Journal of Engineering Research and Reports

Volume 24, Issue 4, Page 1-7, 2023; Article no.JERR.95946
ISSN: 2582-2926

The Design of Sewage Treatment Plant for Agulu Community, Nigeria

N. C. Mmonwuba [a*], Ezenwaka Patrick [a] and Chukwu Elochukwu Caleb [a]

[a] *Department of Civil Enginnering, Chukwuemeka Odumegwu Ojukwu University, Uli, Anambra State, Nigeria.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JERR/2023/v24i4808

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/95946

Original Research Article

Received: 03/12/2022
Accepted: 09/02/2023
Published: 15/02/2023

ABSTRACT

There are two basic reasons for the treatment of sewage, reuse and proper control of wastewater and water pollution, and safeguarding the public and environmental health by protecting water supplies and preventing the spread of waterborne diseases. Proper design, and construction together with good operation and maintenance are important authorities. In the present study, a comprehensive design was developed for the units of Inlet chambers for sewage treatment plants, to produce effluents which are satisfying the safe disposal or reuse prescribed by the regulatory, 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 surface water like the Agulu lake and also groundwater, while also providing clean effluent for disposal that can be further treated for consumption.

**Corresponding author: Email: nwannekammonwuba@yahoo.com;*

Keywords: Design; sewage; treatment plant; Nigeria.

1. INTRODUCTION

A fluid waste of household or Industrial roots that is "Foul" in nature and comprises 99.9% water is called sewage [1]. Sewage can be treated in a sewage treatment plant by collecting all the sewage through the sewerage system and then treating the sewage in different stages that remove some percentage of pollutants from the water [2-6]. The Treatment handle includes an arrangement of treating units that are categorized beneath primary (mechanical) treatment, biological (secondary) treatment, and tertiary (sanitization) treatment [7-10].

According to Premium times, Anambra state government plan to spend 2.5 billion nairas on the 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 the quantity of wastewater produced on daily basic [11-15]. In the current state, the town of Agulu with a population of about 79000 (2016) still produces a lot of wastewater, and the drainage system is very bad and unreliable.

Egboka et al. [16] 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 runoff 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 [17,18].

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 [19-23]. The affluent will act as an additional source of water for the people of Agulu. Also, Sewage treatment creates sewage sludge which can be treated before secure transfer or reuse. The sludge gotten from the STP is often regarded as "biosolids" and can be utilized as a fertilizer [24-30].

2. LITERATURE REVIEW

According to Swati Shree, 2016, the Metro satellite has gotten to be a vital complex region close to the put Palasuni of Bhubaneswar. As the 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 producing 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. STUDY AREA

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 Agulu Lake. It is located at Latitude 6.11° or 6° 6' 36" north and Longitude 7.0724° or 7° 4' 21" east with an elevation of 201meters. It has a population of about 79000 individuals as of 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, Umunnowu, 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;

Pn = Pc × $(t2-t1)$

Where;

Pn = expected population
Pc = population at current year =13,898
k = growth rate = 4%
t_2 = future date = 2052
t_1 = initial date = 2016

:. P_n = 13898 × e0.04(2052 - 2016)

P_n = 58659

So, therefore, taking the estimated total population for this design is 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;

Water supply per day = 59000 × 150 = 8850000 or 8.85 MLD

Average sewage generated = 85% of water supplied per day

Generated sewage = 0.85 × 8.85 MLD = 7.523MLD or 7523 m3/day

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

5. DESIGN OF TREATMENT UNITS

Table 1. Design of treatment units

S/N	Calculation	Output
4.1	**Design Information** Total estimated population in 30 years = 350000 Volume of sewage generated = 44.625MLD = 44625m^3/day Average sewage generated per hour = = 1859.38m^3/hr Assume peak factor = 2.25 Design flow capacity = average sewage generated × peak factor = 1859.38 × 2.25 = 4183.59m^3/hr Design flow capacity in m^3/sec = = 1.16m^3/sec	**1.16m^3/sec**
4.2	**Design of receiving tank** Assume a retaining time of 3hrs, Capacity of receiving tank = 3 × 1859.38 = 5578.125m^3 Assume depth(d) of 8m; ;. Area of receiving tank = = **=** 697.27m^2 Since; L:W = 2:1 L = 2W :. A = L x W W = L = 37.34m **Check;** Volume designed ≥ volume required Volume designed = 37 8 = 5624m^3 Volume requied = 5578.125m^3 Since; 5624 > 5578.125, therefore the design and the assumed values are correct.	**L** **(37)** **m^3**
4.3	**Design of Coarse screen** Peak discharge = 1.16m^3/sec Assume maximum velocity = 0.7m/s :. Channel cross-section (Ac) = = 1.68m^2	

S/N	Calculation	Output
	Given; Ac = d w $1.68 = 1.5w^2$ w = d = 1.06 1.5 = 1.59m Assume :. As = m^2 Anet = As Assume; spacing(s) = 3cm The thickness of bars (t) = 1cm Anet = 3.36 $2.52m^2$ **Check**; VaAc = VbAnet :. Vb = = 0.47m/s Since Vb is less than 0.9 which is the allowable maximum velocity for any screen chamber in an STP, then the design is okay. The number of bars in the coarse screen(n) is gotten by; w = nt + (n-1)s n(1) + (n - 1)(3) = 1.06m = 106cm n = therefore a total of 28 bars are required for the coarse screen.	**n=28 bars**
4.4	**Design of Grit Chamber** Peak discharge = $1.16m^3$/sec Assume detention time of 2min (120seconds) Aerated volume = peak discharge detention time Aerated volume = 1.16 120 = $139.2m^3$ Design 2 grit chambers for this STP. :. ^{3} volumes of each chamber Therefore; w:d = 2:1 Assume a depth of 4m Then width = 8m Length = = 2.175m	**L x w x d** **2.175 x 8 x 4 m^3**
4.5	**Design of Primary Sedimentation tank** Average sewage generated = $1859.38m^3$/hr Assume detention time of 1hrs The volume of sewage = sewage generated detention time Volume of sewage = 244.375 = $1859.38m^3$ Assume, Depth(d) = 5m Volume = r^2d :. r = = 10.88m Diameter(D) = 21.76m = 22m	**:. Diameter(D) × depth(d)** **22 × 5**
4.6	**Design of Aeration tank** Number of tanks = 3 Design flow = $44625m^3$/day = $1859.38m^3$/hr Average flow for each tank = $14875m^3$/day Assume BOD at the inlet to be 300mgl. Bod to be treated = 80% of 300 = 240mgl Maximum efficiency of Aeration tank = = 91.67% Assume; MLSS = 4000ppm, Using; m^3 Assume depth(d) = 8m Since; Width(w) = 2.2 8 = 17.6m Length(L) = = =15.85m **check;** Hydraulic retention time (HRT) = 24hrs= hrs	**L x w x d** **16 x 18 x 8**

S/N	Calculation	Output
	Since HRT is between 3 – 6 hours, then the design is valid.	**m^3**
4.7	**Design of Secondary Sedimentation tank** Design flow = 44625m^3/day Assume Recirculated flow of 53% =0.50 44625 =22312.5m^3/day :. Total inflow = 44625 + 22312.5 = 66937.5m3/hr Assume a Hydraulic retention time of 1hrs Volume of tank = = = 2789.06m^3 Assume d = 8m Area of secondary sedimentation tank(A_1) = = 348.6m^2 Surface loading rate at average flow = 25m^3/m^2 Area of secondary sedimentation tank(A_2) = = 1785m^2 Since A_2> A_1; the value of A2 will be used to determine the diameter of the secondary sedimentation tank. A_2= r^2 r = = 23.84m :. Diameter(D) = 47.67m **Check for weir loading;** Weir loading = = 297.98m^2/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.	
4.8	**Design of sludge drying bed** Assume the amount of sludge to be 100kg/MLD :. Sludge generated = 44.625 100 = 4462.5kg/day Solid content = 2% Specific gravity = 1.015 Volume of sludge tank = = 219.83m^3/day Number of cycles per year = =36.5 = 37 cycles Volume of sludge per cycle = 219.83 10 = 2198.3m^3 Assume 0.3m/ cycle Area of sludge drying bed = ^{2} Provide 10 sludge drying beds; Area of each bed = = 732.77m^2 Therefore, L = 39m 19m	**L = 39m 19m**

6. DISCUSSION AND CONCLUSIONS

The design of a sewage treatment plant (STP), is profoundly impacted by the populace density, populace development, and Industrialization. Design parameters for each unit were carefully calculated or estimated with legitimate checks and units. In this venture, the populace thickness utilized was "350,000" per capita, which brought about in huge sum of created sewage and included bowls utilized. In expansion to physical, chemical, and organic treatment forms, there's a 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 a few businesses. A disinfection unit may too be included to this outlined extent to induce higher water quality.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Bharathi Bhattu, Murthy Polasa P.E. Design of Sewage Treatment Plant for a Gated Community. 2014;3(4). ISSN: 2278-0181
2. Chris Merin Varghese, Anila Tresa Roy, Himasree B, Reeba Mariam Sabu, Srinjitha

Sreekumar. Design of Sewage Treatment Plant at Medicity Hospital. 2021;08(08). ISSN: 2395-0072.
3. Behzadian K, Kapelan Z. Advantages of integrated and sustainability based assessment for metabolism based strategic planning of urban water systems. Science of the total environment. 2015 Sep 15;527:220-31.
4. Benujah BR, Devi G. Site Suitability Evaluation for Sewage Treatment plant in Nager Coil Municipality, Tamil Nadu using Remote Sensing Techniques. India. 2009;5(1):20-33.
5. Punmia BC, Arun Kumar Jain, Ashok Kumar Jain. Environmental Engineering Volume-II (Wastewater),Laxmi Publications Pvt Ltd, 1998 edition;256-259.
6. Lee CC, Lin SD. Handbook of environmental engineering calculations. New York: McGraw-Hill; 2000.
7. Birdie GS, Birdie JS. Water Supply and Sanitary Engineering, Jain book depot, 9th edition.
8. Henze M, Van Loosdrecht MCM, Ekama GA, Brdjanovic D. Biological Wastewater Treatment: Principles, Modelling and Design. IWA Publishing; 2008. DOI: 10.2166/9781780401867. ISBN 978-1-78040-186-7.
9. Ibezue Victoria C. Levels of Concentration of Heavy Metals in Ulasi River, Okija Anambra State Nigeria. 2018;9(2):11– 22.
10. Jones ER, Van Vliet MT, Qadir M, Bierkens MF. Country-level and gridded estimates of wastewater production, collection, treatment and reuse. Earth System Science Data. 2021;13(2):237-54.
11. Andersson K, Rosemarin A, Lamizana B, Kvarnström E, McConville J, Seidu R, Dickin S, Trimmer C. 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. 2016;56. ISBN 978-92-807-3488-1
12. Aswathy M, Hemapriya. Analysis and design of sewage treatment plant of apartments in Chennai. India. 2017;6(5): 7-13.
13. Collins, Meg. "The Infamous Toilet Lock". Lucie's List. Retrieved 24 August 2021.
14. Central Public Health and Environmental Engineering Organization & Japan International Cooperation Agency. Manual on sewerage and sewage treatment. Part A(Final draft). New Delhi; 2012.
15. Duttle, Marsha. NM State greywater advice. New Mexico State University; 1990. Archived from the original on 13 February 2010. Retrieved 23 January 2010.
16. Egboka BC, Nfor BN, Banlanjo EW. Water Budget Analysis of Agulu Lake in Anambra State, Nigeria. Journal of Applied Sciences and Environmental Management. 2006; 10(3):27-30.
17. Van de Poel I. The bugs eat the waste: What else is there to know? Changing professional hegemony in the design of sewage treatment plants. Social Studies of Science. 2008;38(4):605-34.
18. Bhargavi M, Rao EA, Pravallika T, Teja YS. Analysis and Design of Sewage Treatment Plant: A Case Study on Vizianagaram Municipality. SSRG International Journal of Civil Engineering. 2018;5(4).
19. BC Punmia, Er. Ashok K. Jain, Arun k. Jain. Waste water engineering. Laxmi publications(p) ltd, Jodhpur; 1996.
20. Munasinghe DS, Pussella PG, Gunathilaka MD. Integration of GIS and AHP for Suitable Site Selection of Domestic Wastewater Treatment Plant: A Case Study of Akkaraipattu Municipal Council. In Proceedings of International Forestry and Environment Symposium. 2015;20.
21. Ansari F, Pandey YK. Conceptual Design of a Wastewater Treatment Plant for the Dera Bassi Industrial Estate, Punjab (India). Global Journal of Science Frontier Research Environment & Earth Science. 2013;13(4):1-0.
22. Elangovan G. Rajanandhini VM. Analysis and Design of Sewage Treatment Plant: A Case Study Atnagore. 2019;1(6):543-552.
23. Garg SK. Sewage Disposal and Air Pollution Engineering, 23rd ed., Khanna Publisher; 2010.
24. Kärrman E. Strategies towards sustainable wastewater management. Urban Water. 2001;3(1-2):63-72.
25. Khopkar SM. Environmental pollution monitoring and control. New Age International; 2007.
26. Bhargavi M, Rao EA, Pravallika T, Teja YS. Analysis and Design of Sewage Treatment Plant: A Case Study on Vizianagaram Municipality. SSRG International Journal of Civil Engineering. 2018;5(4).

27. Chakor Bushan D, Kolhatkar Servesh H, Rathod Govind U, Trimbaka Dhiraj. Design of Sewage Treatment Plant for Lottegaon Village, Pune, India. 2017;4.
28. Von Sperling M. Wastewater characteristics, treatment and disposal. Water Intelligence Online. 2015;6.
DOI: 10.2166/9781780402086
ISBN 9781780402086
ISSN 1476-1777
29. World Health Organization. Guidelines for the safe use of wastewater, excreta, and greywater. World Health Organization. 2006;31. ISBN 9241546859. OCLC 71253096.
30. 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.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/95946