International Journal of
Biological Studies
(IJBS)

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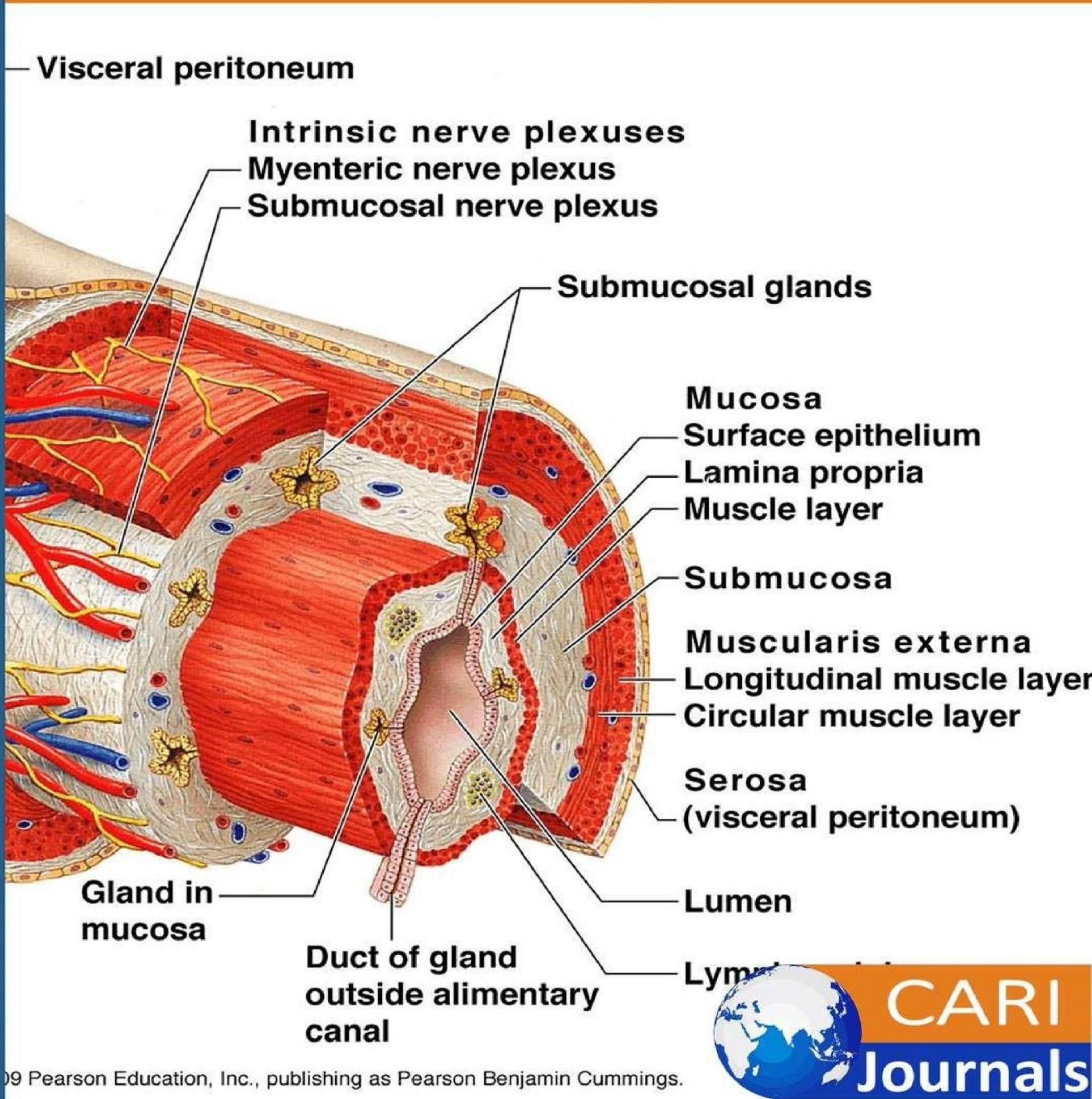

CARI
Journals

International Journal of Biological Studies
ISSN: 2957-7764 (Online)
Vol. 5, Issue No.1, pp 58 - 67, 2025
www.carijournals.org

Biological Characteristics of Septic Tank Sludge Treated With Calcium Oxide in Kinshasa, Democratic Republic of Congo

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Accepted: 14th Sep, 2025, Received in Revised Form:29th Sep, 2025, Published: 13th Oct, 2025

ABSTRACT

Purpose: The purpose of this study is to analyze the influence of these elements on the quality of sewage sludge. The subject of this study is manual sewage sludge collectors who typically use a natural site, such as a hole dug in the ground, as a place to deposit sewage sludge.

Methodology: This laboratory study evaluates sewage sludge treated with calcium oxide (quicklime) to reduce pathogenic contamination. Samples were analyzed at 10%, 15%, and 20% CaO levels, assessing pollution markers like total bacteria, fecal coliforms, streptococci, staphylococci, and helminth eggs. Effectiveness was measured by reduction rates, confirming CaO's potential to improve sludge safety for environmental management.

Findings: The results of the experiment conducted with the 20% treatment are promising. Indeed, data analysis revealed a remarkable reduction rate, varying between 98.00% and 100%, for the bacteriological parameters. The quantities of sewage sludge and lime, their physical state, temperature, pH, contact time, and inhibitors are parameters that influence the speed of this reaction. The results of the study show that chemical treatment with calcium oxide has the potential to reduce the risk of biological contamination. The solid residues from the septic tank sludge treatment process can be used as fertilizer for agricultural soils.

Unique Contribution to Theory, Policy and Practice: This research is of major interest to all those involved in septic tank emptying and researchers interested in this field, as it addresses an aspect of environmental protection practices in the city of Kinshasa that has been overlooked until now.

Keywords: *Septage, Septic Tanks, Quicklime, Total Germs, Fecal Coliforms*

1.0 INTRODUCTION

Globally, in the city of Kinshasa, private manual and mechanical operators provide a more or less informal service for the collection, transport, and disposal of septic tank sludge. To date, wastewater effluent, whether from public or private toilets or septic tanks, is disposed of in the environment without prior treatment. According to Nodalis (2017), this phenomenon can take several forms: burial in the ground, discharge into watercourses, gutters, or other sites. Septic tank sludge is considered hazardous waste due to its high content of pathogenic microorganisms (see reference 2). This situation is likely to expose the population to health and environmental risks.

The lack of adequate sewage sludge disposal systems has repercussions on the environment and public health. It causes pollution of groundwater and surface water, soil, and air, as well as the destruction of the balance of ecosystems. In addition, waterborne diseases and aesthetic and olfactory nuisances are observed.

The aim of this study is to treat sewage sludge, which is generally discharged into the environment by manual emptiers, using a chemical process based on calcium oxide (quicklime). This approach aims to harness the fertilizing properties of this sludge in agricultural practices. In the fight against biological pollution, it is imperative to reduce, or even completely eradicate, pathogenic microorganisms that pose a risk to public health.

There are a range of processes for treating raw sewage sludge, the main objectives of which include reducing its volume, destroying pathogenic germs and microorganisms, reducing organic pollution, stabilizing it (to reduce the fermentability of the sludge), reducing odors, and managing micropollutants (Strauss et al., 2003). These elements are stabilized using biological (aerobic or anaerobic), chemical, or thermal processes (Defo, 2000). The physical and chemical properties and uses of quicklime are exploited for the treatment of septic tank sludge (https://www.internaute.fr/bricolage/chaux-vive-proprietes-et-utilisation-au-jardin/barbe-et-brocheton-2001). To our knowledge, the treatment of sewage sludge with quicklime is a novel innovation in the Democratic Republic of Congo.

2.0 MATERIAL AND METHODS

Environment

Sampling site

The septic tank from which the sewage sludge sample (SS) was taken (Table 1, Figure 1) is located in the city of Kinshasa, in the Democratic Republic of Congo.

Site selection

The sampling site was selected based on the following criteria:

- A non-urbanized neighborhood that uses manual emptying;
- A neighborhood close to the National Pedagogical University to facilitate the transport of samples to the laboratory within the required time frame;

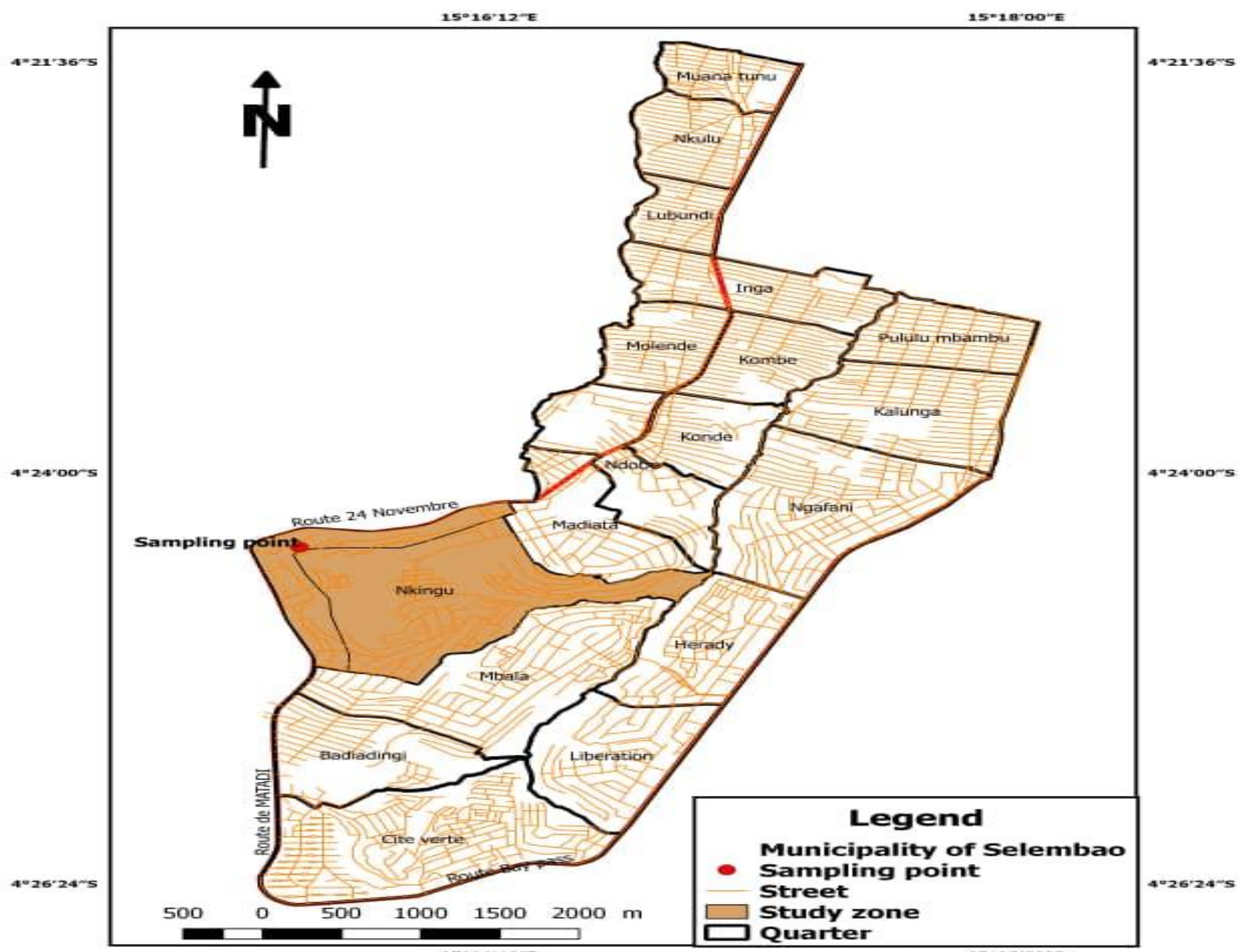
- Difficulties in accessing the site by sewage truck;
- A public toilet used by several households in the neighborhood.

Table 1: Geographic references of the sampling site and dimensions of the septic tank

Latitude	Longitude	Altitude (m)	Dimensions of the FS	
			Height (m)	**Diameter (m)**
04°25'27,6''S	015°15'30,3''E	495	2,40	0,80

Source: GPS

The septic tank in our study is cylindrical (two metal drums stacked on top of each other), with a capacity of: $(0.40)^2 \times 3.14 \times 2.40\ m^3 = 1.206\ m^3$ ($R^2 \times \pi \times h = V$).



Source : Roland Kakule, Ikonos, QGIS 2.14, Projection WGS 84, 2018

Figure 1: Geolocation of the BV sample collection site

Materials

These are fresh or partially mineralized sewage sludge, liquids resulting from the storage of sewage and excreta, drawn from a public toilet whose septic tank does not comply with standards (non-compartmentalized tank).

Methods

The methodology used for BV analysis includes sludge sampling and biological analysis methods in the laboratory.

BV sampling and packaging

The sampling protocol complies with the protocol for sampling sewage sludge from septic tanks, as described elsewhere (Gabert, 2018: Kone and Strauss, 2004; Larvido and Dodane, 2011): Sampling date: October 12, 2019: last emptying: February 12, 2019.

The sampled BVs are packaged in sterile glass bottles and transported in coolers containing ice cubes until they arrive at the laboratory.

Bacteriological analyses

The bacteriological analysis methods used are presented in Table 2

Table 2: Summary of bacterial

N°	Parameter	Units	Culture medium	Incubation temperature (°C)	Methods
01.	Biotic	CFU/100mL	Mac Conkey agar	37	Dilution, inoculation, and enumeration
02.	Total bacteria	UFC/100mL	Eosin or methylene blue agar	44.5	Dilution, inoculation, and enumeration
03.	Fecal coliforms	UFC/100mL	Blood agar	37	Dilution, inoculation, and enumeration
04.	Total streptococci	UFC/100mL	Blood agar	44.5	Dilution, inoculation, and enumeration
05	Fecal streptococci	UFC/100mL	Baird Parker agar	37	Dilution, inoculation, and enumeration

The biological parameters of raw sewage sludge and the same parameters of treated sewage sludge can be used to calculate the reduction rate using the following formula: R(%) =(Pe-Ps)/Pe x 100

Where:

R (%) is the reduction rate for a given parameter.

Pe is the value of the parameter for raw sludge.

Ps is the value of the parameter in the treated sludge.

(Fahmi et al., 2013)

3.0 RESULTS AND DISCUSSION

Results

The pH measurement is as follows in BVs with different degrees of liming: BVs limed at 0%: 7.12; BV limed at 10%: 12.3; BV limed at 15%: 12.4 and BV limed at 20%: 12.3.

Table 3 presents the results of the bacteriological parameter analyses in the treated BV and the reduction rate.

Table 3: Results of bacteriological analyses of BV and reduction rates

Bacteriological parameters (CFU/100 ml)	Limed sewage sludge at				Reduction rate (%)		
	0% (E)	**10% (E_1)**	**15% (E_2)**	**20% (E_3)**	**E_1**	**E_2**	**E_3**
Total germs	150.10^6	70.10^5	14.10^5	101.10^3	95,33	99,07	99,93
Log N	8,175	6,845	6,1405,004	5,004			
Fecal coliforms	71.10^6	5.10^5	1.10^5	Stérile	99,30	99,86	**100**
LogN	7,851	5,699	5,0	-			
Total streptococci	146.10^5	180.10^2	47.10^2	9.10^2	99,88	99,97	99,99
Log N	7,164	4,255	3,672	2,954			
Fecal streptococci	8.10^5	11.10^2	1.10^2	Stérile	99,86	99,99	**100**
Log N	5,903	3,041	2,0	-			
Staphylococci	5.10^6	31.10^5	7.10^5	1.10^5	38,00	86,00	98,00
Log N	6,699	6,491	5,845	5,0			

Legend: Log N: decimal logarithm of the concentration in CFU/100mL.

The concentration of total bacteria, fecal coliforms, total streptococci, fecal streptococci, and staphylococci decreases with the degree of liming.

The rate of microorganism reduction increases with the degree of liming at 10% (E1), 15% (E2), and 20% (E3).

Treatment of fresh raw milk with 20% calcium oxide (E3) results in 100% elimination of fecal coliforms and fecal streptococci, indicating complete disinfection.

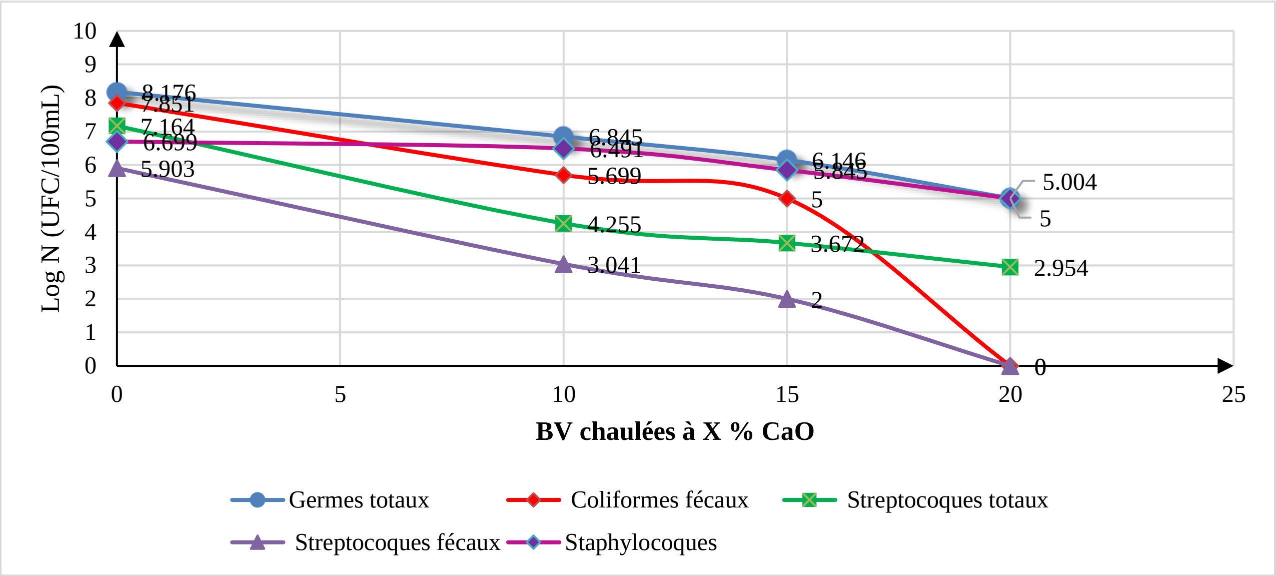


Figure 2: Changes in bacteriological parameters in BV

Source: Table 3

Limed raw milk shows a significant reduction in microorganisms. It appears that all biological parameter curves are decreasing. Treatment of fresh raw milk with calcium oxide (at 20%) results in 100% destruction of fecal coliforms and fecal streptococci. This CaO concentration appears to be the most suitable for total disinfection of BVs from fecal coliforms and fecal streptococci, protecting the health of handlers and the environment of latrine users.

Changes in parasitological parameters in treated BV

Table 4: Results of parasitological analyses of BV

Echantillon	**Parasitological analyses/Ch**				**Organic and mineral elements/Ch**		
	Helminth eggs	Protozoa	Cysts	Intestinal worms	Cellulose and other plant cells.	Grains of sand.	Striated in disintegration
Fresh BV	Ascaris 85	No vegetative forms	*Entamoeba hystolyca*+ *Entamoeba coli 10*	-	Yeasts + A few cellulose filaments 15	15	-
BV treated with 10%	Ascaris 20 Tricocéphale 5	Charcot Leyden crystals 5/Ch Intestinal trichomonas 30/	*Entamoeba coli* 5	-	10	10	-
BV limed at 15%	Ascaris 20	-	-	-	10	10	-
BV limed at 20%	Ascaris 20	-	*Entamoeba coli* 5	-	10	10	-

Source: Sample analysis

Legend:

Ch: Microscopic field

Ascaris reduction rate $= \frac{85-20}{85} = 76{,}5\%$

A significant reduction (76.5%) in helminth eggs is observed per microscopic field. This destruction is progressive depending on the concentration of quicklime disinfectant in the BV (10%, 15%, 20%): quicklime is a disinfectant. The basic pH and the age of the microorganisms are also factors that influence the rate of destruction of helminth eggs. Compared to bacteria and viruses, helminths show resistance to lime treatment. These microorganisms are sensitive to the prolonged action of the high pH of sludge (Barbe and Brocheton, 2001).

Interpretation

Fresh sewage sludge contains microorganisms that are pathogenic to humans. Due to their physical, chemical, and microbiological composition, sewage sludge is considered hazardous waste that poses numerous health and environmental risks (Ouedraogo, 2016).

They contain too many biological pollutants to be discharged into surface waters or treated as wastewater (Kone and Strauss, 2004). Treating fresh BV ensures minimal risk of environmental pollution, resulting in safe disposal or reuse (Klingel et al, 2002). Fecal coliforms and fecal streptococci are completely destroyed (100%) in manure treated with 20% lime, total bacteria by 99.93%, total streptococci at 99.99% and staphylococci at 98%, with very low resistance due either to the presence of organic matter (inhibitors) or to the short contact time between manure and CaO.

A concentration of 20% CaO appears to be the most suitable for treating BV to eliminate fecal coliforms and fecal streptococci. This situation is the result of interactions between quicklime and the constituent molecules of the bacteria, as well as the basic pH > 11.7.

The treatment ensured a reliable reduction in various groups of pathogens (http://www.who.int/water_sanitation_health/wastewater/volume4_chap05_fr.pdf; Nsavyimana et al., 2013).

4.0 CONCLUSION

The risk of infection from untreated septic tank sludge is high. These infections or contaminations could be prevented by treating the sludge to significantly reduce the number of pathogens. Disinfection is a chemical reaction. Quicklime disinfects through its basic pH and its saponification reaction with the lipids in microorganisms, enhancing the inactivation of pathogens. The physicochemical properties of quicklime and certain factors (physical state, temperature, pH, concentration, age of microorganisms, inhibitors such as soaps and organic matter) are responsible for the characteristics of BV treated in this study. The highly significant value of the R2 determination coefficients allows the good quality of the results to be assessed. After alkaline treatment, the fertilizer obtained could be beneficial for improving many marginal soils. This study also demonstrates that these wastes can be considered a resource rather than a problem.

We recommend that sewage sludge handlers protect themselves from health risks. To do so, they must be properly equipped with personal protective equipment and must wear it during emptying operations to avoid any contact with sludge and disease vectors. Farmers should not use raw (fresh) sludge for spreading on fields due to the high concentrations of pathogenic microorganisms. When treated, this sludge becomes a valuable fertilizer for crops. Politicians should separate the laws and regulations that apply to septic tank effluent from those that apply to urban wastewater, or update them to reflect the dangers of septic tank effluent. They should also work to provide the public with ways to treat septic tank effluent. collaborate with universities to support fundamental research that provides solutions to the serious problems faced by the population.

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