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Contribution to the Management of Fecal Sludge in the Urban Commune of Mamou (Republic of Guinea)

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Abstract: In the town of Mamou, all homes with sanitation systems are equipped with autonomous installations not connected to a sewer network. The emptying service is provided by manual emptiers and by the living environment and sanitation service of the urban municipality which has a single 6 m^3 truck. The objective of this work is to determine the quantity of fecal sludge produced within the city for sustainable management. The methodology adopted is based on a field survey and the use of three methods for evaluating the quantities of sludge (specific production, quantity of sludge collected by the sludge truck and the total production of sludge produced in the various sludge works). The results obtained show that, out of the 2,940 sanitation works identified, 2,936 works have been emptied at least once since their construction. Then 2,307 structures are emptied manually or 78.57%, against; 619 structures emptied mechanically or 21.08%. The structures are emptied on average every 3 years for septic tanks and every 5 years for dry latrines. The specific production of sludge is 685,241,532 m^3/year; the production of sludge by the mechanical emptying technique varies from 588,641.57 m^3/year to 724,800.46 m^3/year and the production of sludge by manual emptying is 1,573,709.33 m^3/year, for a total quantity of sludge produced including between 2,162,350 m^3/year to 685,241,531.9 m^3/year.

Key words: Management, fecal sludge, sanitation, specific production, Mamou.

1. Introduction

The sanitation needs of more than 2.7 billion people worldwide are covered by non-collective sanitation systems, a figure expected to reach 5 billion by 2030. Rapid population growth in developing and developing countries in the multiplication of residential areas increases the need for urban sanitation [1, 2]. The sanitation sector in developing countries is a complex area, interacting with other sectors, notably: water supply, town planning and housing, territorial administration, public health, environmental protection, etc. [3].

Faecal sludge is a mixture of feces, urine and water of varying consistency collected by on-site sanitation systems or not connected to the sewer network. Their color varies from dark brown to black. Black faecal sludge or stable sludge comes from septic tanks. Brown sludge is called putrefying and comes from public toilets or family latrines emptied every year or every two years or even more [4].

In Guinea, the sanitation subsector is by far the least developed. Individual on-site sanitation is almost the only method used and 2/3 of households use latrines, the majority of which are uncovered for 44.4% of the population. These facilities consist of latrines or septic tanks. When they are filled, their contents are emptied most often by manual emptiers who are found next to homes with all the risks or by emptying tanks. These emptying services, essential to improve the quality of the living environment, are not neither planned nor regulated by the authorities [5]. Sanitation brings together all concerns related to the collection and treatment of liquid, solid or gaseous waste (effluents) from residents and their activities, whether domestic or economic [6].

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The management of human excreta or fecal sludge is subdivided into three links: the upstream link consisting of the emptying of pits, the intermediate link consisting of the evacuation and transport of sludge, and the downstream link relating to landfill, the treatment or recovery of collected sludge. Determining or estimating the quantity produced in sanitation works remains essential before planning improved management or valorization of fecal sludge at the municipal, prefectural, regional or national scale [7].

This study is part of this dynamic. Its main objective is to contribute to the management of fecal sludge in the urban commune of Mamou.

2. Materials and Methods

2.1 Description of the Study Area

Located 275 km from Conakry, the town of Mamou is between 9°54′ and 11°10′ north latitude and 11°25′ and 12°26′ west longitude. It covers an area of 2,350 km^2 with a population of 81,992 inhabitants, or an average density of 35 inhabitants per km^2. It is made up of 28 urban and peri-urban districts, limited: to the east by the sub-prefecture of Dounet; to the west by the sub-prefecture of Konkouré; to the north by the sub-prefecture of Boulivel; to the south by the sub-prefecture of Soya. Its climate is Foutanian type, characterized by the alternation of two seasons of equal duration, a dry season from November to April and a rainy season from May to October [8]. The different types of existing structures in Mamou are: traditional latrines, VIP double pit latrines and manual flush toilets.

2.2 Methods

The different stages of this study concern: the development of survey sheets and the identification of sanitation works. Several methods are used for the quantification of fecal sludge [9, 10]. The first method involves determining the specific quantity of fecal sludge produced.

The specific quantity of sludge produced Q (m^3/year) is determined by Eq. (1).

$$Q = 365 \times (P_{FS} \times \frac{q_{FS}}{1000} + P_{LS} \times \frac{q_{LS}}{1000}) \quad (1)$$

With: P_{FS}: septic tank users; P_{LS}: users of dry latrines; q_{FS}: specific production of fecal sludge for septic tanks; q_{LS}: specific production of fecal sludge for dry latrines.

The second method makes it possible to evaluate the quantity of sludge collected by the emptying truck. This quantity of sludge drained Q_{mec} (m^3/year) is determined by Eq. (2).

$$Q_{mec} = \frac{P_{mec} \times N}{F_{mec}} \times v \times \eta \quad (2)$$

N: oautonomous sanitation works emptied in the town of Mamou; P_{mec}: proportion of structures drained mechanically; F_{mec}: mechanical drain emptying frequency; V: average volume of sludge drained per structure; η: number of rotations required to empty a sanitation facility

The third method makes it possible to evaluate the sludge produced in sanitation works. This quantity of sludge produced Q (m^3/year), in sanitation works is determined by Eq. (3) [11].

$$Q = Q_{mec} + Q_{man} \quad (3)$$

$$Q_{mec} = \frac{P_{mec} \times N}{F_{mec}} \times V \quad (4)$$

$$Q_{man} = \frac{P_{man} \times N}{F_{man}} \times V \quad (5)$$

Q_{man}: quantity of sludge drained manually; P_{man}: proportion of structures emptied manually; F_{man}: average frequency of manual draining; V: average volume of sanitation works in Mamou.

The average emptying frequencies and the portions of structures emptied mechanically and manually come from the results of surveys of different households.

3. Results and Discussions

3.1 Results

3.1.1 Specific Production of Sludge

The specific sludge production is given in Table 1.

This table shows the number of inhabitants who use each type of latrine (traditional and VIP improved) and the sum of users of these types of latrines constitutes

users of dry latrines. Dry latrines consist of traditional and VIP improved latrines. Other residents use septic tanks. Thus, the specific production (Q) of sludge given in the table is determined by (Eq. 1).

3.1.2 Production of Sludge during Mechanical Emptying

The production of sludge in mechanical emptying in the town of Mamou is summarized in Table 2. The production of sludge by mechanical emptying in the town of Mamou is summarized in Table 2. This table presents the number of sanitations works identified, the rate of works emptied mechanically by the truck, the average duration of emptying of the works which is every 3 years. Then, the volume of the truck is 6 m^3, the average number of turns for emptying each structure is seven (7). Thus, the quantity of sludge emptied by the truck is determined by (Eq. 2).

3.1.3 Volume of Sanitation Works

The average emptying frequencies and the portions of structures emptied mechanically and manually are given in Table 3. This table thus takes stock of the total quantity of sludge produced (Eq. 3), which is the sum of the sludge emptied mechanically (Eq. 4) and manually (Eq. 5). They take into account the number of sanitations works, the mechanical and manual emptying rates, and also the frequencies of mechanical emptying (every 3 years) and manually (every 5 years). While taking into account the average volume of works.

3.1.4 Comparison of Results from Different Methods

Table 4 shows the comparison of the quantities of sludge produced by the different methods.

This table compares the annual quantities of sludge production according to the three methods used, which depend on the different formulas. The value of the first

Table 1 Specific sludge production.

Parameters studied	Symbols	Values	Units
Traditional latrines	P_{LT}	6,652	Residents
Improved latrines (VIP)	P_{VIP}	29,557	Residents
Users of dry latrines	$Ls = (P_{LT} + P_{VIP})$	36,209	Residents
Septic tank users	P_{FS}	40,189	Residents
Specific production of sludge	Q	685,241,531.9	m^3/year

Table 2 Quantity of sludge in mechanical emptying.

Parameters studied	Symbols	Values	Units
Sanitation works identified at Mamou	N	2,936	Work
Portion of structures emptied mechanically	P_{mec}	21.08	%
Frequency of oil changes mechanical	F_{mec}	3	year
Average volume of sludge emptied per work and per trip	V	6	m^3/rotation
Number of rotations on average per work	η	7	-
Quantity of sludge in mechanical emptying	Q_{mec}	724,800.46	m^3/year

Table 3 Estimated production of mechanical and manual fecal sludge.

Parameters studied	Symbols	Values	Units
Number of sanitation works in Mamou	N	2,936	
Portion of structures emptied mechanically	P_{mec}	21.08	%
Portion of structures emptied manually	P_{man}	78.57	%
Frequency of mechanical oil changes	F_{mec}	3	year
Fmanl manual oil change frequency	F_{man}	5	year
Average volume of sanitation works	V	34.11	m^3
Quantity of sludge produced by mechanically emptied structures	Q_{mec}	588,641.58	m^3/year
Quantity of sludge produced by structures emptied manually	Q_{man}	1,573,709.33	m^3/year
Total quantity of sludge produced	Q_{total}	2,162,350.91	m^3/year

Table 4 Comparison of results.

Production	Method 1 (m^3/year)	Method 2 (m^3/year)	Method 3 (m^3/year)
Q_{mec}	-	724,800.46	588,641.57
Q_{man}	-	-	1,573,709.33
Q_{total}	685,241,531.9	-	2,162,350.90

method is calculated by (Eq. 1), that of the second method is determined by (Eq. 2). Those of the third method are calculated by (Eq. 3, Eq. 4 and Eq. 5).

The methods used use data collected by the field survey of the study area. The quality of the data depends on the information of the people interviewed and their ability to reconstruct the information.

The first method allows the planner and municipal authorities to make a rapid estimate of the quantities of sludge potentially produced in the city; it requires a basic study to estimate specific production per city taking into account the total population of different neighborhoods and other movements of people (transport, festivals, cultural, sporting activities, tourism, etc.).

The second method made it possible to evaluate the quantity of sludge obtained by mechanical emptying. With the third method, we consider that the volume of sludge drained corresponds to the total volume of the structure. Manual emptying extracts all the contents of the pit. On the other hand, when emptying is mechanical, the contents of the bottom of the pit may sometimes not be sucked up. The calculated volume is therefore increased. This method can also be improved by building structures of standardized dimensions and carrying out awareness campaigns to empty sanitation structures.

3.2 Discussions

During the survey period, 2,940 sanitation works were identified in the 28 districts of the town of Mamou, an average of 105 works per district.

3.2.1 Distribution of Types of Works

The distribution of types of structures or latrines (traditional latrines, VIP double pit latrines and manual flush toilets) is illustrated in Fig. 1.

Fig. 1 shows the distribution of the different types of structures, namely: 1,090 traditional latrines, or 37.07%; 1,710 improved latrines (VIP), or 58.16%, and 140 septic tanks, or 4.7%. This inequality of distribution is due to the living conditions of the populations and the different activities carried out in each neighborhood.

3.2.2 Users of Sanitation Works

The distribution of the number of users of sanitation works is illustrated in Fig. 2.

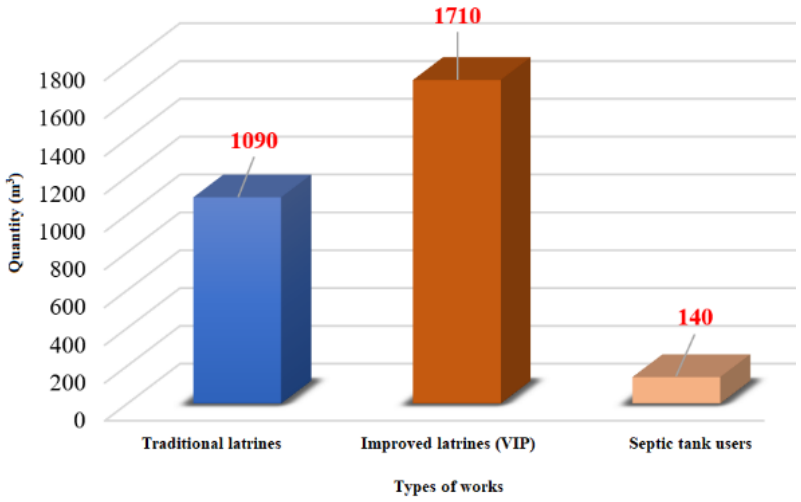

Fig. 1 Types of latrines used in Mamou.

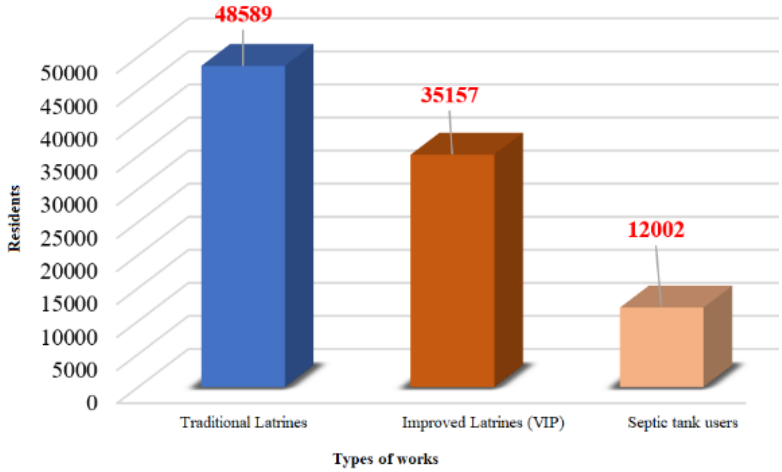

Fig. 2 Users of sanitation works in Mamou.

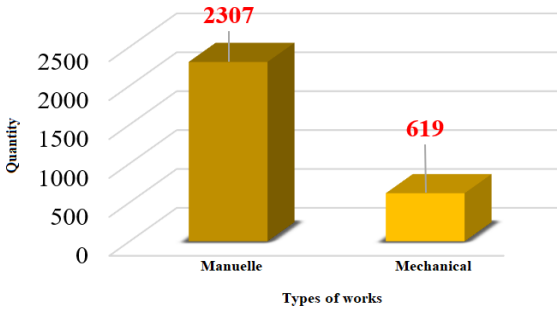

Fig. 3 Emptying portion of sanitation works.

The results of the survey carried out on a sample of 2,940 structures surveyed in the different districts of the urban commune of Mamou, made it possible to know the frequencies of use of each type of latrine. These surveys show that: 6,652 people on average use traditional latrines per year; 29,557 people use improved latrines per year and 40,189 people use septic tanks in the different neighborhoods of the town of Mamou.

3.2.3 Types of Drains Used

The distribution of the method of emptying sanitation works is illustrated in Fig. 3.

Of the 2,940 sanitation works identified, 2,936 works were emptied at least once. Fig. 2 shows that 2,307 structures are emptied manually, or 78.57% (traditional and improved latrines), compared to 619 structures emptied mechanically, or 21.08%, mainly latrines for mass use (septic tanks and some improved latrines). The emptying frequency is a parameter which indicates the period of sludge extraction before being transported to the treatment sites. The investigation revealed that, in the town of Mamou, the works are emptied on average every 3 years for septic tanks and every 5 years for dry latrines.

As part of this study, the results of the different methods made it possible to deduce that: The specific production of sludge is estimated at 685,241,531.9 m^3/year; The production of sludge by mechanical emptying varies from 724,800.46 to 588,641.57 m^3/year; The production of sludge by manual emptying is estimated at 1,573,709.33 m^3/year and the total quantity of sludge produced is between 2,162,350 m^3/year and 685,241,531.9 m^3/year

4. Conclusion

Determining the quantity of fecal sludge produced in the absence of a database in the towns of Guinea in general and that of Mamou in particular led us to carry out a household survey during the period from January 15 to June 15, 2023 in the different districts of the urban commune of Mamou. Through interviews with municipal officials, heads of households and public and private establishments, we identified: 1,090 traditional latrines; 1,710 improved latrines; 1,040 septic tanks for a total of 2,940 sanitation works, or 105 works per district.

Traditional and improved latrines constitute 78.57% of structures emptied manually compared to 21.08% of

mechanical emptying of septic tanks and a few improved latrines. The average emptying frequency is every 3 years for traditional and improved latrines and every 5 years for septic tanks. The cost of mechanical emptying by truck is currently 760,000 GNF per 6 m^3. The cost of manual emptying is negotiated between operators and those responsible for the works depending on the volumes, it varies from 500,000 to 1,500,000 GNF.

The results obtained during this study constitute a database for improving fecal sludge management techniques in the town of Mamou. These results can be improved by consolidating the data collected through new surveys and regular monitoring of emptying activities.

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