World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(Research Article)

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Study of the sizing of a fecal sludge treatment station in the town of Kissidougou (Republic of Guinea)

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World Journal of Advanced Research and Reviews, 2024, 22(01), 322–328

Publication history: Received on 24 February 2024; revised on 02 April 2024; accepted on 05 April 2024

Article DOI: https://doi.org/10.30574/wjarr.2024.22.1.1071

Abstract

The management of fecal sludge is a concern for cities in Guinea such as the city of Kissidougou. This study aims to evaluate the feasibility of setting up a fecal sludge treatment station at the Songbo public landfill, 3 km from the city center of Kissidougou.

The methodology adopted for this study is based on: the choice and installation site of the treatment structure, the determination of the geometric parameters of the station, the identification of construction materials and the estimation of the cost of carrying out the the work. For this reason, the upstream hypotheses were defined and the analytical formulas were used.

The emptying flow produced by the urban municipality is estimated at 176 m^3/day of materials. The volumes of these works are: optional basin (1300 m^3); anaerobic pond (384 m^3) and maturation pond (1828 m^3). The investment cost of building the station amounts to 25 301 546 000 GNF over a requested area of 2 hectares.

However, before the establishment of these stations, the Guinean government, through state structures, should carry out preliminary actions to raise awareness among all stakeholders in the sector and regulate it in order to be able to perpetuate this study project.

Keywords: Faecal Sludge; Treatment Station; Anaerobic Ponds; Facultative and Maturation

1. Introduction

While the problem of liquid sanitation is already well mastered in most industrialized countries, it still remains a real challenge to overcome in developing countries. In Africa, only 45% of the population has sanitation facilities and 62% of Africans do not have access to adequate sanitation facilities [1]. In these countries, liquid sanitation still constitutes a major public health problem and an important environmental issue [2]. The impacts of wastewater treatment on the living environment, the health and well-being of populations as well as the preservation of natural resources no longer need to be demonstrated. There is a relationship between treatment and proper disposal of excreta and the spread of gastrointestinal diseases [3].

In general, most African cities, particularly in Guinea, have the majority of the population using individual excreta disposal facilities (traditional latrines and improved latrines). However, a large part of the fecal sludge produced,

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collected and evacuated either manually or mechanically in these cities is not subject to any evaluation or treatment. And also, we witness the abundant dumping of sludge in the open air in the middle of the bush, in wastelands or used in the fields without treatment or randomly in the alleys, gutters, estuaries, the sea or the river courses. water) [4].

In Guinea, very few studies have focused on evaluating the methods of emptying, collecting and treating this sludge, unlike in other countries. This situation leads to a continued spread of lung diseases, gastrointestinal diseases that cannot be mentioned and to great environmental pollution, which would contribute to the promotion of greenhouse gases in our cities [2]. The Guinean state, through its foreign financial partners, must set up a program for the installation of treatment centers and waste management, but above all the installation of wastewater treatment stations. and fecal sludge in good numbers within the country [3].

Thanks to this future program, our country will carry out many autonomous type works and several public buildings for a very consistent investment of billions of our francs, spread over a well-defined period. It should also be emphasized that these future installations will certainly produce significant quantities of sludge, fumes and they can even be a source of income for our communities and employment for unemployed youth [5]. It is for this reason that it is important to sound the alarm to fight against poor sludge management and improve the living environment by building a fecal sludge treatment plant in order to avoid exposing populations to numerous nuisances and diseases caused by the incomplete system at the environmental and public health level.

2. Materials and Method

2.1. Study framework

Kissidougou is located approximately 600 km from the capital Conakry, in the administrative region of Faranah, and in the natural region of Forest Guinea. In Kissidougou and Gueckedou we mainly speak: kissi, mandinka, lele, kouranko, etc. Kissidougou prefecture is an area with significant precipitation of 1083.9 mm of water per year. The dry season lasts from November to March. The average annual temperature in Kissidougou is 26.2°C. The population of the urban commune of Kissidougou in 2016 is estimated at 110000 inhabitants, to date it is estimated at nearly 160000 inhabitants. The construction site of the wastewater treatment plant is at the Songbo public landfill, 3 km from the city center of Kissidougou, on the road to the Yombiro sub-prefecture. Songbo is a sector of the Missira district, it covers an area of 800 m^2 [6].

2.2. Methodology

The methodology adopted for this study is based on: the choice and installation site of the treatment structure (study framework), the determination of the geometric parameters of the station, the identification of construction materials and the estimate of the cost of carrying out the work. For this, the upstream hypotheses will be defined and the analytical formulas will be used.

2.2.1. Assumptions upstream of determining the geometric parameters of the station

The hypotheses upstream of determining the geometric parameters of the station are [7, 8]: Average study temperature (T= 25 °C); Number of pools for each category (N = 1); Anaerobic pool depth (H = $3m$); Optional pool height (H = $1.5m$); Basin slope slope (n = 1); Retention time (5 days); Revenge (r = 0.5 m); Length/width ratio ((L/l =3); Clogging coefficient due to faecal sludge for manual cleaning (C = 0.3); Supernatant flow rate (Qs = 80% × Q); Reduction yield of the BOD_5 at the level of the biodigesters ($RDBO_5$ = 60%); Average BOD_5 concentration is determined in the laboratory; Free spacing between (e=15 mm) and bar (b=10 mm) and Speed of passage of sludge between the bars for a manual cleaning (V=1m/s).

2.2.2. Geometric parameters of the station

The geometric parameters of the different compartments of the fecal sludge treatment station are given in table 1.

Table 1 Station sizing parameters [9, 10]

Parameters	**Symbol**	**Formulas**	**Unit**
Anaerobic pond			
Volume load	C_v	$T + 100$	gDBO5/m^3.j
Daily amount of DBO_5	M_{DBO5}	$Q \times C_m$	kg/j
Daily BOD5 load in the anaerobic basin	C_{DBO5}	40% ×$MDBO_5$	kg/j
Anaerobic pool volume	V_a	$\frac{CDBO_5}{Cv}$	m^3
Surface at mid-depth of the anaerobic basin	S_a	$\frac{V_a}{H}$	m^2
Residence time	Ts	$\frac{V_a}{Qs}$	j
Optional pool			
Rate of BOD5 eliminated in the anaerobic basin	RDBO5	$2 \times T + 20$	%
Surface load	C_s	$350 \times (1.107 - 0.002T)^{-25}$	kgDBO5/ha.j
Supernatant flow	Q_s	$80\% \times Q$	m^3/j
Daily mass of BOD_5 in the facultative basin	C_{DBO5}	$\left(1 - \frac{RDBO_5}{100}\right) \times MDBO_5$	kg/j
Surface at mid-depth of optional pool	S_{bf}	$\frac{CDBO_5}{Cs}$	m^2
Optional basin volume	V_{bf}	$S_{bf} \times H$	m^3
Residence time	Ts	$\frac{V_{bf}}{Qs}$	j
Maturation basin			
Kinetic constant	K_b	$2.6 \times (1.19)^{-20}$	-
Supernatant flow	Q_s	$70\% \times Q$	m^3/j
Volume of the maturation basin	V_m	$T_r \times Q_s$	m^3
Mid-depth surface of the Maturation Basin	S_m	$\frac{Vm}{H}$	m^2
Parameters common to different basins (anaerobic, facultative and maturation)			
Raw flow	Q	$Q_{mena} + Q_{mine}$	m^3/j
Width at mid-depth of the pool	l	$\sqrt{\frac{Sa}{2}}$	m
Length at mid-pelvis depth	L	$2 \times l$	m
Bottom length	L_f	$L - n \times H$	m
Bottom width	l_f	$l - n \times H$	m
Bottom surface	S_f	$L_f \times l_f$	m^2
Top length	L_{sup}	$L + n \times (H + 2 \times R)$	m
Top width	l_{sup}	$l + n \times (H + 2R)$	m

Upper surface of the basin	S_{sup}	$Lsup \times lsup$	m^2
Screen settings			
Truck opening diameter	D	0.15	m
Truck opening surface	S	$\pi \times \frac{D^2}{4}$	m^2
Maximum speed when exiting the truck	V_m	4	m/s
Drain flow	Q_p	$S \times Vm$	m^3/s
Useful surface	S_u	$\frac{Q_p}{V_p}$	m^2
Wet section	S_m	$\frac{Su}{\theta(1 - C)}$	m^2
Clogging coefficient due to the size of the bars	θ	$\frac{e}{e + b}$	-

3. Results and discussions

Based on the assumptions and applying the formulas in Table 1, we obtain the dimensions of the structures of the proposed treatment plant (Table 2). The external dimensions for the cut are given in Table 3.

3.1. Treatment station structures

Table 2 Dimensions of the treatment station structures

N°	Sizes	Symbols	Units	Facultative basin	Anaerobic basin	Maturation basin
1	Area	S	m^2	867	192	1219
2	Volume	V	m^3	1300	384	1828
3	Depth	H	m	1,5	2,5	1
4	External length	L_{ext}	m	60	33	70
5	Interior length	L_{int}	m	51	24	61
6	Exterior width	l_{ext}	m	20	11	23
7	Interior width	l_{int}	m	11	2	14
7	Retention time	T	h	7	2	10

3.2. Exterior dimensions for excavation

Table 3 Exterior dimensions for excavation

N°	Sizes	Symbols	Units	Facultative basin	Anaerobic basin	Maturation basin
1	Wall thickness	e	m	0.10	0.10	0.10
2	Depth	h	m	2	2.1	1.5
4	Exterior length	L_{ext}	m	52.2	24.2	70.2
6	Exterior width	l_{ext}	m	11.2	2.2	23.2
7	Revenge	a	m	0.5	-	0.5

The dimensions of the works of the faecal sludge and wastewater treatment station at the Songbo site in Kissidougou represent a good database for very precise sizing on a community scale. The volumes of these works are: optional basin (1300 m^3); anaerobic pond (384 m^3) and maturation pond (1828 m^3).

3.3. Execution plan of the station works

The execution plan of the station works is shown in Figure 1.

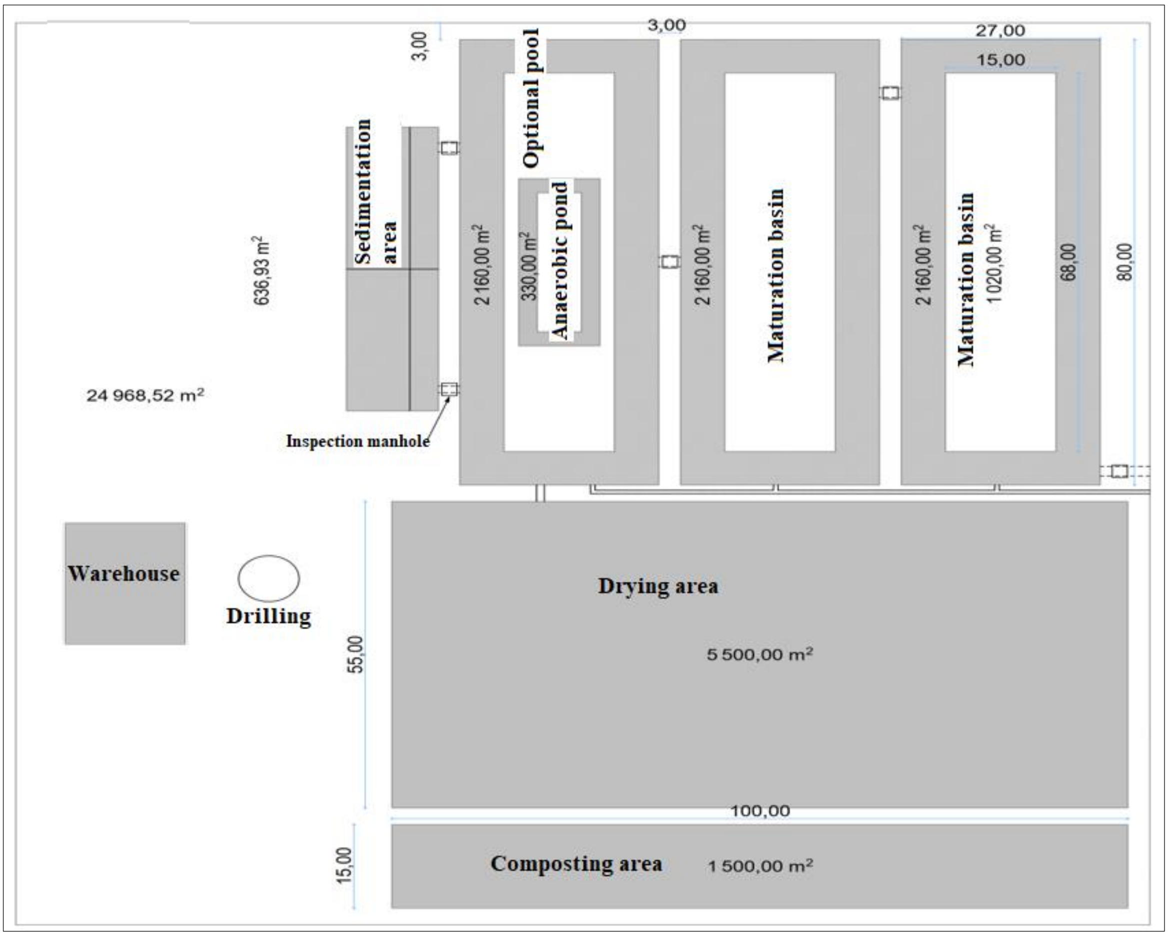

Figure 1 Execution plan of the station works

3.4. Station construction costs

Construction costs were calculated for the treatment line to be installed on the Songbo site and which must treat a flow rate of 176m^3/d of waste materials produced by the urban municipality.

Table 4 Estimated cost estimate for the construction of the station basins

N°	Designation	Amount (GNF)
1	Construction of Basins	2 218 458 000
2	Construction of a chain link fence	1 13 630 000
3	Drilling castle and solar pump	121 530 000
4	Construction of store and guard’s accommodation	76 536 600
Total		2 530 154 600

Estimating the costs of the station is necessary to be able to find financing for the project. These are construction, equipment and operating costs. The investment cost of the complete station receiving a daily flow of 176 m^3/d amounts to 2530154600 GNF and for the establishment of the station, the area requested is approximately 2 ha. Unlike the study carried out by Koffi Serge Kablan in Abidjan in 2015. [11, 12]. In Houndé, the study carried out by Bintou Sylla in 2019, notes that for an average volume of 23.78 m^3/d, the cost of implementing the station amounts to 77623439 FCFA and the area of land necessary for it implantation of the station is 0.25 hectare [13, 14].

The present study is a contribution to the management of fecal sludge, which allows a reduction in the risk of diseases due to illegal dumping of fecal sludge. Carrying out this project is financially advantageous because it ensures a collection rate and it effectively contributes to improving the living environment of the Kissidougou populations.

4. Conclusion

It emerges from this investigation that the installation of a treatment center (wastewater treatment station, drying beds) or installation of digesters (anaerobic treatment) of the city's solid and liquid waste could be used to satisfy the needs of the city part of the energy needs of communities, as well as the production of compost for agriculture and in particular in large cities for market gardening.

The treatment of fecal sludge using the anaerobic digestion method would reduce the production of greenhouse gases in the city of Kissidougou; this treatment technique could help in the sanitation of cities, the reduction of water and atmospheric pollution, corollaries of the health of populations and also generate income for communities.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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