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Faecal sludge management in the city of Bukavu, Democratic Republic of Congo

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Abstract

In the city of Bukavu, like most major African cities, autonomous sanitation works are the only ones used to manage wastewater and excretas. These structures produce sludge that must be properly drained and treated in order to preserve the health of populations and protect the environment. The objective of this work is to describe the faecal sludge management system in the city of Bukavu, identify the shortcomings in order to propose alternatives for better management of this sludge. The results show that the sanitation works used by households in the city are such that in Ibanda, there are 40.4% septic tanks, Kadutu 42.6% gun latrines and Bagira 38.5% traditional latrine. The emptying of these sanitation works is done manually (47%), mechanically (23.7%). Another category, 29.3% of households, use pipes connected to latrines and which evacuate excrement directly to rivers or gutters. Only two emptying trucks are used to remove the sludge. In general, in the city of Bukavu, the faecal sludge is not treated at all. A significant amount is directed to undeveloped dump sites and another amount is dumped into nature using gutters and rivers with significant health and environmental risks. The provision of a management plan and a well-developed unloading site would solve the problems caused by faecal sludge in this city.

1. Introduction

In most African cities, rapid population growth and the proliferation of informal settlements make the problem of solid waste management and urban liquid sanitation particularly complex (Koanda, 2006). In these same cities, it is estimated that more than 85% of homes have non-collective (or autonomous) sanitation systems, i.e. not connected to a sewer network (Montangero & Strauss, 2002). ANC structures, installed at the household level, intended to collect and store wastewater and excreta consist mainly of latrines in various forms or septic tanks (Bigumandondera, 2014). When these structures are filled, their contents called faecal sludge are either emptied mechanically

using a drain truck, or emptied manually, or the structure is filled in to dig another if space permits. (Defo *et al*., 2015; Merghem *et al.* (2016),). The management of materials from the ANC in African cities is faced with enormous problems such as the existence of sanitation works that do not meet health and environmental standards, the wild / clandestine evacuation of this faecal sludge due to lack of a suitable unloading site, the increase in manual emptying which presents high health risks both for the emptyers and for the inhabitants of the plot and the surrounding households as well as the the lack of appropriate technologies to treat/recover this sludge (Montangero *et al*., 2002; Klingel *et al*., 2002; Bolomey *et al*., 2003; Chaggu, 2003, Letema, 2012 & Bigumandondera, 2014).
In DR Congo, the city of Bukavu is not immune to this problem of faecal sludge management and the population of this city continues to grow. According to the Provincial Statistics Division (DPS, 2019), the population increased from 979,870 inhabitants in 2000 to 1316140 inhabitants in 2019. This population explosion in the city of Bukavu is explained in particular by the rural exodus due to the instability in the region and the natural increase of the population within the city. Like developing countries, the inhabitants of the city of Bukavu live in precarious conditions (WHO/UNICEF, 2010). The environmental challenges faced by the inhabitants of this city include problems of access to drinking water, uncontrolled urbanization and quasi-non-functional sanitation services (Lina, 2016).
The objective of this article is to conduct a study that integrates faecal sludge management in all these components, i.e. from upstream to downstream. The goal is to propose a methodology for better management of this category of waste. To achieve this objective, it will be specifically to analyze the influence of the socio-economic characteristics of households on the management of faecal sludge, to document the types of sanitation facilities available to households, the mode of evacuation / transport of sludge as well as the mode of treatment or recovery of faecal sludge in the city of Bukavu.

2. Materials and methods

2.1. Description of the study area

Located by the coordinates 20°30' south latitude and 28°50' east longitude, the city of Bukavu, capital of South Kivu Province, is located in the east of the Democratic Republic of Congo (Moeyersons *et al*., 2003). It has an area of 63 km² of which 43 km² is dry land and 20 km² is occupied by the waters of Lake Kivu (Chamaa *et al*. 1981).
This city (**Figure 1**) includes 3 communes: Ibanda commune with 3 districts (Ndendere, Nyalukemba and Panzi), Bagira commune also formed by 3 districts (Kasha, Lumumba and Nyakavogo) and Kadutu commune which includes 7 districts (Cimpunda, Kajangu, Kasali, Mosala, Nkafu, Nyakaliba and Nyamugo) (Kalikone *et al.*, 2017).

2.2. Sampling criteria

The results of this study were obtained using non-probability quota sampling. The objective is to obtain in the sample a sufficient representativeness of socio-demographic aspects as well as other important variables characterizing the target population. For this purpose, we constructed the sample according to a reduced population model according to predefined quota criteria, i.e. grouped into social categories of high standing (HS), medium standing (MS) and low standing (BS) (**Table 1**).
In accordance with these criteria, two districts per municipality were selected taking into account the high population rate and the standard of living of households.

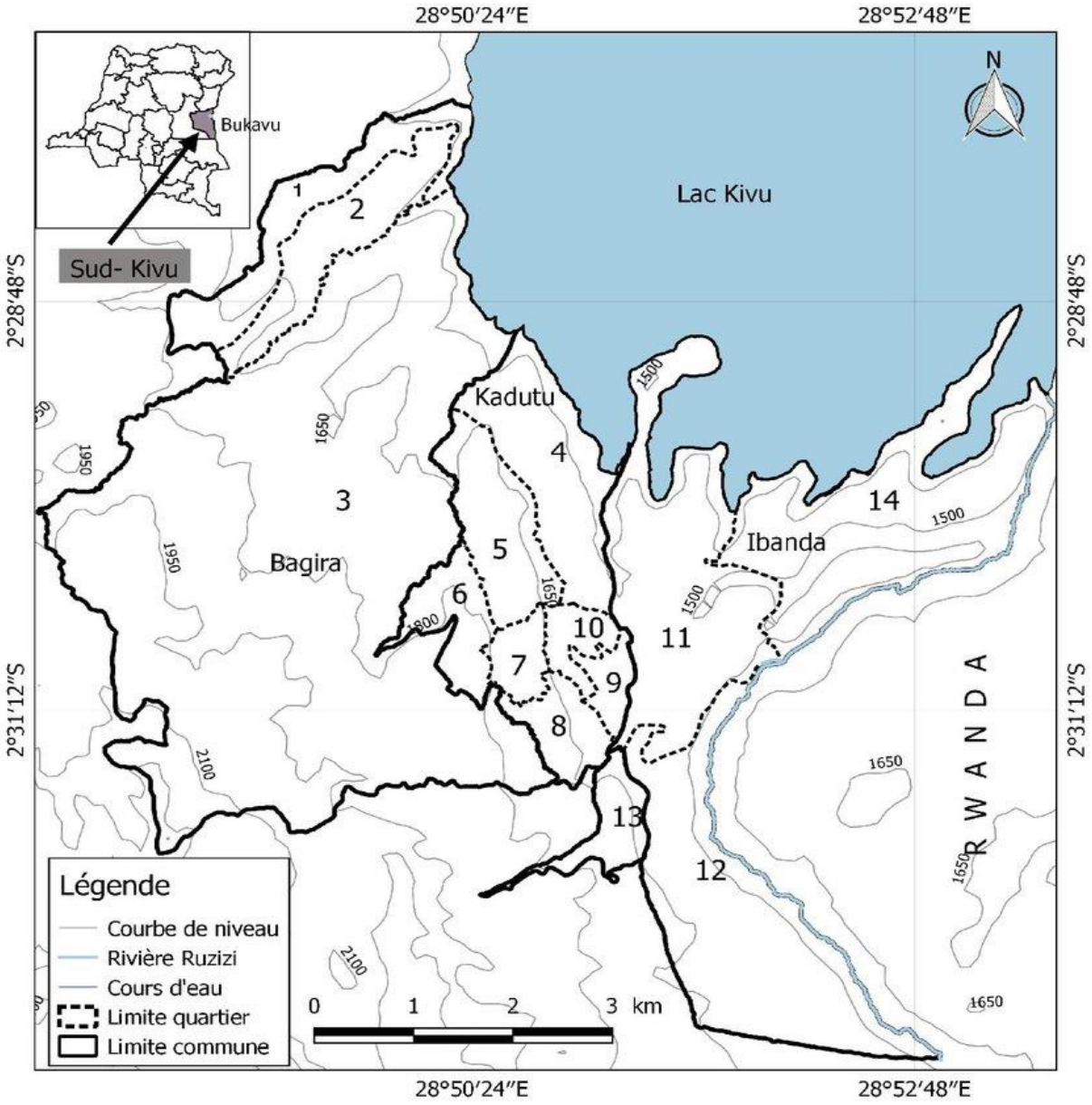

Figure 1. Administrative map of the city of Bukavu

Legend: ***Names of neighborhoods 1: Nyakavogo, 2: Lumumba, 3: Kasha, 4: Nkafu, 5: Nyakaliba, 6: Kajangu, 7: Cimpunda, 8: Mosala, 9: Nyamugo, 10: Kasali, 11: Ndendere, 12: Panzi, 13: Cahi, 14: Nyalukemba.***

2.3. Methodology for determining the sample

The choice of the number of households to be surveyed was made on the basis of the Nortest principle (1995) cited by Aloueimine (2006), which sets a sampling rate of 0.013i.e. 13 for a total of 1000 households with a standard margin of error of 5% and a confidence interval of 95%. According to IPS (2016) and WHO (2015), which estimate an average of 8 people per household in the city of Bukavu, the six neighborhoods to be surveyed thus bring together a population of 949,552 inhabitants, dividing it by 8, which gives us 118,694 households. However, the percentage distribution of households to be sampled by social affiliation is determined by the total number of households in each neighbourhood to which the sampling rate of 0.013 is applied (Table 1).

Table 1. Determination of the number of households to be surveyed by neighbourhood

Social categories	Selected neighbourhoods	Population by neighbourhood	Number of households per neighbourhood	Households to be sampled (0,013)	% by neighbourhood	Households to be surveyed by neighbourhood
High standing	Ndendere	226 724	28 341	368	24	88
	Nyalukemba	203 182	25 398	330	21	71
Medium Standing	Nyakavogo	139 332	17 417	226	15	33
	Nkafu	101 475	12 684	165	11	18
Low standing	Kasha	172 020	21 503	280	18	51
	Nyamugo	106 819	13 352	174	11	20
Total		**949 552**	**118 694**	**1 543**	**100**	**280**

In sum, the survey covered a total of 280 households selected from non-probability quota sampling. The number of households chosen represents 72% of the total households in the city of Bukavu, i.e. 118694 out of a total of 164518 households.

2.4. Household survey

In addition to the household survey questionnaire, there was also talk of using direct interviews with people who cannot read and write.

2.5. Survey of emptying companies

This survey was conducted in conjunction with household surveys. All companies operating in the city of Bukavu have been identified. The main purpose of the questionnaire used was to collect information on the following aspects: collection system used, quantities of sludge collected, dumping sites, methods of treatment/recovery of faecal sludge. The routing of the emptying trucks in their "drained households - unloading site" circuit was also carried out.

2.6. Data analysis and processing

Data collected from survey sheets and interviews were encoded in a SPSS version 16 database.The analysis of the data initially consisted of interpreting respondents' opinions and the proportions were determined by calculating the percentages as follows:

% = Fo × 100/Ft, where Fo = observed frequency and Ft = total sample frequency.

Then, cross-analyses of different variables were carried out using SPSS version 16 software in order to identify any dependencies between these variables considered.
Pearson's Chi^2 test was used to check for deviation from independence.

3. Presentation of results

3.1. Household survey

The characteristics provided at the sample level concern gender, the age group of the respondents, the number of persons living in the concession and the level of education of the head of household, as well as the sanitation facilities used by households. For a sample of 280, 76.4% of respondents to the survey are male. The age distribution of respondents varies globally between 25 and 55 years, with a predominance of the 25-35 age group or 62.2%; This means that we have investigated the adults who have mastered the situation. For proper planning of faecal sludge management, knowledge of the number of people living in a plot is important (**Table 2**).

Table 2. Distribution of people living in the plot

Number of persons in the plot	**Percentage**
4-10persons	66.7
10-20persons	18.1
> 20 persons	15.2
Total (N = 280)	**100**

The results of **Table 2** show that 66.7% of the households surveyed have between 4-10 persons in the plot, 18.1% of households contain 10-20 persons while 15.2% of households, this number is > 20. The latter case was encountered mainly in low-standing and high-density neighbourhoods. In relation to the level of education (**Figure 1**), in the municipality of Ibanda, 43% of the households

surveyed, the heads of households have a university level. While in the communes of Kadutu and Bagira, the secondary level dominates 36.7% and 36.3% respectively.

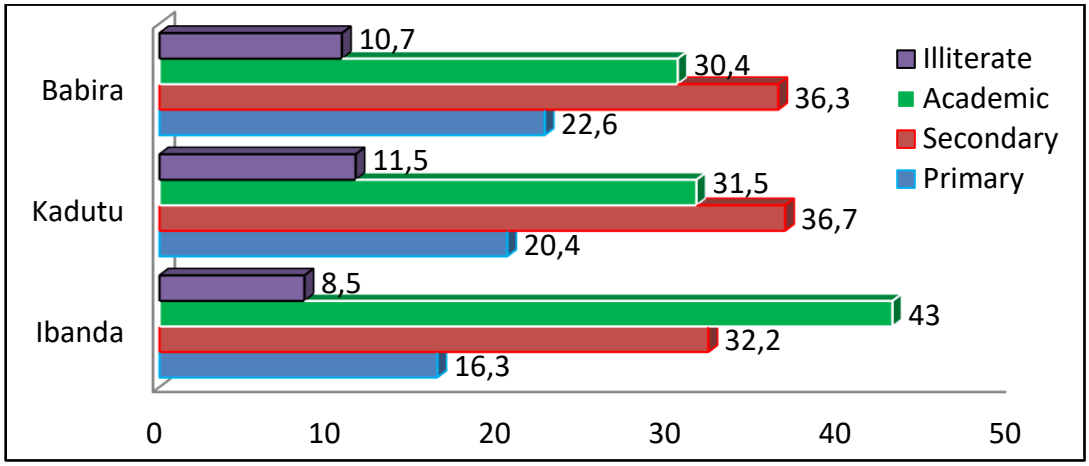

Figure 2. Distribution of educational attainment (%) of heads of household

In the field of sanitation, knowledge of the level of education of heads of households helps to understand the degree of awareness of households on the dangers of poor management of faecal sludge through an inadequate sanitation system. It is also a data that remains necessary and on which we must base ourselves if we want to work with the populations benefiting from sanitation services. With respect to the distribution of excreta collection books in the study area, the situation is shown in **Figure 3**.

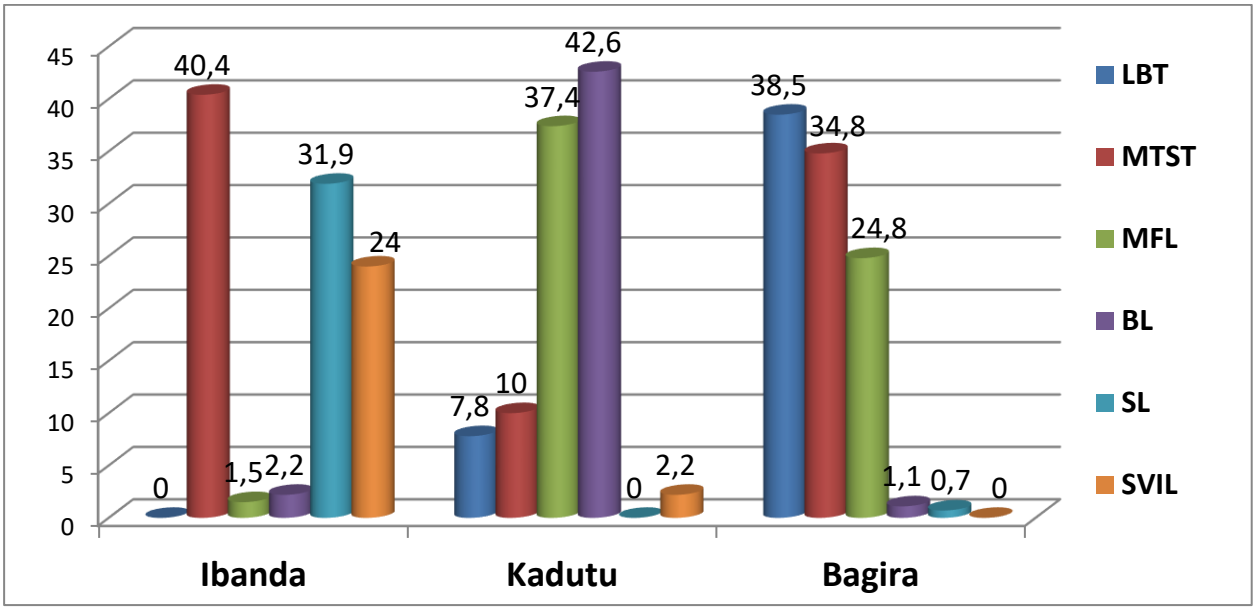

Figure 3. Distribution of excreta collection works (%) by municipality

Legend: **TBL**: traditional bleed latrines; **MTST**: modern toilet with septic tank; **MFL**: manual flush latrines; **BL**: barrel latrine; **SL**: siphon latrines, **VIP**: ventilated improved pit or self-ventilated improved latrine (**SVIL**).

3.2. Cross-analysis of survey results

The purpose of cross-analysis between two variables is to understand the relationships that could exist between them, relationships that can lead to the emergence of alternatives towards the

resolution of a particular problem. Below are the tables 3 & 4 with two entries crossing the variables are presented. Figures showing the appearance of certain phenomena such as the frequency of emptying, the places of discharge of faecal sludge and wastewater are also presented. From **Table 3,** to collect excretas, it should be noted that the social categories of high and medium standing use the septic tank at a rate of 69.3% and 47.3% respectively. On the other hand, low-end households, at 41.3%, use the traditional bleed latrine and 36% use the barrel latrine. REGIDESO is the public company for the production, distribution and marketing of drinking water in the city of Bukavu. The results in **Table 4** show that REGIDESO (61.9%) is the only water supplier in the three municipalities. According to the results, the amount provided by this company does not cover the water needs of the population, from where 28% of households use water through public fountains. In addition, the variable "Other" refers to the secondary mode of water supply in the city of Bukavu.

Table 3. Relationship between sanitation mode and social categories

	Social categories / ***Sanitation mode***	**High Standing**	**Medium Standing**	**Loz Standing**	**Total Line**
Number	Traditional bleed latrines (TBL)	0	9	31	40
%		0	16.4	41.3	14.8
Number	Modern toilet with septic tank (MTST)	97	26	7	130
%		69.3	47.3	9.3	48.1
Number	Manual flush latrines (MFL)	33	15	10	58
%		23.6	27.3	13.3	21.5
Number	Barrel latrineS (BL)	8	1	0	9
%		5.7	1.8	0	3.3
Number	Ventilated improved pit (VIP)	2	4	27	33
%		1.4	7.3	36.0	12.2
Number	Total	140	55	75	270
%		100.0	100.0	100.0	100.0
	Chi² de Pearson: 96.297, dl=6, p=0.0000				

Table 4. Drinking water supply in the study area

	Commune / **Supply**	**Ibanda**	**Bagira**	**Kadutu**	**Total Line**
Number	REGIDESO	85	37	47	167
%		60.7	67.3	62.7	61.9
Number	Public fountain	12	7	9	28
%		8.6	12.7	12.0	10.4
Number	other	45	11	19	75
%		30.7	20.0	25.3	27.8
Number	Total	140	55	75	270
%		100.0	100.0	100.0	100.0
	Chi² de Pearson: 96.2917, dl=4, p=0.0000				

Table 5. Choice of actions to address septic tank filling by social category

	Social categories / *Choice of action*	High Standing	Medium standing	Low Standing	Total Line
Number	emptying	140	31	30	201
%		100.0	56.4	40.0	74.4
Number	Realization of another Pit	0	17	42	59
%		0.0	30.9	56.0	21.9
Number	Other	0	7	3	10
%		0.0	12.7	4.0	3.7
Number	Total	140	55	75	270
%		100.0	100.0	100.0	100.0
	Chi² de Pearson: 96.2917, dl=4, p=0.0000				

The results in **Table 5** show that there is a strong significance between the variables (p=0.00000). Whatever the social category, the preferred choice of households is oriented towards the emptying of sludge (mechanical or manual), 74.4% in case of pit filling for two social categories (High and Medium Standing). The construction of another pit represents 21.9% for low-end households. The practice of emptying in different communes **Figure 4**, is such that in Ibanda, it represents 96%, in Bagira 49% against 29% in Kadutu. For the latter, 68% of households use the variable "Other" when the pit is full.

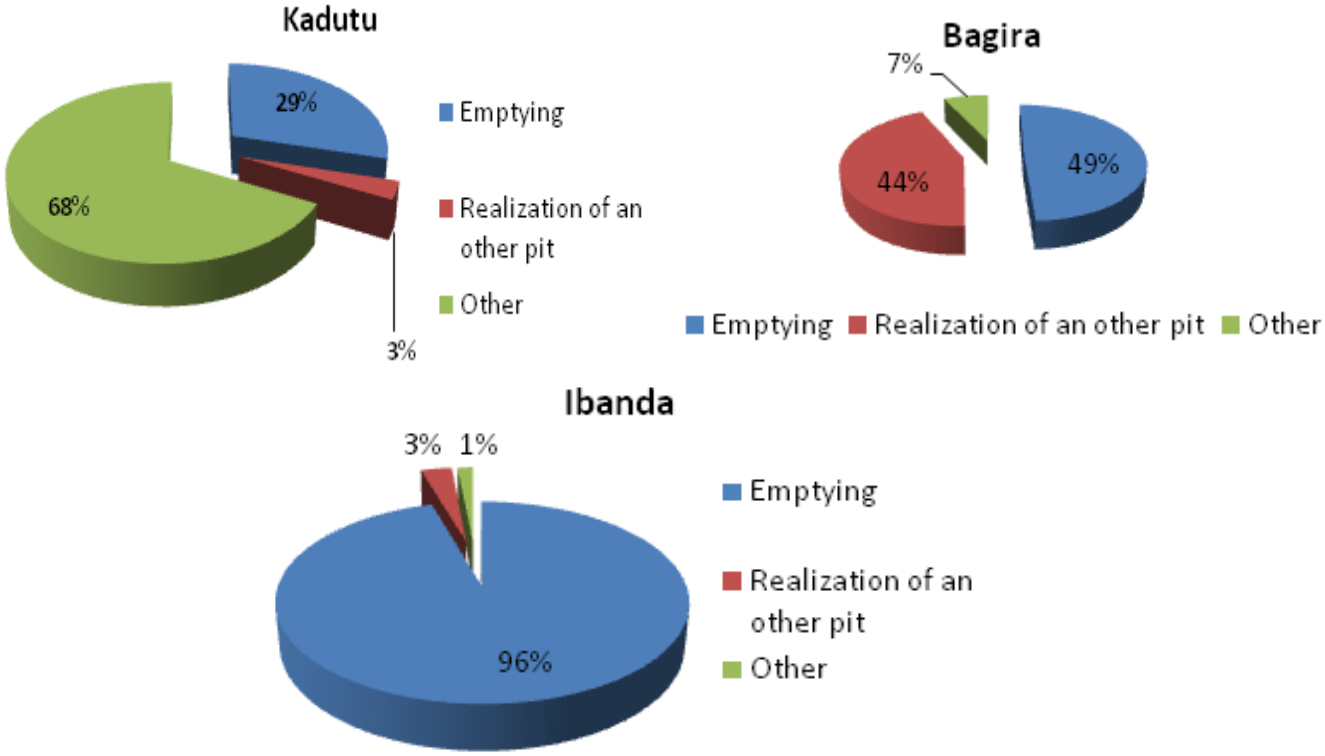

Figure 4. Actions to fill the sanitation structure

The "other" practice consists of the use of traditional gun latrines and toilets with pipes that evacuate excrement directly to rivers or gutters. This practice is mainly found in households living near a gutter or river.

Table 6. Relationship between emptying mode and social categories

	Social categories / *Mode of emptying*	**High Standing**	**Medium Standing**	**Low Standing**	**Total Ligne**
Number	Specialized gun	48	9	7	64
%		34.3	16.4	9.3	23.7
Number	By hand or manually	62	27	38	127
%		44.3	49.1	50.7	47.0
Number	Other	30	19	30	79
%		21.4	34.5	40	29.3
Number	Total	140	55	75	270
%		100	100	100	100
	Chi² de Pearson: 65.538, dl=4, p=0.0000				

The results of **Table 6** show that manual emptying remains the main mode of emptying used in the three communes of the city of Bukavu. The "Other" variable consists either of digging a new pit or of the use of pipes connected to the latrine and which evacuate the excrement directly to the rivers or gutters.

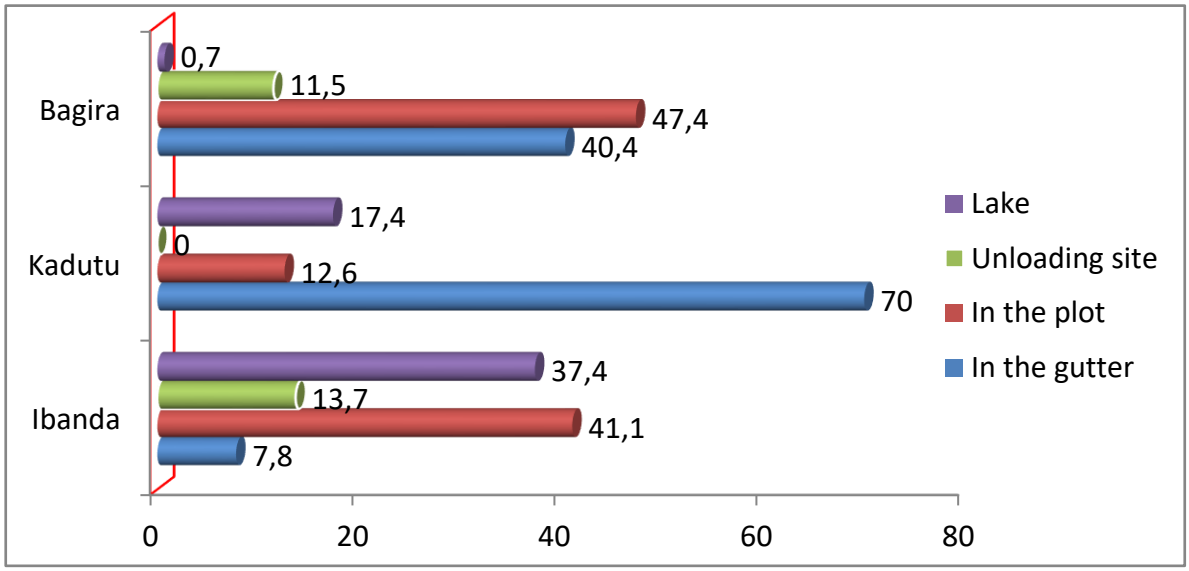

Figure 5. Destination of the faecal sludge in the city of Bukavu

For the unloading of faecal sludge, the priority choice in the communes of Bagira (47.4%) and Ibanda is to bury the sludge in the plot, while in Kadutu (70%), the gutters, initially intended to transport rainwater, are widely used. In the city of Bukavu, unloading sites correspond to an empty space on the outskirts. Unfortunately, this space is not equipped to receive and properly treat the drained sludge. The results of **Figure 6** show that the gutters initially designed for the evacuation of rainwater, constitute the places of discharge of domestic wastewater (Kadutu 70% and Ibanda 50.4%). This wastewater, being mainly made up of shower, laundry and kitchen water, is loaded with pollutants.

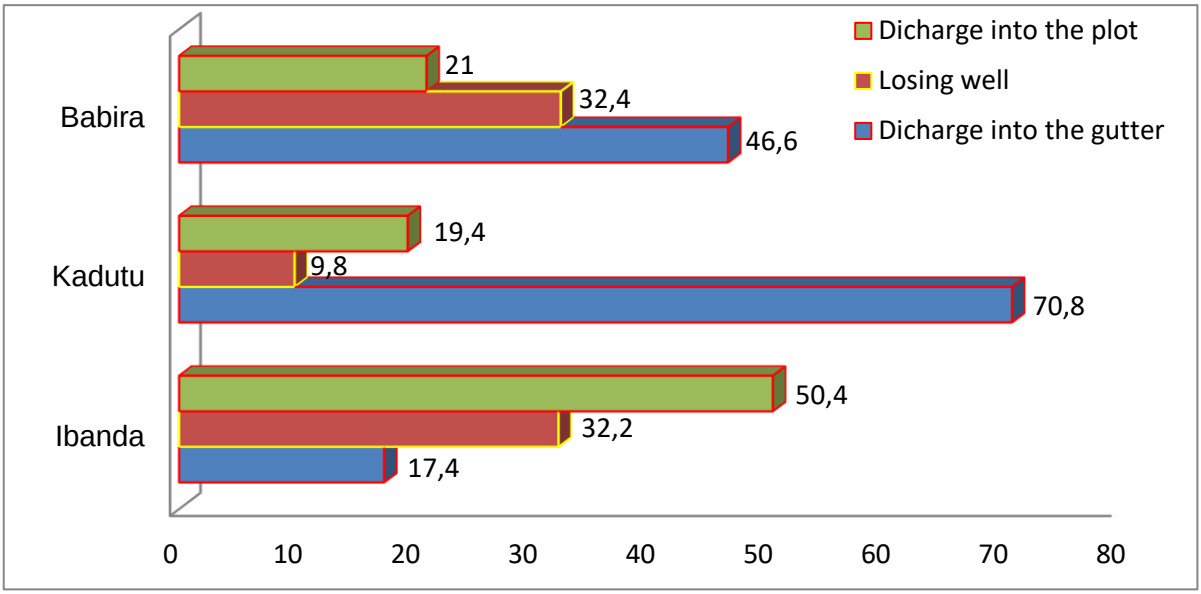

Figure 6. Place of discharge of domestic wastewater

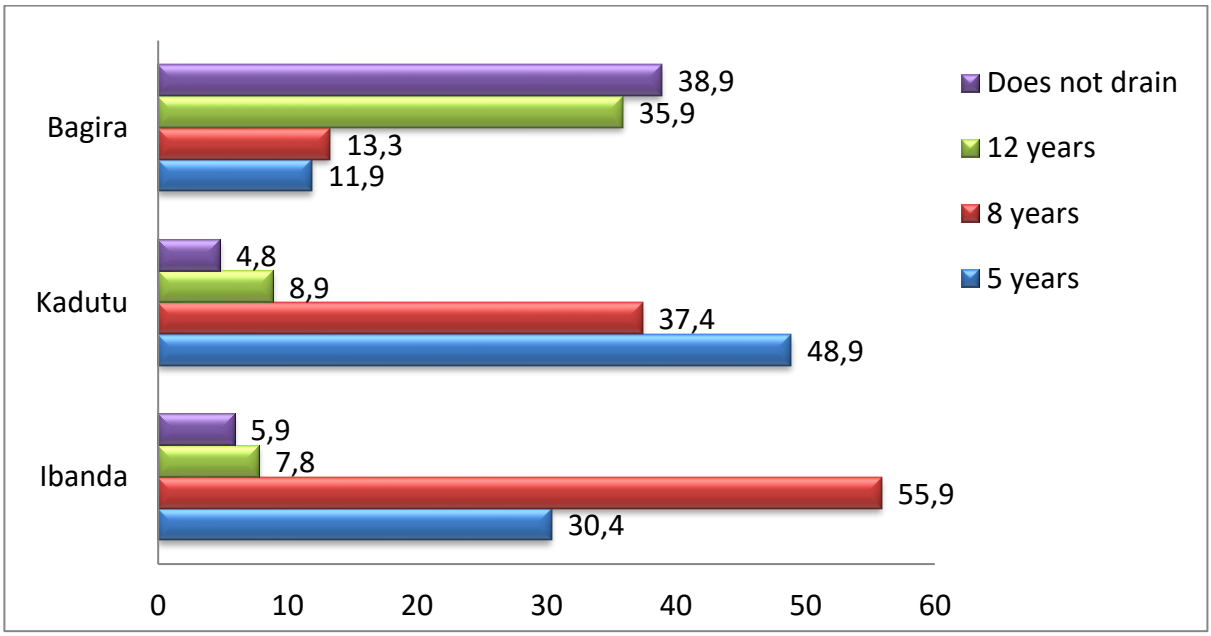

Figure 7. Frequency of sludge emptying

In the communes of Ibanda and Kadutu, respectively 55.9% and 37.4% of households surveyed empty every 8 years, while 48.9% (Kadutu) and 30.4% (Ibanda) of households empty every 5 years. In the Commune of Bagira, a large proportion of households (38.9%) do not empty; When the latrine is full, they close it instead to build a new one in the plot. In the same commune, 35.9% of the households surveyed claim to have emptied their structures after 12 years of operation.

Households in different communes of the city of Bukavu (Ibanda 56.7%, Kadutu 51.9% and Bagira 52.2%), know almost to the same degree as, the Town Hall is the key service in charge of sanitation. On the other hand, a percentage of households say they are not aware of any service in charge of faecal sludge management in the city of Bukavu. This is due to a lack of information and awareness on the part of the competent authorities.

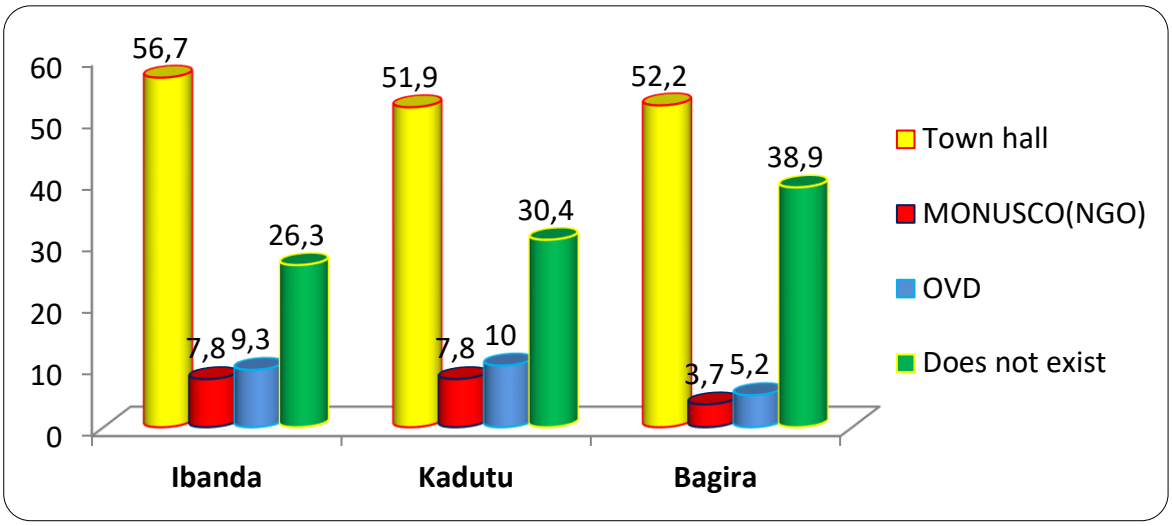

Figure 8. Knowledge of the existence of faecal sludge services

Table 7. Accessibility of the Drain Truck to the sanitation work according to social categories

	Social categories / ***Truck access***	High Standing	Medium Standing	Low standing	Total Line
Number	Easy access	70	7	2	79
%		50.0	12.7	2.7	29.3
Number	Difficult access	45	26	37	108
%		32.1	47.3	49.3	40.0
Number	Not accessible	25	22	36	83
%		17.9	40.0	48.0	30.7
Number	Total	140	55	75	270
%		100.0	100.0	100.0	100.0
	Chi² de Pearson: 96.297, dl=6, p=0.06120				

Pearson's Chi² test, with a p-value greater than 0.05, shows that there is no relationship between truck access to drain structures and social class.

3.3. Survey of emptying companies

This survey provides information on the number of emptying trucks operating in the city, the laps made per day, the time allotted to the mechanical emptying operation and the estimated quantities mechanically emptied.

Table 8. Companies involved in faecal sludge management

Company name	**Number of trucks in possession**	**Capacity in (m^3)**
Town hall	2 whose 1 in ailure	8
MONUSCO (CONGO)	1	14
KADUTU (Commune)	1 in failure	6

During the field period for this study, we noticed only two emptying trucks (that of the town hall and MONUSCO) in good traffic.

Table 9. Distance and time travelled by the dump trucks to the dumped sludge disposal **site.**

Companies	Average time	Average distance	Unloading site
MONUSCO	30 ± 7.07 min	27.5 ± 3.54 km	INERA/Kavumo
Town hall	25 ± 7.07 min	20 ± 7.07 km	Cidaho/Kabare

Table 9 shows that the two companies involved in the sludge emptying service each have a dumping site, which unfortunately do not meet the standards for sludge dumping sites.
The MONUSCO Truck travels an average distance of 27.5±3.54km for an average duration of 30±7.07min while that of the City Hall travels an average distance of 20±7.07km for an average time of 25±7.07min to reach the respective dumping sites. During the routing of dump trucks, it was noted that 328 m^3 of faecal sludge was dumped at the two sites or 9.37 m^3/day.

Table 10. Estimating the amount of sludge dumped during routing

N°	Company	Truck capacity in m^3	Number of laps made during 35 days	Total m^3	m^3/day
1	MONUSCO	14	16	224	6.4
2	Town hall	8	13	104	2.97
	Total		**29**	**328**	**9.37**

3.4. Discussion of results

The socio-economic characteristics of households that provide information on the number of people living in the plot and the level of education of the head of household are important to know if a diagnosis of sanitation in a given locality is to be made. Indeed, the results of **Table 2** show that 66.7% of the households surveyed live between 4-10 people against 18.1% and 15.2% who house between 10-20 and >20 people respectively. The number of persons per household is a necessary data to fix the required space for the storage of wastewater and excreta at the level of the plot. Indeed, the sizing of wastewater and excreta storage facilities is based on the sludge accumulation rate per capita which is between 0.29-0.21L/inhabitant/day for a 4-year operation (Philip *et al*., 1993 & Bigumandondera, 2014).
Compared to the educational level of heads of households, **Figure 2** shows that 43% had a university level compared to 36.7% at the secondary level, a result that differs, however, from that of Jiokeng (2016) where 54.86% had a secondary level and that of Bolomey (2003) where 78% of respondents did not go beyond primary school. In developing countries, the establishment and maintenance of NCA facilities is the responsibility of households. Knowledge of the level of education of the head of household can therefore help to determine the degree of awareness by households in relation to the dangers arising from poor sanitation. According to Sy *et al.* (2014) & Bigumandondera (2014), the more you study, the more likely you are to have a job that improves living conditions, including in the sanitation sector. In the city of Bukavu, the fact that there is on average a lower number of people per household, combined with the relatively high level of education (43%), heads of households should be seen a priori as levers of action to promote efficient liquid sanitation systems.

As for the management of faecal sludge, it depends on the importance offered, the knowledge available and an overview of the technique to bring to it. For the storage of excreta at the plot level, different types of sanitation works ranging from the septic tank considered the most efficient to the rudimentary latrine such as the gun latrine are used (**Figure 3**). This diversity can be explained by certain factors such as household income, user preference and habits, the level of knowledge of those who install sanitation works, the space available at the plot level, the lack of information on the health and environmental impacts associated with the installation of one or the other structure. In the city of Bukavu, 69.3% and 47.3% of the social categories of high and medium standing use modern toilets with septic tanks respectively. On the other hand, low-end households mainly use the traditional FP latrine (41.3%) or the gun latrine (36%). Here household incomes influence the type of structure installed in the homes of individuals, the wealthiest install the septic tank and the less fortunate use the traditional latrine or the gun latrine. The latter two are subject to high health and environmental risks and should be replaced by others that are more respectful of human health and the environment.

In the three municipalities, a good proportion of the population has access to drinking water (**Table 4**) despite untimely cuts and insignificant amounts. WHO/UNICEF (2013) highlights the importance of water in ensuring a satisfactory level of hygiene, especially for households using sanitation facilities such as septic tanks and manual flush latrines that require running water at home to operate sanitation facilities. According to UNDP (2006), the water crisis is linked to poverty, regional disparities and inadequate management policies. As for the results on access to water in our study environment, they do not meet those of PNHAB (2013) according to which more than half of the population does not have easy access to drinking water.

For the choice of action in case of filling of sanitation works (**Tables 4 & 5**), whatever the social category, in the municipalities of Bagira and Ibanda, the preferred choice of households consists of mechanical or manual emptying with a high proportion (74.4%) for manual emptying. In Kadutu, the practice called "others" consists of sending the contents of the pits to rivers or gutters, both for manual emptying. It should be noted that these are options with serious health and environmental consequences. They also contribute to the pollution of water bodies potentially usable for drinking.

Manual emptying has also been deplored by Klingel *et al*. (2002) who state that manual handling of sludge is risky and should therefore be abandoned. In addition, this method of emptying leads to the unloading of sludge in the gutters or in the free space surrounding the emptied pit. The other practice in the city of Bukavu is to dig a new pit once the first one is full. The risks of returning to the old pit before the stabilization of its contents are not to be excluded in the conditions of small space available within the plot.

Mechanical sludge emptying remains the best option because it is hygienic and can transport and contain the sludge far from homes. This mechanical emptying is nevertheless conditioned by certain prerequisites including the availability of emptying trucks, accessibility on the road and the provision of a well-equipped unloading site. For the first prerequisite, the city of Bukavu suffers from a lack of emptying trucks. Indeed, at the time of the study, only 2 trucks (**Table 8**) were functional, which remains insufficient to cover the entire city for an estimated population of more than 1,000,000 inhabitants (DPS, 2019). In Bafoussam-Cameroun, Defo *et al*., (2015) highlight the existence, in this city, of 5 companies working in the collection of faecal sludge unlike the city of Bujumbura. Bigumandondera (2014) identified 6 emptying companies for a total of 9 emptying

trucks. Compared to the accessibility of Camion garange to sanitation works (**Table 7**), household survey results show that overall throughout the city, the balance leans towards difficult and inaccessible access where the two variables total a score of 70.7% while easy accent represents only 29.3%. It should be noted that these multiple difficulties of accessibility are largely explained by urban planning problems, roads and the anarchic construction of houses in disadvantaged neighborhoods in particular.

This also meets what was observed by Defo *et al*., (2015) who, in their studies in Bafoussam (Cameroon), state that "access to structures by emptying trucks is very difficult due to lack of road". This leads to anarchic emptying by households and yet, until the hour, in urban areas, the emptying truck is the only emptying mode offering a minimum of safety. As the city of Bukavu does not have a well-developed dumping site until now, the virtues traditionally attributed to the mechanical emptying of sludge are destroyed by this state of affairs.

It should be noted that in the literature, both modes of emptying (mechanical and manual) are reported in other regions of Africa. For example, Bolomey (2003); Defo *et al.,* (2015) and Kassa (2004) showed respectively that mechanical emptying was the choice of 56% (Commune IV of Bamako), 61.5% (Yaoundé II) and 77% (Commune of Sam Notaire). In the Kibera district of Nairobi city, manual emptying is practiced by 28% of households against 33% for mechanical emptying (WSP, 2005).

In Kadutu and Bagira, respectively the gutters and the burial of mud in the plot remain the privileged places of unloading. In Ibanda, dumping into the lake and burial in the plot are privileged with a predominance of the latter option; the reason for this is probably the fact that this municipality has relatively large plots and large courtyards. The discharge of sludge into the gutters or into the lake is preferably done during the night or during rainy events to allow a rapid evacuation of the sludge out of sight of neighbors. This anarchic and illegal dumping is explained in particular by: the absence of sludge management regulations or policies, lack of an official dumping site, unawareness of the problems generated by the practice and the lack of importance given to the sanitation of a city. A similar situation is encountered in the city of Yaoundé (Mpakam *et al.,* 2006 & Kuitcha *et al*., 2008) where households empty their pits manually during the rainy season and deposit the drained sludge in open surfaces or in channels so that runoff water can take care of its transport.

The frequency of sludge emptying observed is such that in the communes of Ibanda and Kadutu, respectively 55.9% and 37.4% of the households surveyed empty almost every 8 years and others after 5 years (30.4% and 37.4%). In the commune of Bagira, 35.9% empty every 12 years.

Contrary to the results of Bolomey (2003) and WSP (2005) found average emptying frequencies respectively is 18 months for Commune VI of Bamako and 10 months for the city of Kibera in Kenya. CREPA (2002) meanwhile, the emptying frequency is 18 months at Sam Notaire, 24 months at Koalack and 8 months at Saint-Louis. MEF (2008) and Hina (2009) recommend that excreta storage facilities should be emptied once every four years, when it is assumed that the contents of these structures are more or less stabilized and therefore pose less health and environmental risk. The great variability of emptying frequencies can be explained by multiple causes: the typology of latrines, the non-standardization of dimensions, the quality of construction, the modes of use by households, the number of users and the choice of emptying at the desired time.

Conclusion

The city of Bukavu uses exclusively an autonomous sanitation system. In households, sewage and excreta storage facilities consist of modern toilets with septic tanks, traditional bleed latrines, manual flush latrines, gun latrines, siphon latrines and improved self-ventilated latrines. Traditional and gun latrines pose health and environmental problems. These structures should be replaced by others with less impact. In the event of filling of the structures, the actions carried out concern in particular: manual emptying, mechanical emptying, the construction of a new pit or the use of pipes connected to the latrine and which evacuate the excrement directly to rivers or gutters. The management of faecal sludge in the city of Bukavu remains problematic from an environmental and health point of view.

Indeed, mechanically drained sludge is transported to unloading sites planned outside the city but which sites are not set up to offer adequate treatment. The rest is dumped anarchically into stormwater drains, streams, vacant spaces in the city and its periphery. The control of liquid sanitation in the city of Bukavu requires revisiting the three links of the ANC: the upstream link by the compliance of sludge storage structures, the intermediate link by the provision of sludge emptying technologies and appropriate tools in terms of sludge pumping and transport as well as the downstream link by the development of dumping sites that comply with environmental standards and sanitary.

Conflict of interest

We affirm that the authors do not declare any conflicts of interest in connection with this work.

Authors' contributions

Bigumandondera Patrice and Lina Alex supervised this study, Bagalwa Léon carried out field trips, analysis of survey results, processing of statistical data and formatting with the help of Bayumbasire Cléophace, Ndagano Kamole K'Eka Crispin and Nyabukara Jean-Jacques. In short, all authors have read and approved the final version of this work.

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Declaration of competing interests

All the authors state: no financial interest characterizes him and no personal relationship could seem to influence the work reported in this article.

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