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Implementing biowaste source segregation for sustainable decentralized composting schemes in Tiassalé, southern Côte d'Ivoire

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Abstract

Research in sub-Saharan Africa has shown failures in most of municipal waste composting initiatives because of bad-quality composts due to the lack of biowaste source segregation. Until now, very few biowaste source-segregation initiatives have been carried out on this part of the world. This study aimed at assessing the biowaste sorting efficiency and the attitude of households towards a pilot biowaste source-segregation system linked to a decentralized composting plant in Tiassalé. For this purpose, the impurity rate of source-segregated biowaste was monitored through the first year of implementation. Then, a cross-sectional survey was conducted to evaluate households' attitude. The results have shown that the average impurities rate in source-segregated biowaste was very low (1%). This finding was confirmed by the results of laboratory analysis which revealed a very low heavy metals (0.2, 12.4, 7.1 and 15.5 mg kg^{-1} DS for Cd, Cr, Ni and Pb, respectively) contamination in the compost produced. Regarding the acceptability of the source-segregation system, the results showed that the majority (75%) of the participants accepted the source-segregation system of biowaste and almost half (47%) of them were ready to pay for such a collection service. In conclusion, this study revealed that providing households with the needed municipal solid waste management infrastructures and rising awareness about biowaste source segregation are keys for the establishment of such a collection system in Tiassalé and similar urban areas. The findings also proved the effectiveness of biowaste source-segregation system in the production of high-quality compost.

Keywords

Biowaste, source segregation, composting, low-income urban context, Côte d'Ivoire

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Introduction

Access to effective municipal solid waste (MSW) management services remains critical in any city of sub-Saharan Africa. Inadequate waste management has drastic effects on the environment, public health and the quality of life of urban residents (Kaza, 2018a). Recent research has shown that landfilling is still the main disposal option (76%) for MSW in sub-Saharan Africa (Kaza, 2018b; Oberlin and Szanto, 2011; UNEP, 2018), despite its numerous negative environmental impacts (greenhouse gas emissions and water and soil pollution). These negative impacts are mainly due to the degradation of the biodegradable fraction which represents about 50%–70% of MSW streams in these countries (Bezama et al., 2007; Mrayyan and Hamdi, 2006). Recycling of this fraction could therefore reduce the environmental impacts of MSW management systems and significantly extend the lifetime of existing landfills (Cofie et al., 2009; Couth and Trois, 2012).

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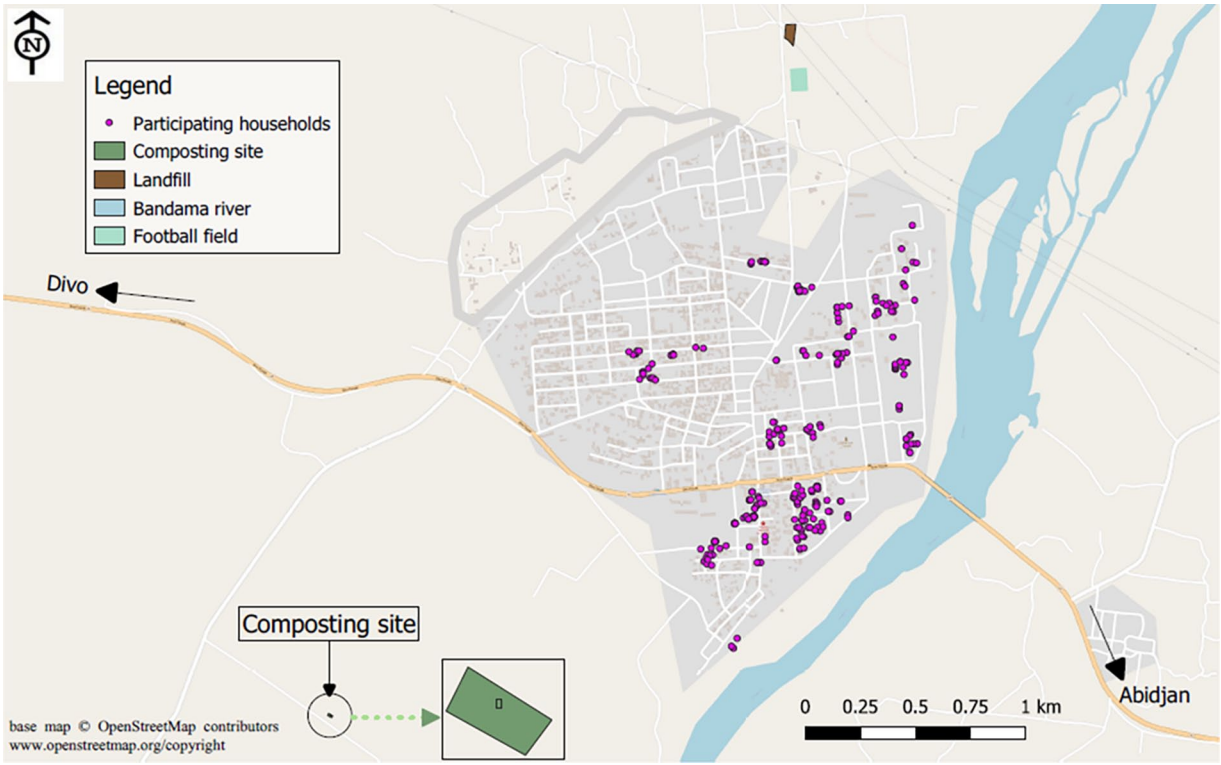

Figure 1. Map of the town of Tiassalé presenting the selected households.

Among the existing valorisation options for biodegradable wastes, composting seems to be the most appropriate for sub-Saharan African countries context (Couth and Trois, 2012; Ncube et al., 2022). In fact, composting process is relatively simple, low-cost and more environmental friendly compared to the other treatment options. Moreover, composting produces a biofertilizer and soil improver that can be used for agricultural crop production (Yeo et al., 2020). However, until now the potential of this biotechnology is still under-exploited in sub-Saharan Africa given the failure of the first composting initiatives. These failures were mainly attributed to the high investment and operation costs, inappropriate technologies and above all, the high heavy metal content in the compost produced. This poor quality of the composts was mainly due to the fact that these plants were processing mixed MSW instead of source-segregated biowastes (Kabera et al., 2019; Marmolejo et al., 2012; Oteng et al., 2013).

In developed countries where composting plants are widespread, these units are most of the time linked to a source-segregation system (Comesaña et al., 2017; Jensen et al., 2017; Oteng et al., 2013; Pognani et al., 2012). Compared to mixed wastes composting, source-segregated biowaste composting has several advantages: (1) it saves a substantial time (as sorting can represent up to 50% of working time), (2) it avoids contaminating compostable waste with dangerous products or materials and (3) it reduces the proportion of sand in compostable wastes. In sub-Saharan Africa, very few source-segregation initiatives have been implemented until now (Chisholm et al., 2021; Kihila et al., 2021). Source segregation is still perceived by decision-makers as a more costly system that is doomed to failure, since they do not believe that households will accept such a practice (Mbiba, 2014).

In 2017, the Swiss Centre for Scientific Research in Cote d'Ivoire with the support of the Volkswagen foundation has installed a pilot decentralized composting unit with source-segregation system of biodegradable wastes in the city of Tiassalé, southern Côte d'Ivoire. This study aimed at assessing the attitude of households towards source-segregation system practices a year after the establishment of this system. Specific objectives of the research were to evaluate: (1) the biowaste sorting efficiency and (2) the social acceptance of the source-segregation system. The results of this research could help upscaling the biowaste source segregation for the whole city of Tiassalé and in similar urban centres in sub-Saharan Africa. In the following sections of this article, we present the study area, followed by a description of the research methodology, its results and discussion and finally a conclusion.

Study Area presentation and MSW management in Tiassalé

Study area

This research was conducted in Tiassalé (Figure 1), a town located at about 130 km from Abidjan, the capital city of Cote d'Ivoire in West Africa (N'krumah et al., 2017). The town extends over an area of 6.6 km^2 and has a population of 20,057 inhabitants with an average household size of six persons (INS, 2015). Based on housing typology, road and sanitation conditions, the town of Tiassalé can be subdivided into three categories of standing: (1) the progress housing or 'Yards' for low-income households consist of small apartments of one-floor

building constructed on limited surface areas and sharing the same courtyard, (2) economic housing for middle-class households corresponds to a group of state-owned or private-owned small autonomous apartments in one- or several-floor buildings and (3) the high-class housings for high-income households corresponds to individual fully equipped houses with a private courtyard.

MSW management in Tiassalé. In Cote d'Ivoire, MSW management is financed by taxes such as waste collection tax which is indexed on electricity consumption ($0.0042 kWhour^{-1} in Abidjan and $0.0017 kWhour^{-1} for other cities), property tax, health and environmental protection tax and the special tax on specified plastic products (Ludington, 2014). The revenues from these taxes go to the National Waste Management Agency (ANAGED), which is responsible for solid waste management in the country since 2018. Municipalities are only responsible for the regulation of informal pre-collection in their constituency. However, the activities of this state agency are still limited to 13 major cities, where MSW management is handled by private operators paid by ANAGED's resources and government subsidies. In secondary cities like Tiassalé, MSW management is left to the municipality's responsibility. In these cities, ANAGED's support is limited to providing collection and transport equipment periodically. Given their limited financial resources and the lack of qualified staff and equipment, these municipalities are unable to cope with the increasing waste generation. In Tiassalé for example, the technical department of the municipality which is responsible for MSW management was equipped with only two tractors and five three-wheeled motorcycles, and a staff of 20 workers for MSW management was available. Consequently, municipal waste collection service in Tiassalé was limited to main roads, the municipal market and other public spaces, whereas households waste collection was left to informal pre-collectors. These pre-collectors charge 2000 FCFA (about US $3.40) per month in the high- and economic-class housing and 1000 FCFA (US $1.70) in the progress-class housing for their collection service. It should be noted that an important part of the households was practising illegal dumping as they did not subscribe or did not have access to a pre-collection service in their neighbourhood. According to the municipal technical services estimations, the daily waste generation is around 60 tonnes with an average of 55% of biodegradables. Regarding waste treatment, open dumping was the only treatment option applied in this city, and only few workers at the municipal technical department know the composting technology.

Methodology

Setting up of the source-segregation system. The implementation of Tiassale's pilot source-segregation system was carried out in several steps, which can be divided into three mains stages. The first one was households' sampling, followed by a participatory workshop and the last step was waste bin distribution.

Sampling. In this study, the sample size determination was based on the weekly maximum processing capacity of the composting facility, which was 2.5 tonnes of biodegradable waste per week. To achieve this amount of waste with a daily biodegradable waste production of 0.3 kg day^{-1} hour^{-1} and a household size of six persons (Kouakou and Anoua, 2017), a sample of 200 households is required. However, to compensate for any drop-outs, the sample size was increased by 15%, giving a total of 230 households. The size of the buffer value in this study was based on the capacity of the collection vehicle and the composting plant. This sample size was far larger than the sample size recommended with a confidence level of 90% using the statistical formula $S = N/(1+N)e^2$ (where S is sample size, N is the total number of households (4453) in the study area and e is the error margin), confirming the representativeness of our sample size.

According to Tiassale's municipal authorities, 48% of the population are living in the progress housing or yards, 35% in economic-class housing and 17% in high-class housing. Based on these proportions, the sample was proportionally stratified by standing, that is, 110, 80 and 40 for the progress-, economic- and high-class housing, respectively. The household selection process was carried out in three stages. Firstly, the neighbourhoods of each standing were numbered (except for the high standing, which consists of a single neighbourhood), then four neighbourhoods were randomly selected using the random number table. The second step consisted in numbering the streets of each selected neighbourhood using Google Earth images and then applying the previous method to select two streets per neighbourhood, that is, eight streets per standing. In the high-standard housing, four streets were selected in the unique neighbourhood of this standing. The third and final stage was households' selection on the ground. Systematic sampling method was used to select the households along the roadside of the selected streets. In each neighbourhood selected, one-quarter of the total sample of the standing was selected. In each household visited, the objectives of the study were explained to the head of the household and/or his/her spouse, and they were then invited to take part in a training workshop.

Workshop. When establishing a source-segregation system, it is crucial to let the citizens know the importance and the benefits of the waste sorting and to train them to this practice. It is for this purpose that a one-day workshop was held with the selected households and the key stakeholders, including community leaders, youth and women's association leaders, heads of municipal technical services and the Agnéby-Tiassa service centre, representatives of farmers' associations, NGOs and pre-collectors. The activities during this workshop were divided into three mains phases.

- The first one was devoted to the technology of urban waste composting, which was presented as an alternative for sustainable management of municipal waste and urban vegetable farming. The relationship between the management of municipal waste and vegetable farming activities was

highlighted. Farmers were encouraged to change their practices that are heavily based on the use of chemical fertilizers and thus pose potential risks to people and the environment. Given that this was the first time for some participants to hear about composting as an approach for biodegradable waste management, a video projection allowed a deeper understanding of this technology. The video projection raised a few questions and triggered an animated discussion and a platform for exchange of ideas.

- The second phase focussed on biodegradable waste differentiation from non-biodegradable waste. This phase started with a video projection presenting the different categories of biodegradable wastes. Then a practical exercise on biodegradable sorting was done with some participants.
- And the third and last phase consisted of a full description of the composting chain from biodegradable waste sorting and collection to the production of compost and its use for soil improvement and fertilisation.

Waste bins distribution. Waste bins distribution was carried out a week after the workshop and took 6 days. These bins had a capacity of 25 L and were distributed along with polypropylene-woven reusable bags inside. In each household visited during this operation, all the family members were briefly trained again to source segregation of household waste into two fractions: biodegradable and non-biodegradable fractions. The biodegradable organic fraction was stored into the waste bin provided, whereas non-biodegradables were stored in the household's former waste bin.

Description of the pilot composting system. The pilot decentralized composting plant of Tiassalé is located at about 3.5 km from the city centre and covers an area of 200 m^2 (20×10 m). This pilot composting plant is managed by two former informal waste pre-collectors. Beside biowaste collection from the 230 households selected, they were also in charge of running the composting process. The bags containing the biodegradable fraction (Figure 2) were collected door to door (Figure 3) three times a week to avoid unpleasant odours, and clean replacement bags were supplied at each collection. During the collection, the collectors were asked to check quality of the biowastes so that they could help the household in need. The collection and transportation to the composting plant was carried out by using a three-wheel motorcycle.

The separate collection service started in Nov 2017 and was free of charge. For participating households who subscribed to the informal pre-collection service, an agreement was concluded with the pre-collectors to halve their collection fees, since they would be collecting only the non-biodegradable fraction. This agreement was facilitated by the municipal authorities. The biowastes collected during the first and the second collection were kept in the bags until the third collection day when they were weighted and piled into windrows of 2 m diameter and 1.5 m height. For each windrow, the composting process took 3 months for the compost to mature during which the piles were regularly turned and watered. More detail on the composting process can be found in Yeo et al. (2020).

Figure 2. Biodegradable waste bin.

Figure 3. Biodegradable fraction collection.

Evaluation of biowaste sorting efficiency. The evaluation of the sorting efficiency was carried out in two steps. Firstly, the impurities rate in the sorted biowastes was monitored throughout the duration of the study (12 months) and secondly, chemical analyses were performed to assess the heavy metal content in the composts produced.

Monitoring of the impurity rate. During biowaste piling phases, the non-biodegradable matters such as plastic bags still present in the source-separated biowastes were manually extracted. When turning the piles, few non-biodegradables still present in the biowastes were also extracted. The weight of non-biodegradable extracted during the piling and turning phases was weekly measured using a mechanical balance. Then, using the weights of the collected biodegradable wastes and the extracted non-biodegradables, the impurity rate was monthly determined

based on equation (1). This impurity rate monitoring was carried out from Nov 2017 to Oct 2018 (12 months).

$$I = \frac{100 \times W_{\text{non-biodegradables}}}{W_{\text{biodegradables}}} \quad (1)$$

where I is the impurity rate (%); $W_{\text{non-biodegradables}}$ is the weight of non-biodegradable wastes (kg) and $W_{\text{biodegradables}}$ is the weight of biodegradable wastes (kg).

Chemicals analysis. The development of the modern industrial society has increased anthropogenic fluxes of heavy metals in MSWs. When considering contaminants in compost produced from MSW, heavy metals are especially dangerous because of their persistence and toxicity. These types of contaminants can be transferred to the ecosystem components such as underground water or crops and can thus affect human health (Mitra et al., 2022). To determine the heavy metal content in the compost produced from source-segregated biodegradable wastes, two sampling campaigns were carried out. At each campaign, a sample of 1 kg was taken from three different windrows. These samples were then mixed in a bucket and successively reduced using the quarterly method to obtain a final sample of about 0.5 kg for laboratory for analysis (Chee and Sunami, 2015). This analysis consisted firstly in the mineralization of the samples in a sulphuric acid medium. Then, the heavy metal content (Cd, Cr, Ni, Pb, Cu, Zn and Hg) was determined by inductively coupled plasma optical emission spectroscopy (Knoop et al., 2018).

Evaluation of households' attitude towards the source-segregation system. The households' attitude towards the biowaste source-segregation system was evaluated through a household survey conducted in November 2018. This survey the concerned 230 households initially selected randomly for biowaste source segregation. The questionnaire was mainly related to the household's socio-demographic characteristics, their opinion of this collection method and their willingness to pay for such a service. The method used was a face-to-face interview, with an interviewer helping the interviewee to complete the questionnaire. The interviewing team consisted of two persons, and each interview took about 15 minutes. Interviews were conducted in French; however, when the respondent was illiterate, a translator was solicited. The data collected were encoded using the open access software EpiData version 3.1 developed by The Centers for Disease Control and Prevention (CDC) and then statistically analyzed using another open access software R studio developed by Posit Software, PBC. This analysis consisted in descriptive statistics and ANOVA test to compare the means observed in the different housing types.

Results

Biowaste sorting efficiency

The results of this study have shown that the impurity rate of the source-segregated biowaste was very low with an annual average of 1% on wet weight basis. These impurities consisted mainly of plastic bags (Figure 4). Figure 5 shows the trend of the impurity rate of biodegradable wastes arriving at the composting plant. As it can be seen, the curve in Figure 5 shows two phases: (1) an impurity decreasing phase from the first to the seventh month, during which the impurity levels fell from 2.1% of impurities in the first month to around 0.5% at the seventh month and (2) and a stable phase from the seventh to the twelfth month, where the impurity rate was constantly around 0.5%.

Figure 4. A view on the separated impurities.

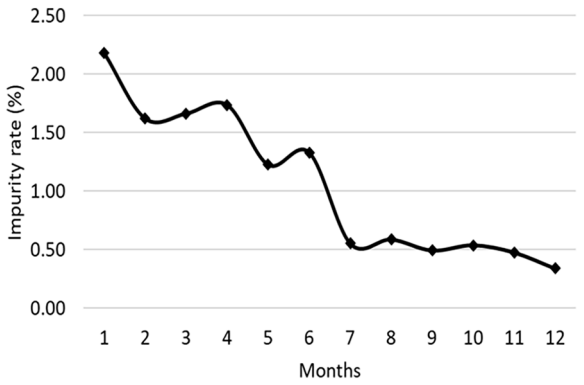

Figure 5. Trends of impurity rates in the biowastes.

Heavy metal content

The heavy metal content in the source-segregated biowaste compost was very low as highlighted by the previous chemical analysis results published in Yeo et al., 2020. In the Table 1, the results obtained on Tiassale's pilot composting are compared to the composts produced from mixed MSW in the cities of Dschang and Bobo Dioulasso. These composts were selected for three main reasons: (1) an urban context closed to Tiassale's one, (2) the numerous heavy metals analysed, which is rare in sub-Saharan African literature and (3) the quality of these composts which are often presented like some of the best in the region. As can be seen from the table below, the values found in Tiassalé are much lower than those reported for these cities, except Cu and Zn, which concentration in Tiassale's compost was higher than Bobo

Table 1. Heavy metal content (dry substance basis) in Tiassale's compost compared to other African cities composts and French compost standards (in mg kg^{-1} DS).

Parameters	Cd	Cr	Ni	Pb	Cu	Zn	Hg
France Limits (NF U44-051)	*3.0*	*120*	*60*	*180*	*300*	*600*	*2.0*
Dschang (Temgoua et al., 2014)	12.6	191.2	46.7	24.7	37	215	—
Bobo-Dioulasso (Compaoré and Nanéma, 2010)	—	—	13.7	37.5	15.0	130	—
Tiassalé	**0.2**	**12.4**	**7.1**	**15.5**	**29.7**	**221.6**	**0.4**

—: not measured.

Figure 6. Proportion of households continuing biowaste sorting.

Figure 7. Household's levels of satisfaction.

Dioulasso's compost. Furthermore, the heavy metal content in Tiassale's compost was far below the threshold limits of French compost standard (NF U44-051), which is commonly used in west Africa.

Attitudes of households towards the source-segregation system

The results of the household survey had revealed that the biowaste source-segregation system was accepted. In fact, from 230 households initially selected, 76% were still practising the source segregation of biowastes after 12 months. This proportion was decreasing from the progress-class housings to high-class housing with the proportions of 83%, 72% and 70% for progress-, economic- and high-class housing, respectively (Figure 6).

Regarding the levels of satisfaction, only 25% of the 173 households continuing source segregation had stated that they were not satisfied with the selective-collective system. The highest proportion (42.8%) of unsatisfied households (Figure 7) was found in the high-income areas (high-class housing), whereas the lowest (10%) was in the low-income areas (progress-class housings).

This survey had also shown that households continuing the source-segregation system were ready to pay for this selective-collective service. Indeed, almost half of these households (48%) were ready to pay for such a selective-collective service. This proportion was decreasing with households living standards (Figure 8). The majority (90%) of these households were those who subscribed to the informal pre-collection service, in other words those who had the habit to pay for waste collection.

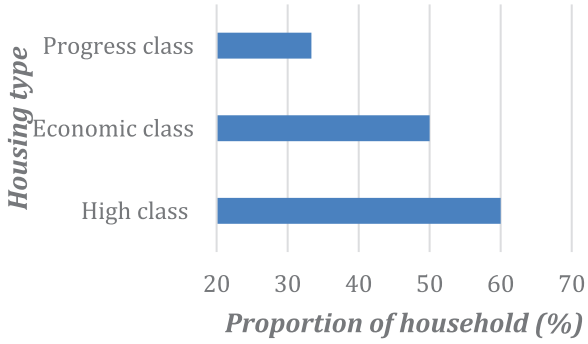

Figure 8. Households willingness to pay for biowaste collection.

Concerning the question of how much the respondents were ready to pay, the results showed that from the four propositions (500, 1000, 1500 and 2000 FCFA), 73% of the respondents' willing to pay opted for 1000 FCFA per month (US $1.70). This amount was largely suggested by the households of high- and economic-class housing, whereas the majority of progress-housing households preferred to pay half of this amount that is, 500 FCFA per month (US $1.35; Figure 9). These amounts correspond in each housing type to half of the baseline collection fees.

Discussion

Biowaste sorting efficiency

The presence of impurities in biowaste negatively affects the quality of the compost produced and hence its market value. In fact, a strong correlation has been established between impurities rate in

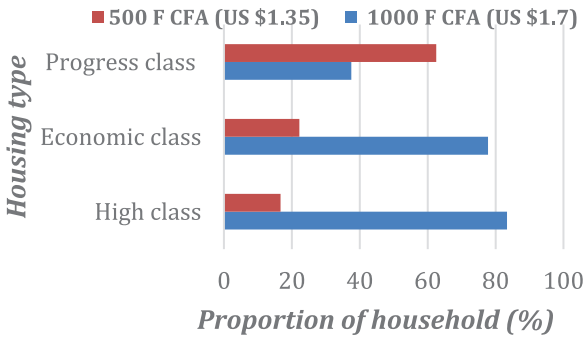

Figure 9. Collection fees suggested by households.

biodegradable wastes and the heavy metal content in composts (Soliva et al., 2006, 2008). The results of this study have shown two phases in the impurities rate evolution. An adaptative phase starting from the 1st to 7th month and the second one going from the 7th to the 12th month during which the impurity rate was very low and stable. This result indicated that by the 7th month, the biowaste sorting practice was incorporated in the households' habits. The average impurity rate found in biowastes was very low (around 1%). Moreover, this low impurity rate has been confirmed by the laboratory analysis which revealed a very low heavy metal contamination in the compost produced. In fact, the heavy metal content in the compost produced in Tiassalé was in line with the French compost standard. Furthermore, the heavy metal content in the compost of Tiassalé was lower than those reported for Bobo Dioulasso and Dschang except for copper and zinc. In fact, the contents of these elements were slightly higher inTassale's compost than Bobo Dioulasso's compost. This slight difference is certainly due to the long stocking time in Tiassalé (about a week) which favoured the diffusion of copper and zinc into the biowaste because of their high affinity for biowaste (Paradelo et al., 2011). Indeed, in Tiassalé, the source-segregated biodegradable waste was stocked during a week before being sorted and composted, whereas in Bobo Dioulasso, the sorting was done just after the collection. The low level of contamination of the source-segregated biowaste in Tiassalé proves the efficiency of door-to-door collection system implemented in this pilot project. In fact, door-to-door collection system has the advantage of allowing a close relation with the households who were continuously guided by the collection team. This result confirms those of Soliva et al. (2006), who showed that small, decentralized composting units processing source-segregated biowaste had lower impurity rates than centralized composting which generally cover thousands of households. In this study, biowaste sorting efficiency (99%) was higher than the value of 81% reported by Gallardo et al. (2021) for the city of Castelló de la Plana in Spain. This difference could be due to the self-delivered collection system used in Castelló de la Plana. Indeed, it has been proven that door-to-door collection has lower impurity rate over self-delivered collection system (Puig-Ventosa et al., 2013). Another reason could be the type of container used for biowaste storage. In Tiassalé, reusable bags were used while non-compostable plastic bags were used in Castelló de la Plana, which has the disadvantage of increasing the proportion of impurities arriving at treatment plant. Moreover, the proportion of non-biodegradable wastes in developed countries is much important than in low- and middle-income countries (Kaza, 2018a). Hence, biodegradable sorting is much easier in Tiassalé than in Castelló de la Plana. The impurities found in the source-segregated biodegradable wastes in Tiassalé consisted mainly of plastic bags. This finding demonstrates that the decree N.2013-327 banning the use of plastic bags in Côte d'Ivoire taken by the government in 2013 is not respected in Tiassalé as elsewhere in the country. In fact, the use of plastic bags is very inky in people's habits, and until now there is no credible alternative. This situation is not specific to the city of Tiassalé since similar results have been observed in the district of Água Grande (São Tomé and Principe) and in the village of Tinos in Greece (Vaz et al., 2015; Panaretou et al., 2019). These results demonstrate that raising awareness in households and practical trainings on biowaste source segregation and valorisation are the keys for the establishment of sustainable source-segregation system in Tiassalé and similar urban areas. If these steps are carefully implemented and coupled to a regular monitoring strategy, the adaptation time which lasts 7 months in this study could be much lower. Furthermore, the impurity rate could be much lower if the municipal authorities enforce the plastic bag ban. This requires a collaboration between municipal authorities and plastic bag dealers in order to find reliable suppliers of alternative packaging such as fabric and paper bags on one hand and on the other hand to set up a control unit in charge of enforcing this regulation.

Attitudes of households towards the source-segregation system

The results of the household's survey showed that 83.3% of respondents were women. This finding clearly demonstrates the strong commitment of women in biowaste sorting in the city of Tiassalé. As an illustration, in some households, the interview sometimes began with the 'chief of household', but after the survey objectives had been presented, the chief of household asked his wife to continue the interview. Similar studies carried out in Uganda (Ekere et al., 2009) and Iran (Babaei et al., 2015) also reported that women were more active than men in separating waste at source. This shows that when scaling up this collection system in Tiassalé or in similar urban areas, it is crucial to put women at the centre of the process. The majority (75%) of the households initially selected were still practising biowaste source segregation a year after the beginning of the project. Moreover, the higher proportion of these households was found in progress-class housing that was not expected, given the high proportion of illiterates in these areas. Those who abandoned the source-segregation system justify their act by the irregularity of biowaste collection and the bad state of replacement bags. The same problems were also underlined by the unsatisfied households. The irregularities in biowaste collection were due to engine failures of the collection vehicle and impassable roads in raining seasons, whereas the bad conditions of the replacement bags were due to

bags shortage and sometimes due to the negligence of the collectors. This result confirms the necessity to have monitoring service when scaling this system for the whole city of Tiassalé or in similar urban centres. In addition of helping households to improve their sorting efficiency, they will also be supervising the collectors' work, which will reduce dropouts due to malfunctions. Regarding the participants willingness to pay, this study shows that almost half (48%) of them were willing to pay for such a selective-collective service. This proportion was decreasing with household standard of living, with significant statistical difference ($p < 0.05$) between the three types of housing. These findings confirm the hypothesis according to which households' willingness to pay for waste collection depends on their living standard. The proportion of households willing to pay in this study is higher than the 35% reported by Babaei et al. (2015) for the city of Abadan in Iran. Two main reasons were advanced by the households who were not willing to pay for biowaste selection service. The first argument was the fact that they were already paying a tax for waste collection on their electricity bill. And secondly, some households consider that they should be paid for their contribution to biowaste sorting instead of paying for such a service. Awareness campaigns with the support of municipal authorities are then needed to convince these households to pay for biowaste collection. Regarding collection fees, the households willing to pay suggested an amount corresponding to half of the baseline collection fees. This result shows that these households are ready to contribute to improving waste management by sorting the biowaste at source, without increasing their waste management spendings. This finding is relevant in the sense that if all the households accept to pay, the funds collected will be enough to cover the collection cost that is, the fuel costs, the collectors' salary and maintenance costs. For instance, if the 230 participants households in this project agreed to pay the amount suggested in each housing type, that will represent a total of 175,000 FCFA (US $295,50) per month. This amount is practically equal to the collection cost, which was 170,000 FCFA (US $289).

However, this study did not go to the payment phase which would have provided factual data on the financial viability of such a source-segregation collection system. Moreover, the amount of biowaste generated daily by each household throughout the year have not been monitored. Hence, further research is needed to address these limitations.

Conclusion

The objective of this study was to evaluate biowaste sorting efficiency and the attitude of households towards a pilot source-segregation system of biowastes implemented in the town of Tiassalé. The results revealed a high level of cooperation of the households with an average sorting efficiency of 99%. This finding was confirmed by the low heavy metal content in the composts produced. Most of the households initially selected have appreciated the biowaste source-segregation system and kept practising it during a full year. Regarding the willingness of households to pay for this type of collection service, the results showed that half of the households were reluctant to payment. Awareness campaigns are then necessary to help these households to understand the necessity to contribute financially to the sustainability of such a collection system. The outcomes of this study revealed that providing household with the needed MSW infrastructures and improving awareness about biowaste source segregation are keys for the establishment of such a collection system in Tiassalé and similar urban area. These remarkable results pave the way for the spread of successful decentralized composting system with source segregation of biowastes in Cote d'Ivoire urban centres and in sub-Saharan Africa in general.

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