, can vary from location to location based on the kind of industries and industrial facilities. Wastewater from households, offices, hotels, restaurants, and hospitals comes in contact with the environment, are major source of pollution and disease-causing bacteria when not collected and treated properly. To deliver clean and safe drinking water to the public, numerous water treatment facilities employ a combination of disinfection, filtration, sedimentation, and coagulation. The development and processing of sewage or wastewater has contributed validly to its utilization from it physical, chemical and biological attributes.

Microorganisms are critical to water quality and waterborne illnesses (Adetunde and Glover, 2010). All of these can lead to cholera, gastroenteritis, dysentery, diarrhoea, and typhoid fever. The most hazardous type of water pollution happens when feces contaminate the water supply. Many diseases are perpetuated by the faecal-oral route of transmission in which the pathogens are shed only in human faeces (Adetunde and Glover, 2010). The presence of fecal coliforms of E. coli is used as an indicator of the presence of any of these waterborne pathogens (Adetunde and Glover, 2010). Groundwater contamination is the leading cause of death and illness worldwide, accounting for over 14,000 daily deaths, the majority of whom are children under five. Public worry about groundwater quality has grown in recent years as a result of numerous reports of contaminants in groundwater. Children are generally more vulnerable to intestinal pathogens and it has been reported that about 1.1 million children die every year due to diarrhea diseases (Steiner and Gurrant, 2006). The contaminants in wastewater include suspended solids, biodegradable dissolved organic compounds, inorganic solids, nutrients, metals and pathogenic microorganisms.

The aim of this work is to design a wastewater treatment for proper and safe disposal of wastewater without posing danger to the environment and health related challenges.

II. METHODOLOGY

The wastewater treatment tank's design includes primary and secondary treatment units. The primary treatment unit consists of a primary sedimentation tank for storing the sewage where heavy solids can settle to the bottom while lighter materials float to the surface, the floating materials are removed during the primary treatment, then the heavy liquid are passed to the secondary stage for further treatment. The aeration tank and clarifier, which eliminate the suspended and dissolved biological material, are part of secondary treatment.

The ultra violet (UV) disinfection unit forms the tertiary treatment in order properly disinfects the water.

The system can be divided into the sections:

1. Mechanical treatment
2. Biological treatment
3. Sludge treatment

a) Mechanical treatment

Wastewater contains impurities and some are in suspension, in the mechanical treatment, suspended solids are mechanically removed from the wastewater, the wastewater passes a primary clarifier before entering the aeration tank, where air bubble will be supplied by an air compressor, and then the water flows into a grit chamber.

In this sedimentation tank, the preliminary treatment removes larger debris and this includes screening and grit removal which are heavy inorganic particles (such as sand and heavy particulate). Since organic solids settle much more slowly than sand, a low-velocity sedimentation phase is necessitated for their separation.

This necessitated a permeability and porosity of material meet for the sedimentation. The materials used for the investigation includes;

i. Three empty 1-liter plastic bottles
ii. Clay soil, sand and pebbles/gravel
iii. A thumb tack and scissors
iv. Stopwatch/clock
v. Liquid measuring cup
vi. Three plastic containers/beakers (to catch the draining liquid) and water.

Permeability Test:

The bottoms of the three 1-liter plastic bottles were cut off to form a funnel each. The thumb tack was used to poke the same number of holes in each bottle cap and keep it screwed on. The bottle was then filled about half to three-quarter with the following materials;

1. Bottle A: Clay soil
2. Bottle B: Sand
3. Bottle C: Pebbles/gravel (make sure the gravel is clean).

The bottles were held on a container to catch the percolating water, and 500ml of water was poured into the bottle first bottle half, and the time it takes for the water to percolate through the bottle (time from when the water was poured into the bottle to the time the first water drips into the container) is recorded. This process was repeated for all the samples.

TABLE 1: Results Percolation Time

S/n	Soil Type	Percolation Time (Seconds)			
		5 mins	**10 mins**	**15 mins**	**20 mins**
1.	Clay soil	0 ml	0 ml	0 ml	0 ml
2.	Fine grain sand	62.5 ml	125 ml	187.5 ml	250 ml
3.	Coarse sand	360 ml	477 ml	-	-

TABLE 2: Results for Porosity

S/n	Soil Type	Amount of water drain in the soil	Amount of water retained in the soil
1.	Clay soil	0 ml	500 ml
2.	Fine grain sand	265 ml	235 ml
3.	Coarse sand	477 ml	23 ml

TABLE 3: Results Percolation Time

S/n	Soil Type	Parameters		
		Quantity of water drained	**Time of drainage**	**Flow rate of water**
1.	Clay soil	0 ml	0 seconds	0 m^3/s
2.	Fine grain sand	250 ml	20 seconds	$20.83x10^{-8}$ m^3/s
3.	Coarse grain sand	477 ml	10 minutes	$79.5x10^{-8}$ m^3/s

Water did not percolate the clay soil, in the fine gain sand it takes two minutes for the water to percolate while in the coarse grain sand it takes three seconds for the water to percolate. The flow rate of water was faster in coarse grain sand and moderate fine grain sand. Therefore, for effective sedimentation process to separate the organic solids (with a low velocity) from the wastewater, the tank was designed to accommodate a combination of clay and sand in ratio 1:3 to enhance proper sedimentation of organic solid from the wastewater. The bottom of the tank just immediately below the water outlet was filled with coarse grain sand to enhance flushing of the sludge from the tank.

A rectangular sedimentation tank with an average length-to-width ratio of 1 to 5 is used with water inlet at the center of the tank to enable radial flow of the wastewater and outlet at the middle right-side of the tank, this enhances the settling and removal of settled solids at the bottom of the tank.

Umoru Titi Abdulasisi, Sule Tunde Usman Nurudeen, Umoru Jessica Faith, Idris Gimba Nurudeen, Adeleye Bunmi Omotola, and Sado-Alimikhena. E, "Design of Wastewater Treatment Plant," *International Journal of Multidisciplinary Research and Publications (IJMRAP),* Volume 7, Issue 11, pp. 85-87, 2025.

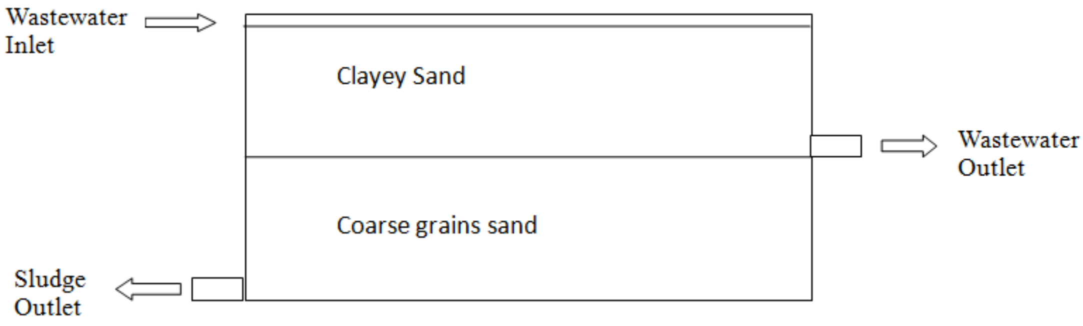

Figure 1: Design of the Sedimentation Unit

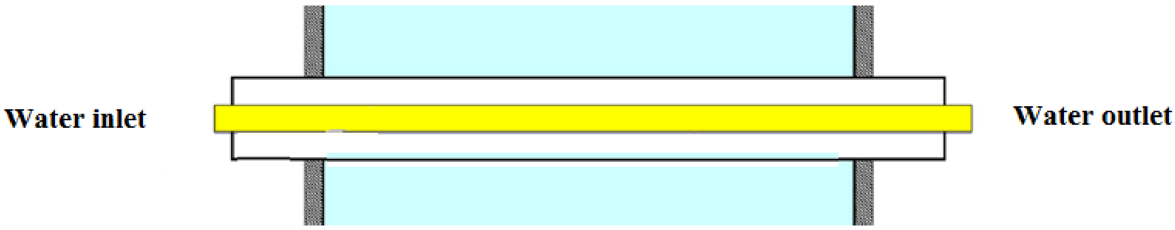

Figure 2: UV Light Disinfection

b) *Biological treatment*

Mechanical treatment was followed by biological treatment of the wastewater. The wastewater was aerated in the aeration tank the aim of biological treatment was to transfer dissolved organic contaminants from soluble form into suspended matter in form of cell biomass, which can be remove by particle-separation or sedimentation processes. The aerobic process, which improves oxygen mixing with the wastewater, was the appropriate biological procedure. Before the primary sedimentation, lime and alum were added as an alternative to the biological. This enhances the precipitation of phosphate as well as hardness cations and organic matter in the wastewater. An ultra-violet (UV) disinfection was used to disinfect the water.

c) *Sludge treatment*

The wastewater sludge was collected and treated in order to reduce the volume, reduces the pathogens and odour of the sludge for proper and safe disposal.

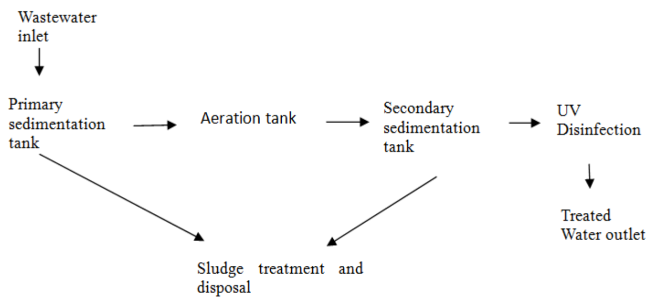

Figure 3: Flow chart showing design of the wastewater treatment unit

III. Conclusion

Wastewater has been a serious environmental threat, especially when it finds it ways into the water bodies and soil, causing great deal of environmental degradation. This search has showcased a wastewater design in handling wastewater and shown that with an effective waste water treatment plant, environmental threat of such water can be minimized before disposing it.

Many people in developing and third world countries still do not have access to any form of proper sanitary system, thus they usually practice open defecation especially in remote villages and rural areas compared to urban areas, on a larger scale of wastewater and runoff treatment, there is need to design and fabricates an effective wastewater treatment to handle wastewater from runoff and municipal waste, to prevent environmental pollution and related health challenges associated to wastewater.

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