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Vermicomposting of Sludge from the Camp SIC Cité-Verte Wastewater Treatment Plant (Yaounde-Cameroon)

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Abstract

In Yaounde, as in most sub-Sahara African cities, wastewater management is a major concern. Through its national sanitation strategy, Cameroonian government takes many initiatives to improve the urban sanitation situation by constructing social housing, where wastewater treatment plants are integrated. However, their purification performance is often low and the by-products represent great risk factors. This paper focuses on preserving the health of the population, reducing environmental pollution, and improving soil fertility by vermicomposting sludge from the Yaounde Camp SIC Cité-Verte wastewater treatment plant. The methodological approach consisted of the characterisation of sludge, followed by the vermicomposting test. At the end of the 35-day process, the produced vermicompost was characterized, and its agronomic efficiency was tested on waterleaf (Talinum triangulare) cultivation. The Yaounde Camp SIC Cité-Verte wastewater treatment plant consistently produces an average of 239 Kg of sludge per day. The sludge is primarily composed of high carbonaceous material (53%) and contains essential nutrients for plant growth (NPK: 13%), along with pathogenic microorganisms and heavy metals in low concentrations. The characterisation of the vermicomposts obtained after 35

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days showed a conservation of nutrients (NPK) concentration and a decrease in carbonaceous matter and heavy metals. Moreover, there was a complete absence of fecal pathogens in the vermicompost of the two setups. The agronomic efficiency of the vermicomposts on waterleaf was shown by a high germination rate (100 % for vermicomposts), a high number of leaves (28 ± 15), a deep green coloration of plants, a great plant length (17.3 ± 4.6 cm), and a large stem diameter (2.1 ± 0.4 cm). The NPK content (>7%) indicates that the vermicompost produced can be used as an agricultural organic fertilizer.

Keywords: Sewage sludge, Biological treatment, Vermicomposting, Fertilization

1. Introduction

In most African cities, on-site sanitation is the most commonly used technology to improve access to sanitation (Gnagne et al., 2015). However, these systems produce important quantities of by-products (sludge scum, treated water, grit refuse…). Some of these products such as sludge contain organic matter and NPK which are fertilizing elements (SPANC, 2019). Throughout the years and even today, people have been using sewage sludge to fertilize fields and fishponds in order to maintain or regenerate the soil organic fraction. This particular by-product mostly undergoes treatment in order to limit sanitary and environmental risks due to its discharge and/or its reuse in agriculture (Bouzid & Djadi, 2015). The conversion of organic waste into vermicompost is of double interest because in addition to treating pollution, it also converts waste into fertilizing material (Bhat et al., 2015).

Yaounde, through the urban council, has 13 domestic wastewater treatment plants, most of which are managed by a private institution called SOPREC (Société de Prestation et de Construction). Among them is the wastewater treatment plant of Camp SIC Cite-Verte. It produces a large quantity of sludge collected as scum which needs to be well managed. In Cameroon, composting is more often applied among the potential techniques for biological transformation of fermentable material. However, due to its liquid appearance, raw sludge causes volume problems in terms of management, handling, and maneuverability. They also cause social reluctance for their safe handling due to their pathogenic and toxic pollution (risk of contamination of composting agents during their homogenization and aeration by manual turning). Therefore, the use of worms during vermicomposting ensures not only homogenization and aeration but also the rapid stabilization of organic matter. This non-thermophilic oxidation, which preserves the extremely volatile ammoniacal nitrogen, allows for obtaining a better quality product that is beneficial for the soil and plants. The general objective of this study is to contribute to the preservation of the environment

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and the health of populations downstream of wastewater treatment plants, as well as to support urban agriculture through sustainable management of sewage sludge. The specific objectives are as follows:

- To characterise the sludge from the Camp SIC Cité-Verte WWTP;
- To proceed with vermicomposting of the sludge and characterise the composts produced;
- To test agronomic efficiency of those vermicomposts on waterleaf cultivation.

2. Material and Methods

2.1. Presentation of the Camp SIC Cité-Verte WWTP

The Camp SIC Cité-Verte WWTP is a hybrid wastewater treatment plant with a planted filter. The different processes involved are as follows:

For pre-treatment:

- Screening: The wastewater is filtered through a grid whose bars are more or less spaced out to retain large materials;
- Grit removal tank: It consists of removing sand and inorganic particles through decantation, based on their weight;
- Fats and oil removal tank: It consists of eliminating fats and oil by flotation.

For primary treatment:

- Settling tank: Here, larger and heavier particles of sludge are drawn downward by gravity action in the tank;
- The Manhole (observation tank): It acts as a dashboard by giving an easy summary reference on the progress of the treatment.

For secondary treatment:

- Activated sludge: At the Camp SIC Cité-Verte WWTP, this system is dysfunctional;
- The planted filter: This treatment system aims at reducing dissolved pollution through the help of plants.

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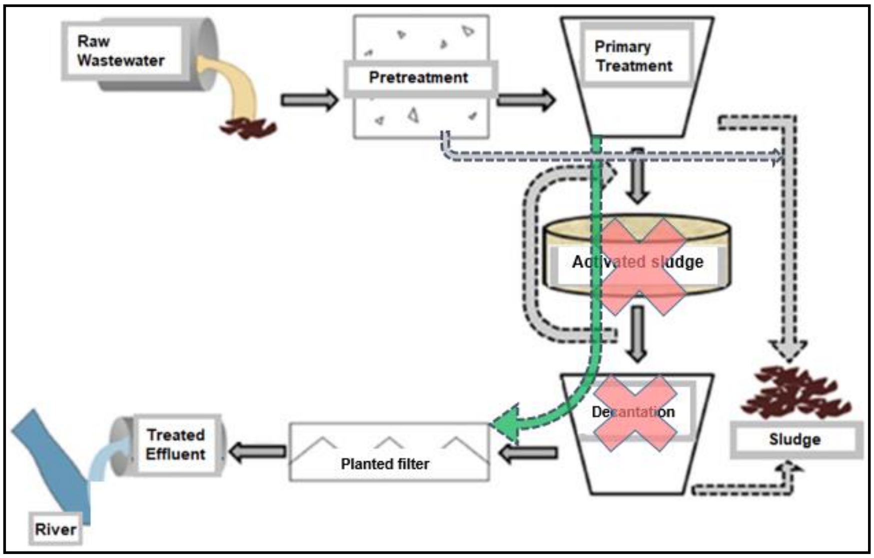

Figure 1. Summary diagram of Camp Sic Cité-Verte wastewater treatment plant

2.2. Characterisation of Sludge from the WWTP

2.2.1. Quantification of the Sewage Sludge

In order to estimate the quantity of sludge produced by the WWTP, interest was focused on daily production. This involved recording the quantity of sewage sludge skimmed in the different basins between the 15th of March and the 14th of April 2023.

2.2.2. Sampling of the Sewage Sludge

The sludge used for analysis was collected as scum from the pre-treatment and primary treatment basins (grit, fat and oil removal, settling tank and manhole). Collection was done directly by removing the sludge in the various basins with a shovel and a ten liter bucket. Thereafter, these sludge were mixed, loaded in four plastic bottles, and conserved in a cooler before transportation to the Hydrobiological and Environmental Laboratory of the University of Yaounde 1 for analysis (Figure 2).

Figure 2. Collection of samples for analysis (Source: Tambe, 2023)

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2.2.3. Analysis of the Sewage Sludge

The physicochemical and bacteriological analysis of the sludge was carried out in the laboratory stated above. The analysed physicochemical parameters include temperature, pH, Total Carbon (C_T), Total Nitrogen (N_T), Total Phosphorus (P_T), Potassium (K), heavy metals (Hg, Pd, Cd, Cr, Cu, Ni, Zn, As), and microbiological parameters, such as Faecal Streptococcus (F.S) and Faecal Coliforms (F.C).

2.3. Vermicomposting Process and Characterisation of the Composts Produced

2.3.1. Inputs

In order to carry out the vermicomposting process using sewage sludge, it was important to add some facilitating elements (Table 1). The inputs used during this process consisted of earthworms, household waste, leaf litter, and sawdust (Figure 3). Three setups (S1, S2 and S3) were put in place (Table 2).

Table 1. Reasons for choosing the various inputs

Inputs	Importance
Earthworms	To facilitate breakdown and aeration of the sludge To eliminate pollution in the sludge
Household waste	To boost and diversify the organic matter content of the compost
Leaf litter	To boost and diversify the organic matter content of the compost
Sawdust	To increase the dry matter content of the compost To increase the aeration and spacing of the compost's constituent particles

Table 2. Setups put in place during the vermicomposting process

Setup	**Sludge** (Kg)	**Earthworms** (*Eisenia fetida*)	**Sawdust** (Kg)	**Household waste** (Kg)	**Leaf litter** (Kg)
S1	9	200	/	/	/
S2	9	200	3	/	/
S3	9	200	/	1.5	1.5

Figure 3. Various inputs from the left to the right: Raw sludge, Earthworms, Household waste, Leaf litter, Sawdust (Source: Tambe, 2023)

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2.3.2. Vermicomposting System

The three setups were displayed in a bin of 1.8 m length, 0.5 m width, and 0.7 m height for a total volume of 0.63 m³. Thereafter, this bin was divided into 3 compartments, each having the following dimensions: length = 0.55 m, width = 0.5 m and height = 0.7 m for a total volume of 0.19 m³ each (Figure 4).

The setups were allowed for 35 days (maturation period) and the following maturation parameters were monitored: temperature, odour, colour, and microorganism activity.

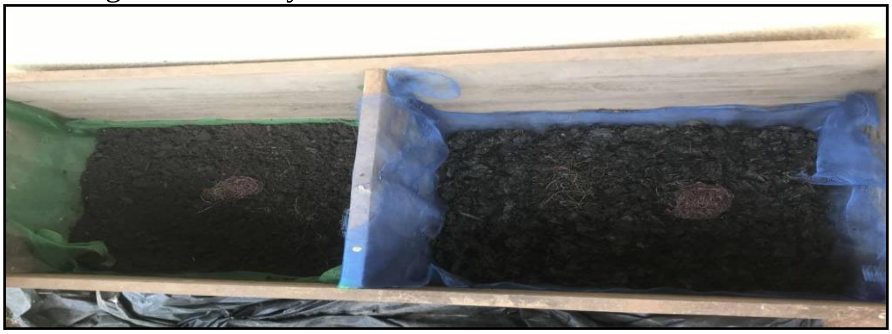

Figure 4. Experimental setups of vermicomposting test at Camp SIC Cité-Verte WWTP (Source: Tambe, 2023)

2.3.3. Analysis of the Vermicomposts

After the 35 days process, 100g of each vermicompost sample were taken to the laboratory in plastic containers for analyses. The analysed physicochemical parameters include temperature, pH, dry matter (MS), total carbon (C_T), total Nitrogen (N_T), total Phosphorus (P_T), Potassium (K), heavy metals (Hg, Pd, Cd, Cr, Cu, Ni, Zn, As), and microbiological parameters, such as Faecal Streptococcus (F.S) and Faecal Coliforms (F.C). These analyses were carried out in the Hydrobiological and Environmental Laboratory of the University of Yaounde 1.

2.4. Agronomic Efficiency Test

2.4.1. Criteria for Choosing the Crop

Below are some reasons why waterleaf (*Talinum triangulare*) was chosen as the crop for this study:

- Waterleaf is a short life-span species and takes an average of 30-45 days from planting to harvest;
- The edible leaves of the plant are soft, succulent, and highly nutritious;
- The demand for waterleaf in local markets is high, and during certain seasons, it is subjected to high scarcity;
- The marketability of waterleaf could result in high income generation.

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2.4.2. Agricultural Application and Monitoring of Parameters

The test crops were planted on the resulting vermicomposts from the different setups. Ten substrates were used (Figure 5):

- 100% Soil (M0) as reference;
- 100% Vermicompost (S1, S2, S3);
- 25% Soil + 75% Vermicompost (S1, S2, S3);
- 75% Soil + 25% Vermicompost (S1, S2, S3).

Each substrate was made of 3 repetitions within polyethylene bag containing 4 waterleaf plants each. Thereafter, monitoring of growth parameters was carried out. These observations focused on examining the plants' progression from planting to maturity (30 days). In the process, four parameters were considered to evaluate the efficiency of the vermicomposts produced: number of leaves, colour of leaves, plant length, and stem diameter.

Figure 5. Some substrates setup (Source: Tambe, 2023)

3. Results and Discussion

3.1. Characterisation of Sludge from the Camp SIC Cité-Verte WWTP

3.1.1. Quantity of Sewage Sludge

From the 15th of March to the 14th of April 2023, 7,180.5 Kg of sludge were produced at the camp Sic Cité-Verte WWTP. The sludge primarily originated from the pre-treatment process (Grit removal tank: 51%; Fats and oil removal tank: 32%; Table 3). There was a significant fluctuation in the daily sludge production (239.4 ± 101.5 Kg) according to the fluctuations in household activities (Figure 6).

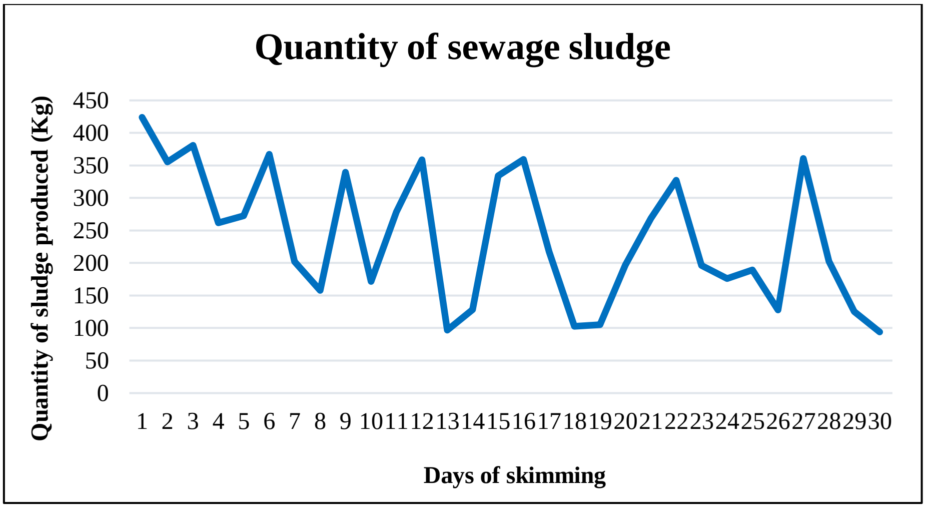

Figure 6. Daily quantity of sewage sludge

Table 3. Origins of sewage sludge

Period / **Structure**	**Daily production** (Kg)	**Monthly production** (Kg)
Grit removal tank (Kg)	122.9 ± 68.3	3 687
Fats and oil removal tank (Kg)	76.6 ± 25.1	2 299
Settling tank (Kg)	26.9 ± 7.7	806.5
Manhole (Kg)	12.9 ± 2.6	388
TOTAL (Kg)	**239.4 ± 101.5**	**7 180.5**

3.1.2. Quality of Sewage Sludge

The WWPT's sludge are liquid (MS = 7.2%) and originate from pre-treatment and primary treatment. Nonetheless, they can assimilate to secondary sludge based on their high carbonaceous matter rate (53%). They also possess a low concentration of pathogenic microorganisms and heavy metals (Table 4). Collected daily as scum, they are discharged into nature but fail to meet local discharge standards. Essential nutrients for plant growth, such as NPK (13.2%), are present. The temperature and pH values are ideal for worm growth and activity, ensuring a proper functioning of the decomposition process. Therefore, the sludge could be vermi-stabilised and valorised for agricultural purposes.

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Table 4. Results of analysed parameters of sewage sludge

Parameters	Values on sewage sludge	Limited values (NC-2867)
pH	8.2	6.5-8.5
Temperature (^{0}C)	25	30°C
MS (g/L)	72	50 mg/L
C_T (%)	53.01	-
P_T (%)	2.5	10 mg/L
N_T (%)	8	30 mg/L
K_T (%)	2.7	-
Heavy metals	**Values on sewage sludge (mg/Kg)**	**Limited values (NC-2867)**
Cr	53.9	0.2 mg/L
Cu	103	0.15 mg/L
Ni	53.85	0.2 mg/L
Zn	250	0.1 mg/L
As	6	0.3 mg/L
Cd	2.69	0.02 mg/L
Pb	108	0.1 mg/L
Hg	1	25 µg/L
F.S (CFU/100mL)	128	1000
F.C (CFU/100mL)	166	2000

3.2. Implementation Process of Vermicomposting and Characteristics of the Composts Produced

3.2.1. Vermicomposting Process

Vermicomposting in wooden bins was the technique used because it is adequate for small scale vermicomposting. The following maturation parameters were observed during the process of vermicomposting:

- **Odour and colour change**

In all three setups, it was observed that the products gained a darker coloration by the end, with setup 3 being the darkest. The dark colour is due to the increase in humus matter following decomposition of organic matter in the setup. After 35 days of vermicomposting process, the bad smell that was present at the start of the experimentation turned into earthen smell. It is suggested that when vermicompost matures, it becomes darker and the initial unpleasant smell disappears (Gnanasekaran et al., 2023).

- **Temperature Variation**

The details on the temperature variation in the course of the vermicomposting process in (°C) are given in Table 5 and Figure 7.

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Table 5. Temperature variation in the different setups

Setup	Day 1	Day 5	Day 10	Day 15	Day 20	Day 25	Day 30	Day 35
S1	23.5	30.4	29.5	26.8	24	22.8	22.5	22.5
S2	23.3	29.8	29.4	27.9	24.5	23.1	23	22
S3	24.3	30.1	29.7	27.6	22.6	22.6	22.3	21.6
Average	**23.7 ± 0.5**	**30.1 ± 0.3**	**29.5 ± 0.2**	**27.4 ± 0.6**	**23.7 ± 1.0**	**22.8 ± 0.3**	**22.6 ± 0.4**	**22 ± 0.5**

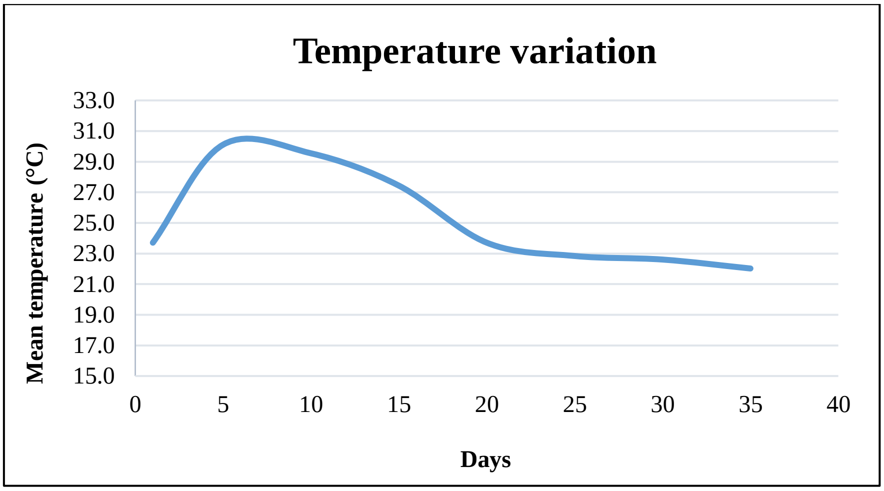

Figure 7. Temperature variation during vermicomposting

Since vermicomposting is a non-thermophilic oxidation of organic matter, in the three setups, the high temperatures observed between the 5th and 10th day did not reach 31°C. They were moderate around the 20th day (24°C) and became stable from the 25th to 35th day (22°C). Contrarily to the thermophilic compost which can generate temperatures up to 65°C, the vermicompost is an ambient temperature product (Alfred, 2020).

3.2.2. Characteristics of Vermicomposts Produced

The quantity and characteristics of vermicomposts produced are given in Tables 6 and 7.

Table 6. Quantity of different vermicomposts produced

Vermicompost Setups	Inputs	Quantity obtained (Kg)	Conversion rate (%)
S1	9 Kg sludge + 200 worms	4.2	47
S2	9 Kg sludge + 3 Kg saw dust + 200 worms	6.8	57
S3	9 Kg sludge + 1.5 Kg Household waste+ 1.5 Kg Leaf litter + 200 worms	6.1	51
TOTAL	**33 Kg + 600 worms**	**17.1**	**52**

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Table 7. Characteristics of different vermicomposts produced

Parameters	S1	S2	S3	Average	AFNOR NF U-44-095
pH	8.11	8.22	8.40	**8.2 ± 0.15**	6-9
Temperature (°C)	22	23	22.5	**22.5 ± 0.50**	<30
C_T (%)	44	48	59	**50.3 ± 7.76**	/
P_T (%)	2.5	2.8	3.1	**2.8 ± 0.3**	<3%
N_T (%)	2.06	2.85	3.05	**2.7 ± 0.52**	<3%
K_T (%)	2.7	3.1	2.9	**2.9 ± 0.19**	<3%
C/N ratio	21.36	16.84	19.34	**19.2 ± 2.26**	<20
Heavy metals		**Values(mg/Kg)**			**Limited values (NFU 44-051)**
Cr	26.9	27.4	26.7	**27 ± 0.4**	120
Cu	25.1	24.8	24.6	**24.8 ± 0.3**	300
Ni	6.8	6.3	6.5	**6.5 ± 0.3**	60
Zn	206	203	201	**203.5 ± 2.5**	600
As	1.6	1.4	1.3	**1.4 ± 0.2**	18
Cd	0.7	0.5	1	**0.7 ± 0.3**	3
Pb	30.2	30.2	30.5	**30.3 ± 0.2**	180
Hg	0.04	0.03	0.07	**0.05 ± 0.02**	2
F.S (CFU/100mL)	27	Ab	Ab	**9**	1000
F.C (CFU/100mL)	36	Ab	Ab	**12**	2000

During the vermicomposting process, a reduction in the mass of decomposing materials was observed in the three setups, with an emphasis in the first setup (S1). This is essentially due to the transformation of carbon and nitrogen, as well as the bio-evaporation of water, by the activity of earthworms and decomposer microorganisms present. The addition of carbonaceous matter and structuring elements in setups 2 and 3 allowed for the improvement of the efficiency of the process. According to Glenn (2020), during vermicomposting, the weight of final product is very close to 50% of the weight of inputs.

The vermicomposts produced generally comply with the qualitative criteria of French standards NFU 44-095 and NFU 44-051, which is specific to composts produced from sludge and organic amendments. At first glance, the environmental safety of these composts is verified by the contents of trace metallic elements (heavy metals) and pathogens (F.S and F.C), which are below the limit values. The vermicomposts produced also have good amending values (C_T >40%) and good fertilizing values (NPK >7%), with a graduation from S1 to S3. Since the obtained values fall within the recommended standard range, these composts can be used safely in agriculture, serving not only as an amendment but also as an organic fertilizer.

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From the above data, raw sludge was compared to vermicompost (average) based on their physicochemical and microbiological parameters (Figures 8 and 9).

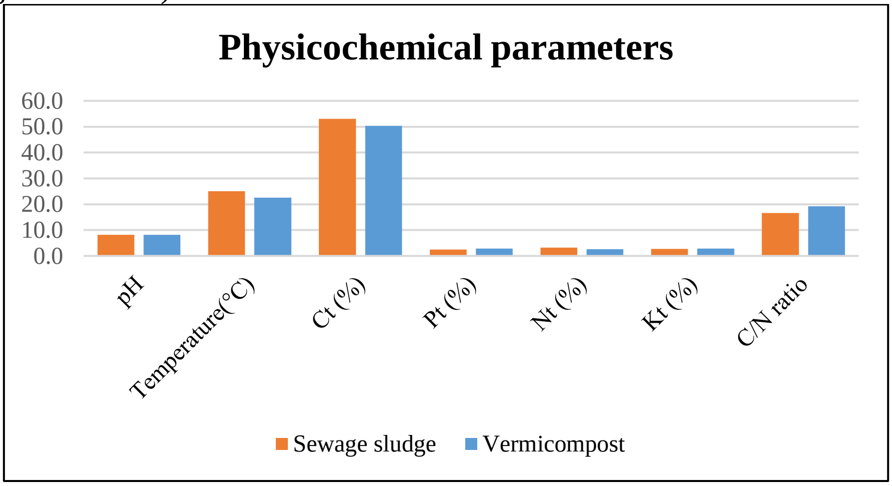

Figure 8. Comparison of sewage sludge and vermicompost based on physicochemical parameters

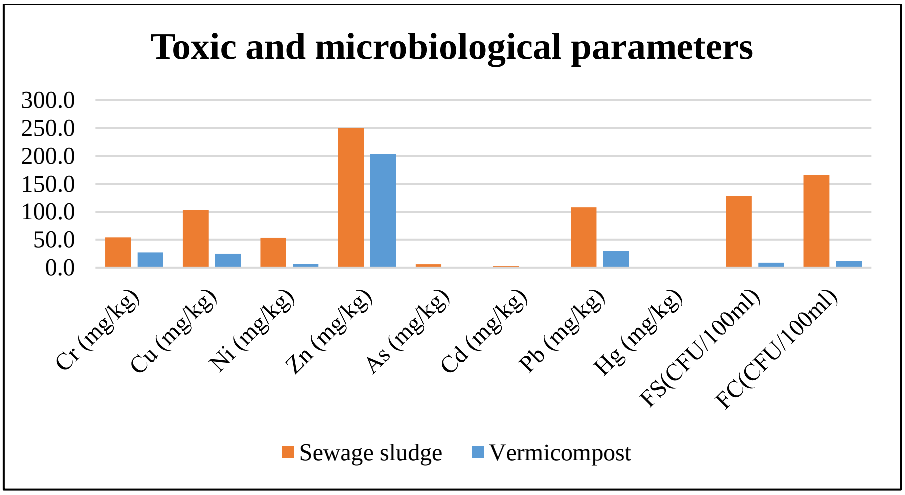

Figure 9. Comparison of sewage sludge and vermicompost based on toxic and microbiological parameters

Compared to the initial sludge used for the vermicomposting, there is a decrease of Carbon in the composts produced. It is due to the fact that during the vermicomposting process, microorganisms and earthworms use carbon as a source of energy for mineralization and decomposition of organic matter. Singh et al. (2013) attributed the decrease in organic carbon by the end of vermicomposting to the worm consumption of carbon and its transformation into CO_2 through respiratory activity.

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The total nitrogen in the vermicompost samples appeared to be slightly lower than that of the initial sludge. However, there is a conservation of ammoniacal nitrogen due to the absence of thermophilic phase during vermicomposting process. The C/N ratio of the vermicompost samples appeared to be slightly higher than the C/N ratio of the initial sludge due to the decrease of the carbon content and the conservation of the nitrogen content during the vermicomposting process.

The potassium concentration in the initial sludge was slightly lower than that in the vermicompost. Subsequently, the increase in potassium is due to the enhanced microflora present in earthworm gut (Sharma & Garg, 2022).

Compared to the initial sludge, there is an increase in phosphorus levels in vermicomposts. This is also reported by Liegui (2019) in vermicomposting of household waste. Furthermore, during the passage of organic matter in the intestines of earthworms, organic acids and phosphatases solubilize phosphorus and make it readily available (Bhat et al., 2017).

The quantity of heavy metals decreased in all three vermicompost samples compared to the raw sludge and the results from the microbiological analysis indicated a total reduction in the pathogenic population in the vermicompost S2 and S3. Similar results were reported by Kumar and Sekaran (2005), who observed a decrease in E. coli count from $8x10^2$ to 0.00 CFU g in the vermicomposting of 20 Kg of sugar cane trash and cow dung for 60 days. It is suggested that enzymes from the earthworms have an antiseptic effect on bacteria during the digestion process (Lotzof, 1999). Pierre et al. (1982) also mentioned that earthworms partially detoxify and disinfect the end product which is nearly odourless.

3.3. Agronomic Efficiency Test on Waterleaf

3.3.1. Germination Rate and Leave's Colour

All four plants cultivated on each of the nine soil profiles that received different doses of the vermicomposts produced grew (Table 8). This demonstrates the non-phytotoxicity and maturity of the vermicomposts produced. Zucconi et al. (1981), cited by Chennaoui et al. (2016), reported that compost with germination rates greater than 50% was free of phytotoxins and considered fully mature.

After receiving different doses of vermicompost, the different plant leaves presented various green colorations with the time. The plants that grew on the substrates without or with a little dose of vermicompost showed yellow and light green colours due to a progressive reduction in nitrogen content as the plants grew (Table 8). Yellow leaves are an indication that a plant is up taking little nitrates (Fabien, 2021).

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Table 8. Germination rate and leave's colour of the ten substrates

Substrates	100%Soil	100%(S1,S2,S3)	75%(S1,S2,S3)	25%(S1,S2,S3)
Germination rate	75%	100%	100%	100%
Leave's colour	Light and yellow green	Deep green	Deep green	Light green

3.3.2. Growth Parameters

The number of leaves, length of plants, and diameter of stems obtained after the maturity period (30 days) are presented in Figures 10 to 12.

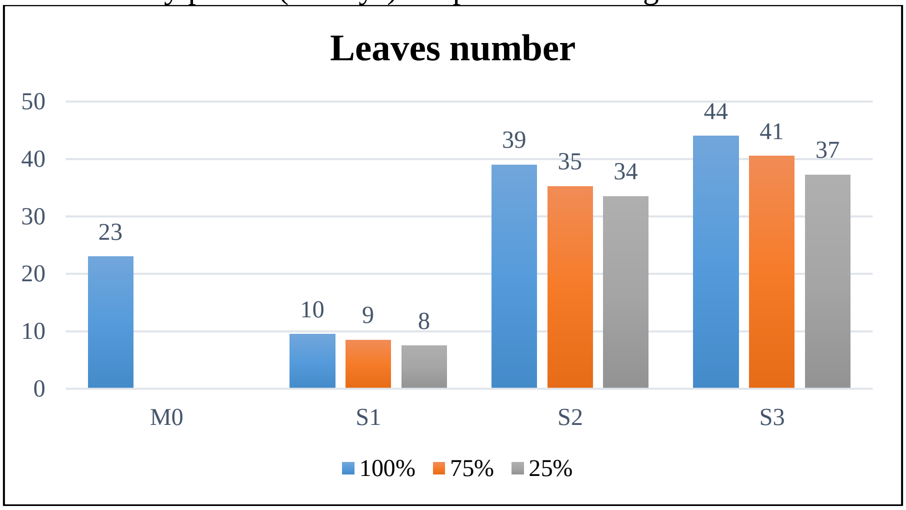

Figure 10. Number of leaves of plants on different substrates

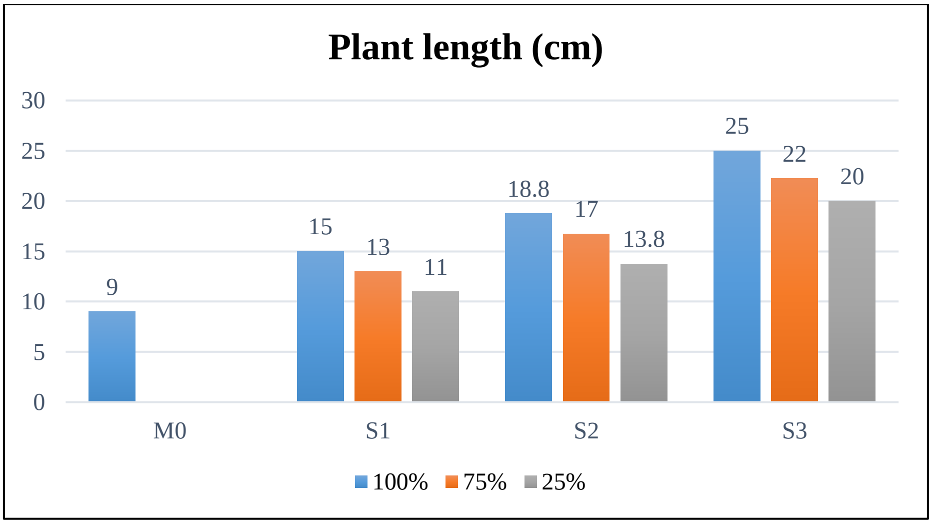

Figure 11. Length of plants on different substrates

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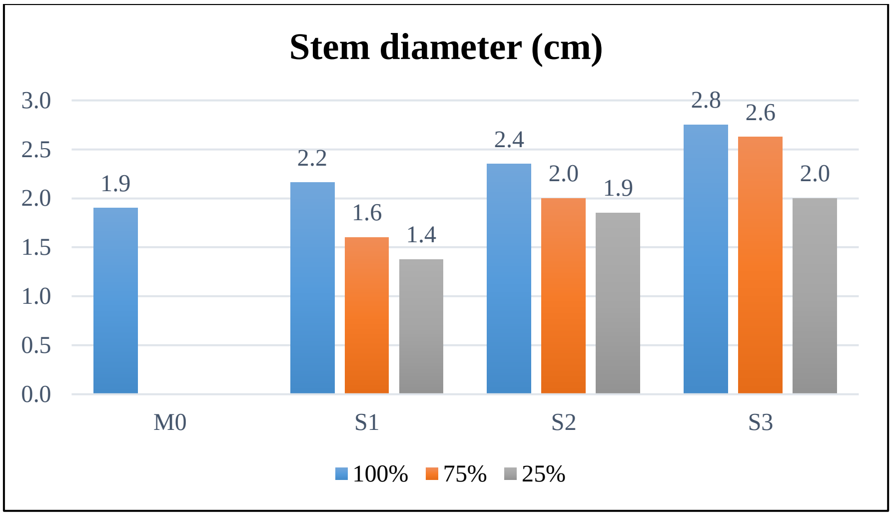

Figure 12. Diameter of stem of plants on different substrates

The plants with the greatest growth parameters are those which were cultivated on vermicompost samples S3, followed by those of samples S2 and S1. Finally, the plants from the control sample (M0) displayed the lowest growth. This disparity can be attributed to the higher content of organic matter and nutrients in setup 3 compared to the others, providing it with superior amending and fertilizing values. It is noteworthy that the diversification of fermentable inputs improves the quality and agronomic efficiency of vermicompost.

In addition, for plants cultivated on substrates which received different rates of the same vermicompost (S1 or S2 or S3), growth efficiency was dependent on the vermicompost rate. Therefore, the plants cultivated on substrates with 100% of different vermicomposts (S1 or S2 or S3) grew better than those on substrates with 75% of different vermicomposts, which in turn, outperformed those on substrates with 25% of different vermicomposts. The quantity of vermicompost also significantly affects the bioavailability of nutrients and structure of the soil.

Conclusion

At the end of this study, characteristics of the wastewater treatment plant of Camp SIC Cité-verte are known. It is observed that this domestic sanitation structure produced approximately 239 Kg of sludge daily during the period from 14th March to the 15th of April 2023. These sludge were charged with carbonaceous matter, nutrients for plant growth, and slightly with toxic and pathogenic components.

The vermicomposting experimentation of these sludge in wood bin during the 35 days process made it possible to obtain products whose characteristics, although varying with the inputs used, generally comply with international compost standards. It is observed that the variation in parameters during the process indicates a positive shift towards stabilisation of the final products. Red worms used for the study at the Camp SIC Cité-verte WWTP demonstrated their already known ability of converting organic matter to plant-usable forms while simultaneously reducing pollution.

The cultivation test permitted the evaluation of the agronomic efficiency of the different vermicomposts produced on waterleaf plants. It was found that the plants that received vermicompost of setup 3 (S3: sludge + leaf litter + household waste + worms) and those cultivated on substrates with 100% of different vermicomposts grew faster than the others. Thus, vermicompost boosts plant growth and this effect is amplified with the good quality and the sufficient quantity of vermicompost applied.

Vermicomposting of sewage sludge appears to be a viable and sustainable solution to overcome the risks presented by their disposal in nature and their direct spreading in urban agriculture. However, a detailed assessment of the costs and conditions relating to its implementation would further help in decision-making. To complete and perfect the study of the agronomic efficiency of the different vermicomposts, it is recommended to carry out tests on other crops and to weigh the quantities of edible plant biomass obtained.

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References:

1. Alfred Grand (2020). *Compost : Vermicompost*. Fiche technique, Best4Soil, 2 p.
2. Amir, S. (2005). *Contribution à la Valorisation de Boues de Stations d'Epuration par Compostage : Devenir des Micropolluants Métalliques et Organiques et Bilan Humique du Compost.* Thèse de Doctorat, Institut National Polytechnique, Toulouse, France.
3. ANOR NC-2867 (2021). *Environnement-Exigences relatives aux rejets des effluents liquides industriels*. Agence des Normes et de la Qualité, ICS N°13-030-40, 71 p.
4. Bhat, S. A., Singh, J., & Vig, A. P. (2017). *Instrumental characterization of organic wastes for evaluation of vermicompost maturity*. Journal of Analytical Science and Technology, 8(2), 12p.
5. Bhat, S. A., Singh, J., & Vig, A. P. (2015). *Potential utilization of bagasse as feed material for earthworm Eisenia fetida and production of vermicompost. Springerplus.* 28p.
6. Bouzid, M. & Djadi A. (2015). *Revaluation of activated sludge and chicken manure through composting by aerobic process*. Afr. J. Agric. Res., 10(52), pp 4831-4836.
7. Chennaoui, M., Salama, Y., Makan, A., & Mountadar, M. (2016). *Valorisation agricole d'un compost produit à partir du compostage en cuve des déchets municipaux.* ESJ, vol. 12, N° 35, pp 247-265.
8. Etsè, A., Sanonka, T., Kokou, S., Magnoudéwa, B. B., Kokou, D., Koffi, K. A., Gado, T., & Gnon, B. (2014). *Etude de la disponibilité du phosphore assimilable des composts des déchets urbains dans deux sols différents.* European Scientific Journal, ESJ, 10(6), pp 156-167.
9. Fabien (2021). *Reconnaitre les carences des plantes d'aquarium*. Aqua Store, 4 p.
10. Fernando, M., Aira, M., & Jorge D. (2009). *Changes in bacterial numbers and microbial activity of pig slurry during gut transit of epigeic and anecic earthworms* J. Hazard. Mater. 162, pp 1404-1407.
11. Glenn Munroe (2020). *Guide du lombricompostage et de la lombriculture à la ferme.* Centre d'agriculture biologique du Canada, 37 p.
12. Gnagne, Y. A., Yapo, B. O., Meite, L., Kouamé, V. K., Gadji, A. A., Mambo, V., & Houenoul P. (2015). *Caractérisation physico-chimique et bactériologique des eaux usées brutes du réseau d'égout de la ville d'Abidjan*. Int. J. Biol. Chem. Sci., 9(2), pp 1082-1093.
13. Gnanasekaran, R., Jerin Rexiya, S., Dhanalakshmi, M., Abinaya, M., Priyadharshini, B., Sharmilee, D., & Udayamathi, M. (2023). *Utilization of Lagerstroemia speciosa dry leaf litter combined with cattle dung for the production of enriched vermicompost – A possibility*

 ISSN: 1857-7881 (Print) e - ISSN 1857-7431

of valorization. International Journal of Recycling of Organic Waste in Agriculture, 12(4), pp 699- 708.

14. Kathy Donohoe (2018). *Chemical and Microbial Characteristics of Vermicompost Leachate and their Effect on Plant Growth*. Doctor of Philosophy thesis, School of Life and Environmental Science, University of Sydney, 287 p.
15. Kavita Sharma & Garg, V. K. (2020). *Conversion of a toxic weed into vermicompost by Eisenia fetida : Nutrient content and earthworm fecundity*. Bioresource Technology Reports, volume 11, page 100530.
16. Liegui Ginette Sandrine (2019). *Une alternative durable de valorisation des déchets organiques ménagers en maraichage périurbain à Yaoundé (Cameroun).* Mémoire de fin d'études de Master, Université de Liège, Belgique, 79 p.
17. Lotzof, M. (1999). *Very Large Scale Vermiculture In Sludge Stabilisation.* Paper Written by Vemiitech Pty Ltd., Darlinghurst, Australia: 26p.
18. Pierre, V., Phillip, R., Margnerite, L., & Pierrette, C. (1982). *Anti-Bacterial Activity of the Haemolytic System from the Earthworms Eisenia fetida andrei*. Invertebrate Pathology, Vol. 40, No. 1, pp 21-27.
19. Singh, S., Khwairakpam, M., & Tripathi, C. N. (2013). *A comparative study between composting and vermicomposting for recycling food wastes.* International Journal of Environment and Waste Management: https://doi.org/10.1504/jewm.2013.056119, 231p.
20. Subler, S., Edwards, C.A., & Metzger, P. J. (1998). *Comparing vermicomposts and composts.* Biocycle, pp 63-66.
21. SPANC (2019). *Synthèse sur la valorisation agricole des boues de vidange dans la commune d'Aného.* 17 p
22. Toundou, O., Tozo, K., Amouzouvi, K. A. A., Kolani, L., Tchangbedji, G., Kili, K., & Gnon, B. (2014). *Effets de la biomasse et du compost de Cassia Occidentalis L. sur la croissance en hauteur, le rendement du maïs (Zea Mays L.) et la teneur en NPK d'un sol dégradé en station expérimentale*. European Scientific Journal, ESJ, 10(3), pp 294-308.
23. Vaidyanathan, G. & Vijayalakshmi, A. (2017). *Effect of vermicompost on growth and yield of tomato.* European Journal of Pharmaceutical and Medical Research, pp 653-656.