

Original Research Article

THE DESIGN OF SEWAGE TREATMENT PLANT FOR AGULU COMMUNITY, NIGERIA

ABSTRACT

There are two basic reasons for treatment of sewage., reuse and proper control of waste water and water pollution, and safeguarding the public and environmental health by protecting water supplies and preventing the spread of water borne diseases. Proper design, construction together with good operation and maintenance are important for sewage treatment plants, in order to produce effluents which are satisfying the safe disposal or reuse prescribed by the regulatory authorities. In the present study a comprehensive design developed for the units of Inlet chamber, Screen chamber, Grit Removal Unit, sedimentation Tank, Clari-Floculator, Aeration Tank, Sludge Drying Beds etc. as they are commonly used in the field of wastewater treatment. The plant which is designed to treat 44.625MLD of sewage generated by the inhabitants of Agulu will use as many sustainable and energy efficient concepts as possible, while still keeping construction and maintenance costs low. The overarching goal of the project which is designed to serve for the next 3 decades is to prevent the contamination of the surface water like the Agulu lake and also ground water, while also providing clean effluent for disposal and can be further treated for consumption.

Keywords: Design, Sewage, Treatment plant,

1. INTRODUCTION

A fluid waste of household or Industrial Root which is “Foul” in nature and comprises of 99.9% water is called sewage. (Bharathi, 2014). Sewage can be treated in a sewage treatment plant by collecting all the sewage through the sewerage system and then treat the sewage by different stages that remove some percentage of pollutants from the water. The Treatment handle includes an arrangement of treating units which are categorized beneath primary (mechanical) treatment, biological (secondary) treatment and tertiary (sanitization) treatment.

According to Premium times, Anambra state government plan to spend 2.5 billion naira on Agulu lake transformation project which would make the lake a very attractive tourist center to attract both local and international tourist, with this in mind an expected increase in population and commercial activity will follow and thereby leading to increase in quantity of waste water produced on a daily basis. At current state the town of Agulu with population of about 79000 (2016) still produces a lot of waste water and the drainage system is very bad and unreliable.

Egboka et al, (2006) concluded in their research that rainfall is the foremost cause of flooding and siltation of streams, waterways, agrarian lands, property and now and then misfortune of lives. They too included that the Water budget examination for the region (Agulu) has recognized August to October as the months amid which disintegration is at its crest, the anthropogenic and common causes of gully/soil disintegration. Research has shown and proven that a sewage treatment plant can also be designed to treat not only sewage but also run off and produce effluent which can be discharged to the surroundings for irrigation or any other agricultural purposes, can be further treated for drinking and human consumption, and also can

be discharged into water bodies and will not have a negative effect on the water quality.

The final effluent from the sewage treatment plant can be used by the residents of Agulu for irrigational purposes, recreational purposes, construction purposes and even for drinking. The effluent will act as an additional source of water for the people of Agulu. Also, Sewage treatment create sewage sludge which can be treated before secure transfer or reuse. The sludge gotten from the STP often regarded as "biosolids" and can be utilized as a fertilizer.

2. LITERATURE REVIEW

According to Swati Shree, 2016.

Metro satellite has gotten to be as vital complex region close the put Palasuni of Bhubaneswar. As population increases and the basic infrastructures grow there would be a rise in the amount of domestic sewage produced. The objective of this sewage treatment plant is to treat the domestic sewage generated by removing contaminants and produce environmentally friendly effluent. The different treatment units designed include screening, grit chamber, skimming tank, sedimentation tank, auxiliary clarifier, actuated scum tank and scum drying beds. The design is to treat sewage produced by a total population of 10000 individuals.

3. CASE STUDY

Agulu being a huge town in Anambra State, Nigeria, is found in Anaocha Neighborhood Government Zone. Agulu is beneath the Anambra Central

Senatorial Area. It is domestic to the Agulu Lake. It is located at Latitude 6.11° or 6° 6' 36" north and Longitude 7.0724° or 7° 4' 21" east with elevation of 201 meters. It has a population of about 79000 individuals as at 2016. Agulu community has noticeable men and ladies in legislative issues, businesses, the scholarly community and the government. Agulu comprises twenty towns. These are: Nwanchi, Nneohia, Okpu, Ama-Ezike, Odidama, Amorji, Isiamaigbo, Ukunu, Uhueme, Obeagu, Obe, Nkitaku, Okpu-Ifite, Umubialla, Amatutu, Umuowelle, Umunnwu, Ifiteani, Umuifite, and Nneogidi.

4. METHODOLOGY

4.1 Population Forecast

The population of Okija was estimated to be about 13,898 in 2016 according to the Nigerian population commission, so therefore exponential growth method will be used to estimate the proposed population for the design.

Exponential growth method

Using; $P_n = P_c \times (t_2 - t_1)$

Where; P_n = expected population

P_c = population at current year = 13,898

k = growth rate = 4%

t_2 = future date = 2052

t_1 = initial date = 2016

$\therefore P_n = 13898 \times e^{0.04(2052 - 2016)}$

$$P_n = 58659$$

So therefore, taking the estimated total population for this design as 59000.

4.2 Volume of Sewage Generated.

In the next 3 decades, Okija is expected to have a population of approximately 59,000 individuals including children.

Assuming an individual consumes 150 liters of water per day,

Therefore, the total water supply per day will be;

$$\text{Water supply per day} = 59000 \times 150 = 8850000 \text{ or } 8.85 \text{ MLD}$$

$$\text{Average sewage generated} = 85\% \text{ of water supplied per day}$$

$$\text{Generated sewage} = 0.85 \times 8.85 \text{ MLD} = 7.523 \text{MLD or } 7523 \text{ m}^3/\text{day}$$

This brings the design volume to a total of approximately = 7.523 MLD or 7523m³/day.

5. DESIGN OF TRETMENT UNITS

Please see table 1.

Table 1 : Design of Tretment Units

s/n	CALCULATION	OUTPUT
4.1	<p>Design information Total estimated population in 30 years = 350000 Volume of sewage generated = 44.625MLD = 44625m³/day Average sewage generated per hour = = 1859.38m³/hr Assume peak factor = 2.25 Design flow capacity = average sewage generated × peak factor = 1859.38 × 2.25 = 4183.59m³/hr Design flow capacity in m³/sec = = 1.16m³/sec</p>	1.16m ³ /sec
4.2	<p>Design of receiving tank Assume retaining time of 3hrs, Capacity of receiving tank = 3 × 1859.38 = 5578.125m³ Assume depth(d) of 8m; ∴ Area of receiving tank = = = 697.27m² Since; L:W = 2:1 L = 2W ∴ A = L x W W = L = 37.34m Check; Volume designed ≥ volume required Volume designed = 37 8 = 5624m³ Volume requied = 5578.125m³ Since; 5624 > 5578.125, therefore the design and the assumed values are correct.</p>	L (37) m ³
4.3	Design of Coarse screen	

	<p>Peak discharge = $1.16\text{m}^3/\text{sec}$ Assume maximum velocity = 0.7m/s \therefore Channel cross section (A_c) = 1.68m^2 Given; $A_c = d \cdot w$ $1.68 = 1.5w^2$ $w =$ $d = 1.06 \cdot 1.5 = 1.59\text{m}$ Assume $\therefore A_s = m^2$ $A_{net} = A_s$ Assume; spacing(s) = 3cm Thickness of bars (t) = 1cm $A_{net} = 3.36 \cdot 2.52\text{m}^2$ Check; $V_a A_c = V_b A_{net}$ $\therefore V_b = 0.47\text{m/s}$ Since V_b is less than 0.9 which is the allowable maximum velocity for any screen chamber in a STP, then the design is ok.</p> <p>Number of bars in the coarse screen(n) is gotten by; $w = nt + (n-1)s$ $n(1) + (n - 1)(3) = 1.06\text{m} = 106\text{cm}$ $n =$ therefore a total of 28 bars are required for the coarse screen.</p>	<p>n=28 bars</p>
<p>4.4</p>	<p>Design of Grit Chamber Peak discharge = $1.16\text{m}^3/\text{sec}$ Assume detention time of 2min (120seconds) Aerated volume = peak discharge \cdot detention time Aerated volume = $1.16 \cdot 120 = 139.2\text{m}^3$ Design 2 grit chambers for this STP. \therefore 3 volume of each chamber Therefore; $w:d = 2:1$ Assume depth of 4m Then width = 8m Length = 2.175m</p>	<p>L x w x d 2.175 x 8 x 4</p>

		m³
4.5	<p>Design of Primary Sedimentation tank Average sewage generated = 1859.38m³/hr Assume detention time of 1hrs Volume of sewage = sewage generated detention time Volume of sewage = 244.375 = 1859.38m³ Assume, Depth(d) = 5m Volume = r²d ∴ r = 10.88m Diameter(D) = 21.76m = 22m</p>	<p>∴ Diameter(D) × depth(d) 22 × 5</p>
4.6	<p>Design of Aeration tank Number of tanks = 3 Design flow = 44625m³/day = 1859.38m³/hr Average flow for each tank = 14875m³/day Assume BOD at inlet to be 300mg/l. Bod to be treated = 80% of 300 = 240mg/l Maximum efficiency of Aeration tank = 91.67% Assume; MLSS = 4000ppm, Using; m³ Assume depth(d) = 8m Since; Width(w) = 2.2 × 8 = 17.6m Length(L) = 15.85m check; Hydraulic retention time (HRT) = 24hrs = hrs Since HRT is between 3 – 6 hours, then the design is valid.</p>	<p>L x w x d 16 x 18 x 8 m³</p>
4.7	<p>Design of Secondary Sedimentation tank Design flow = 44625m³/day Assume Recirculated flow of 53% = 0.50 × 44625 = 22312.5m³/day ∴ Total inflow = 44625 + 22312.5 = 66937.5m³/hr Assume Hydraulic retention time of 1hrs Volume of tank = 66937.5m³ Assume d = 8m Area of secondary sedimentation tank(A₁) = 348.6m² Surface loading rate at average flow = 25m³/m²</p>	

	<p>Area of secondary sedimentation tank(A_2) = = 1785m^2 Since $A_2 > A_1$; then value of A_2 will be used to determine the diameter of the secondary sedimentation tank. $A_2 = r^2$ $r = = 23.84\text{m}$ \therefore Diameter(D) = 47.67m Check for weir loading; Weir loading = = $297.98\text{m}^2/\text{day}$ Check for solid loading; Total solid flow = total in flow MLSS = 66937.55×4 = 267750 kg/day Solid loading rate = 149.99 Since the solid loading rate is greater than 100 and less than 150, then the design is valid.</p>	
<p>4.8</p>	<p>Design of sludge drying bed Assume amount of sludge to be 100kg/MLD \therefore Sludge generated = $44.625 \times 100 = 4462.5\text{kg/day}$ Solid content = 2% Specific gravity = 1.015 Volume of sludge tank = = $219.83\text{m}^3/\text{day}$ Number of cycles per year = = $36.5 = 37$ cycles Volume of sludge per cycle = $219.83 \div 10 = 2198.3\text{m}^3$ Assume 0.3m/ cycle Area of sludge drying bed = $\frac{\text{Volume}}{\text{Depth}}$ Provide 10 sludge drying beds; Area of each bed = = 732.77m^2 Therefore, $L = 39\text{m}$ 19m</p>	<p>L = 39m 19m</p>

6. CONCLUSION

Discussions and Conclusions:

- 1- Design of sewage treatment plant (STP), is profoundly impacted by the populace Density, populace development and Industrialization.
- 2- Design parameters for each unit was carefully calculated or estimated with legitimate checks and units.
- 3- In this venture the populace thickness utilized was "350,000" capita, which brought about in huge sum of created sewage and included bowls were utilized.
- 4- In expansion to physical, chemical, and organic treatment forms, there's an progressed treatment utilized to expel those constituents, that are not satisfactorily expelled by the past strategies of treatment, and the delivered water can be utilized for cooling and for a few businesses.
- 5- Disinfection unit may too be included to this outlined extend to induce higher water quality.

REFERENCE

- Andersson, K., Rosemarin, A., Lamizana, B., Kvarnström, E., McConville, J., Seidu, R., Dickin, S. and Trimmer, C. (2016). *Sanitation, Wastewater Management and Sustainability: from Waste Disposal to Resource Recovery Archived 2017-06-01 at the Wayback Machine*. Nairobi and Stockholm: United Nations Environment Programme and Stockholm Environment Institute. ISBN 978-92-807-3488-1, p. 56
- Aswathy. M, Hemapriya,(2017). “*Analysis and design of Sewage Treatment Plant of Apartments in Chennai*”, India, Vol 6(5) pp7-13,.
- Chris Merin Varghese, Anila Tresa Roy, Himasree B, Reeba Mariam Sabu, Srinjitha Sreekumar (2021), Design of Sewage Treatment Plant at Medicity Hospital. Volume: 08 Issue: 08 p-ISSN: 2395-0072.
- Bharathi Bhattu, Prof. Murthy Polasa (P.E.),(2014). Design of Sewage Treatment Plant for a Gated Community. Vol. 3 Issue 4, ISSN: 2278-0181
- Behzadian, k; Kapelan, Z (2015). "Advantages of integrated and sustainability-based assessment for metabolism based strategic planning of urban water systems" (PDF). *Science of the Total Environment*. 527–528: 220-231.
- Benujah B.R, Mrs.G.Devi,(2009). “*Site Suitability Evaluation for Sewage Treatment plant in Nager Coil Municipality ,tamilnadu using Remote Sensing Techniques*”, India. Vol 5(1); pp 20-33.
- B.C.Punmia, Arun Kumar Jain & Ashok Kumar Jain, Environmental Engineering Volume-II (Wastewater),Laxmi Publications Pvt Ltd, 1998 edition, pp 256-259.
- C.C. Lee, S.D. Lin, *Handbook of Environmental Engineering Calculations*", 2nd ed, McGraw Hill, 2007, Pages 1.418-1.510.

- Collins, Meg. "*The Infamous Toilet Lock*". Lucie's List. Retrieved 24 August 2021.
- Central Public Health and Environmental Engineering Organization & Japan International Cooperation Agency. (2012). *Manual on sewerage and sewage treatment. Part A(Final draft)*. New Delhi: Author.
- Duttle, Marsha (January 1990). "*NM State greywater advice*". *New Mexico State University*. Archived from the original on 13 February 2010. Retrieved 23 January 2010.
- Dr.B.C Punmia, Er.Ashok k.Jain, Dr.Arun k.Jain “*Waste water engineering*” ,laxmi publications(p) ltd, jodhpur,1996.
- D.S.Munasinghe, P.G.R.N.I. Pussella, M.D.E.K, Gunathilaka, “*Integration of GIS and AHP for suitable site selection of Domestic waste water Treatment Plant: A case study of Akkaraipattu Municipal Council*”, Srilanka, 2015.
- Farid Ansari & Yashwant K. Pandey (2013), *Conceptual Design of a Wastewater Treatment Plant for the Dera Bassi Industrial Estate, Punjab (India)*. Volume 13 Issue 4 Version 1.0.
- G.Elangovan 1& V.M. Rajanandhini. (2019). *Analysis and Design of Sewage Treatment Plant: A Case Study Atnagore*. 1(6); 543-552.
- Garg S.K, (2010). *Sewage Disposal and Air Pollution Engineering*, 23rd ed., Khanna Publisher.
- G.S.Birdie&J.S.Birdie, *Water Supply and Sanitary Engineering*, Jain book depot, 9thedition.
- Henze, M.; van Loosdrecht, M. C. M.; Ekama, G.A.; Brdjanovic, D. (2008). *Biological Wastewater Treatment: Principles, Modelling and Design*. IWA Publishing. doi:10.2166/9781780401867. ISBN 978-1-78040-186-7.
- Ibezue Victoria C. (2018). *Levels of Concentration of Heavy Metals in Ulasi River, Okija Anambra State Nigeria*. Vol. 9(2); 11 – 22.

- Jones, Edward R.; van Vliet, Michelle T. H.; Qadir, Manzoor; Bierkens, Marc F. P. (2021). "Country-level and gridded estimates of wastewater production, collection, treatment and reuse". *Earth System Science Data*. 13 (2): 237–254. Bibcode:2021ESSD...13..237J. doi:10.5194/essd-13-237-2021. ISSN 1866-3508.
- Karrman. E. (2001) *Strategies towards sustainable wastewater management. Urban Water.*;3(1-2):63-72
- Khopkar, S.M. (2004). *Environmental Pollution Monitoring And Control. New Delhi: New Age International*. p. 299. ISBN 978-81-224-1507-0.
- M. Bhargavi, E. Ananta Rao, T. Pravallika & Y. Sri Teja. (2018). *Analysis and Design of Sewage Treatment Plant: A Case Study on Vizianagaram Municipality*. 5(4), 23-28.
- Mr.Chakor Bushan D, Mr.Kolhatkar Servesh H, Mr. Rathod Govind U, Mr.Trimbaka Dhiraj, "Design of Sewage Treatment Plant for Lottegaon Village", Pune, India, Volume No4, 2017.
- Von **Sperling, M.** (2015). "Wastewater Characteristics, Treatment and Disposal". *Water Intelligence Online*. 6. doi:10.2166/9781780402086. ISBN 9781780402086. ISSN 1476-1777.
- World Health Organization (2006). *Guidelines for the safe use of wastewater, excreta, and greywater*. World Health Organization. p. 31. ISBN 9241546859. OCLC 71253096.
- *Wastewater engineering: treatment and reuse*. George Tchobanoglous, Franklin L. Burton, H. David Stensel, Metcalf & Eddy (4th ed.). Boston: McGraw-Hill. 2003. ISBN 0-07-041878-0. OCLC 48053912.