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Physico-chemical Characterization of the Leachate from Fermentation Composts Treated with Lime and Soda: Case of the Composting Platform in Aného, Togo

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Authors' contributions

This work was carried out in collaboration among all authors. Author EKK designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author NM'BK and E A managed the analyses of the study. Author KNS managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

This study aims to determine the parameters measuring the reduction rate of the organic matter during fermentation and its bio-availability after maturation of the compost made using fermentable fractions of household waste. Thus, a physico-chemical characterization of the raw leachate and the leachate treated with lime and caustic soda was carried out. The results showed that, the contents of the other parameters measured are higher for the raw leachate compared to those obtained for the treated leachate. Organic and inorganic pollution is reflected by high Chemical Oxygen Demand (COD), absorbance at 254 nm, turbidity and suspended matter. The COD values in the raw leachate

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vary between 13000 and 19150 mg/O_2/L; those of the absorbance at 254 nm between 30.5 and 34.15 OD; those of turbidity between 156 and 255 NTU (Nephelometric Turbidity Unit) and those of suspended matter between 48 and 1600 mg/L. In the treated leachate, the COD values oscillate between 4489 and 8743 mg/O_2/L; those of the absorbance at 254 nm between 6.69 and 31.1 OD; those of turbidity between 57.8 and 122 NTU and those of suspended matter between 70 and 92 mg. These results reflect a good reduction after treatment with lime and soda.

Keywords: Abatement; absorbance; leachate; turbidity; compost.

1. INTRODUCTION

Composting is one of the most popular urban waste management solutions in the world. The aim is to face not only the problems of unsanitary conditions in cities, in particular cities in developing countries (DCs), but also to deal with the thorny problems of environmental pollution. One of the major concerns associated with this management method is the production of large quantities of liquid effluents which are very rich in different substances, namely organic and mineral matter called leachate or juice. Indeed, this leachate comes from the percolation of rainwater through the deposits as well as the water contained in the waste and that of its degradation [1,2]. Once deposited, this waste undergoes degradation phenomena or processes due to fairly complex physico-chemical and biological reactions. The water infiltrates and produces leachate rich in organic substances (biodegradable, but also refractory to biodegradation) and minerals which are at the origin of organic and inorganic pollution, linked to the natural biodegradation of the contained waste. These leachates would be a potential source of contamination of the surrounding environments if they are not collected and treated [1,2]

Thus, in Morocco, the study of the physico-chemical quality of groundwater near the Casablanca landfill revealed high levels not only of major elements but also of metallic elements from the leachate from this landfill [3]. Studies carried out by [4] on the leachate from the Technical Landfill Center (CET) in the city of Oujda (Morocco) showed high levels of biodegradable organic matter, heavy metals, mineral matter and suspension [5], in Algeria, in their study on the Tiaret landfill, showed that the leachate contains many organic and metallic contaminants above the accepted standards. [6] in their work on the El Kerma landfill showed similar results [7]. In Côte d'Ivoire in 2000, carried out specific studies on the evaluation of the physico-chemical parameters of surface water downstream of the Akouédo landfill in order to assess their degree of contamination by leachate. On the other hand, [8] using a mathematical model, followed the evolution of leachate from the Akouédo landfill and assessed their impact on the quality of groundwater. The studies carried out by Adjiri in 2010 made it possible to characterize the chemical and microbiological pollution of the Akouédo environment in order to quantify the health risks associated with this pollution.

This study aims to determine the parameters measuring the reduction rate which provides information on the evolution of organic matter during fermentation and its bio-availability after maturation of the compost produced with fermentable fractions of solid waste at the composting platform in the city of Aného, Togo.

2. MATERIALS AND METHODS

2.1 Study Zone

The study area is in the municipality of Lakes 1 (Fig. 1) located in the prefecture of lakes with the capital of Aného which is located in the maritime region. The Municipality of Lakes 1 is bounded to the North and North-East by the Municipalities of Lakes 4 (Anfoin, Fiata, Ganavé) and Lakes 2 (Aklakou, Agouègan), to the South by the Atlantic Ocean, to the East by the Republic of Benin and to the West by the Municipality of Lakes 3 (Agbodrafo).

The Commune is characterized by the tropical climate of the Guinean type which manifests itself by two rainy seasons (March-July and September-October) and two dry seasons (August-September and October-February). These different seasons are increasingly disrupted by climatic anomalies. The rains become irregular, sometimes abundant (which causes flooding in places), sometimes rare. The average rainfall varies between 900 and 1500 mm per year, and temperatures vary between 25°C and 37°C. At times, a higher or lower temperature trend is recorded.

The vegetation to the south of the Commune is made up of aquatic trees (planted mangroves) and coconut palms, many of which have been destroyed by Kangnikopé disease or washed away by the ever-advancing sea. There are sandy soils favorable to the planting of coconut palms and market gardening. The forest tends to disappear due to human actions.

In the north of the Commune, the vegetation is made up of trees of different forest and aquatic species, all of which form the savannah, with a good number of forests being destroyed for the benefit of agriculture. Even the sacred forests have suffered heavy losses today. These are essentially the two sacred forests Avégbatso in Glidji Kpodji and Ananavé in Glidji, which host worship and ritual ceremonies. The Municipality opens onto a sea plan (about 12km) and has a network of rivers: the Gbaga channel and Lake Zowla.

2.2 Compost Raw Materials

The raw materials used for composting in this study are the fermentable fractions of household waste. These composts were produced on the composting platform of Aného managed by the municipality unlike that of Lomé, managed by the NGO ENPRO (Ecosystème Naturel Propre). Unlike ENPRO, failure to control the amount of water to be supplied to the piles (windrows) produces enormous leachate especially during pile formation and during fermentation. This therefore creates an environmental nuisance. This waste is deposited alternately in a series of layers and to allow aeration of the mixture an inversion is carried out every week.

2.3 Preparation of Samples

Four piles were prepared and watered in the same manner as all the others on the platform (Fig. 2). Small basins are created to collect the leachate. The leachate samples (E_1, E_2, E_3, E_4) were taken at the end of the fermentation and sent to the Laboratory.

2.4 Analyzes Carried Out on the Leachate from the Compost

The study of the characterization of the leachate resulting from the composting of fermentable fractions of household waste is a key factor which indicates the predisposition of waste deposits to biodegradation. Samples were taken during fermentation and maturation. The quantity of uncollected leachate on the composting platform is estimated at 5500 liters per month. The leachates from the composts are prepared in a solid / liquid ratio equal to 1/2, i.e. 25 g of compost sieved at 2 mm in 50 mL of distilled water. In the absence of reference parameters, the parameters deemed to be the most relevant are only taken into account in this study. Parameters such as pH, conductivity, volatile fatty acids (VFA), UV-254 absorbance, COD, turbidity, suspended matter (SS) are taken into consideration to characterize the different leachate. These various parameters are measured on the raw leachate and on the leachate treated (with lime and soda) according to the AFNOR standards in force.

2.5 Statistical Analysis

The data collected were subjected to a two-tailed equality of expectations test. The means were compared using the Student-Newman-Keuls test at the 5% threshold. Values followed by the same letter are not significantly different (Duncan, $p \leq 0.05$).

3. RESULTS AND DISCUSSION

Characterization of the raw leachate and the leachate after settling and filtration.

The characterization of the leachate resulting from the open-air composting of agricultural waste mixed with household waste produced on the Aného composting platform focused on various parameters. To determine these parameters, several analyzes are carried out either on the raw leachate, or on the leachate after settling and filtration, or on the raw leachate treated with lime or soda and either on the treated and filtered raw leachate.

The measurement of suspended matter (SS) makes it possible to evaluate the particle transfer between the solid and liquid phases during the leaching test and to deduce the degree of mechanical degradation of the materials put into composting. Estimating the organic load of leachate is a key indicator of the state of degradation of composted waste. This evaluation of the organic load is made by combining several parameters, namely the Chemical Oxygen Demand (COD), the UV absorbance concentration at 254 nm, the turbidity and the content of Volatile Fatty Acids (VFA).

Thus, in Table 1, the results of analyzes of the various parameters on the characterization of the

raw leachate and the leachate after settling and filtration are presented.

Analysis of the results of the pH measurement shows that the pH of the raw leachate varies between 7.54 and 7.76; on the other hand, the pH of the leachate after decantation and filtration varies between 6.07 and 7.94. The raw leachate has a slightly alkaline pH, which could be due to the presence of ash in the composted waste. This presence of ash is probably due to the fact that in Aného, most households use wood or charcoal for cooking. This result corroborates with those of the literature [9,10] Moreover, these high pH values obtained show that the leachate is no longer young [11]. The difference between the two measures is not significant ($p \leq 0.05$).

The determination of the ionic conductivity provides information on the quantity of charged species present in the various leachate. This is a key parameter for estimating the mineral load. The conductivity is higher in the raw leachate compared to that of the leachate after settling and filtration.

The VFA concentration of the raw leachate is 3.36 g/L and that of the leachate after settling and filtration is 2.04 g/L. These low values are indicative of low chemical stability and therefore of a high content of easily biodegradable organic matter [12]. The VFA contents greater than 10g / L are a sign of low degradation of organic matter [13].

The COD contents of the raw leachate are very high compared to those of the leachate after decantation and filtration. This difference in values is significant ($p \geq 0.05$) (Table 3). These high COD contents are linked to the high rate of Total Organic Carbon in the basic waste, thus indicating a high organic load. For a leachate of organic matter from a stable waste compost, the COD must be less than or equal to 1220 mgO_2/L [14,15] The COD contents of the raw leachate are greater than 1220 mgO_2/L and those of the leachate after settling and filtration are lower than 1220 mgO_2/L. These results indicate stability of the waste after settling and filtration and therefore show the positive effect of settling and filtration.

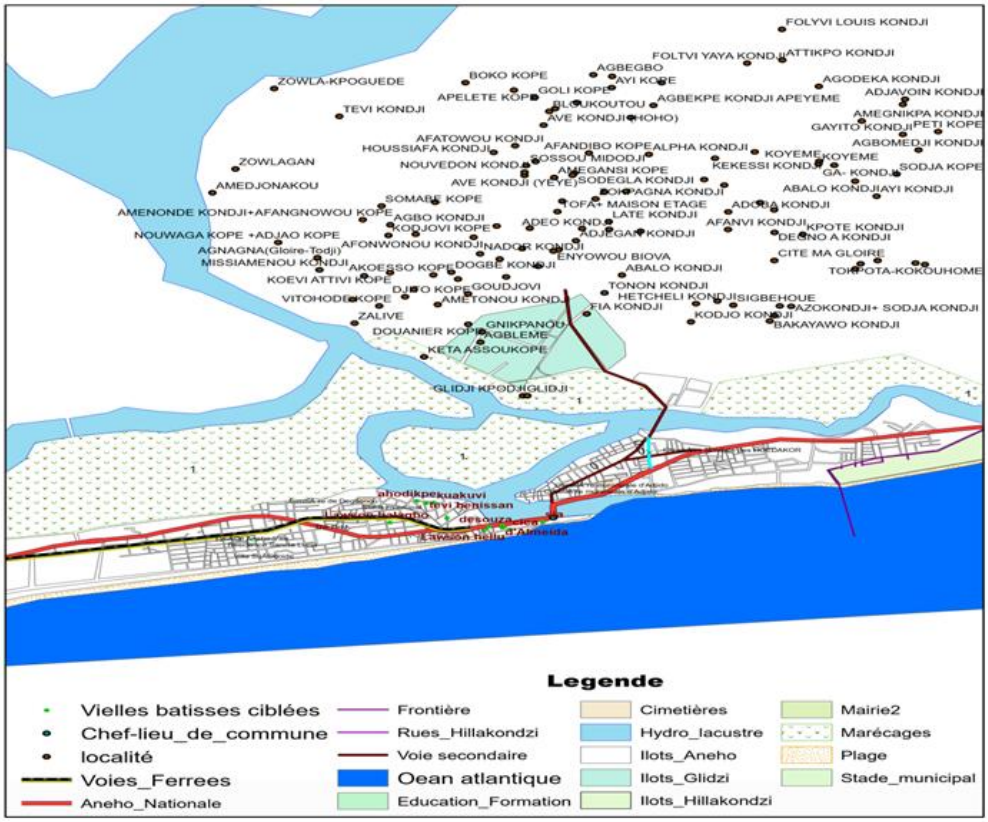

Fig. 1. Map of the municipality of lakes 1

Fig. 2. Pile of composts on the Aného composting platform

The UV absorbance measurement at 254 nm of the raw leachate is very high compared to that of the leachate after settling and filtration. This measure of absorbance shows significant differences ($p \geq 0.05$) (Table 3) between the raw leachate and the leachate after settling and filtration. This difference could be due to the retention of organic matter after passing through the permeate. These high absorbance values show that the raw leachate is very rich in organic matter.

The turbidity and suspended matter measured in the raw leachate are much higher than those measured in the leachate after settling and filtration. The difference between the two measurements is very significant (Table 3) ($p \geq 0.05$). These high values (of turbidity and suspended matter) are attributable to organic and inorganic materials. These results are also linked to the low concentration of dissolved oxygen [16].

Characterization of raw leachate treated with lime and with soda

Table 3 shows the results of parameter measurements on the leachate treated with lime.

Analysis of the results of the pH and absorbance measurement shows that with lime treatment, the pH and absorbance have the same value for the raw leachate as that obtained after filtration. Whatever the leachate, the pH is alkaline but this value is higher than that obtained for the leachate that has not undergone any treatment. The initial pH is acidic because this leachate corresponds to the fermentation phase of the garbage which is generally acidic during composting. On the other hand, the absorbance values decreased compared to the leachate without treatment. This result indicates that the lime has absorbed part of the organic matter. For leachate treated with soda, there is an increase between the raw leachate and that which has been filtered. This increase is due to the alkaline nature of soda.

The COD contents of the raw leachate treated with lime are very high compared to those of the leachate after settling and filtration. This difference in values is significant ($p \geq 0.05$) (Table 3). However, these contents are lower than those of the untreated raw leachate. Which indicates lime will absorb chemically oxidizable organic material. The COD increased after treatment with soda compared to the leachate treated with lime; which indicates a low absorption capacity of organic matter of soda compared to that of lime.

Table 1. Characteristics of the methods and apparatus used for the physico-chemical analyzes of leaching juices

Parameters	Unit	Cutoff threshold	Reference and standards	Methods and device	Accuracy and limit detection
pH	Unit pH	Gross Centrifugation	NF T90-008	pH meter: Eutech Instrument Model : CyberScan pH 510 Electrode: Ag / AgCl combined glass	± 0.1 unit pH
Conductivity (χ)	ms/cm	Gross Centrifugation	NF EN 27888 T90-031	Brand : WTW Model : LF 538 Measuring cell: Tetracon 325	10C<T°C<+55°C erreur max = 0.5%.
Volatile fatty acid	gCH_3COOH/L	0.45 µm	NF T90-105	Potentiometric dosage	-
Chemical oxygen demand (COD)	mgO_2 /L	0.45 µm	T90-101 ISO-15705	Technique : Rapid analysis kit Technique: UV spectrophotometer - visible	150 – 1000 mgO_2/L ± 6 mg O_2/L
Absorbance UV-254nm	-	0.45 µm	-	Technique : UV spectrophotometer - visible Brand : Shimatzu UV 1700 Pharmas Pec double beam - quartz tank 1cm	± 0.005 unit DO
Turbidity	NTU	-	-		-
MES	mg/L	1.2 µm glass fiber filters (Whatman brand)	NF T90-105	Drying at 105 ° C to constant mass	-

Table 2. Characterization of the raw leachate and the leachate after settling and filtration

Raw compost leachate parameters							MFT	Compost leachate parameters after settling						
VFA	**pH**	**COD**	**Abs UV 254**	**Turbidity**	**MES**	**Conductivity**	**F =0.2 mm**	**VFA**	**pH**	**DCO**	**Abs UV 254**	**Turbidity**	**MES**	**Conductivity**
gCH_3COOH/L		mgO_2/L	DO	NTU	mg/L	mS/cm	PTM= 1-2 bar	gCH_3COOH/L		mgO_2/L	DO	NTU	mg/L	mS/cm
	7.76	17068	30.5	156	1600	11.49	Qr = 2 m^3/H		7.42	11680	24	3.26	160	11.05
	7.54	13000	34.15	250	350	10.05			7.94	10512	20	17.6	28	10.59
	7.6		31.5	255	379				6.93		18.2	7.6	27.6	
3.36	7.56	19152	31.69	212	48	9.6		2.04	6.07	7956	14.79	1.86	4	7.35

Table 3. Characterization of the leachate treated with lime

LP supernatant parameters							MFT	Permeate P parameters						
VFA	**pH**	**COD**	**Abs UV 254**	**Turbidity**	**MES**	**Conductivity**	**F =0.2 mm**	**VFA**	**pH**	**COD**	**UV Abs 254**	**Turbidity**	**MES**	**Conductivity**
gCH_3COOH/L	12	mgO_2/L 8743.00	DO 6.69	NTU 57.8	mg/L 92	mS/cm	PTM= 1-2 bar Qr = 2 m^3/H	gCH_3COOH/L	12	mgO_2/L 7613	DO 6.69	NTU 12.2	mg/L 36	mS/cm

Table 4. Characterization of the leachate treated with soda

Raw leachate parameters							MFT	Permeate P' parameters						
VFA	**pH**	**COD**	**Abs UV 254**	**Turbidity**	**MES**	**Conductivity**	**F =0.2 mm**	**VFA**	**pH**	**COD**	**UV Abs 254**	**Turbidity**	**MES**	**Conductivity**
gCH_3COOH/L 4.8	7.57	mgO_2/L 14489.20	DO 31.1	NTU 122	mg/L 70	mS/cm 8.34	PTM= 1-2 bar Qr = 2 m3/H	gCH_3COOH/L 4.2	13.4	mgO_2/L 11374.2	DO 17.1	NTU 2.05	mg/L 6	mS/cm 14.55

Table 5. Abatement of raw leachate

	E_1	E_2	E_3	E_4
	Yield %	**Yield %**	**Yield %**	**Yield %**
COD	31.57%	19.14%	-	58.46%
UV Abs 254	21.31%	41.43%	42.22%	53.33%
Turbidity	97.91%	92.96%	97.02%	99.12%
MES	90.00%	92.00%	92.72%	91.67%
Conductivity	3.83%	-5.37%	-	23.44%
VFA	-	-	-	39.29%

Table 6. Reduction of leachate treated with lime and soda

	Leaching treated with lime	Reduction of leachate treated with soda
Parameters	**Yield %**	**Yield %**
COD	12.92%	21.50%
UV Abs 254	0.00%	45.02%
Turbidity	78.89%	98.32%
MES	60.87%	91.43%
VFA		12.5

Turbidity and suspended matter decreased when passing from the raw leachate and that filtered after lime treatment. The values obtained are lower than those obtained for the leachate which had not undergone any treatment. This result confirms that the lime treatment resulted in the reduction of organic and inorganic matter.

For leachate treated with soda, the values of the leachate treated are lower than those of the raw leachate and also lower than those of the leachate that has not undergone any treatment.
Organic matter reduction rate in leachate.

The parameters measuring the reduction rate provide information on the loss of organic matter, its evolution during fermentation and its bio-availability after maturation of the compost. Thus, in Table 5, the results of the reduction rate of organic matter on the raw leachate are presented.

Analysis of the results shows that the abatement is optimal for turbidity and SS. On the other hand, the reduction in dissolved OM is low, as is that in salinity. The last yields are perhaps exaggeratedly good on soluble COD due to the clogging of the membranes which improves, if not the flow rates produced, at least the quality of the permeate.

From these results, it is essential that these leachate, which constitutes a source of contamination of the surrounding environments, be collected and treated before any discharge. The reduction rates of organic matter in the leachate treated with lime and soda is presented by Table 6.

The analysis of the results of the characterization of the leachate shows, after treatment, a significant decrease in the various parameters determined. This significant difference thus indicates the effect of the treatment on the determined parameters.

Indeed, precipitation with lime in pretreatment is effective on the reduction of dissolved OM but not entirely, which is logical given the presence of AGV. Another advantage is also the speed of settling of the precipitate. The addition of lime at this pH <12-13> has another advantage, apart from the cost, it is the possible stripping of the ammonia. The treatment with soda is not as effective as that with lime in pretreatment before microfiltration, which is logical insofar as the excess calcium allows better precipitation of carbonates.

After treatment of the raw leachate with lime and soda, these high COD values; absorbance at 254 nm; turbidity and suspended matter have become very low, reflecting a high rate of abatement.

4. CONCLUSION

The characterization of the leachate resulting from the composting in fermentation of the composting platform of the city of Aného in Togo revealed a low chemical stability and consequently a high content of easily

biodegradable organic matter, thus translating a significant mineral and organic load. The organic and mineral load is reflected in the high COD values; absorbance at 254 nm; turbidity and suspended matter. The contents obtained in these pollutants remain higher than the accepted standards indicating the importance of the mineral and organic loads. However, after treatment of the raw leachate with lime and soda, these high COD values; absorbance at 254 nm; turbidity and suspended matter have become very low, reflecting a high rate of abatement. From this study, monitoring analyzes and controlling the leachate is essential before any release into the surrounding environment.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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