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Emmanuela Chem BERINYUY

CLIMATE CHANGE MITIGATION THROUGH MUNICIPAL SOLID WASTE COMPOSTING IN DSCHANG, CAMEROON.

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Supervisor: Dr. Eric Moye KONGNSO

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CLIMATE CHANGE MITIGATION THROUGH MUNICIPAL SOLID WASTE COMPOSTING IN DSCHANG, CAMEROON.

DEDICATION

This work is dedicated to composting facilities all round the world making a difference and mitigating climate change especially in most vulnerable societies already facing the negative impacts of this change.

And

To my beloved brother Chem Elvis Dzelamonyuy (of blessed memory) for inspiring me and instilling in me a commitment to hard work.

STATEMENT OF THE AUTHOR

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Dr. ERIC MOYE KONGNSO

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Supervisor Signature Date

ABSTRACT

Climate change is a major global concern with developing countries being most vulnerable to its devastating impacts. One of the causes of this change in climate is poor waste management. The management of municipal solid waste in developing countries seems to be very challenging due to the lack of technical know-how. The city of Dschang in Cameroon has seen significant increase in waste generation due to increase in population. To solve this problem, public and private partners in the mid-2000s established a project for collection and recovery of household solid waste through composting in Ngui and Siteu. The aim of this study was to demonstrate the role of composting in reducing greenhouse gas emissions. To achieve this, we first collected secondary data, collected primary data, then carried out field surveys, interviews with actors in this sector and participatory observations. The results obtained were processed, analyzed, and interpreted in figures, graphs, chats, tables and text. Dschang municipality produces an estimated 25000 tons of waste annually and just about 10,000 tons of this waste is collected. In 2024, the total waste collected from pre-collection services alone was 3651 tons and 3221 tons of the collected waste composted, giving an 88% compost rate. This method of waste management helps to avoid methane (CH4) emissions through aerobic decomposition, which releases just a little CO_2 and steam as by products, giving us the opportunity to assess the avoided emissions. From 2017 to 2023, about 17955 metric tons of carbon equivalent emissions have been avoided through this project. Compost produced was found worthy with acceptable NPK and C/N ratios after analysis in relation to the NF U 44-051 norms. This compost has been instrumental in augmenting agricultural yields, soil quality and reducing the use of chemical fertilizers saving cost. Between 2015 and 2024 the project generated over 59 million FCFA in compost sales and has received about 10.000euros annually since 2017 as carbon credits. The compost facility provides employment to over 45 people which has significantly improved the living standards of the people. How ever several challenges still hinder the scaling up of the project and its sustainability such as lack of awareness, source segregation among others. The study recommended measures that can improve project efficiency, scale up and sustainability.

Keywords: climate change, composting, emission reductions, benefits and challenges.

RÉSUMÉS

Le changement climatique est une préoccupation mondiale majeure dont les pays en développement sont les plus vulnérables à ses effets dévastateurs. L'une des causes de ce changement climatique est la mauvaise gestion des déchets. La gestion des déchets solides municipaux dans les pays en développement semble être très difficile en raison du manque de savoir-faire technique. La ville de Dschang au Cameroun a connu une augmentation significative de la production de déchets en raison de l'augmentation de la population. Pour résoudre ce problème, des partenaires publics et privés ont mis en place au milieu des années 2000 un projet de collecte et de valorisation des déchets solides ménagers par compostage à Ngui et Siteu. L'objectif de cette étude était de démontrer le rôle du compostage dans la réduction des émissions de gaz à effet de serre. Pour y parvenir, nous avons d'abord collecté des données secondaires, collecté des données primaires, puis réalisé des enquêtes de terrain, des entretiens avec les acteurs de ce secteur et des observations participatives. Les résultats obtenus ont été traités, analysés et interprétés sous forme de chiffres, de graphiques, de chats, de tableaux et de textes. La commune de Dschang produit environ 25 000 tonnes de déchets par an et à peine 10 000 tonnes environ de ces déchets sont collectés. En 2024, le total des déchets collectés par les services de pré-collecte s'élevait à 3651 tonnes et 3221 tonnes des déchets collectés ont été compostés, soit un taux de compostage de 88%. Ce mode de gestion des déchets permet d'éviter les émissions de méthane (CH_4) grâce à la décomposition aérobie, qui libère peu de CO_2 et de vapeur comme sous-produits, ce qui nous donne l'occasion d'évaluer les émissions évitées. De 2017 à 2023, environ 17955 tonnes d'émissions équivalent carbone ont été évitées grâce à ce projet. Le compost produit a été jugé digne avec des ratios NPK et C/N acceptables après analyse par rapport aux normes NF U 44-051. Ce compost a contribué à augmenter les rendements agricoles, la qualité des sols et à réduire l'utilisation d'engrais chimiques, ce qui a permis d'économiser des coûts. Entre 2015 et 2024, le projet a généré plus de 59 millions de FCFA de ventes de compost et a reçu environ 10 000 euros par an depuis 2017 sous forme de crédits carbone. L'usine de compostage fournit de l'emploi à plus de 45 personnes, ce qui a considérablement amélioré le niveau de vie de la population. Cependant, plusieurs défis entravent encore la mise à l'échelle du projet et sa durabilité, tels que le manque de sensibilisation et le tri à la source, entre autres. L'étude a recommandé des mesures qui peuvent améliorer l'efficacité, la mise à l'échelle et la durabilité du projet.

Mots clés: Changement climatique, compostage, réduction des émissions, avantages et défis.

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I would like to express my gratitude to my loving mother, Bongmbah Doris Lungla for her unwavering support, love and prayers throughout my academic journey. May God bless her abundantly.

Special thanks to Ndzeshang Glen Rodrique N. for his physical and emotional support, grateful to my twin brother Fomonyuy Emmanuel Chem, my sisters Chem Flora Burinyuy and Chem Bridget Suilareng, to Dr. Charlotte… as well as everyone who has contributed to the success of this research project and thesis writing.

Above all, I thank the Almighty God for granting me the strength and good health to undertake this research work.

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF PHOTOS

LIST OF ABREVATIONS

ADECOTEC : Actions de développement des collectivités territoriales au Cameroun

AEO: African Environmental Outlook

AIMF: Association of French-speaking mayors

AMGED : agence municipale responsable de la gestion des déchets

AMS-III F: Avoidance of methane emissions through composting

C/N: Carbon-Nitrogen

CEPREPADE : Centre Francophone de Recherche Partenaire sur l'Assainissement, les déchets et l'Environnement

CH4: methane

CIE: Interministerial Committee for the Environment

CO2: Carbon dioxide

COP: Conference of the Parties

DDF: start date for heap formation

DFF: end date for heap formation

ENSPY: École nationale supérieure polytechnique

ERA CAMEROON : Environnement Recherche Action Cameroun

FAO: Food and Agricultural Organization of the United Nations

FFEM : Fond français pour l'environnement mondial

GEVALOR: Gestion durable et valorisation des déchets et des matières premières minérales

GHG: greenhouse gas

GRET: Research and technological exchange group

GWP: Global Warming Potential

IPCC: Intergovernmental Panel on Climate Change

IUCN: International Union for Conservation of Nature

LUCF: land use, land-use change, and forestry

MINEPDED: Ministry of the Environment, Nature Protection and Sustainable Development

MSW: Municipal solid waste

MSWM: Municipal solid waste management

N2O: nitrous oxide

NFU: French-European norms

NGO: Non-Governmental Organizations

NPK: Nitrogen phosphorus and potassium

PCM: Programme municipal de développement

PPE: Personal protective Equipment.

PSEAU : Programme Solidarité eau

REDD+: Reduced Emissions from Deforestation and Forest Degradation and other forest related activities in developing countries.

SDG: Sustainable Development Goals

SSA: Sub-Saharan Africa

TOCKEM: local name means solidarity tourism.

UNDP: United nation development program

UNDP: United Nations Development Programme

UNEP: United Nations Environment Programme

UNFCCC; United Nations Framework Convention on Climate Change

UNFPA: United Nations Population Fund,

UPE: Urban Political Ecology

USAID: U.S. Agency for internation development.

TABLE OF CONTENTS

CHAPTER ONE

1 GENERAL INTRODUCTION

1.1 Background of study

Climate change is a global crisis that results from several factors including inappropriate waste disposal. According to the World Bank report (2018), annual municipal waste produced already exceeds 2 billion tons and is projected to reach 3.4 billion tons by 2050 due to increase in population and high rates of urbanization (Sharholy *et al.,* (2007). The challenge of managing municipal solid waste in developing countries, Cameroon inclusive have led to landfilling of waste and open dumps that increase methane emissions. The issue of climate change generally is part of sustainable development goal (SDG) 13 (climate action) which schools us on waste recycling and composting as measures to reduce climate change while waste management is part of a number of SDGs (SDG 6: target 6.3; SDG 11: target 11.6; SDG 12: target 12.3 and 12.4; SDG 14: target 14.1) meanly encouraging the reducing, recycling and recovery of waste as a mitigation measure for climate change. Several organizations such as the United Nations Framework Convention on Climate Change (UNFCCC), Intergovernmental Panel on Climate Change (IPCC), Reduced Emissions from Deforestation and Forest Degradation and other forest related activities in developing countries (REDD+) have been set up to combat climate variability. These issues are raised and addressed in high-level meetings like the conference of parties (COP), organized by the United Nations to discuss environmental issues particularly climate change. The main sectors responsible for greenhouse gas emissions according to the Conference of Parties (COP21), held in Paris in 2015 are: transport (20.7%); energy (17.9%); processing (16.4%), residential (15.6%); industries (combustion 11.6%), agriculture (10.3%); heating (tertiary 5.3%), waste (3.2%); and others (0.5%).

The annual volume of waste generated in Sub-Saharan Africa increased from 81 million tons to 174 million tons between 2012 and 2016 and is projected to reach 269 million tons in 2030 (Adedara *et al.*, 2023). In 2018, the municipal solid waste (MSW) collection coverage in Sub-Saharan Africa was estimated at 44% and greenhouse gas (GHG) emissions per person from urban waste management activities are greater in sub-Saharan African countries compared to other developing countries (Parrot *et al*., 2009). Figure 1 indicates waste generations per capita in sub-Saharan African (SSA) countries.

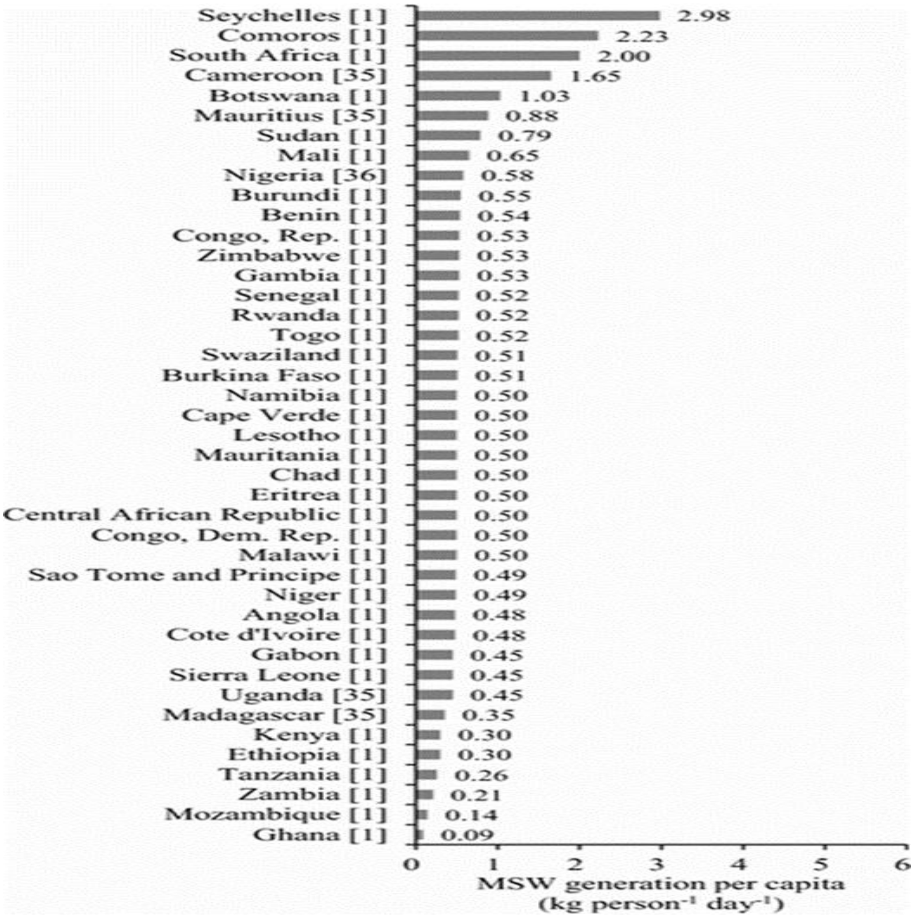


Figure 1. MSW generation per capita in Sub-Saharan Africa

Source: kawai and Tasaki, (2015)

Figure 1 shows that the per capita waste production capacity of countries in Sub Saharan Africa vary between 0.09 to 2.98kg/persons/day. Cameroon has a high rate of 1.65kg/person/day, which is above the average for the sub region. The high production rates do not tally with collection and treatment facilities. Studies have revealed that less than half of the waste generated in sub–Saharan Africa is collected and treated due to several challenges including inadequate financial resources and equipped waste treatment platforms to properly manage waste (Kongnso *et al.,* 2024; Ngnikam *et al*.,2002). Some of the problems associated to this municipal solid waste management in developing countries are inadequate service coverage and operational inefficiencies of services, limited utilization of recycling activities, inadequate landfill disposal, and management of hazardous and healthcare waste as highlighted by Zurbrugg (2003). These challenges have led to illegal dumping and landfilling, practices that degrade our environment and contributing to green gas emissions.

1.1.2. Context of the study

Waste from urban areas across Africa is often dumped on the ground with little control over, resulting in greenhouse gas emissions. In Cameroon, the average amount of waste produced per day per household is set at 0.6 kg (Ngnikam and Tanawa, 2006). In 2007, Cameroon set up a national waste management strategy and several institutions for the protection of nature (cleaning up) and the fight against climate change, including: the MINEPDED (Ministry of the Environment, Nature Protection and Sustainable Development), the Interministerial Committee for the Environment (CIE) as well as the implementing and management institutions (district municipalities and urban communities) set up by the law of July 27, 2004. Cameroon urban population has experienced an increase over the years, which is inherent to waste production. The city of Dschang has an estimated daily waste production average of 0.41 kg/inhabitants/day (Djousse, 2018). Cameroon has made significant progress in waste management strategies particularly through the setting up of a decentralized composting facility in Dschang. Composting is identified as a cost-effective way to control GHG emissions from waste by stabilizing waste and using composted material as a soil improver or organic fertilizer (Couth and Trois 2012). A study by Ngnikam *et al*., (2002) has shown that in Dschang, waste is commonly disposed of in open dumps, which are unhealthy and pose a threat to the environment as harmful gases are released into the atmosphere such as methane. Hence, by mitigating climate change through composting in Dschang, Cameroon presents an opportunity to address environmental challenges while promoting sustainable practices. Composting plays a vital role in reducing greenhouse gas emissions and enhancing soil health as well as contributing significantly to mitigating climate change by minimizing methane and other emissions if carried out effectively and efficiently (Vergara & Silver, 2023).

The ongoing project in Dschang, focuses on improving waste pre-collection and collection services, developing composting to reach a production of 10,000 tons of compost per year and treat about 40% of the city's household and restaurant waste. Composting has the potential to sequester carbon by stabilizing waste and using the composted material as a soil improver or organic fertilizer (kongnso *et al.,* 2024). This approach aims to mitigate GHG emissions from the waste sector. Hence, monitoring, verifying and quantifying the actual amount of carbon sequestration achieved through composting in this city is necessary. This study focuses on assessing the impact of municipal waste composting in Dschang Cameroon, aiming to quantify the amount of methane sequestrated through composting, evaluate socio-economic benefits, and identify barriers and opportunities for scaling up composting initiatives.

By addressing these research objectives, the study aims to provide valuable insights into the role of composting in mitigating emissions and promoting sustainable waste management practices in the region.

1.2 PROBLEM STATEMENT

Greenhouse gas emissions from the waste sector have almost doubled globally from 1970–2010, reaching more than 1400 Mt CO2e in 2010, making about 3% of global emissions (Alsabbagh, 2019). Urban population increase in most developed and developing countries, Cameroon inclusive has continuously posed a major challenge for municipalities to collect, recycle, treat, and dispose of increasing quantities of solid waste and wastewater produced (Bogner *et al.,* 2007). As such, greater quantities go to open dumps and landfills that continue to release greenhouse gases and pollute the natural environment. With rising environmental concerns, there has been dire need for alternative and sustainable waste treatment methods. Composting is therefore a cost-effective method that reduces harm on the environment and reshape practices. As such, within the context of decentralization, the Dschang municipality introduced composting as a waste treatment strategy and was pioneer to transform its waste treatment facility into a development project. Created in the mid-2000s with support from local structures like ERA (Environmental Research Association) Cameroon and development partners such as the European Union and the French Global Environment Facility, it has contributed greatly in the management of urban waste and in promoting sustainable development. However, the composting process is less adequate as more than 50% of waste produced in the town is still dumped in the natural environment.

Composting according to Couth and Trois (2012), is a very efficient and cost-effective way to control GHG emissions. Composting diverts a significant amount of organic waste from landfills and open dumps, reducing GHG emissions (methane) and contributing to climate change mitigation. However, the state of composting practices in Dschang remains underdeveloped, and faces several challenges such as technical and infrastructural constraints, financial constraints, socio-cultural and political constraints. With the global engagement to fight against climate change through local initiatives, there is need to evaluate the composting capacity of the project to sequester methane, and the extent to which composting can be integrated into the waste management system. Such an evaluation is vital and would provide valuable insights into the environmental benefits of composting and its role in sustainable waste management in Dschang.

In addition to its environmental benefits, composting and compost use in agriculture also offers socio-economic advantages, such as enhancing soil fertility which improves agricultural productivity and reduces over reliance on chemical fertilizers.

Furthermore, composting creates economic opportunities to improve livelihoods through job creation in waste collection, processing, and selling of compost. Most of these opportunities are still underexplored, leaving gaps in understanding its full potential and upscale, emphasizing why this study is necessary. However, several barriers hinder its widespread adoption in Dschang, such as limited public awareness and inadequate policy support, among others. These barriers require a comprehensive approach which incorporates public-private partnerships and community-based initiatives to address and scale up composting efforts. This will not only enhance environmental sustainability but also support socio-economic development and contribute meaningfully to climate change mitigation efforts in the region. The idea defended in this work is the inability of municipalities to properly manage municipal organic waste which has led to increased GHG emissions even though composting is considered a cost-effective method to reduce these emissions and ensure socio economic sustainability.

1.3 RESEARCH QUESTIONS:

Main question

How has municipal solid waste composting contributed to reducing emissions and mitigating climate change in Dschang Cameroon?

Specific questions

1. What is the state of municipal composting as an alternative waste treatment method in Dschang?
2. What is the quantity of methane (carbon equivalence) sequestrated per ton of organic waste composted in Dschang
3. What are the socio-economic benefits of composting in Dschang?
4. What are the barriers hindering the widespread adoption and scalability of composting initiatives in Dschang?

1.4 RESEARCH OBJECTIVES:

Main Objectives

Examine the potential of municipal waste composting in reducing emission and contributing to climate change mitigation.

Specific Objectives

1. Assess the state of composting as a waste treatment method in Dschang Cameroon.
2. Evaluate the quantity of methane sequestrated during composting in Dschang.
3. Investigate the socio-economic benefits of composting practice in Dschang.
4. Identify barriers for scaling up composting efforts in Dschang Cameroon.

1.5 WORKING HYPOTHESIS:

Main hypothesis

Waste treatment by composting can significantly reduce emission and mitigate climate change.

Specific Hypothesis

1.There is still open dumping of waste in Dschang because municipal composting is not yet advanced.

2.Composting sequesters a significant quantity of methane (carbon equivalent) per ton of organic waste in Dschang.

3.Composting practices in Dschang positively impact soil health and agricultural productivity, resulting in increased crop yields, and improved livelihoods for local farmers.

4.The scalability of composting efforts in Dschang is hindered by various factors, such as limited institutional support, insufficient infrastructure, and low public awareness.

1.6 Relevance of the study

This study is relevant for advancing environmental sustainability, mitigating climate change by reducing greenhouse gas emissions and improving the livelihood and well-being of local communities in Dschang Cameroon as follows:

1. Addressing Climate Change: Composting has the potential to significantly reduce greenhouse gas emissions, particularly methane, which is a potent greenhouse gas and contributor to climate change. By quantifying the impact of composting on emissions reduction, the study can provide valuable insights into effective climate change mitigation strategies at the local level.

2. Promoting Sustainable Waste Management: Dschang, like many other urban and peri-urban areas in Cameroon, faces challenges with regards to waste management, including inadequate collection systems, infrastructure/dumpsites, and environmental pollution. Using composting as a sustainable alternative to the existing conventional waste disposal methods can contribute to improving waste management practices and reducing environmental pollution and degradation.

3. Enhancing Soil Health and Agricultural Productivity: Composting and compost-based farming improves soil moisture and fertility, and promotes nutrient cycling, leading to increased agricultural productivity and food security. Understanding the socio-economic and environmental benefits of composting in Dschang can promote development of strategies to support smallholder farmers and improve local livelihoods.

4. Informing Policy and Decision-Making: The findings of the study can inform policy formulation and decision-making at the local, regional, and national levels. By understanding the effectiveness of composting as a climate change mitigation strategy and identifying barriers to its scalability, policymakers can develop targeted interventions and allocate resources to promote sustainable development in Dschang and Cameroon in general.

1.7 Scope of the study

Geographical Scope: This study is limited to the Dschang municipality in Cameroon with a focus on the Ngui composting facility and existing solid waste management practices.

Thematic Scope: The thematic scope will cover

1) Composting process and practice: This will examining how municipal solid waste is collected, processed, and transformed into compost and a conceptual framework for composting.
2) Climate Change Mitigation: This thematic will assess how composting reduces greenhouse gas emissions compared to the traditional waste disposal method of landfilling.
3) Socioeconomic Benefits: this aspect will evaluate the socioeconomic benefits of composting in terms of job creation, agricultural practices, and community engagement.
4) Challenges faced: Identify barriers for project scale up such as operational, financial, and policy-related challenges affecting composting efficiency and propose recommendations for improvement.

Methodological Scope:

Data Collection: this study made use of both primary and secondary data. Primary data was collected from participatory observations, interviews with facility workers and farmers, and secondary data from reviewing relevant literature from articles online, libraries and municipal waste management reports.

Analysis: analysing compost quality, waste reduction impact in the city, quantity of methane sequestrated, and the potential contribution of composting to sustainable waste management in Dschang.

CHAPTER TWO

2 LITERATURE REVIEW

Introduction

Climate change coupled with poor waste management is a major concern in most communities in developing countries. This chapter aims to explore extant scholarly literature on the contribution of the waste sector into global emissions and the role of composting in curbing emissions. It has two sub parts, the conceptualization of key concepts and the empirical literature. The empirical literature is divided into four thematic that correspond with the specific objectives of this study.

2.1 Conceptual framework

2.1.1 Composting

The Food and Agricultural Organization defines composting as a natural process of organic matter degradation or decomposition by microorganisms under well-defined or favourable conditions. According to Di Maria *et al*. (2017), Composting is an eco-friendly biological process that converts organic waste into nutrient-rich material known as compost. This process relies on the activity of naturally occurring microorganisms such as bacteria, fungi, and decomposer organisms like earthworms to break down organic matter into simpler components. Composting offers a sustainable solution for managing biodegradable waste, such as food scraps, garden trimmings, and agricultural residues, transforming them into a valuable resource for soil enrichment (Abubakar *et al.,* 2022). The practice of compost use enhances soil fertility, improves water retention, and supports plant growth, making it an integral part of sustainable agriculture and waste management systems. Composting is therefore a waste management practice.

Bogner *et al.,* (2007) defines waste as any material or substance be it solid, liquid or gaseous, that has lost its primary value and is disposed of, intended to be disposed of, or recycled. It can be hazardous or non-hazardous, organic or inorganic. According to the environmental framework law of Cameroon on environmental management (Law No. 96/12 of 5 August 1996), waste is any residue from a production, transformation or use process or more generally, any movable or immovable property abandoned or intended for abandonment. This framework further defines waste management as the process of collecting, transporting, recycling and disposing of waste, including the monitoring of disposal sites. As such, composting is a waste management strategy that involves only biodegradable solid waste.

In most developing countries, the management of such waste is placed under the responsibility of municipalities.

Municipal solid waste management (MSWM) as defined by the IPCC (2006), is the collection, transfer, treatment, recycling, and resource recovery of waste with the aim of protecting public health, promoting environmental quality, and support economic productivity. A study by Yarboro *et al.,* (2021) states that municipal solid waste management encompasses the collection, transportation, treatment, and disposal of waste produced by households, commercial establishments, and institutions within urban areas. The study indicates the primary objective of MSWM which is to ensure public health and hygiene while fostering environmental sustainability. Effective MSWM systems are critical for minimizing environmental pollution, preventing the spread of diseases, and enhancing the quality of urban life. These systems involve multiple stages, including waste segregation at the source, transportation to designated facilities, treatment processes like recycling or composting, and safe disposal of residual waste in landfills or through incineration. A key challenge in MSWM lies in integrating these stages to achieve a balance between efficiency and environmental conservation. For instance, developing countries like Cameroon often face difficulties related to inadequate infrastructure, funding shortages, and inconsistent policy enforcement, which hinder the implementation of comprehensive waste management strategies (Albrecht *et al.,* 2022).

In the context of this work, we can therefore define municipal solid waste as any material dumped or discarded from households, commercial centres or institutions and collected by municipalities or local authorities. And define composting as the natural breakdown of organic waste materials such as food scraps, and plant materials (agricultural and yard waste) by microorganisms in the presence of oxygen into nutrient rich soil amendments called compost. The conceptualized framework for this composting is indicated in figure 2 following its dimensions, components and indicators.

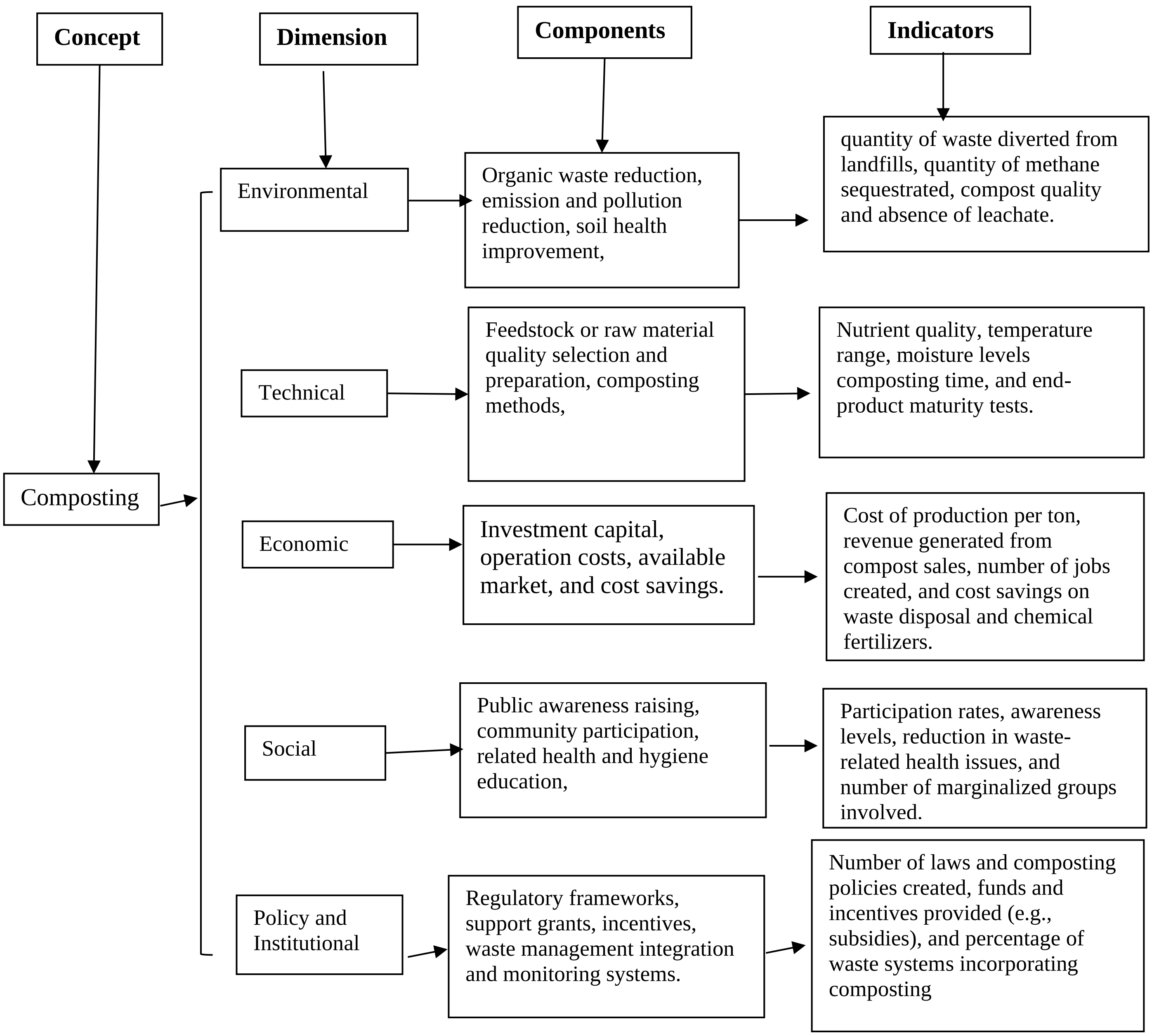


Figure 2: conceptualisation of composting

Figure 2 shows that composting addresses environmental, technological, economic, social, and policy aspects, making it a comprehensive waste management solution. By recycling nutrients, it improves soil health and drastically lowers greenhouse gas emissions and landfill waste. Strong community involvement in waste segregation, market expansion for compost products, and operational efficiency are all critical to its success. Furthermore, to enforce waste management procedures and encourage composting projects, supportive laws and regulations are essential.

Composting has the potential to improve agricultural output, reduce environmental problems, and advance sustainable development in Dschang, Cameroon, if technical difficulties, community involvement, and financial feasibility are successfully resolved.

2.1.2 Carbon sequestration

Carbon sequestration is the long-term removal, capture, and storage of atmospheric carbon dioxide (CO2) to mitigate climate change (IPCC, 2018). Carbon sequestration refers to the process by which atmospheric carbon dioxide (CO_2) is captured and stored in a stable form within ecosystems, particularly soil, through natural processes. This occurs primarily via photosynthesis, where plants absorb CO_2 and convert it into organic carbon, which is then deposited in the soil, forming what is known as the soil carbon pool. Within the soil ecosystem, carbon undergoes various dynamic processes, including production, consumption, turnover, fixation, exchange, and migration. These processes facilitate the storage of carbon in the soil or its eventual release back into the atmosphere through the carbon cycle. Soil carbon sequestration is significant as it enhances soil fertility and structure, supports crop growth, and mitigates climate change by reducing greenhouse gases in the atmosphere (Shove & Spurling, 2013). The Kyoto Protocol (1997) shows us the main greenhouse gases which are: methane (CH4), carbon (CO2), nitrous oxide (N2O), sulphur hexafluoride (SF6) and fluorocarbons (HFCs and PFCs). These gases in their various quantities are responsible for the climate change we face globally today.

The United Nations Framework Convention on Climate Change (UNFCCC) 2015, attribute climate change directly or indirectly to human activity that alters the composition of the global atmosphere, and which is in addition to natural climate variability observed over comparable time periods. Climate change refers to any substantial and long-term alteration in weather patterns over decades or longer. These changes may result from natural factors, such as volcanic eruptions and solar variations, or from human activities like deforestation and burning of fossil fuels. Anthropogenic influences have been identified as the primary drivers of recent climate change, mainly due to the emission of greenhouse gases such as carbon dioxide, methane, and nitrous oxide into the atmosphere (Mbiba, 2014). These gases trap heat, leading to a rise in global temperatures, a phenomenon known as global warming. In order to mitigate global warming and climate change, efforts are made to either limit the emission of these gases or reduce their quantities in the atmosphere.

Therefore, carbon sequestration can be described in this context as the natural process that absorbs atmospheric carbon dioxide (CO_2) and store it in a stable form inside ecosystems, especially soil to reduce global warming and climate change. Carbon sequestration through composting entails absorbing and storing carbon by turning organic waste into stable organic matter (compost) as explained in the figure 3. The important aspects include indirect sequestration (which lowers methane emissions by keeping garbage out of landfills), biological sequestration (which stores carbon in compost and soil), and economical benefits (which include waste management and carbon credits).

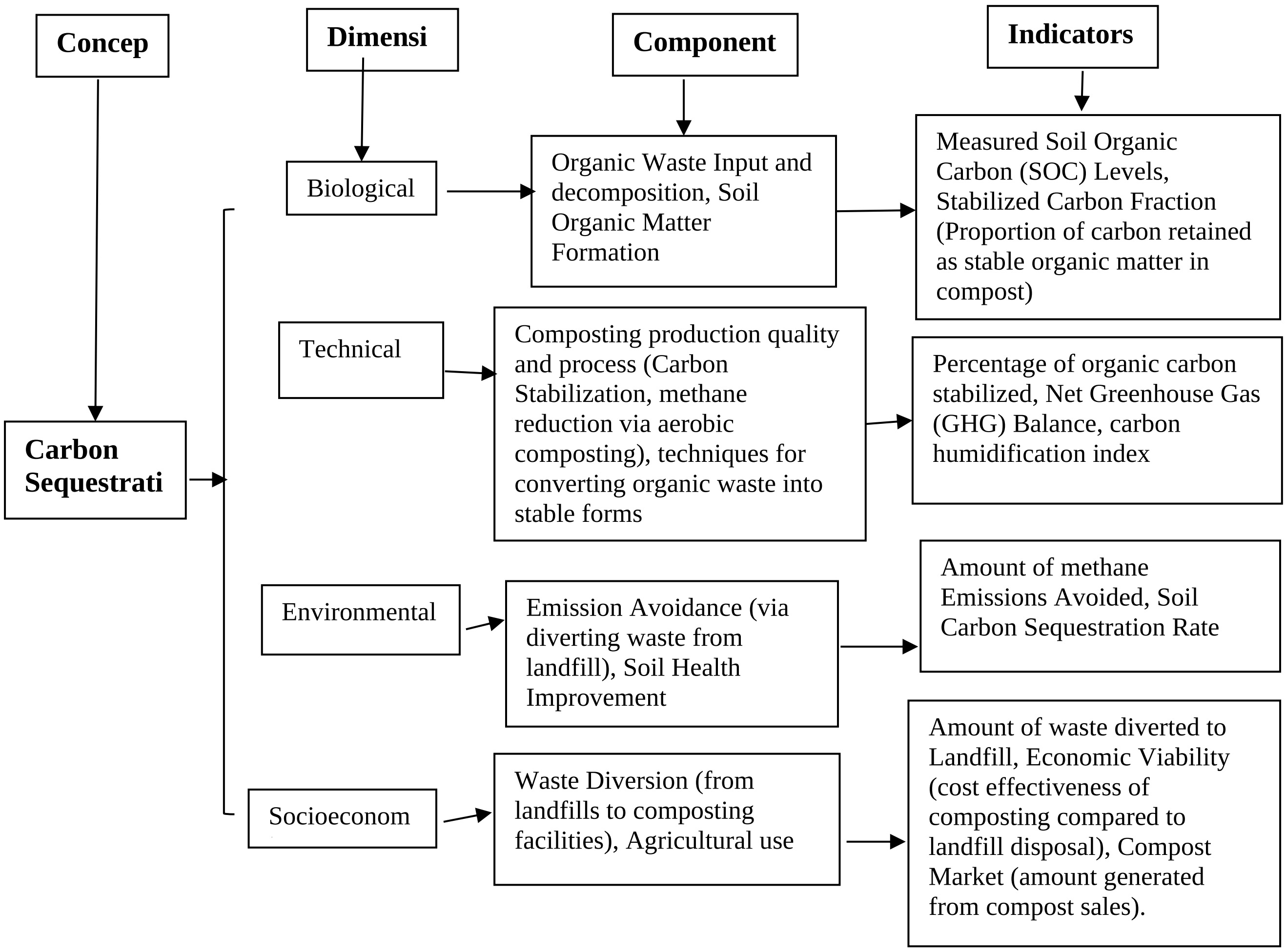


Figure 3: conceptual representation of carbon sequestration

Figure 3 shows that carbon sequestration requires multiples dimensions, but the primary objective is to reduce emissions. In the waste sector, the main greenhouse gas emitted is methane, but it is calculated as carbon equivalence. Methane can be quantified during composting in terms of avoided emissions and reduced emissions.

2.1.3. Climate change mitigation

According to the United nation development program (UNDP, 2024), any action performed by governments, corporations, or individuals to lessen or stop greenhouse gas emissions, or to improve carbon sinks that absorb them from the atmosphere, is referred to as climate change mitigation. The atmosphere of our planet remains warm because of these gases' ability to retain solar heat. Human activity has resulted in the release of hazardous amounts of greenhouse gases since the start of the industrial period, which has caused climate change and global warming (UNDP, 2024). However, greenhouse gas emissions continue to rise despite clear-cut science showing how human activity affects the planet's climate and increased awareness of the serious threat that climate change poses to our civilizations. We can slow down the rate of climate change and prevent its worst effects if we can reduce the increase of greenhouse gases.

Mitigation is described as "human intervention to reduce the sources or enhance the sinks of greenhouse gases" in the IPCC's fifth assessment report (IPCC, 2014b). In a more comprehensive sense, this term can be expanded to include additional pollutants and/or atmospheric constituents that contribute to climate change, such as black carbon particles or changes in albedo brought on by land usage. According to the United Nations Intergovernmental Panel on Climate Change (IPCC 2014)) mitigation aims to prevent major human interference with Earth's climate and "stabilize greenhouse gas levels in a time frame sufficient to allow ecosystems to adapt naturally to climate change, ensure that food production is not threatened, and to enable economic development to proceed in a sustainable manner. The goal of climate change mitigation is to stabilize the atmospheric concentration of greenhouse gases at a level that would avoid harmful human interaction with the climate system. This temperature was set at 2ºC in Article 2 of the Paris Agreement (FAO, 2024).

The 2015 Paris Agreement, which was ratified by 196 Parties, is a worldwide pledge to keep global warming below 2°C, ideally 1.5°C, over pre-industrial levels. This challenging goal is especially important for vulnerable areas that are already seeing the worst effects of climate change, like Africa (UNDP, 2024). Reducing warming to less than 1.5°C might protect ecosystems and biodiversity, lessen the strain on food and water systems, and lessen extreme weather. Significant greenhouse gas (GHG) reductions are required to meet this target, with net-zero emissions by 2050 and 45% by 2030. This calls for a combination of technology advancements, cooperative efforts, and policy tools, with African nations facing potential difficulties in this international endeavour (UNDP, 2024).

In this context, we can define climate change mitigation as measures taken to lower the amount of heat-trapping greenhouse gases that enter the atmosphere, either by improving the sinks that absorb and store these gases (such as soil, forests, and oceans) or lowering the sources of these gases (such as the burning of fossil fuels for transportation, heat, or electricity). Figure 4 indicates the some of the dimensions, components and indicators involved in climate change mitigation.

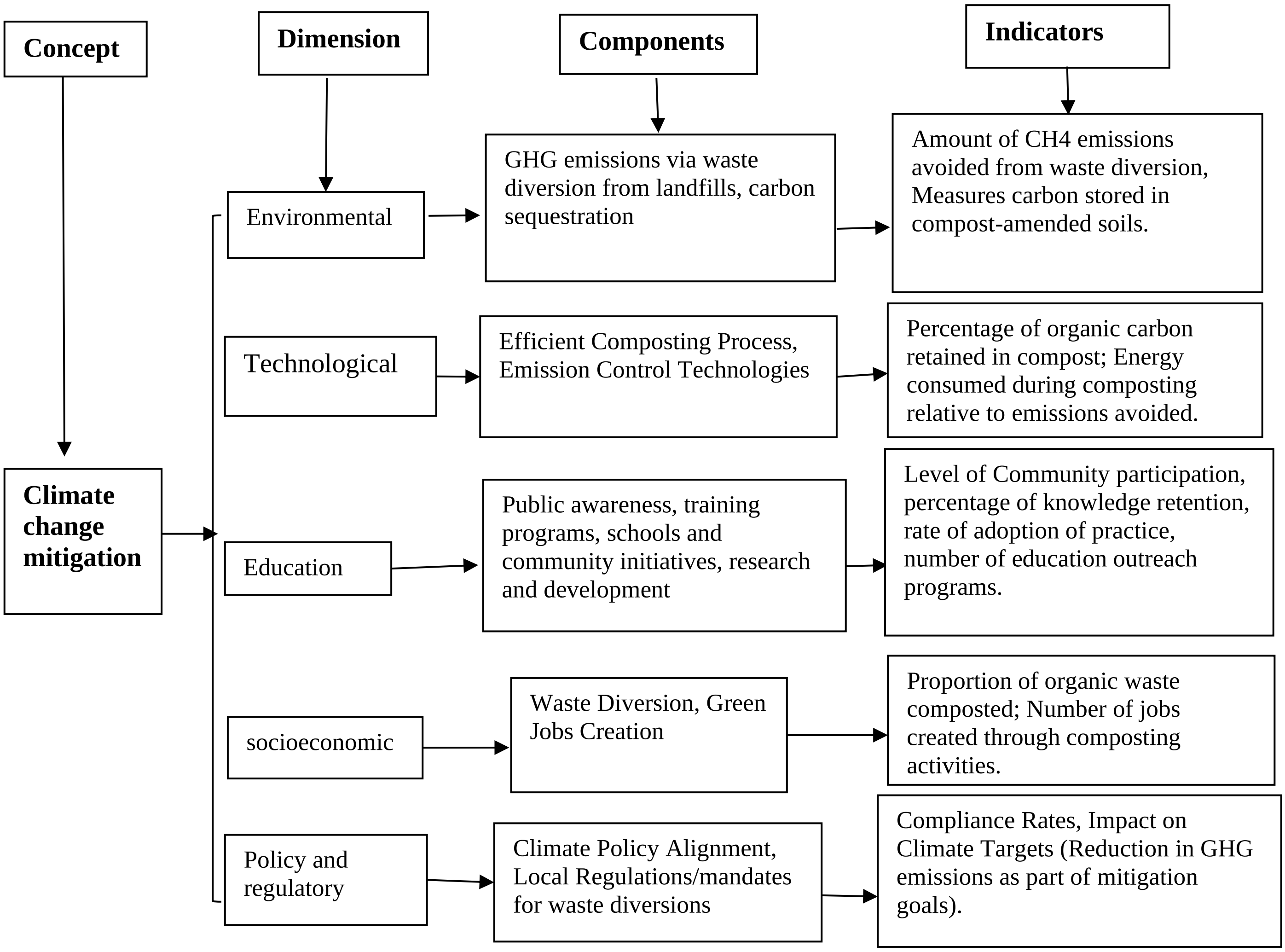


Figure 4: conceptualisation of climate change

Figure 4 demonstrates key dimensions of intervention that range from policies, complex technological interventions but also sound environmentally friendly practices at the local levels. Cost effective methods of combating climate change include composting. Besides its environmental benefits, composting as a climate combating practice has socio-economic benefits which many developing countries are yet to exploit.

2.2. Empirical Literature

Empirical literature on this subject matter is examined and critiqued according to the following sub themes.

2.2.1 Municipal Solid Waste Management (MSWM) in developing countries

Globally, CO_2e emissions from the waste sector have almost doubled over the period 1970–2010, reaching more than 1400 Mt CO_2e in 2010 making up 2.9% of the world's total CO_2e emissions, with emissions from developing countries expected to grow over the coming years (Alsabbagh, 2019). In most developing countries with increasing population, development, and urbanization, it remains a major challenge for municipalities to collect, recycle, treat, and dispose of increasing quantities of solid waste and wastewater (Bogner *et al.,* 2007). Most of the waste in developing countries ends up in landfills and these landfills account for about 5% of global greenhouse gas emissions from waste and about 12% of methane emissions globally.

The selective system of waste collection should constitute an integrated waste management program which could combine policies aimed at reducing the quantity of waste and recovering the by-products. Household waste reduction strategies or policies could include measures relating to saving in general, product hardship, new product design. The main aim of these strategies is to reduce the production and formation of waste. As for the recovery of by-products, the existing systems can be defined in two main categories; Mechanical sorting, in which the solid waste mixture is separated into certain number of fractions and the separation at source of certain components collected, transported and treated separately for later reuse Pokrel D and Viraraghavan (2005).

In Lomé, Togo, the waste collection rate is only 35% and trash management is rarely efficient, according to Koledzi, E. (2011). Decentralized composting is being promoted as a waste management technique by a network of researchers since organic waste makes up most of the garbage. In the same light, Topanou, A. (2012) studied household trash management in Abomey-Calavi, Benin, and showed that the city's rapid spatial and demographic growth is responsible for both the qualitative and quantitative rise in amount of household solid waste. After characterizing and classifying the garbage by season, he suggests composting as a waste management technique based on the element's types. According to Ngnikam *et al.* (2017), the average daily production of waste in the city of Yaoundé ranges from 0.5 to 0.8 kg per person per day.

Cameroon in managing municipal solid waste has employed waste collection and disposal services like HYSACAM (Hygiène et Salubrité du Cameroun) in most of its regions and implemented a waste management platform in Dschang municipality to manage waste through composting. However, despite the improvement in waste management, there is little information on waste quantification and opportunities involved in composting as a mitigation measure for climate change in Dschang Cameroon which we seek to address

Waste generation can be difficult to address but MSWM is very important as most of the waste is disposed of poorly and unscientifically posing significant health related challenges to the population and the environment (Srivastava *et al.* 2015). Some developing African countries currently face numerous challenges, such as human health, environmental, and socio-political threats, pushing decision makers to integrate more solid waste management approaches to their system (Mathlouthi *et al.*, 2024). Proper sanitary landfills are still lacking in most African cities, and waste is often thrown around in heaps. This is the direct cause of most African cities being perceived as unhealthy. By 2030 more than 50% of the population in sub-Saharan Africa will be living in the cities. This is likely to raise the daily rate of waste production by as much as 1,0 kg per capita. For instance, the African Environmental Outlook (AEO) of the United Nations Environmental Programme (UNEP) estimates that the per capita generation of solid waste is an average of 0,7 kg/day in Zimbabwe and 1,0 kg/day in Tanzania. This increase in waste production without any improvement in management conditions have led to more negative efforts on the environment. Apart from methane emissions from landfills, research has identified the possibilities of potential threat to the soil fertility of MSW dumped on agricultural land as MSW contains different pathogens and pollutants (such as heavy metals, organic pollutants, pesticides, herbisites etc.) (Crecchio *et al*. 2004). Continuous dumping or application of MSW in agricultural field may lead to heavy metal accumulation overtime (Lopes-Mosquera *et al.* 2000) which can be absorbed from the soil by food crops and taken into our bodies through consumption.

Generally, rates and quantities of waste generation, composition and disposition vary across Africa, these being linked to local economies, levels of industrial development, waste management systems and lifestyles of the country concerned. The quality and availability of data on solid waste generation and management in Africa are, however, scanty, and this impedes the development of programmes that will promote efficient use of solid waste in Africa. Developing a broader understanding of the types of solid waste that are generated by African cities and researching how these can be used to advance development is now more than desirable, as solid waste is increasingly seen as a resource.

This work seeks to fill this knowledge gap by poising that proper waste management can reduce emissions and generate economic benefits.

2.2.2. Organic waste generation and contributions to greenhouse gas emissions:

Over the years, waste generations rates have increased globally due to increased population growth. With the world's urban areas contributing highest to this waste generation (amounting to a footprint of 0.74 kg per person per day). This waste generation rate is expected to rise to about 3.40 billion tons in 2050 which is a 70% increase from 2016 (Mathlouthi *et al.,* 2024). Waste management or GHGs mitigation from the waste sector is in fact easier compared with other emitting sectors as the sector has the potential to reduce carbon footprint and switch from a net emitter to a net reducer of GHGs (Hani *et al.,* 2019). Germany in 16years, decreased emissions from waste management sector from 38 million Mg of CO2-eq in 1990, to about 18 million Mg of CO2-eq in 2006, a 20 million Mg of CO2-eq reduction which was mainly due to the introduction of mechanical treatment, biological treatment and source separation (Dehoust *et al.,* 2010). Another example is in the study of Weitz *et al.,* 2002 in United States, where he stated that increase in recycling and composting of municipal solid waste between the year 1974 and 1997 have resulted in the avoidance of over 1000 kg of CO2-eq. The room for reduction of GHGs is greater in developing countries, where the municipal solid waste stream contains more than 50% of organics that still finds its way to the landfills and dumping sites (Hani *et al.,* 2019). In cities of developing countries, waste management is a major concern, and landfills receive less than 50% of waste and the rest is left untreated (Kaza *et al* 2018). Most developing countries practice open burning of waste which is a significant local source of air pollution, constituting a health risk for nearby communities even though Composting and other biological treatments prevent this pollution and emit very small quantities of GHGs (Bogner *et al.,* 2007). Waste management in most developing countries present challenges such as lack of best measures to address increase in urban municipal waste, lack of management strategies including operational enforcement, sustainable financing, public awareness, trained staff, reliable data, basic know-how, and appropriate technologies (Mathlouthi *et al.,* 2024) which hinder waste quantification and composting initiatives. For example, in Tunisia, amount of municipal solid waste generated annually is about 2.6 million tons, with an estimated growth rate of 2.5% per annum. This waste is mainly composed of biodegradable waste which accounts for about 63% of the waste generated that is according to the National Waste Management Agency (AMGED) (Mathlouthi *et al*., 2024).

Globally, all human and animal activities result in the generation of waste (Brunner and rechberger 2014). According to the, United Nations Population Fund, (UNFPA 2008) about 3.3 billion of people live in towns and cities (urban areas) and this number is expected to increase to about 5 billion by 2030 (UNFPA 2008). Efforts to maintain the quality of the environment is connected to sustainable development and is now needed to be followed by the government as well as international organisations. For instance, a clean environment and effective waste management system is the 7th objective of the United Nations Sustainable Development Goals (SDGs). Waste management affects every person in the world. By 2050, the world is expected to increase waste generation by 70 percent, from 2.01 billion tonnes of waste in 2016 to 3.40 billion tonnes of waste annually. Greenhouse gas (GHG) emissions from the waste sector in sub–Saharan Africa according to the Sub-Saharan Africa Regional Network for Waste Management (2019 to 2021) account for 9% of total emissions in this region. In East Africa, GHG emissions from land use, land-use change, and forestry (LUCF), agriculture, and energy sectors combined account for 91% of total regional emissions, while emissions from waste and industrial processes account for the remaining 9% (USAID 2015).
The carbon Atlas (Global carbon Atlas) indicated that Cameroon's carbon emissions were 0.3 tCO2 per capita in 2021. The second national communication (2015) in Cameroon, stipulated sectors contributing significantly to pollution which are agriculture; energy; industrial processes; waste; and land use, land-use change, and forestry in the following proportion: industrial processes 47% of emissions, land use, land-use change, and forestry 27%, energy 16%, agriculture 13%, and waste 3%. The contribution of the waste is usually not considered in many mitigation policies, especially in developing countries where attention is geared towards the forest as major carbon sinks. However, urban canters have become too sensitive to climate change. The UN-Habitat estimates that 200 million people in sub-Saharan Africa lived in slums in 2010, or 61.7 % of the region's urban population, the highest rate in the world (UN-HABITAT, 2013). Within this context, and as part of broader debates on the implications of rapid urbanization for development and poverty reduction in the developing countries, more attention is paid on urban environmental risks that might disturb the living of poor urban dwellers. One of such great concern is the poor management of waste and the other disadvantage that comes with such as frequent flooding in the context of climate change (Sakijege *et al.,* 2012). As such, this work has implications for knowledge, practices and policies as many works have not sufficiently examined the role of waste in greenhouse gas emission at the local scale.

2.3 Composting as a waste management strategy in Africa

Composting as a biological method of waste disposal entails the decomposition or break down of organic waste into simpler forms by naturally occurring microorganisms, such as bacteria and fungi (Abubakar *et al* 2022). Various waste management methods such open dumping, waste-to-energy incineration, mechanical biological treatment, and anaerobic digestion either in a landfill form or independently brought out of the landfill site to be treated at a non-landfill site have varying impacts in terms of the release of methane into the atmosphere. According to the Intergovernmental Panel on Climate Change (IPCC, 2019), composting of biodegradable waste materials forms a key strategy in addressing climate change impacts, especially extreme events like floods and droughts that affect the environment and public health sectors. As such, a study by Couth and Trois (2012) also identifies Composting as a cost-effective way to control greenhouse gas (GHG) emissions from waste by stabilizing the organic waste and using the composted material as a soil improver or organic fertilizer. Also, a study by Ruggieri *et al.*, (2009) which compared external management cost and composting costs of the organic fraction of waste generated from some wine industries discovered that these industries could make an annual saving of €19.56/t using composting process for waste management as compared to external management. Hence, Composting has been described as the most environmentally friendly and cost effective MSWM option, which internalizes biodegradable waste carbon back into the land. Of the available options for organic waste management, composting has been found to offer the best greenhouse gas saving potential; by diverting waste from disposal in landfills and oxidizing the waste under regulated conditions to convert the organic fraction into compost and using the compost to improve soil quality, this could lead to the lowest net greenhouse gas emissions as compared to landfill or incineration

Couth and Toris (2012) stated that the global warming potential of composting municipal solid waste is far below that of open dumping or landfilling. In 2009, the International Solid Waste Association reported a significant 60 kg CO2-eq /Mg-1 of GHG emissions avoided due to MSW composting practices. In Sub-Saharan Africa, decentralized composting of municipal solid waste has been shown to significantly reduce greenhouse gas emissions for instance, a case study in Tiassalé, Côte d'Ivoire, found that from the 59.4 metric tons of organic waste processed by a pilot station, 14.2 metric tons of mature compost was produced, which corresponds to 24% of the input mass on a wet weight basis (Yeo *et al.*, 2020). This composting scenario avoided 87% of the baseline emissions occurring in open dumping.

More so, Kim and Kim (2010) studying and analysing waste management options indicated that composting of the food waste had an average Global GHG contribution of 123 kg CO2-eq Mg-1 compared to landfilling of the food waste that has an average GHG contribution of 1010 kg CO2-eq Mg-1. Modelling environmental inventory with compost and peat in growth media by Boldrin *et al.,* (2010) indicated that, substituting landfills/peats with compost in growth media had significantly reduced average GHG emissions by 70 150 kg CO2-eq Mg-1. GHGs emissions from municipal solid waste disposal in well-constructed sanitary landfills can range from 300 kg CO2-eq Mg-1 to 1000 kg CO2-eq Mg-1 in the case of open dumping of waste (Manfredi *et al.*, 2009). In another case study by Richard *et al.,* (2020) it was found that fugitive emission from a composting process yields 14,290.23tCO2eq, in the northeast geopolitical region in Nigeria while emission from landfilling of the remaining unsorted waste was 103,669.55tCO2eq, he further estimated that, when the humus from the composting process is used as fertilizer in place of chemical fertilizers, 3,334.39tCO2eq will be sequestered in the entire region. The study findings indicated that adopting composting as a replacement for the existing SWM process in the entire northeast region will lead to a net GHG emission of 114,625.40tCO2eq giving a 52% reduction (120,424.78tCO2eq) from the emission obtainable from the current SWM process.

2.3.1 Municipal Composting as a waste treatment method in Dschang

With the financial and technical assistance of the Municipal Development Program (PCM) and the Water Solidarity Program (PSEAU), a coordinated plan for water and sanitation access was created in the city of Dschang in 2005. The feasibility of waste management in the city of Dschang was studied in 2006, and with the assistance of the city's trade centre at the National Higher Polytechnic School (ENSPY), technical and environmental studies for the construction of the municipal landfill of Siteu were conducted in 2007. With the help of Nantes Métropoles, a municipal landfill was constructed in Siteu and placed into service in 2008 after the commune of Dschang was later chosen as an operational project for the development of an operational landfill as part of the Urba.Cam project. A project to be presented to the French Fund for Global Environment's (FFEM) modest projects program was created in 2009 because of a French mission from the non-governmental organization CEPREPADE (French-speaking partner research centre on sanitation, waste, and the environment).

In 2010, a prototype composting unit was established in the Ngui district with funding provided by the International Union for Conservation of Nature (IUCN) and the FFEM.

Based on its relationship with ERA Cameroon (Environnement: Recherche et Action au Cameroun) through CEPREPRADE, GEVALOR (sustainable management and recovery of waste and mineral raw materials) conducted a feasibility study in 2011 to incorporate the composting unit in the city of Dschang as part of the Afri-compost project developed in six African cities. With funding from the French Ministry of Foreign Affairs, the municipality improved its pre-collection and collection equipment, and the Ngui pilot composting platform was created between 2010 and 2014 in collaboration with the French organization Elans (Ensemble pour l'action Nord Sud). Thus, in 2014, the project for the control of the management, treatment and recovery of municipal solid waste (MageTV) was set up, co-financed by the European Union. To ensure the sustainability of the composting activity, a municipal agency was set up within the municipality for the management of household solid waste. Since then, the city of Dschang uses waste composting, a continuous and well-established set of practices that has been used for many years, to manage trash. Its population produces an estimated 0.41 kg of waste per day (Djousse, 2018), with 21,788 tonnes produced annually in 2017 and a 25% collection rate in 2017 (Moumbe, 2021). The population growth in 2023 resulted in 27,514 tonnes of trash output, with a 32% collection rate. The improvement in pre-collection and garbage collection over time, along with the acquisition of new logistical tools, the maintenance of old ones, and the somewhat more regular refuelling of trucks, accounts for this discrepancy. While composting is recognized globally as a waste management method, research in Cameroon, particularly in Dschang, focuses more on landfilling and informal recycling, with minimal assessment of composting's viability and effectiveness as an alternative waste treatment method.

2.4. Barriers for the adoption of composting as a waste treatment method

Many issues have been raised on the sustainability of composting and compost use in agriculture. Barriers on the effective integration of composting practices are many and range from technical, political, economic, socio-cultural and political constraints. According to Delarue *et al.,* (2012), the difficulties of communities in ensuring effective composting depends on the regular supply of fresh organic waste to the composting sites. Waste production is urban canters is very rapid but the timely collection of waste for composting is slow. There are limited collection equipment and manpower which limits the rate of collection and transportation. This situation has consequences on the composting process as waste produced after 72hours or waste in a decaying stage will lead to low quality compost (Kongnso *et al.*, 2024).

Equally, many composting sites are unable to function in full capacity because less than 50% of waste produced does not enter the formal collection circuit. Illegal dumping is a barrier to composting.

A major challenge in the composting process has been the lack of waste segregation at source. Studies by Kaza *et al., (*2018), have shown that in most towns of the developing world, waste is not sorted at source. This challenge has not only increased the time use in composting platforms but has reduced the quality of compost. Pereira *et al.,* (2022) states in Brazil, composting is influenced by level of education, infrastructure and the socio-economic conditions of the population. They identified the ability to engage the population in composting and compost use practices as the main challenge affecting the composting process in Brazil. This is a very important element that influences compost use. Many farmers tend to compare compost with chemical fertilizers and this comparison without understanding that compost is a soil amendment that takes a longer period to nourish the soil before the plants. Equally, waste management regulations in developing countries have not insisted on composting or on compost use in farming and as such, chemical fertilizers are valorised at the expense of compost (Kongnso, 2024).

Equally, financial challenges have hindered the adoption of composting as a waste treatment method. Municipalities have budgetary constraints even as a greater part of their budget goes to waste management and sanitation. Ngnikam & Tanawa (2006), identified this barrier and suggest that financial challenges in waste management can be improved upon by ensuring gains from waste recovery. They consider the sale of compost and objects recovered, as well as the use of recovered biogas for heating and cooking as potential sources of financing. This financial capability is a success story in Dschang as the municipal council transformed its waste treatment facility to an economic project.

Also, waste composting services suffer from lack of know-how and inadequacy techniques. According to Viaene *et al,* (2015), waste collection materials must be adapted to the very nature of the waste produced. Some obstacles we can cite for waste management in sub Saharan Africa include techniques for the public management of waste in urban canters among others; the accelerated increase in population which in turn increases the quantity of waste to collect, the spatial distribution of garbage bins which often does not take into account user needs (quantity of waste produced per person or household, distance to travel, accessibility, various habits, etc.), the design of these bins does not take into account the environmental and living environment concerns of neighbouring populations, the absence of waste pre-collection canters in the areas inaccessible to collection trucks.

These challenges have negatively affected waste management in general and effective municipal composting in particular. There is therefore a dire need to sensitize the population on the benefits of compost and equally redefined farm input policies that favour the adoption of compost.

2.5. Theoretical Framework

This research will use the Urban Political Ecology (UPE) theory. This theory provides clear perspectives for analysing waste segregation, compost use, and urban farming in the context of sustainable development.

Urban Political Ecology (UPE) provides a good framework for understanding the interrelations between social, political, and ecological processes in urban settings (Heynen *et al.,* 2006). Introduced by scholars such as Erik Swyngedouw and Nik Heynen in the early 2000s, UPE examines how power dynamics and institutional decisions shape urban environments and resource allocation. A core tenet of UPE is that cities are not merely physical spaces, but dynamic systems influenced by human activities, ecological factors, and social hierarchies (Heynen *et al.,* 2006). It emphasizes the uneven distribution of resources, such as waste management services, and the inequalities that arise from these disparities. By focusing on the socio-political structures that govern urban systems, UPE allows us to explore how policies, economic structures, and cultural norms interact to create the urban environment.

UPE introduces the concept of urban metabolism, which describes the flow of materials and energy through urban systems, linking human activities and ecological processes. This perspective is vital in analysing how practices like waste segregation and composting influence urban systems. For instance, in a city like Dschang, the improper management of organic waste can create environmental hazards and exacerbates inequalities. UPE provides tools to study how composting can transform these challenges into opportunities by creating a circular urban economy where organic waste is recycled into a valuable resource. This metabolic approach enables us to assess how compost-based farming addresses the "metabolic rift" caused by industrial agriculture and urbanization, promoting sustainability and resilience in urban farming practices.

Relevance to the Study

Urban Political Ecology is deeply relevant to our research as it helps to unpack the socio-political dimensions of compost use in Dschang’s urban farming practices.

The theory examines how power relations between stakeholders such as municipal authorities, farmers, and waste workers influence access to resources and the adoption of sustainable practices. For example, farmers in marginalized communities often face barriers to accessing composting resources or facilities due to inequitable policies or resource allocation. UPE helps us investigate these inequalities, enabling us to propose interventions that ensure fair and inclusive access for all stakeholders. Furthermore, the theory provides a lens to analyse how institutional decisions, and socio-economic dynamics affect the effectiveness of waste management policies, ensuring that our study considers the broader context of systemic challenges.

By focusing on urban metabolism, UPE also allows us to assess how compost-based farming can contribute to reducing environmental and socio-economic inequalities in Dschang. Composting redirects organic waste back into agricultural use, closing the loop in the urban metabolism and mitigating the negative impacts of waste accumulation. UPE’s emphasis on the interplay between social practices, ecological systems, and political structures ensures that our study captures the complexities of implementing sustainable practices in urban settings. The theory is particularly useful for identifying the barriers and opportunities in promoting composting, such as the need for improved composting facilities or compost training programs for farmers. Moreover, UPE’s focus on power dynamics and inequalities ensures that our research recommendations address systemic issues, paving the way for sustainable and inclusive urban farming practices.

CHAPTER THREE

3. MATERIALS AND METHODOLOGY

This chapter outlines the detailed materials and methods adopted for the study on climate change mitigation through municipal solid waste (MSW) composting in Cameroon, with a focus on Dschang. It begins with a presentation of the study area within its geographical and socio-economic and political contexts and clearly indicates data collection sources, methods of collection and analysis. The mixed methods approached employed has added validity to the data collected while the participation observations effectuated during a two-month internship on the compositing was crucial for the quantification of emissions during composting.

3.1 Study Area Description

The study was conducted in Dschang, Cameroon, Located between longitudes 10°01" and 10°06" East of the Greenwich Meridian and latitudes 5°29" and 5°24" North of the equator (Figure 5). It is the head quarter of the Menoua Division in the West region of Cameroon. It covers an area of 123km2, with an urban centre estimated at 7 km2 (kongnso *et al.*, 2024). The city has a population of about 150,000 inhabitants and an average density of about 300 persons/km2, Dschang has an average growth rate of 3.2%, and a student population of about 30,000 persons (kongnso *et al al.,* 2024). The climatic conditions and environment are conducive for urban and peri-urban agriculture with accessible roads to metropolitan cities of Douala and Yaoundé. Dschang has an equatorial monsoon climate with two distinct seasons. The rainy season that runs from mid-March to mid-November with average annual rainfalls of 2500mm and a dry season from mid-November to mid-March with average annual temperatures of about 21°C which have favoured the cultivation of both seasonal and perennial crops (Temgoua *et al.*, 2012).

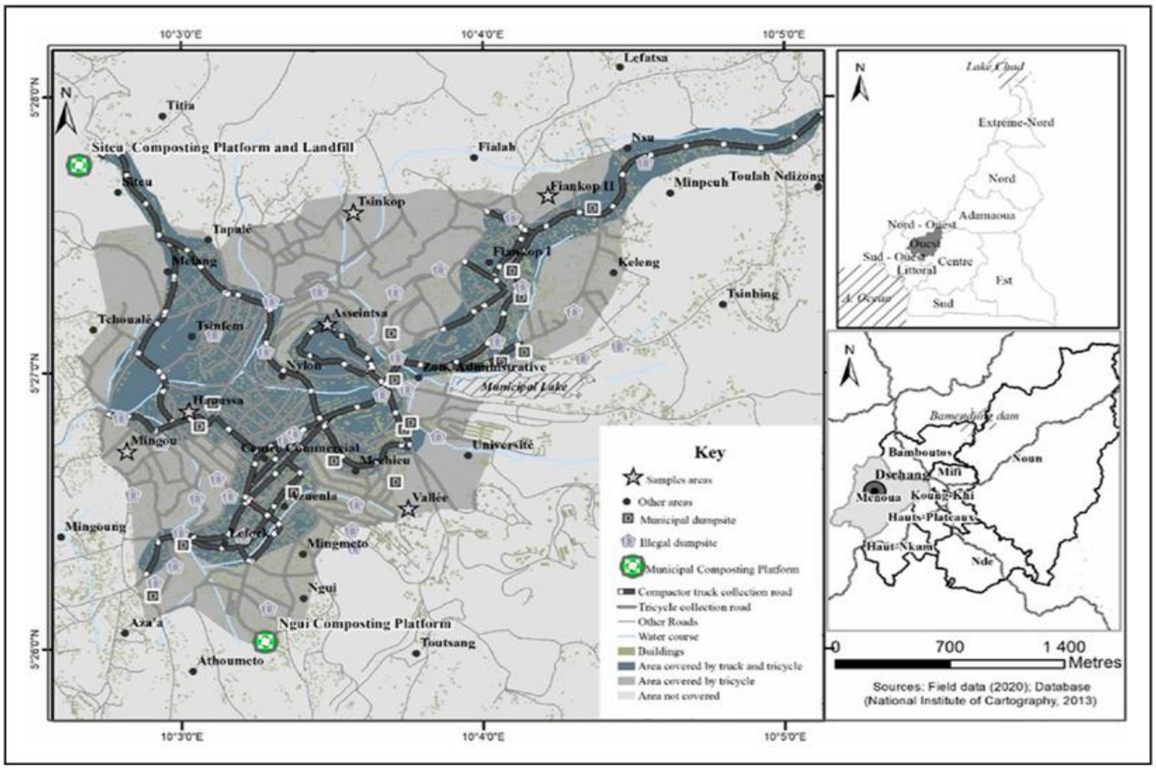


Figure 5: location map of study area

Source: kongnso, (2024)

Dschang is a municipality that was created in 1954 by decree N° 807 of November 29, 1954, with a Rural and an urban council. In accordance with the provisions of Law No. 204/018 of 22 July 2004 on decentralization, the Urban and Rural councils were abolished in favour of a single municipality created by decree N ° 2007/115 of April 13, 2007 of the President of the Republic. The municipality manages local affairs under the supervision of the State to ensure the economic, social and cultural development of its populations. One of such is waste management and sanitation. Cameroon has since the mid-2000s entrusted solid waste management of medium-sized cities to a national private company (Hysacam) implying a shift from municipal management to private-public partnerships (as seen in the capital and medium sized cities). Small cities (ex. Dschang), however, do not fall under this system. The council thus plays an important role in waste management and ensures public hygiene and sanitation. Daily waste collection services of the municipality cover about 35,500 persons in about 800 households (Tamgoua *et al*, 2014). Some quarters, especially at the peripheries are not served by the council waste collection services and they tend to throw their waste in river courses, nearby bushes or use in their farms. The average household waste production per person per day is about 0.6 Kg Meutchieye and Senge (2006). One of the priorities of Dschang council is to ensure effective waste management.

It is with this that in the year 2000, the council in collaboration with ERA-Cameroon developed a composting plant in Ngui that treats about 1000tons of waste per year (Garnier and Njinoh, 2015). Waste collection has been adopting a participative approach with the help of associations such as TOCKEM. In the domain of valorization, ERA-Cameroon is involved in the manufacture, promotion and marketing of compost. The characterization of household waste indicated; green waste 38.58% and food waste 16.22% (Ngnikam, 2013). This facilitated the production of agro compost. Dschang council gets financial assistance from international partners; European Union, Nantes Metropolis, French Development Agency and works in collaboration with de-concentrated services of related Ministries. Under a decentralized cooperation context, Dschang is a pioneer and one of the rare cities in the region whose garbage collection system has been transformed into a developmental project.

3.2. Data collection techniques

3.2.1. Secondary data collection

Secondary data sources used to accomplish the objectives of this research involved reviewing relevant literature on climate change, composting and literature about the Dschang municipality. It used reports, published studies, government documentation articles and scientific documents of interest downloaded from different platforms: Google Scholar, Research Gate, Science Hub. Documents taken from the libraries: the CERETH library, the central library of the University of Dschang, presenting work carried out in our study area and other areas of relevance was used together with theses, dissertations and reports written in our area study. Also, reports from international organizations such as the UNFCCC, IPCC, UN and national organizations such as AMGED, organisations, allowed us to have an overview of the issue of waste management by composting and benefits in the city of Dschang in particular. These documents were very useful in building the theoretical background of this study

3.2.3 Primary data techniques

Observations

Observations were carried out from December 2024 to February 2025. During the various field trips, some data such as photos and videos were taken at the composting sites and waste collection points (dump, market, household) to better illustrate our work. This also allowed us to be in contact with the various users of compost (farmers) and local stakeholders.

These various outings were beneficial, because thanks to them, interviews were prepared and administered efficiently, the field approach was more rigorous, and the subject of study better understood.

Participatory observation:

An internship was carried out with the municipality, for a period of 2 months from January 13th to March 13th, 2025 (appendix 2), to learn the composting process, calculate the quantity of CH4 emissions sequestered in every process. We participated in a complete phase of waste composting, which allowed us to acquire practical knowledge in this area and to master the composting process. During this internship period, data was collected at every stage of the composting process such as the quantities of waste treated on daily basis and amount of compost produced (photo 1). For instance, temperatures changes were closely observed within the windrow during the hot fermentation phase. These temperatures are taken using a temperature probe with a circular, graduated tip and a 30cm long iron extension.

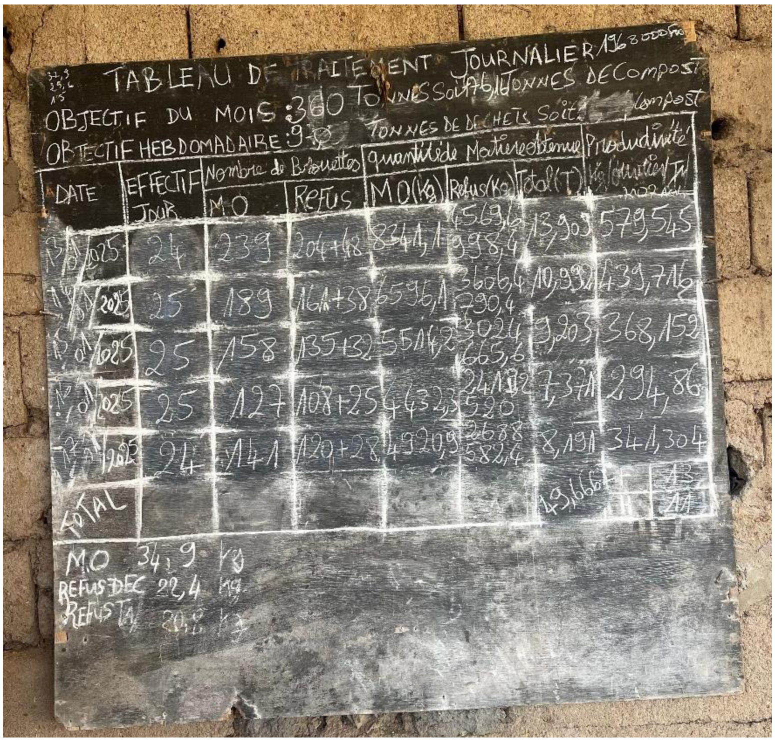


Photo 1: Daily processing table indicating monthly objectives

Source: field survey 2025.

Photo 1 daily processing table indicates the monthly objective of the compost facility. It records the daily quantity of waste collected, quantity treated, that is the quantity of organic matter received, the quantity of waste discarded at each sorting stage (ground and table sorting) and the number of workers present.

The questionnaire

The questionnaire survey was conducted to a targeted group of persons (composters and compost users). The Purposive sampling was used to determine the target population. The choice of farmers selected for this study was based on their use of compost for farming, while the choice of composters as the target population is justified by the fact that they are the ones who carry out the composting activity on the platforms and the team leaders and deputy leaders are responsible for collecting and monitoring data during composting. As such, a total number of 100 structured questionnaires were administered to compost users (appendix 1). The sample size of 100 was adopted because it was considered as a point of saturation whereby adding more participants could not provide new information. On the other hand, 32 composters equally participated in the questionnaire survey to get information on technical aspects of composting as well as challenges at the platform.

Key informant interviews

A series of semi-structured interviews were conducted with the authorities of the Dschang council and AMGED. In total, 05 interviews were conducted with: the director of AMGED, the representative of the NGO ERA Cameroon, the head of service of the Siteu platform, the head of service of the Ngui composting platform; mainly on the issue of waste management by composting and carbon reduction assessment. The interviews were recorded with a smartphone. The discussions were very useful in identifying the barriers faced by the institution in waste management and compost production in particular.

Data collection during Aerobic composting at the Ngui composting platform

During the internship period, data was done at two main phases: the waste characterization phase and the composting phase.

Waste characterization phase

Waste characterization is a process that allows us to know the composition of the waste collected in a specific location. It was carried out according to the AFNOR X300-408 standard. Waste collected is composed of different organic matter, paper, yard waste, metals, glass, rubber, plastic, and/or synthetic products. The characterization process enabled us to understand the quantity, composition, and source of waste arriving at the composting platform. Waste characterisation is done in a number of stages (Plate 1).

Plate 1: Waste characterization stages

Source: field survey 2025.

Plate 1 shows activities and equipment used at every stage of characterization. Firstly, waste was collected in collection trucks from all round the city and brought to the platform and 514kg of the waste was measured and set for homogenisation. During the homogenisation process, the waste was divided into 4 separate piles as indicated in image D (plate 1) and then mixed to ensure a uniform mixture.

The waste was then arranged in a circular form and quartered as indicated in image E (plate 1) using a robe and one quarter of it removed for sampling which measured 130kg. Waste was placed in a 100mm (waste greater than 100mm) characterisation table (image F, plate 1) and characterised into wood, cardboard paper, textile, food waste, green waste, metal waste, hard plastic waste, plastic paper waste, medical waste, electric waste and other waste (consisting of stones, glass, and other unidentifiable materials) (image H, plate 1). The characterised waste was measured and recorded while the remaining waste (< 100mm) was placed in a 12mm characterisation table as seen in image G (plate 1) and still followed the same characterisation process. The characterized waste was measured together with the finished waste (waste below 12mm). This characterization determined the quantity and quality of waste to be composted before composting begun. This process is done every month at the composting platform.

Waste composting processes

Composting is equally done in a number of stages (Plate 2). Waste was collected by collection trucks and each truck takes one ton of waste at a time and transported to the composting facility where it was sorted first on the ground with spade forks to separate larger inorganic materials (Image B, plate 2). After the first sorting phase, it was transported using wheelbarrows to the sorting table for more detailed hand sorting to remove inorganic material. The sorted organic material was transported using wheelbarrows to the formation centre where heaps are formed (Image F, plate 2). Each heap takes a maximum of 250 wheelbarrows and when the required number of wheelbarrows is attained, fermentation process begins and takes up to 15days within which we took daily temperatures and have maximum temperatures ranging from 60°c to 80°c (image G, plate 2). During this stage, we could still see and identify various organic materials present and the heap/pile is turned over in a given order: after 4days, then after 5days and after 6days (photo 2) and watered during each mixing phase

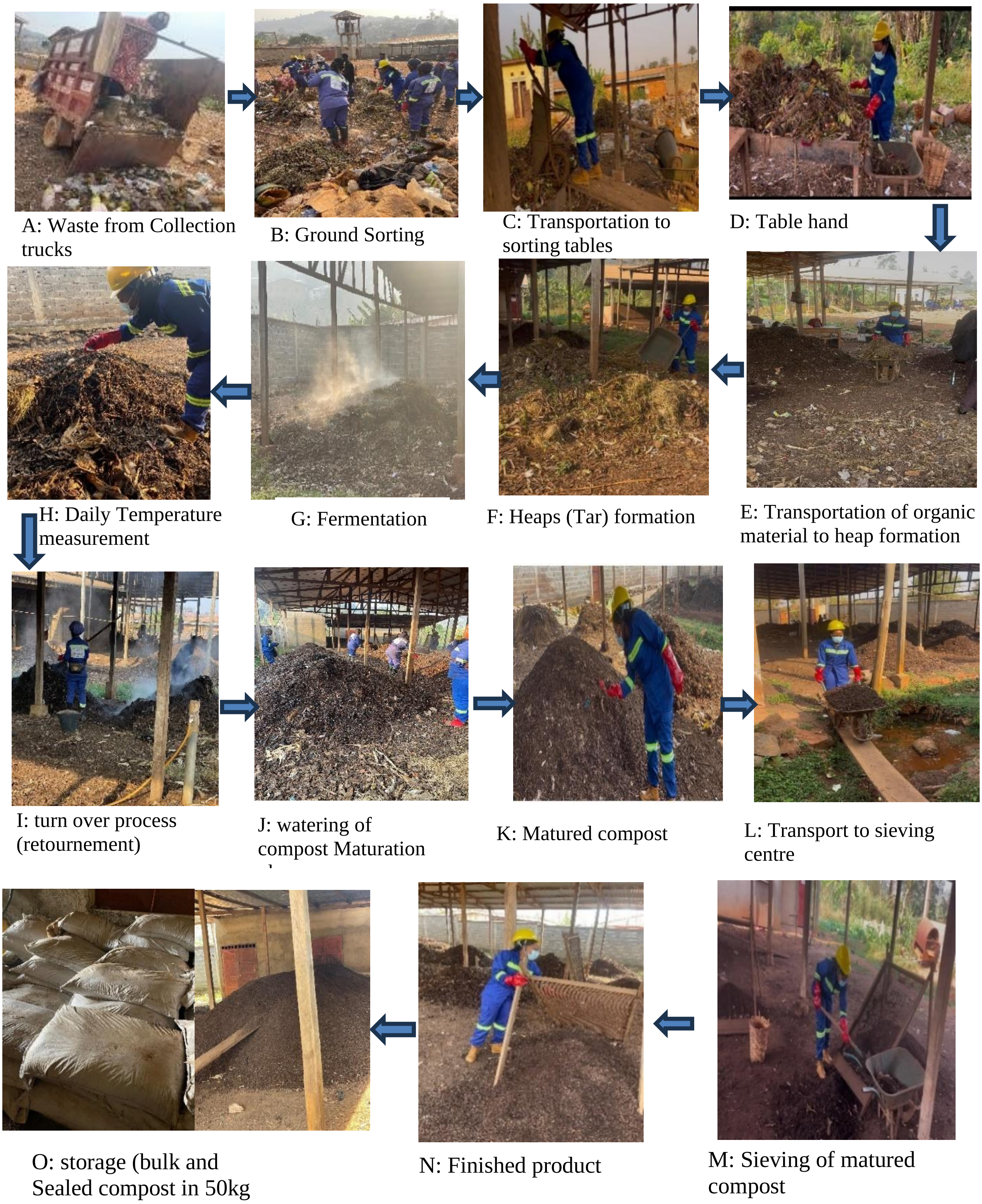


Plate 2: Presents the various stages of compost production

Source: field survey 2025.

Photo 2: turnover placard for compost heap number 827 indicating the start date for heap formation (DDF) and completion of the heap date (DFF)

Source: field survey 2025.

After the fermentation phase it goes to the maturation phase where most of the organic material has been degraded, making them a little difficult to identify. This phase also takes 15 days within which daily temperatures are recorded with maximum temperatures of about 65°c and it is also turned over and watered in 2 shifts: (after 8days and after 7days). From this phase, compost enters the matured phase where we have room temperatures of 37°c. At this stage, the organic material has been degraded, and turnover takes place here with no watering. This lasts for about 45days with turnover after 20 days and after 25days (photo 2). This is enough time for compost to dry out. The matured compost was then transported for sieving (image N, plate 2) to have the final product. Waste from the sieving process is deposited aside, mainly composed of (80%) wood or tree material and given out freely to some farmers or disposed of at the landfill. After this process, it was observed that each heap consisting of 250 wheelbarrows of organic matter produced about 50 to 54 wheelbarrows of compost (one wheelbarrow equals one 50kg bags of compost) which are sealed in bags and sold at a subsidized rate of 2500FCFA (USD 3.97) (image O, plate 2). Therefore, in total the composting process takes 75 days to be completed which is about 2months 2weeks and takes place in 3 states which are fermentation, maturation and matured stages.

3.3. Data treatment and analysis

Questionnaires and Interview

Data collected was treated and analysed quantitatively and qualitatively. Questionnaires items were coded and treated using Microsoft excel. Data obtained is presented using charts, graphs and tables. On the other hand, interviews were treated using content and thematic analysis with the help of Atlas.ti. Firstly, voice notes recorded during interviews were transcribed, coded and analysed according to specific themes and content. Excerpts are captured from some key informant discussions to support arguments and express perceptions.

Calculating emission reductions during composting

For carbon evaluation, parameters for calculating emission reductions during the composting process were employed, permitting the estimation of avoided emissions to be sold in the carbon market. The formula for calculating avoided emissions is that of AMS-III.F "Avoidance of methane emissions through controlled biological treatment of biomass" of the United Nations Framework Convention on Climate Change which stipulates that, to obtain avoided emissions, we proceed by calculating the difference between emissions of the project and those of the reference scenario. The reference scenario is that which prevails in a situation where there is no waste treatment, and the project emissions represent those which take place during the project activity.

The AMS-III.F methodology is the most suitable for calculating reduced emissions with regard to projects for the valorization of solid waste into compost on a small scale (-60,000 tCO2eq / year), on a medium scale and on a large scale. It incorporates measures to avoid emitting methane into the atmosphere, whether from biomass or organic matter found in anaerobic conditions.

To calculate the emissions of the situation without the Composting operation, the formula is as follows:

$$\boldsymbol{BE_Y = BE_{CH4SWDSY} + BE_{WWY} + BE_{CH4manurey} - MD_y * GWP_{CH4}}$$

Where:

BEY= baseline emissions for year y; BECH4SWDSY= Yearly methane emissions from solid waste; BEWWY= BE from wastewater co-composted (BE from composted wastewater); BECH4manurey=BE from manure composted (BE from composted manure);

MDY= methane that would have to be composted and combusted to comply with regulation. GWPCH4 is the global warming potential for CH4 = 23 (the global warming potential of CH4 is 23)

During the composting process, there are very small amounts of greenhouse gas emissions. These emissions are monitored and their values used to calculate project emissions. The formula for calculating project emissions is:

$$PE_Y = PE_{Y,power} + PE_{Y,comp} + PE_{Y,runoff} + PE_{Y,res\,waste}$$

Where:

PEY = project emissions year y; PEY, power = emissions due to electricity; PEY, comp= emissions linked to the composting process; PEY, runoff = emissions due to leachate; PEY, reswaste= emissions linked to anaerobic storage of compost. Waste treatment through composting in Dschang focuses on the fraction of CH4 emissions avoided, so the formula becomes;

$$BE_Y = BE_{CH4SWDSy}$$

Where;

$$BE_{CH4WDSy} = \Phi \times (1-f) \times GWP_{CH4} \times (1-o_x) \times \left(\frac{16}{12}\right) \times F \times DOC_f \times MCF \times \sum_{x=1}^{y} \sum_j W_{j,k} \times DOC_j \times e^{-kj(y-x)} \times (1-e^{-kj})$$

From this formula, we understand that the reductions in CH4 for waste composted in year X do not only apply in year X, but also in future years. More explicitly, it must be understood that the emission reductions in later years are the results of the waste treatment carried out in the beginning. For this reason and for a better understanding of the immediate benefits of composting activity on GHG emissions in Dschang, we adopted this formula while reducing all year-round emissions for landfilling.

Wj= quantity of treated waste “j” monitored, DOCf = Degradable Organic Carbon: default value; Kj= waste degradation rate j by default; Wjx= quantity of waste “j” treated in year x; Wx: total quantity of waste treated; Pjx= average fraction of waste “j” in waste of year X;

DOCj: fraction of degradable organic carbon (weight), in waste type per day and Kj is the waste degradation rate.

Regarding the calculation of project emissions during the composting process, reference is made to greenhouse gas emissions (in very small quantities) but whose values are monitored and used to calculate project emissions. They include;

Emissions due to electricity consumption

$$PE_{Y,power} = \sum jEC \times EF \times (1 + TDL)$$

Where:

EC=quantity of electricity used in the year; EF=default emissions factor of 1.3; (1 + TDL)= network loss by default which is 20%

Emissions linked to the composting process

$$PE_{Y,comp} = Q_y \times EF_{comp} \times GPW_{CH4}$$

Given that the methodology is conservative, it is estimated that there are few emissions where: Qy=quantity of waste treated; EFcomp = default emissions factor which is 4% and=GWPCH4, which is 23. In the case where the oxygen is monitored and is greater than 8% with 90% confidence and 10% error, then PEy,comp = 0

Emissions linked to leachate (PEy, runoff)

$$PE_{Y,runoff} = Q_{y,www,runoff} \times COD_{y,www,runoff} \times B_{o,ww} \times MCF_{ww,treat} \times UF_b \times GWP_{CH4}$$

$$PE_{y,runoff} = 0$$

These emissions were not considered because composting on both sites is done in a shed and therefore the leachate effect is null.

Emissions linked to anaerobic storage of compost PEy, reswaste

In the case of Dschang, compost is stored aerobically so PEy, reswaste = 0.

$$PE_y = PE_{y,power} + PE_{y,comp}$$

3.4 challenges encountered

1) The city of Dschang as other cities in Cameroon faces frequent disruption of electricity. This continuous power outage slowed down work progress by delaying my laboratory results for compost analysis, documentation works and hindering the use of electronic devices such as laptops for project reporting all which relay on stable power supply, requiring visits to shops with alternative power supply sources such as generators for a fee.

2) The city also faces periodic internet disruptions which limited internet access, online research and communication with my supervisor. This slowed down literature reviews, and delayed feedback from the laboratory and supervisors.

These challenges delayed research progress activities and impacted cost but has not affected the research quality.

CHAPTER FOUR

4. RESULTS AND INTERPRETATION

4.1. Municipal Composting as an alternative method of organic waste treatment

In respond to the increased waste production due to increase population in Dschang Cameroon, the Dschang municipality pioneered the valorization of organic waste by turning it into compost. The Municipal Waste Management Agency (AMGED) was created and with support from international partners, it has successfully implemented a comprehensive waste management strategy, one of which includes the creation of waste composting platforms in Ngui and Siteu. These facilities aim to transform organic waste into compost, thereby reducing the volume of waste disposed of in landfills and reducing emissions from this sector. Municipal waste management in Dschang is done by two systems: the pre-collection and collection systems.

4.1.1. Waste pre-collection

Pre-collection is a door –to-door system of waste collection in Dschang. It is participative and is ensured by NGOs that work in collaboration with municipality. Presently, there are three organizations involved in this process; CEPDEL (Centre pour l'environnement le partenariat et le développement local), ADECOTEC (Actions de développement des collectivités territoriales au Cameroun) and TOCKEM. Under the supervision of AMGED, the town is divided into three zones and assigned to each of the organizations. Each organization has the task to collect and transport to the composting platform a total of 64 tons of waste every month. Households adhere freely by accepting to pay a monthly pre-collection fee of 500fcfa while other pay more depending on the size of the household and the quantity of waste produced. The municipality equally support these associations financial and in the purchase of tricycles.

Interviews with waste workers revealed that pre-collection started with the use wheelbarrows and only a few households were involved. This was the only means available during that period and it was very difficult to extend their activities out of Ngui. With the coming of tricycles (plate 3), pre-collection has been extended to nearly all parts of the town and the quantity collected during this process has equally increased significantly.

A

B

Plate 3: Pre-collection with tricycles

Source: field survey, (2025).

The tricycles (plate 3) has significantly improved waste pre-collection. The provision of working tools by AMGED have encouraged waste workers and improved on their productivity. It has equally permitted waste from inaccessible quarters to be included in the municipal collection circuit. Since 2016, total number of registered households has been rising substantially. The number of households adhering to this system has been on the rise since 2016, from 1111 households to about 2500 in 2024. In 2024, the total quantity of waste from pre-collection was estimated at 3651.46tons. The quantity varied according to seasons as indicated in figure 6. These associations also generated money from this activity, and it permitted them to buy equipment and pay salaries. This system of waste management has had positive impacts on the composting process as it ensures the arrival of freshly produced waste to the platforms.

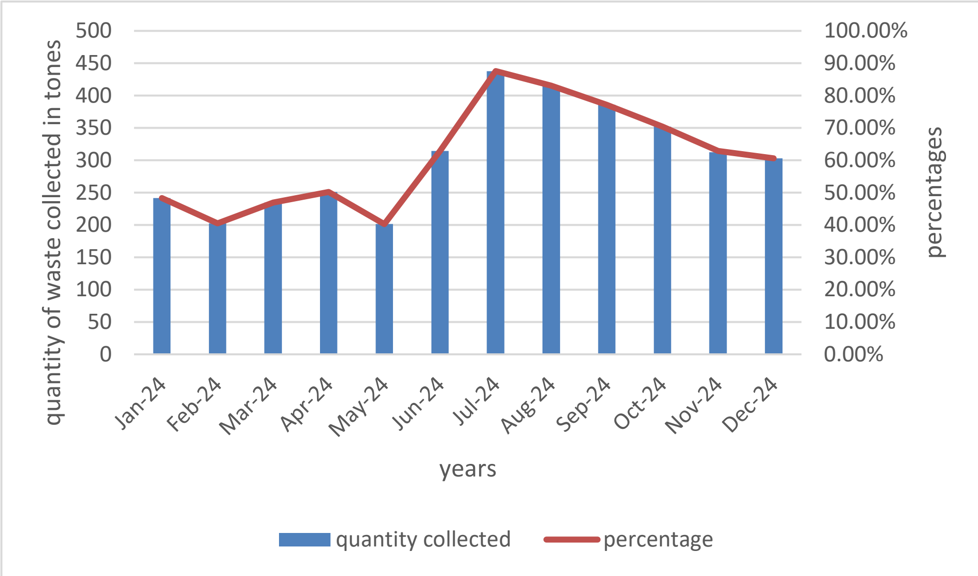


Figure 6: monthly variation of waste collected in 2024

Sources: AMGED (2025).

As observed in figure 6, the quantity of waste collected from pre-collection ranged between 200 to 430 tonnes to in 2024. The lowest quantity was recorded in the month of May which could be because May falls just after the planting season (March and April) where most of the reaming foodstuff are planted as seeds. During this period, the quantity of food supply decreases and a reduced quantity is available in the markets at higher prices reducing consumption, while the highest quantity was recorded in the months of July and august. July and august are harvest seasons in Dschang with abundant food supply at very affordable prices increasing purchasing power and consumption. This explains the fact that agriculture is the main activity in Dschang municipality.

4.1.2. Collection system

This is a system in which waste is collected along major streets and from specific dump sites constructed by the municipality. Households generally dispose of their waste in the collection points identified by the council. These include the inorganic waste from compost facilities, non-degradable waste from households that sort waste (to feed their animals) and general waste from households that do not sort waste. These points are constructed in almost all quarters and in the market and made accessible to the population. Households deposit their wastes at these identified points, and it is collected by the collection agents using compaction trucks (Plate 4).

A B

Plate 4: Waste collection system using compaction trucks along the streets

Source: field survey, (2025)

Households along the major streets and the main road do not dispose of their waste in the collection points. They wait for the compaction truck that passes by at least twice a week and empty their bins into it directly. Others place their dustbins by the roadside and the loaders empty into the collection trucks as they make their rounds. This is called the" bring system" of collection. Waste from inaccessible quarters is carried by household members largely by women, children and young boys, to an identified place where trucks can reach. Along the main streets such as Foto, trucks stand at specific junctions where household members bring their waste. These trucks have a system of horn or a sound to alert households to bring out their waste which is then emptied directly into the trucks by the loaders and the containers are returned to the owners.

However, many quarters do not have access to these collection points constructed by the council, and they sort for other means of waste management. A limiting factor to this method of collection is distance from collection points and inaccessibility of some quarters. Surveys show that about 25% of households leave less than 100m to the waste disposal points and about 14% cover between 100m to 200m to dispose of their waste. It is observed that percentage of households served by collection points reducing with increasing distance from away from collection points. Households deposit their waste in those areas and the municipal agents collect from there using compaction trucks, camions and try-cycles. Waste from this system is transported to Siteu landfill for disposal.

In 2024, a total of 14,172tonnes of waste was collected in Dschang with is collection system Figure 7.

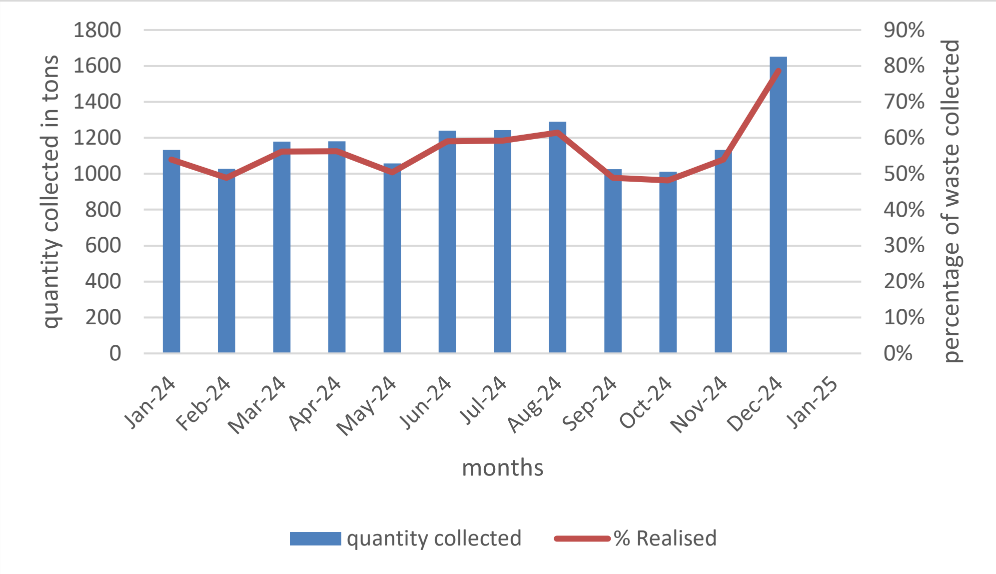


Figure 7: Monthly variation of waste collection and percentages in 2024.

Sources: AMGED (2025).

Figure 7 indicates the monthly variation in waste collection in Dschang using the collection system for the year 2024. As observed the lowest collection rates was in the month September and October this could be due to a number of reasons such as: September and October experiences heavy rainfalls which may impact waste collection, September and October are back to school periods in Cameroon and Dschang inclusive which may impact household routines and reduce the time children have to meet up with collection trucks as they might still be adjusting to the school system. While the December had the highest collection rate. This can be attributed to the fact that December is a holiday and a festive month, with many celebrations which obviously leads to increase waste generation from the many festivities.

4.1.3. Nature, type and composition of waste collected for composting

The nature of waste produced determines the compost quality and quantity. To know the composition of waste supplied to the platform and to identify its source of generation, waste characterization is carried out on monthly basis following the AFNOR X300-408 standards. For the purpose of this study, waste characterization was carried out on January 16th, 2025, and essentially classified waste into 6 categories which are;

Wood and wood products; pulp, paper and cardboard; textile; food waste, beverages and tobacco; garden, yard and park waste; and inert (Figure 8). The inert waste was further divided into metals, hard plastic, plastic bags, medical waste, electric waste and other waste (other waste consists of stones, glass, and other unidentifiable materials).

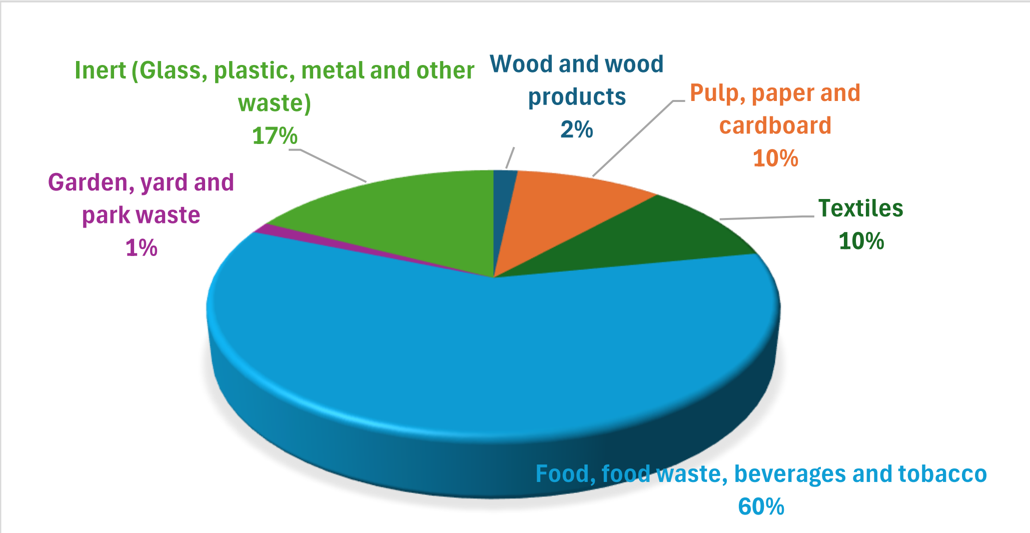


Figure 8: Types and composition of waste at the Ngui platform

Source: Field survey (2025)

Figure 8 show the results gotten from the characterization at the Ngui composting platform. It shows that 60% of the total waste produced was organic, consisting of food waste, beverages, garden and yard waste. Pulp, paper and cardboard constitute 10% due to a large student population. Dschang is a university town with about 25000student population. The Inert waste component represents 17% but with a varied composition (Figure 9.)

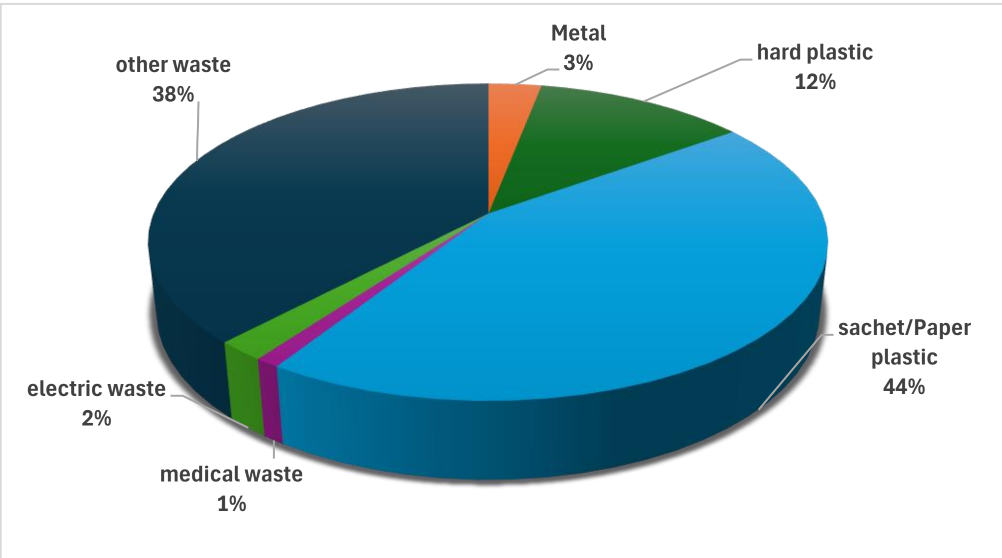


Figure 9: Type and composition of Inert waste

Source: Field survey (2025).

Figure 9 shows the quantity of inert waste had 44% of sachet/paper waste, 12% plastics and 38% of other waste types. This characterization shows a large proportion of organic waste over other waste types. This is an important potential and asset for the implementation of composting practices.

4.1.4. Evolution in the quantity of waste collected and composted over the years,

In Dschang, Cameroon, waste generation has been a growing concern, particularly with the city's growing population and vast urbanization which of cause increases the waste production. As of recent estimates, the city produces approximately 25,000 tons of mixed waste annually. However, only about 10,000 tons (40%) of this waste is collected by municipal services, primarily from central and more accessible areas. This implies that the greatest proportion of waste produced in Dschang is still dumped illegally. Nevertheless, the quantities arriving the composting platforms have been fluctuating but the trends show a steady increase (Figure 10).

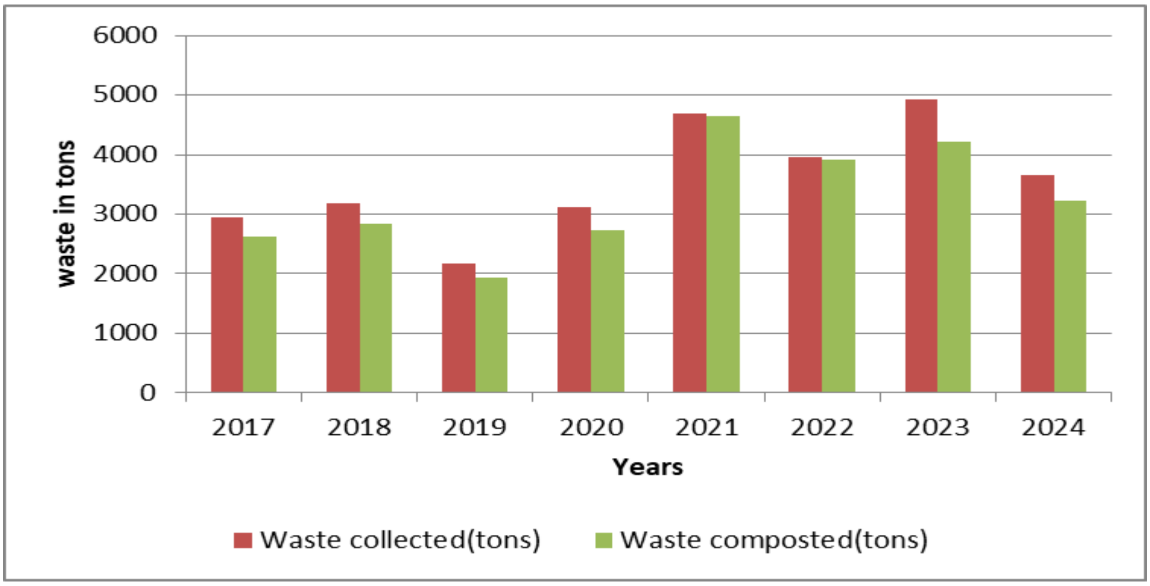


Figure 10: The quantity of waste collected and composted over the years

Source: AMGED, (2025).

Figure 10 shows that waste collected from the pre-collection systems has evolved from 2940.44 tons in 2017 to 3651.46 tons in 2024. This shows a corresponding rise in the quantity of waste composted within the same period (2614.45tons in 2017 to 3221.52tons in 2024). It implies that the quantity of waste composted depended on the quantity collected. Interviews revealed that the amount of waste collected was influenced by a number of factors such as fuel availability for transportation, state of transportation trucks and climatic conditions. It equally shows that more than 80% of waste collected is effectively transformed to compost in the Ngui platform but the quantity reduces in Siteu due to compaction.

Composting is a method of stabilizing and treating biodegradable organic waste using the natural process of decomposition of organic matter in the presence of oxygen. An increase in temperature for several weeks, reflecting the activity of a large number of microorganisms, produces a stable final product called compost. It is an open system with inputs, processes and out puts (Figure 11).

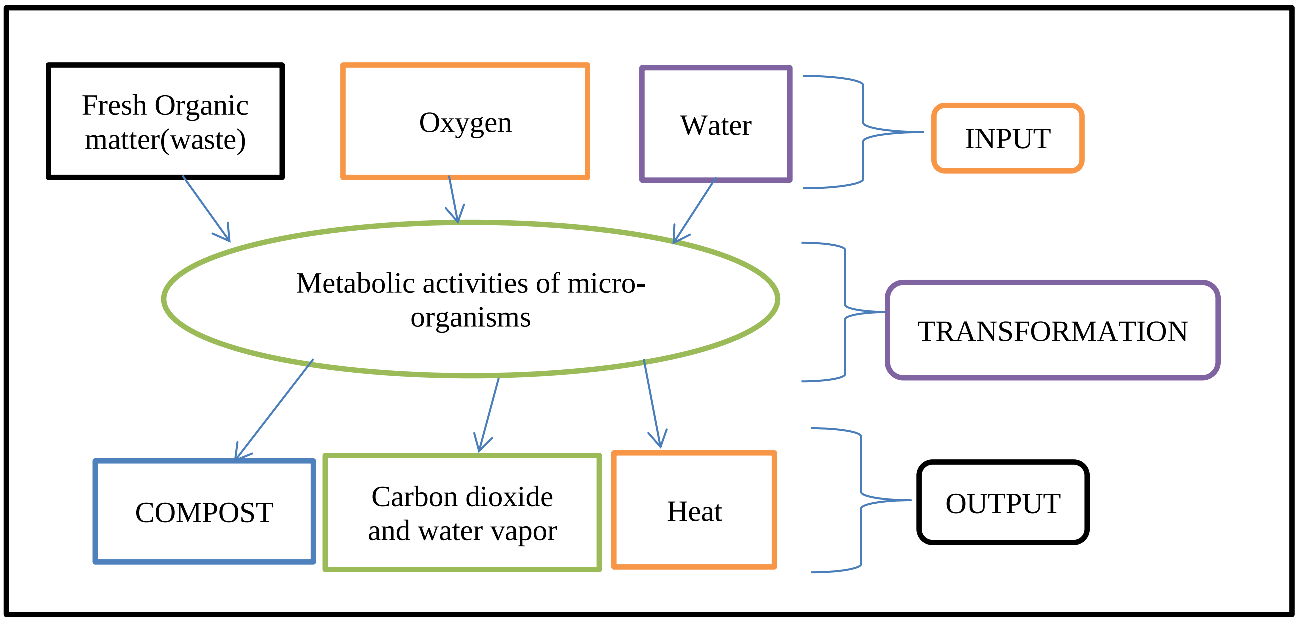


Figure 11: Organic Waste composting system

Figure 11 shows that composting is a natural process, and the inputs are organic waste, oxygen and water. Water and oxygen are naturally available, given the humid climatic conditions. This makes waste the most important input. The transformation by micro-organism activities results to compost as the main product with minimal emissions of carbon-dioxide gas. Nevertheless, this process reduces the emission of methane, a greenhouse gas that causes climate change.

4.2. Climate mitigating potential of composting

4.2.1. Global warming potential (GWP) of methane and emission reductions

The degradation of organic waste in landfills (absence of air/oxygen) produces methane (CH4). This is because in a landfill, bacteria break down organic waste in the absence of oxygen (this is mostly due to the compacted state of the waste) in a process called anaerobic digestion which generates methane as a by-product. The lack of oxygen in these landfills creates ideal conditions for these methane producing bacteria to thrive. Methane is a potent greenhouse gas whose emissions contribute significantly to climate change and global warming. Greenhouse gases do not contribute to global warming to the same degree hence the global warming potential (GWP) which measures the amount of heat a greenhouse gas traps in the atmosphere over time to carbon dioxide (in terms of how much CO2 would produce a similar warming effect). This measurement is generally measured relative to that of CO2 over a period of 100 years. The GWP of methane is 23 which means I ton of methane causes the same amount of warming as 23 tons of carbon dioxide over 100 years.

Before methane evaluation, baseline emissions are first calculated. These are emissions that would have taken place without the composting project. During the composting activities, a carbon monitoring of certain key parameters on the different composting platforms was carried out and used in the calculation of project emissions by ERA Cameroun. The verification of reduced emissions is ensured by a designated operational entity. After calculating project emissions, they are compared to those of the baseline to obtain the reduced emissions (figure 12)

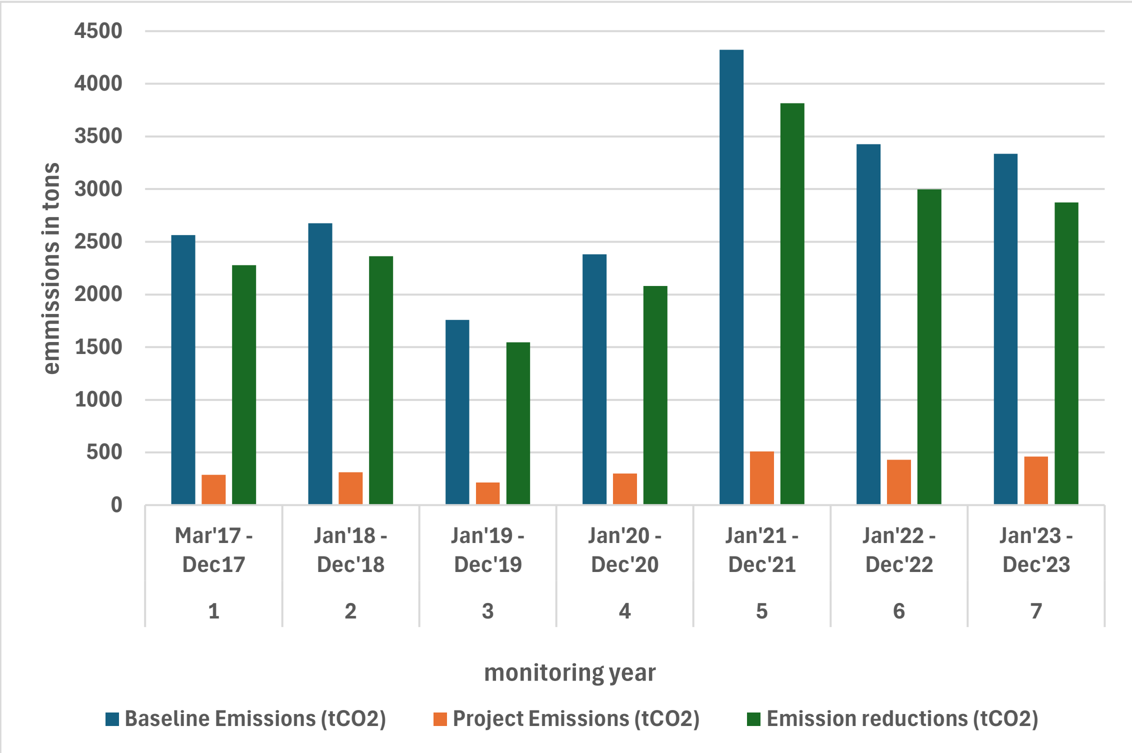


Figure 12: Results of Emission reductions linked to the project

Source: AMGED and Field survey (2025).

Figure 12 demonstrates that by diverting this organic waste from landfills, composting minimizes methane emissions. The project avoided each year more than 90% of CH4 emissions that would have occurred in the absence of a composting project. The city's waste would have produced 20465 tons of carbon equivalence between 2017 and 2023. Thanks to the composting, 17955 tons of CO2eq were avoided. It is important to note that during the composting process, small quantities of other GHGs are emitted especially CO_2. Between 2017 and 2023, 2512 tons of CO2 were emitted from composting activities such as electricity consumption and storage of compost. This result reveals that composting significantly reduces greenhouse gas emissions, pointing out the advantages of composting for environmental sustainability.

4.3. Socio economic benefits of composting

The natural process of decomposing organic waste in Dschang Cameroon offers significant benefits not just to the environment but to the population involved. Some of these benefits include job creation, economic savings, community development, food security and many more, hence saving as a catalyst for economic growth and efficiency.

Importance of compost for soil health and crop production

Compost analysis is a vital process carried out to evaluate physical, chemical and biological parameters of the compost produced to determine its quality and suitability for agricultural use. These analyses have bio-chemical composition of compost that makes it good for soil improvement and agricultural productivity (Table 1.)

Table 1: Dschang compost analysis

Characterization of agronomic value			**Results**		**%**	**NF U 44-051 criteria**	
						Standard threshold	**Compliance with standards**
DETERMINATIONS	symbol	unit	Dry	raw			
Dry matter	MH	%		89.0	**89**	>=30	
Humidity	H	%		11.0	**11**		compliant

pH			9.2		**9.2**	7-9	
Conductivity	THIS	Ms.cm^{-1}	5.18		**5.18**		
			Product composition				
Organic matter ratio	MO	%	24.9		**24.9**		
Global nitrogen	NT	%	1.23	1.10	**1.17**	<3	
Ammoniacal nitrogen	N-NH4	%	0.006	0.005	**0.006**	-	
Nitric nitrogen	N-NO3	Mg.kg^{-1}	193	172	**182.5**	-	compliant
Urea nitrogen	Nurea	%	<0.06	<0.05	**0.06**	-	
C/N ratio			**12.2**		**12.2**		
Sulphur	SO_3	%	0.65	0.58	**0.62**	<3	
phosphorus	PO	%	4.34	3.53	**3.94**		
potassium	K2O	%	2.53	2.25	**2.4**	<3	
Magnesium	MgO	%	0.74	0.66	**0.7**		
Calcium	CaO	%	4.68	4.17	**4.43**		Compliant
Sodium	Na	%	0.39	0.35	**0.37**		
Total NPK		%	**4.43**		**4.43**	**<7**	
Metals							
Cadmium	Cd	mg/kg	0.4	3	**1.7**	<3	
Chromium	Cr	mg/kg	75.1	120	**97.6**	<120	
Nikel	Ni	mg/kg	6.0	60	**33**	<60	
Lead	Pb	mg/kg	12.6	180	**96.3**	<180	compliant
Copper	Cu	mg/kg	75.1	300	**187.6**	<300	
Zinc	Zn	mg/kg	54.0	600	**327**	<600	

Source: Field survey, (2025).

Table 1 shows the properties of compost in relation with the French-European norms called the NF U 44-051 norms. For instance, the Nitrogen content is globally within the expected values, and the carbon-nitrogen (C/N) ratio is quite similar. The pH of composts is slightly higher than the value generally observed in compost, but not an extravagant value (9.2).

The mineral composition of composts is dominated by potassium (2.4%) and calcium (4.43%) and phosphorus (3.94%). It was therefore very likely that the calcium and magnesium present in Dschang composts came from earthy materials mixed with the composted organic material, while potassium was linked to the organic material of composts. Equally, Dschang composts is globally under the standards for heavy metals contamination. The presence of metals such as Cd may come from battery present in organic waste before sorting.

Generally, these findings have shown that Dschang compost is, like any commercial product, subject to market of demand and supply, but above all that of competition. To face competition, the compost produced must be of good quality. The analysis shows that this compost is well positioned in the local and regional market for agricultural inputs. It is technically good and competitive, accessible to small farmers, but also available in quantities for large industrial plantations wishing to reduce their use of chemical inputs. Interviews revealed that compost produced is used in urban agriculture by a significant part of the population. This compost helps to improve soil quality thereby improving crop yield and quality (table 2) hence, improving local agricultural production and contributes to food security in the city.

Table 2: crop cultivated using compost and observed results

		Respondents
Type of crop cultivated (using compost)	Vegetables	40
	Fruits	5
	Grains	3
	all crops	52
	Total	**100**
Observed results	Increased yield	44
	Better soil quality	27
	Reduced chemical fertilizer usage	23
	Pest resistance	4
	Others	2
	Total	**100**

Source: Field survey (2025).

In table 2, 52% of farmers use compost to cultivate all types of crops since the climatic conditions are favourable for agriculture, while 40% of the farmers use compost only for vegetable cultivation with a minority using compost to cultivate just fruits and grains. Over 44% of compost users experienced an increase in crop yield, 27% could observe better soil quality with a significant number reducing chemical fertilizer usage and a minority observing crop resistant to pest. This is because of the essential nutrients found in the compost as observed from our compost analysis in table 1 which enhances soil fertility, improves soil structure, increase organic matter and boosts microbial activity in the soil.

Employment opportunities

Waste management in the Dschang municipality is a development project that offer jobs to the population. The composting plant handles over 40% of the city's waste which is strenuous and demanding, creating jobs in the different phases such as waste collection and processing (sorting, turnover, screening), and contributing to livelihoods sustainability. The composting plants in Dschang serve as a source of employment for over 45 people. This excludes the director of AMGED, the valorization coordinator and data collectors. Participative pre-collection in Dschang is done by private associations (CEPDEL, ADECOTEC and TOCKEM). They receive subventions from the council and equally raise money from household registrations. They have equally created many jobs as each association has at least five permanent with permanent salaries. According to information gotten from interviews at the Ngui composting platform, all the compost workers are registered into the National Social Insurance Fund, a public institution in Cameroon that provides social security and insurance and also pay retirement benefits. Apart from the salaries they receive, compost workers are entitled to family allowances depending on the number of kids a worker has (each child receives 4500FCFA allowance after every 3months which is 13500FCFA annually, childbirth support of 65000FCFA, health insurance and a monthly retirement pension after retirement. These benefits go a long way in ensuring economic stability for workers and improving their living standards. Figure 13 presents respondents' knowledge on existence of jobs created by composting.

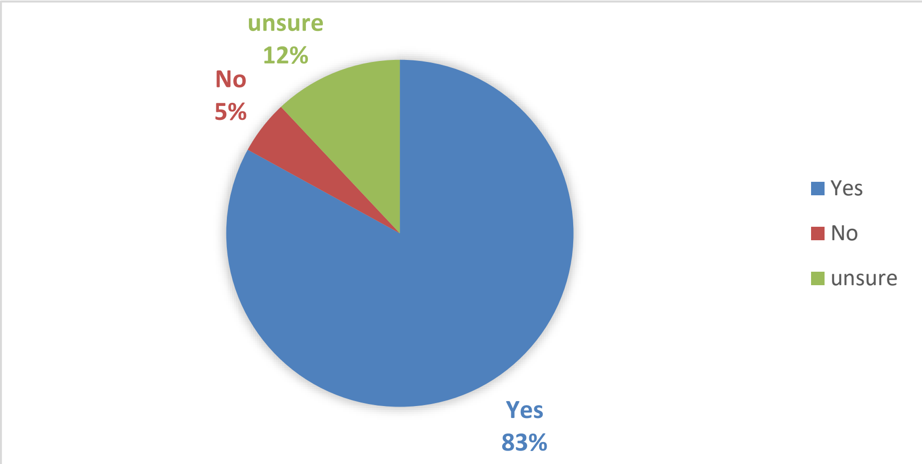


Figure 13: Farmers response on knowledge of existing jobs created by composting

Source: field survey (2025)

In figure 13, 83% of respondents were aware of the jobs created by composting, this is possible because majority of respondents were farmers and purchase compost from the compost facility with over 45 workers while other had relatives and friends working at the compost facility while about 5% of respondent believe compost creates no jobs opportunities. This could be because some of the respondent's practice small household composting for their gardens, have never visited the compost facility or buy compost from the head office with no knowledge of the job opportunities involved.

Income generation from compost sales and carbon credits

The compost produced is sold both to the local population and to the rest of the country with a 50kg bag of compost sold at 2500FCFA. The revenue generated from these sales depends on the quantity of compost available at the municipal platform and demand from buyers. As such it varies from one month to another and corresponds with sales (Figures 14 and 15)

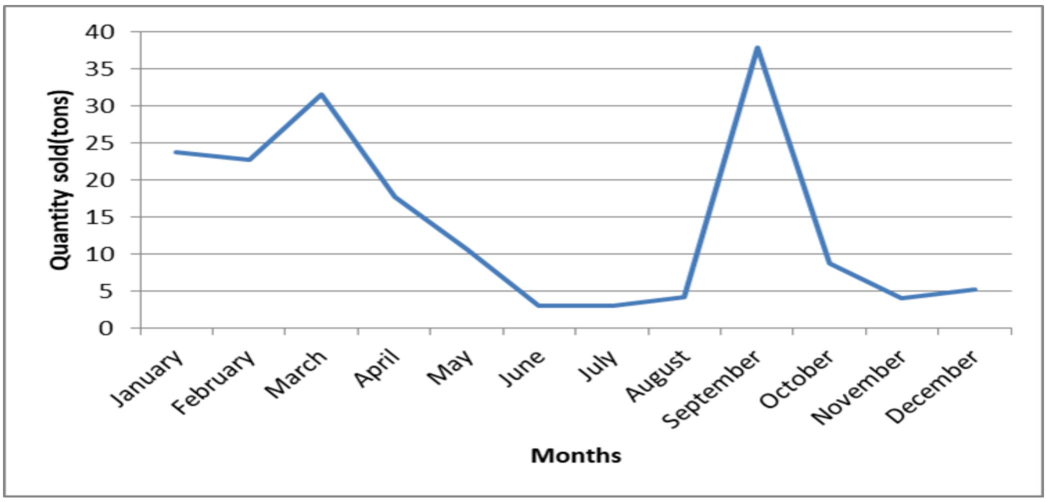


Figure 14: Monthly compost production in 2024

Source: AMGED, (2025)

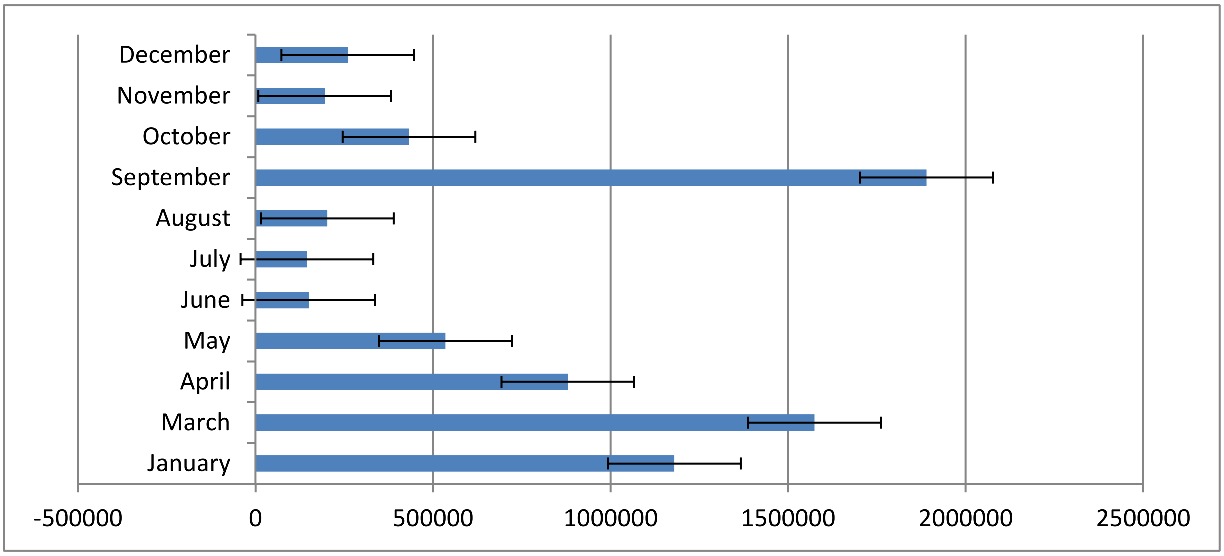


Figure 15: Evolution in revenue from the monthly sale of compost in 2024

Source: AMGED, (2025)

The income generated from the sale of compost is encouraging and has permitted the municipality to finance the waste management sector. In 2024, amounts ranged from 150,000fcfa to 1,890,000fcfa (Figure 15). The highest monthly amounts reflect the quantity of compost produced for that month. These are the revenues from participatory pre-collection. Between 2016 and 2020, the total amount of money made by the pre-collection and collection service was 43,510,750 FCFA, while from 2015 to 2023, the revenue from compost sales amounted to 50,981,128 FCFA. The composting process has equally permitted the municipality to benefit from the carbon credit and the green fund. A sum of 10,000 euros per year has been accorded to the municipality for a period of ten years. This implies that annually, the composting project brings in 6,550,000 FCFA as carbon credit. Figure 16 presents the trend in revenue generated from compost sales over the years.

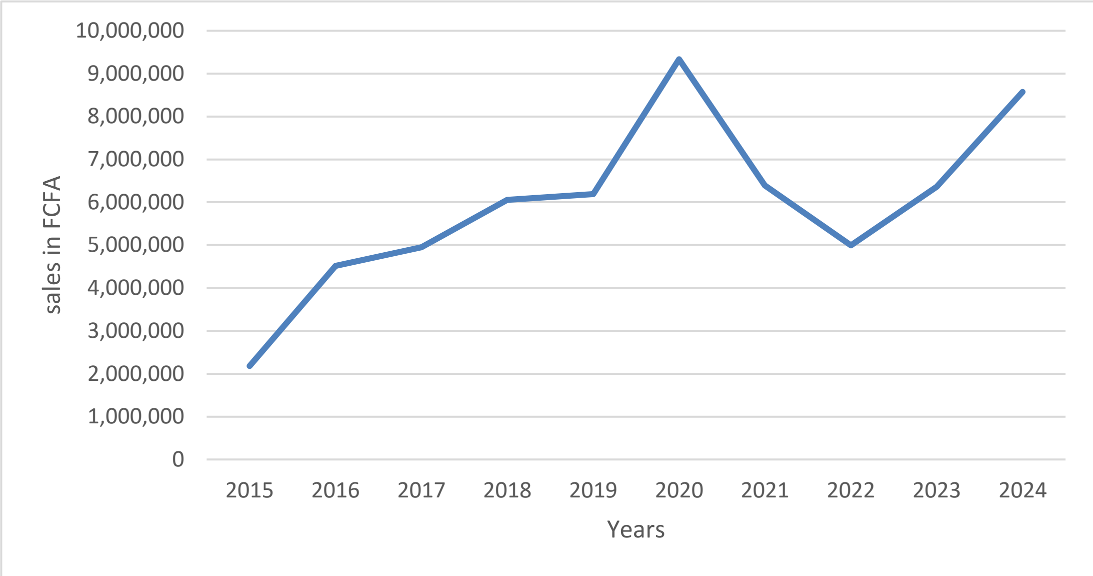


Figure 16: Trend in compost sales over the years

Source: AMGED, (2025)

In figure 16, there is an increasing trend in compost sales over the years in Dschang. 2015 recorded the lowest sales, this could be because this period marked the establishment of the compost facility which still faced challenges such as insufficient equipment's and workers. During this period there was low awareness rate among farmers on the benefits of compost over chemical fertilizers. There was also limited production rate due to insufficient waste collection systems. 2020 recorded the highest annual compost sales which indicated increase in farmers awareness on the benefits of compost, increase compost production capacity and compost prise subsidisation and increase in effective marketing strategies. Even with the increasing trend, some years still recorded low sales which could be associated to some of the technical challenges experienced occasionally in waste pre-collection as the quantity of compost produced largely depend on the quantity of waste received at the compost facility.

Social importance of waste works

Interviews revealed that waste workers have built social ties and relationships that help them beyond the professional cycle. The putting in place of community composting have promoted a spirit of living together and solidarity between residents of some neighbourhoods. They have to come together to compost their waste and use it to cultivate for collective interest.

Apart from socializing during composting, waste workers have organized themselves into self-help groups and njangi groups. They come together each month and make financial contributions as njangi from their salaries. The beneficiary is able to plan and carry out projects such as house construction or pay children's school fees.

Without such contributions, it would be very difficult for them to realize major projects due to their meagre salaries.

Another important aspect of solidarity is demonstrated in the domain of farm work and construction of houses. Female workers for instance organize themselves and work from one member's farm to the other. The farm owner only needs to provide food and drinks during his own turn. This strategy has permitted them to cultivate their farms on time given that most of their time is spent at the composting platform. Men on the other hand work together when a member wants to construct a house. In many cases, they have come together to mold blocks, dig the foundation or provide labour during house construction. This solidarity has motivated many waste workers and given a different image to their activities.

4.4. Barriers for composting, compost use and scaling up strategies

Some of the challenges that hinder the expansion of composting initiatives in Dschang include:

Ineffective waste collection and Transportation

Findings have revealed that only about 40% of the waste produced in Dschang is collected and treated. This implies that a greater proportion still dumped waste illegally into nature (plate 5). The works of pre-collectors and collection agents is negatively impacted by difficult transportation conditions. These difficulties are twofold, the rugged nature of the terrain and the limited number and poor state of tricycles and trucks. Firstly, the hilly nature of Dschang town, with its narrow streets have made the implementation of the door-to-door system of waste collection very difficult. The existing streets have lots of potholes and their muddy nature have prevented heavy duty vehicles like the compaction trucks to effectively implement the "bring system". These challenges have limited waste collection to specific quarters while the inaccessible quarters are completely not served. Second, the number of tricycles and collection trucks are not sufficient to cover the entire town. The few equipment frequently develops technical problems due to the poor state of roads. Normally, collection is done twice a week per quarter but often, such contracts are not respected because vehicles are bad and under repairs. Interviews have reported that composting activities are often ineffective at the platforms for days due to irregular or no supply of waste to the platform. Equally, these delays have waste arrive the platforms at an advanced decaying state, thus resulting to poor quality compost (plate 5).

A

B

Plate 5: Illegal waste dumping

Source: field survey, (2025).

Illegal waste dumping along the streets of is still a norm in Dschang especially in highly and inaccessible areas due to the poor nature of the access roads as seen in plate 5.

Lack of waste segregation at source

Waste management in Dschang has prioritize sorting at the source. The practice of mixing waste at source has increased the rate of contaminations with products such as cadmium from batteries and heavy metals. This has reduced the quality of compost produced. Equally, the lack of sorting at source has increased the time used in composting at the platforms as revealed by the Director of AMGED during an interview in the following excerpt.

"*…..we did a pilot project on source sorting but it did not work. Mixing waste at source challenges the composting process because sorting is the most expensive stage in the composting process. It involves more people and takes ¾ of the time allocated for composting….*" (Interview, 2025).

Lack of Public Awareness and Political will on composting and compost use

Limited public awareness on composting and compost use benefits has limited composting activities. Waste management policies in Cameroon have not prioritize composting as a waste treatment option and compost use tend to compete with chemical fertilizers. The questionnaire survey revealed that urban farmers apply chemical fertilizers (24%), animal droppings (28%), compost (17%) and 26% combines compost with animal dung. The type of fertilizer varies depending on the crop type and crop cycle.

Though the use of chemical fertilizers have been widely discouraged, urban farmers continue to use it. The use of animal droppings dominates. This explains why fowl dung sells very well in the market, and it is highly demanded by those practicing gardening. The mixing of fowl dung with compost produces agro-compost which produces short term results.
Regarding the use of compost by farmers, a number of challenges were identified (Figure 17)

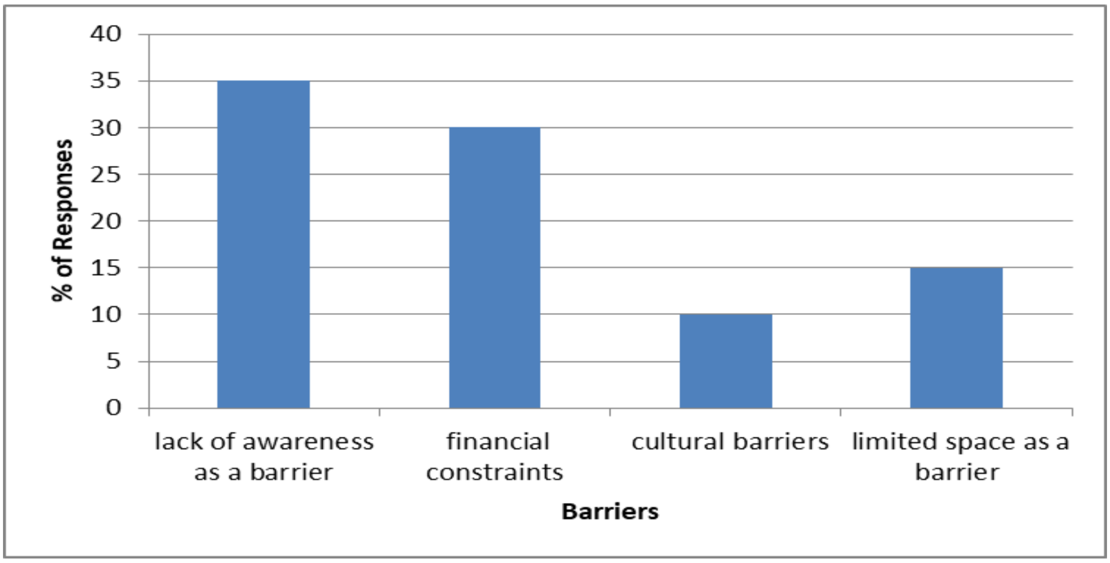


Figure 17: Challenges in the adoption of composting practices and compost use by farmers

Source: field survey (2025)

Figure 17 identifies lack of awareness as the main drawback (35%), followed by financial constraints (30%), cultural limitations (10%) and limited space for composting practices (15%). Waste management in Dschang is challenged by poor habits of the population vis-à-vis waste disposal. Regulations and policies are formulated at all levels and communicated to the population, but their applicability is wanting. Field observations have demonstrated that dwellers do not respect the use of public bins and collection points. It is common to see people dump waste besides the trash can than inside the can and it is worse when children are sent to dispose of waste. Many of them end up throwing either along roadsides or in inappropriate places.

Technical Challenges at the composting platforms

A questionnaire survey with composters revealed a number of challenges at the composting platform that make their tasks difficulty (Table 3).

Table 3: Challenges at the compost production sites

Challenges			Percentage (%)
Fluctuations in quantity of waste handled daily	Poor climatic conditions	1	3.2
	Delays in waste supply	19	61.3
	Fluctuation in number of workers	11	35.5
Total		**32**	**100%**
Operational challenges	Inadequate Materials and equipment	3	9.7
	Irregular payment of salaries	17	54.5
	Low sales	3	9.7
	employee fatigue	9	29.1
Total		**32**	**100%**

Source: Field survey (2025)

Table 3 shows a plethora of challenges at the composting sites. Outstanding are delays in waste supply (61%) and fluctuations in the number of workers (35.5%) and weather conditions that can delay collection and transportation such as heavy rains (3.2%). These main challenges have led to the fluctuation in daily waste treatment capacity from one to 20 tons. Equally, operational challenges may occur and delay the treatment of waste already supplied to the platforms. They include absenteeism due to non-payment of salaries (54.5%), poor state of materials (9.7%), general fatigue (29.1%) and low sales that led to accumulation of compost on the site. These factors have negatively influenced compost production.

Scaling up Strategies for composting and compost use

The questionnaire survey equally looked at possible aspects and opportunities for improvement in compost production and compost use in Dschang. These strategies are seen at the level of compost producers (figures 18 and 19).

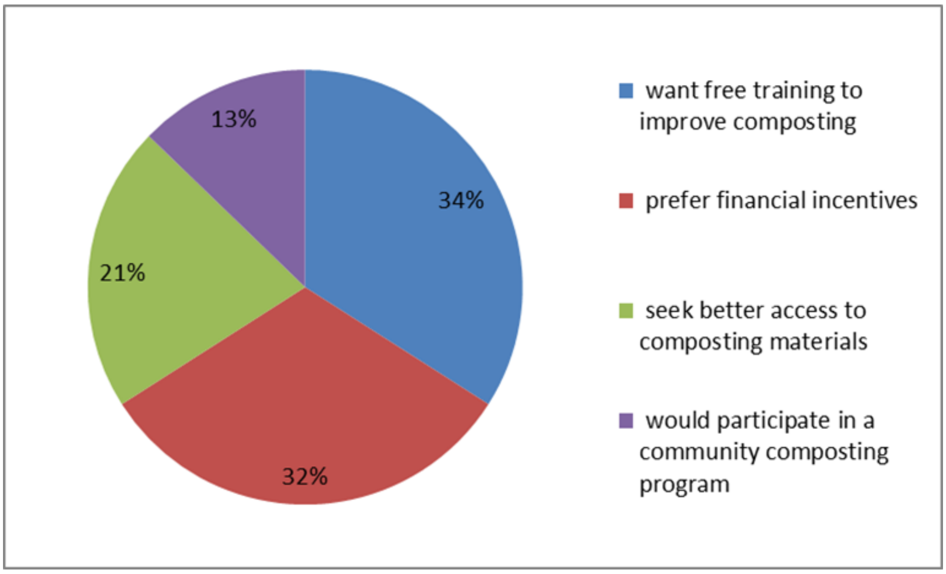


Figure 18: Scaling up strategies at the level of compost users

Source: Field survey, (2025).

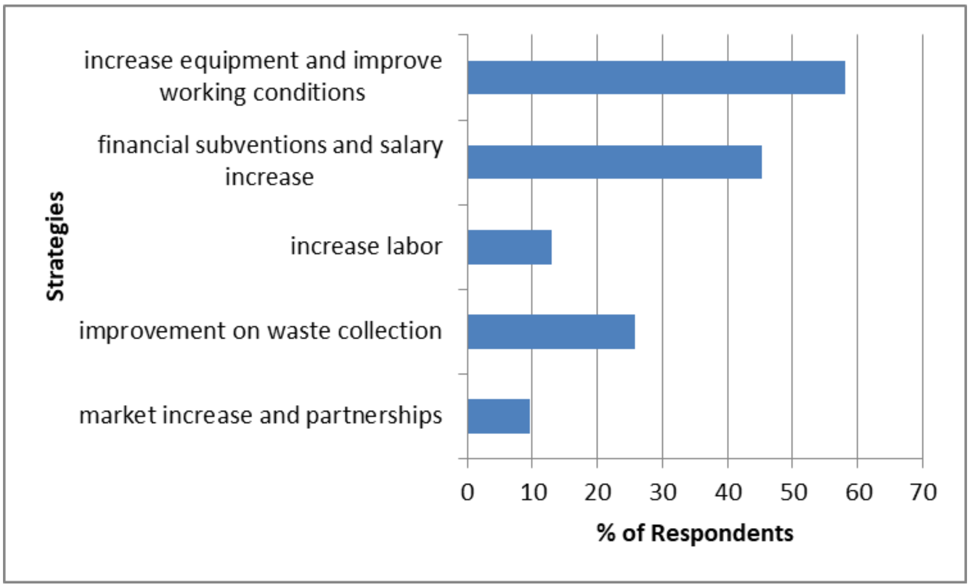


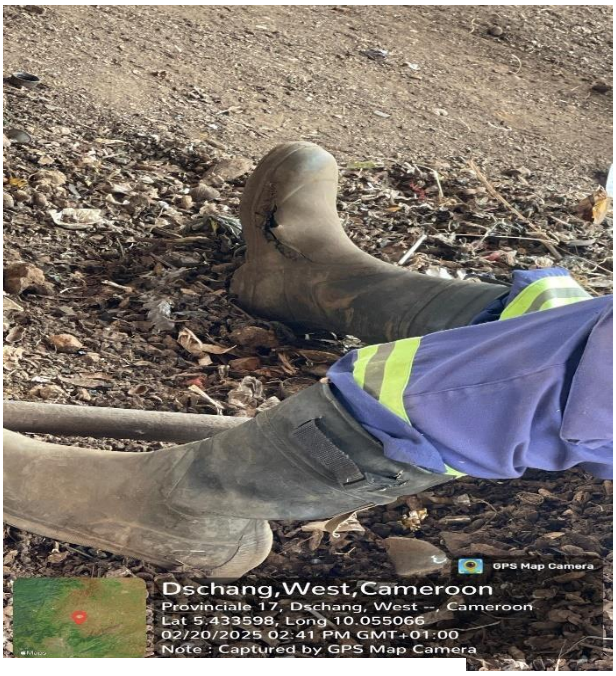
Figure 19: Scaling up strategies at the level of the platforms

Source: Field survey, (2025)

Compost users identified financial challenges (34%) as the main challenging impeding their continuous use of compost. They still see the cost price of 2500fcfa per 50kg bag of compost as high. They decry the increment in price from 2000fcfa to 2500fcfa. Famers compare compost with other inputs such as fowl droppings. This has limited the purchase of municipal compost and farmers wish to engage on community compost production (32%). It should be noted that the municipality-initiated composting at the community levels, but it failed due to ineffective follow up and lack of materials.

At the level of the platforms, technical issues abound but waste workers demand for better working conditions, good salaries and regular payments. This activity is their main source of livelihoods and irregular payments have discouraged many workers. Work equipment and materials are not up to standard (plate 6) and should be improved upon as well the number of workers involved in waste management.

A



B

C

D

Plate 6: challenges faced by employees

Source: field survey, (2025).

As seen on plate 6, workers face challenges working effectively due to the bad state of some working equipment's such as broken spade forks (plate 6, A) and watering pipes (plate 6, D) which leaves standing water (breeding grounds for vector insects) in the work environment. It also indicates the risky state of working condition such as the wooden wheelbarrow ways for transporting organic materials and compost (plate 6, C) and the lack of proper personal protective equipment's (PPEs) (plate 6, B).

4.5 Discussion of findings

Composting as an alternative method of waste management

The first result of this work shows that municipal composting of organic waste in Dschang has replaced the former method of landfilling. This method of waste treatment is cost effective and environmentally friendly. It is a sustainable method of waste treatment as opined by skordilis (2004). As an integrated solid waste management system that takes into consideration environmental, technological, social and financial dimensions, his findings suggested that composting is the most efficient and better alternative for waste management compared to thermal treatment. However, in Dschang, it was revealed that only 40% of waste produced is collected and treated. Waste collected from the city is not uniform and many neighbourhoods are not served by the waste collection systems. This is not a unique case as in major Cameroonian cities, public-private partnerships have been set up for waste collection, but its management remains problematic. Makamté KakeuTardy (2018) notes that in Bafoussam, an unequally distributed collection strengthens inequalities and the marginalization of certain neighbourhoods. The stagnation of waste poses pollution problems but also public health with the presence of bacteria and the appearance of rodents (Bagalwa *et al.*, 2013). The production and use of compost would then be an opportunity not just for better waste management but also for urban agriculture. Composting consists of process of revaluation of organic waste by fermentation, reducing the volume of urban waste, mainly composed of organic waste (Sotamenou and Parrot, 2005)

The Dschang municipality has adopted a partnership with private associations in waste management. They partnered with three private associations to engage in pre-collection and effective supply of waste for composting. This private-public partnership is captured in the urban political ecology approach used in this work. The case of Dschang is a success story as compared to other cities for a number of reasons. First, other municipalities tend to ignore the informal system of pre-collection and concentrate on waste collection already in place in most countries of the South (Durand, 2012).

Second, municipal collection is likely to reinforce inequalities because it is often more advantageous for collectors to officiate in wealthy neighbourhoods (Bertolini and Brakez, 2008). This will increase the illegal dumping of waste. For example, in Yaoundé in 2005, only 43% of solid waste was collected (Sotamenou and Parrot, 2005)

One of the major problems linked to waste management in Cameroon is the lack of collection of household waste in certain neighbourhoods. It is caused by inadequate finances, poor policies and poor infrastructures. Given the strong organic composition of waste produced in Dschang (about 70%), composting then seems to be an interesting alternative to classic landfilling of waste, as well as an effective solution to reduce volumes arriving the landfill. In addition to avoiding a phenomenon of accumulation of waste and therefore pollution (Sotamenou and Parrot, 2005), composting is also a powerful health tool. In effect according to Bagalwa *et al.,* (2013), due to the high temperatures required for the process, the waste undergoes sanitization, reducing the risk of transfer of pathogens. So, the effects of composting are largely positive and should be a major aspect of waste treatment in the municipalities of Cameroon and the world. The global climatic crisis and the desire to reduce emissions of greenhouse gases from the waste sector warrants the adoption of composting as a waste management strategy.

Methane sequestration during composting

The global warning potential of waste is very important as methane constructed a potential greenhouse gas. Findings have shown that the quantity of waste produced in Dschang would have generated 20465 tons of carbon equivalence between 2017 and 2023. However, thanks to the composting project, 17955 tons of CO2-eq were avoided. This is an important contribution in climate change mitigation as the waste sector contributes about 3% of global emissions. According to Bokhoree & Kisnah, (2010) in their study on achieving a green composting system for organic waste, composting has been shown to reduce greenhouse gas emissions. This is because composting is an aerobic process that releases only small amounts of carbon dioxide gas as by-product and when applied to soil it is sequestrated as it is broken down by microbes and converted into stable forms integrated into the soil structure. Onwosi *et al.,* 2017 explains that composting waste is accompanied by volume reductions of up to 60%. These findings agree well with composting practice at the Ngui composting which gives an 80% volume reduction (an organic waste heap of 250 wheelbarrows produces 50 to 54 wheelbarrows of compost giving an 80% reduction in mass) making it a suitable solution for waste management. Therefore, composting is considered as a suitable and sustainable organic waste management solution.

Compared to landfill, aerobic decomposition and incineration which produce greenhouse gases such as methane and nitrous oxides with higher global warming potentials, Composting has been considered as a climate mitigation solution for the waste management sector due to the fact that only carbon dioxide is produced as emissions. A study by Hani *et al*., (2019) concluded that about 2.6 million Mg CO2-eq y-1 can be avoided in landfills by composting 70% of separately collected food waste contained in mixed municipal solid waste. Also, Kim and Kim (2010) indicated that composting of food waste had an average Global GHG contribution of 123 kg CO2-eq Mg-1 as compared with landfilling of the food waste that has 1010 kg CO2-eq Mg-1 which means composting of food waste avoids 887 kg CO2-eq Mg-1 emissions from landfills. Boldrin *et al.,* (2010) confirms this by indicating that practicing composting as opposed to peat dumping reduces GHG emissions by 70150 kg CO2-eq Mg-1 while Couth and Toris (2012) in their study on sustainable waste management in Africa confirms that the global warming potential in composting municipal solid waste is by far below that of landfilling. Manfredi *et al.,* (2009) threw more light on this by further explaining that emissions from municipal solid waste disposal can range from 300 kg CO2-eq Mg-1 to 1000 kg CO2-eq Mg-1 when disposed of in sanitary landfill or in open dumps as compared to 60 kg CO2-eq /Mg-1 avoided GHG emissions from waste composting. According to the international Solid Waste Association 2009 report, composting is a more sustainable waste management practice and a mitigation measure for climate change.

Socio economic benefits of composting

Findings have shown that composting and compost use has benefits that go beyond climate change mitigation. Firstly, compost production has generated financial benefits. It serves as a source of employment for over 45 people and good number working private associations involved in pre-collection (CEPDEL, ADECOTEC and TOCKEM). Income is generated from the sale of compost and carbon credits. In 2024, amounts ranged from 150,000fcfa to 1,890,000fcfa, the composting project brings in 6,550,000 FCFA as carbon credit. These financial gains gotten from composting have equally been identified by Moumbe *et al.,* (2020).

Once produced, compost also becomes a resource since it can effectively serve as a natural fertilizer. Dschang composts were globally under the standards for heavy metals contamination in compost, except concerning Cd, which was present in Ngui municipal compost and agrocompost was above the standard line. Cd may come from battery present in organic waste before sorting (Temgoua *et al.,* 2014) Therefore, its use, particularly in urban agriculture, contributing to a waste recovery process.

Using compost has many benefits for urban farmers. Kakai *et al.*, (2010) highlight, for example, its benefits in terms of productivity, yield and necessary water supply compared to fertilizers chemicals. Compost is an effective fertilizer since it provides crops with the elements NPK minerals (nitrogen, phosphorus and potassium) and organic matter. Furthermore, the use of compost has a positive effect on the balance of the soil since it improves its physical properties (Sotamenou, 2010). Then, Sotamenou (2012) also sees compost as a solution to the difficulty of accessing inputs, identified by Mfoukou-Nstakala *et al.*, (2006). In fact, the use of compost from local organic waste ensures a regular and accessible supply in natural fertilizers. Finally, note that the benefits induced by composting exceed the areas of waste management and urban agriculture. For example, the different activities organized around the collection, production and sale of compost also allow creating a new type of livelihood (Essougong, 2017)

Barriers for composting and compost use

Composting as a waste treatment method is challenged by many factors. They include technical, financial, policy, infrastructural and socio-economic factors. Delarue *et al.*, (2012) studying Sustainable development of household waste management and carbon financing looking at developing countries stated that there is difficulty in ensuring the regular collection or supply of organic waste to most composting units which depend heavily on this organic matter supply, which very much ties with our results where workers in the platform clearly stated that the quantity of compost produced depends on the amount of waste supplied to the platform. About 32% of the workers also indicated that the challenges they faced with waste collection and supply with most of the issues linking to tricycle breakdown and lack of fuel to collect and transport the waste to the platform.

Waste is not sorted at source in Dschang, and this has reduced the quality of compost produced. Kongnso *et al.*, (2024) already indicated the importance of waste segregation at source in the composting process. Difficulties in the implementation of sorting practices are linked to financial difficulties faced by certain communities and socio-cultural barriers. Moumbe *et al.*, (2020) revealed that many waste workers are stigmatized and this discourages them from working in the waste sector. Despite the numerous benefits induced by the production of compost and its use in urban agriculture, its use is not yet widespread. Sotamenou (2012) notes four levels of compost adoption by urban farmers and peri-urban areas: no use of fertilizer (23%), exclusive use of mineral fertilizers (41%), the exclusive use of compost (15%) and the combined use of mineral fertilizers and compost (21%).

The latter also identifies four significant factors for the adoption of compost in Cameroon: belonging to a peasant society, property rights, cultivation market gardening and home-plot proximity. Another important challenge is at the level of policy. In Cameroon, the waste management regulation has not insisted on composting as a waste treatment method. Equally, chemical fertilizers are prioritized over compost. As such, understanding the complexities of roles, power relations and challenges in addressing the production and use of compost is an important element of urban political ecology (Kongnso *et al.*, 2024)

CHAPTER FIVE

5. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The study carried out in the city of Dschang on the theme climate change mitigation through municipal solid waste management in Dschang Cameroon, examined the role of composting in reducing emissions, its socio-economic benefits, and the challenges hindering its scalability in Dschang, Cameroon. The mean question for this study asked how municipal solid waste composting has contributed to reducing emissions and mitigating climate change. While the main research objective was to examine the potential of municipal waste composting in reducing emission and contributing to climate change mitigation. Our mean research hypothesis stated that waste treatment by composting can significantly reduce emissions and mitigate climate change. This work was carried out using secondary data collected through documentary readings and a practical internship undertaken to carry out the composting process, carbon evaluation and laboratory analysis. The internship recorded data from field observations, interviews and questionnaire surveys. The AMS-III.F methodology proposed by the UNFCCC was used to calculate and obtain reduced emission by comparing baseline emissions and project emissions. These analyses are made using the lens of urban political theory. An approach that considers power relations between stakeholders, opportunities and constraints in waste management streams and how emerging interventions and policies can reshape waste management practices.

This study shows that over the years, the Dschang municipality through its composting facility collected and treated thousand tons of waste in the municipality. As of recent estimates, the city produces approximately 25,000 tons of mixed waste annually. However, only about 10,000 tons (40%) of this waste is collected by municipal services, primarily from central and more accessible areas diverting it from landfills. From 2015, the municipality has constructed two composting platforms for the treatment of organic waste. Since then, the quantity of compost produced has been rising (from 2614.45tons in 2017 to 3221.52tons in 2024). The treatment of waste through composting has a lot of benefits. Composting helps to reduce methane emission and mitigate climate change. Composting of household waste is done by the fermentation of biodegradation of waste in the presence of oxygen. This aerobic degradation, unlike anaerobic fermentation in landfills, does not produce methane. Aerobic degradation of organic matter produces steam water, carbon dioxide (emission compensated by the quantity of CO_2 consumed by plants during photosynthesis) and heat.

Part of organic and mineral nitrogen is converted into gaseous nitrogen but the latter not being a greenhouse gas as it has no effect on global warming. Compared to landfilling, composting therefore makes it possible to reduce greenhouse gas emissions. Between 2017 and 2023, the municipality has reduced 17,955 tons of methane, calculate as CO_2 equivalents. From a socio-economic perspective, composting and compost use has several advantages. Besides directly employing about 45 persons, financial gains are made from compost sales and the carbon credit. For instance, composting has benefits 6,550,000 FCFA as carbon credit annually. Also, it was revealed that compost availability has led to the development of compost-based farming and a reduction in the use of chemical fertilizers. Those who use compost in their farms or gardens have experienced an increased yield, better soil quality or a reduction in the use of synthetic fertilizer. The chemical composition analysis of compost in Dschang revealed a compliant C/N ratio of 12.2% according to the NFU 44-051 criteria/standard, and a favourable total NPK of 4.43% indicating its potential as a soil amendment. Although the presence of heavy metals such as lead 96.3mg/kg and cadmium (1.7) though in compliant with the NFU 44-051 standards raises concerns about possible contamination, and the necessity to improve waste sorting and compost quality monitoring and control.

However, significant challenges hindering the scalability and widespread adoption of the composting practice in the Dschang municipality were identified. The interactions between policies, practices, infrastructures and socio-cultural factors have affected political ecology and waste management through composting and compost use. Surveys revealed lack of awareness (56%), financial constraints (54%) and cultural practices (17%) as limiting the adoption and use of compost by farmers. On the technical perspectives, lack of waste sorting at source has increased production cost and reduced the quantity and quality of compost produced per ton of waste treated. Generally, the minimize drawbacks; improve scalability and widespread adoption, strategic interventions are needed to accurately deal with existing challenges.

5.2. Recommendations

Improve Awareness and Education

The Public education campaigns and community training programs on the practice and benefits of composting, especially its role in climate change mitigation should be implemented. This can be done through media platforms, community heads and nongovernmental organizations (NGOs) that share similar goals to increase outreach.

Education should equally tackle the confusion of comparing compost with synthetic fertilizers. This will permit compost users distinguish the role of each input. Information on the right dosage and manner of application should also be made available to farmers. Climate Change education and waste management through composting should be included in the school curriculum both as a theoretical and practical cause to increase knowledge and awareness.

Implement waste segregation at source

Lack of waste sorting at source has been a major drawback in the composting process. Households should be provided with appropriate receptacles and encouraged to sort waste at home. The existing pre-collection system is an opportunity to use and introduce sorting. Given that households pay 500fcfa monthly, we suggest that the price could be reduced for those willing to sort waste. This will encourage them.

Subsidies and financial incentives

Many farmers complained of the high compost prices. Given that some compost users have been discouraged by the rise in compost prices, it is suggested that price of compost be reduced from 2500fcfa to 2000cfa as was the case a few years ago. This increases the number of farmers using compost and compost demand will increase. Provide incentives to encourage composting at the household and municipal levels. This can be done through setting up microfinance schemes to support small scale compost entrepreneurs and farmers who can take compost on credit with 0% interest to pay back at a specified period.

Equipment and materials

Waste management equipment is largely insufficient. To scale up waste collection and treatment, there is need to increase the number of collection trucks and tricycles and provide up to date equipment to composters such as wheelbarrows, spade forks and personal protective equipment's (PPEs) to enhance the practice. These materials will permit the expansion of the collection circuit to all parts of the city and reduce illegal dumping. Encourage the population by providing public streets around the city with proper waste bins for waste segregation and disposal.

Improve on the quality of compost

Implement more strict waste segregation policies and procedures to reduce compost contamination by hazardous waste and promote the use or addition of other organic materials such as eggshells, grass clippings, sawdust and others to increase compost quality which enhances soil health and safety. Compost quality assessment should also be carried out more regularly to ensure compliance with soil and environmental standards.

Expanding Socio-Economic Opportunities

The Dschang municipality can Support and partnership with entrepreneurial initiatives that seeks to commercialize composting as a business as this will improve awareness and increase sales. Train local farmers on the proper use and benefits of compost to enhance and boost agricultural productivity. This rise of biological farming is an opportunity to improve on compost use in farming. The benefits from the carbon credits should trigger down to households that produce waste and supply to the platforms.

Policy support

Advocate for the adoption of policy's that promote composting as a mandatory component of waste management. Within the context of decentralization, policies that support organic farming and mandate at least 10% organic use in every farmland will boast the rate of compost production and methane sequestration. This will encourage the use and adoption of composting practices.

Perspectives for further Research

An analysis on soils amended with compost can be done with a comparative studies on yields from compost based farming and synthetic fertilizer based farming.

REFFERENCES

Abubakar IR, Maniruzzaman KM, Dano UL, AlShihri FS, AlShammari MS, Ahmed SMS, Al-Gehlani WAG, Alrawaf TI. (2022). Environmental Sustainability Impacts of Solid Waste Management Practices in the Global South. *Int J Environ Res Public Health*. doi: 10.3390/ijerph191912717. PMID: 36232017; PMCID: PMC9566108.

Adedara, M.L.; Taiwo, R.; Bork, H.-R. (2023). Municipal Solid Waste Collection and Coverage Rates in Sub-Saharan African Countries: A Comprehensive Systematic Review and Meta-Analysis. *Waste 2023*, 1,389–413. https://doi.org/ 10.3390/waste1020024

Albrecht, E., Nkem, A., & Ernest, E. (2022). The legal aspect of waste management in Cameroon with focus on the Buea municipality. *Journal of Geoscience and Environment Protection*, 10(08), 9–23. https://doi.org/10.4236/gep.2022.108002

Alsabbagh M., (2019). Mitigation of CO2e Emissions from the Municipal Solid Waste Sector in the Kingdom of Bahrain. *Climate 2019*, 7, 100; doi:10.3390/cli7080100

AMGED. (2015). Rapport diagnostic de la gestion des déchets. Agence Municipale de la Gestion des Déchets.

AMGED. (2020). Rapport Annuel D'activité. Agence Municipale de la Gestion des Déchets.

Bagalwa, M., Karume, K., Mushagalusa, N. G., Ndegeyi, K., Birali, M., Zirirane, N., Masheka, Z., & Bayongwa, C. (2013). Potential risks of household waste on the health of populations in rural areas: The case of Irhambi Katana (South Kivu, Democratic Republic of Congo). *VertigO, 13(2)*. https://id.erudit.org/iderudit/1026443ar

Bertolini, G. and Brakez, M. (2008) . Waste management, innovations and territories Feedback and contextual research. *Market and organizations*, No. 7(2), 92-113. https://doi.org/10.3917/maorg.007.0092

Bogner J., Pipatti R., Hashimoto S., Diaz C., Mareckova K., Diaz L., Kjeldsen P., Monni S., Faaij A., Gao Q., Zhang T., Ahmed M., R.T., Gregory S., (2007). Mitigation of global greenhouse gas emissions from waste: conclusions and strategies from the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report. Working Group III (Mitigation) *Intergovernmental Panel on Climate Change (IPCC):* Working Group III (Mitigation). DOI: 10.1177/0734242X07088433

Bokhoree C. & Kishnah S. (2010). Towards achieving a green composting system for organic waste treatment: a modelling approach. *International Journal of Climate Change: Impacts and Responses. Vol. 2(1), 173-194*

Boldrin, A., Hartling, K. R., Laugen, M., & Christensen, T. H. (2010). Environmental inventory modelling of the use of compost and peat in growth media preparation. *Resources, Conservation and Recycling*, 54(12), 1250–1260. https://doi.org/10.1016/j.resconrec.2010.04.003

Couth R, Trois C. (2012). Cost effective waste management through composting in Africa. *Waste Management.* 2012 Dec;32(12):2518-25. doi: 10.1016/j.wasman.2012.05.042. Epub 2012 Aug 2. PMID: 22857939

Crecchio, C., Gelsomino, A., Ambrosoli, R., Minati, J., Ruggiero, P., (2004). Functional and molecular responses of soil microbial communities under differing soil management practices. *Soil Biol Biochem.* 36. 1873-1883.

Dehoust, G., Jepsen, D., Knappe, Wilts H., (2010). Substantive implementation of article 29 of directive 2008/98/EC, scientific-technical foundation for a national waste prevention programme. *Umwelt Bundesamt*. ISSN 1862-4804. https: www.umweltbundesamt.de/publikationen/substantive-implimentation-of-article-29-of

Delarue J., Flipo B., Morizot G. and Tiberghien M., (2012): Sustainable development of household waste management and carbon financing: the conditions for joint implementation in developing countries, in Gevalor, 101 rue de la source, *45160 olivet, France b good planet, 1 allée de Longchamp, 75016 Paris, France.*

Di Maria, F., Mersky, R. L., Daskal, S., Ayalon, O., & Shechter, M. (2017). Preliminary comparison among recycling rates for developed and developing countries: The case of India, Israel, Italy, and USA. *In Proceedings of the 7th International Conference on Solid Waste Management (IconSWM),* Hyderabad, India. Retrieved from https://www.researchgate.net/publication/321965483

Djousse, R, Dissertation 2018, << Evolution of the characteristics of household waste in the city of Dschang and carbon monitoring >>, *National Polytechnic School of Yaoundé, commune of Dschang, 10&11p.*

Durand, M. (2012). Waste management in a developing city: Capitalizing on current difficulties in Lima*? Environmental Research, 42*(1), 10–25. https://doi.org/10.1016/j.envsci.2012.02.003

Essougong, U., (2017). Urban and peri-urban agriculture in Cameroon: Status and perspectives for development. *International Journal of Agronomy and Agricul-tural Research*, *The International Network for Natural Sciences,* 11(3), 116-127

Food and Agriculture Organization of the United Nations (FAO). (2024). *The state of food security and nutrition in the world 2024. FAO*. Retrieved from https://openknowledge.fao.org/items/ebe19244-9611-443c-a2a6-25cec697b361

Garnier J. & Njinoh B. (2015). Diagnostic de la filière DSM de la commune de Dschang. Rapport, 65 p

Hani Q., Wuensch C., Dornack C., & Nassour A., (2019). The role of solid waste composting in mitigating climate change in Jordan. *Waste Management & Research.* 2019;37(8):833-842. doi:10.1177/0734242X19855424

Heynen, N., Kaika, M., & Swyngedouw, E. (2006). In the nature of cities: Urban political ecology and the politics of urban metabolism. *Routledge*

Intergovernmental Panel on Climate Change (2018). IPCC special report on climate change and land. Geneva, Switzerland.

IPCC (intergovernmental panel for climate change), (2006). guidelines for national greenhouse gas inventory volume 5(waste).

IPCC, 2019: Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems [P.R.

IPCC, Climate Change 2014 Mitigation of Climate Change Working Group III Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. 2014.

Kakai, H., kakai A., and Tohouegnon A., (2010). Agriculture urbaine et valorisation des déchets au Bénin: Une approche de développement durable. *VertigO - la revue électronique en sciences de l'environnement, 10(1*). https://journals.openedition.org/vertigo/9994

Kawai, K. & Tasaki, T., (2015). Revisiting estimates of municipal solid waste generation per capita and their reliability. J. Mater. *Cycles Waste Manag*. 2015, 18, 1–13.

Kaza, S., Yao, L. C., Bhada-Tata, P., & Van Woerden, F. (2018). What a waste 2.0: A global snapshot of solid waste management to 2050. World Bank. https://doi.org/10.1596/978-1-4648-1329-0

Kim, M., & Kim, J., (2010). Comparison through a LCA evaluation analysis of food waste disposal options from the perspective of global warming and resource recovery. *Science of The Total Environment*, 408(19), 3998–4006. https://doi.org/10.1016/j.scitotenv.2010.04.049

Koledzi, E., Baba, G., Feuillade,G., Matejka G. (2011) Physical characterization of urban solid waste in Lomé, Togo, with a view to decentralized composting in neighborhoods. Environment, Engineering; Development, No. 59, pp.14-22.⟨10.4267/*waste-sciences-techniques.28*51⟩.⟨hal-03172289⟩DOI: 10.4267/dechets-sciences-techniques.2851,.

Kongnso E., (2024), Practice of compost use in urban farming: Opportunities and constraints in the West Region, Cameroon. International Journal of Environment, Agriculture and Biotechnology Vol-9, Issue-5; Sep-Oct, 2024 Peer-*Reviewed International Journal Journal Home Page Available: https://ijeab.com/ Journal* DOI: 10.22161/ijeab

Kongnso, E., Yemmafouo, A., Moumbe, J., Makamté K., R. C., Sahakian, M., & Véron, R. (2024). Of Practices and (Micro)politics: Challenges of Organic Waste Segregation in Dschang, Cameroon. *The Journal of Environment & Development*, 0(0). https://doi.org/10.1177/10704965241246708

Law No. 96/12 of August 5, 1996 framework law relating to environmental management Cameroon.

López-Mosquera, M., Moirón, C., & Carral, E. (2000). Use of dairy-processing sludge as fertilizer on grasslands in northwest Spain: Heavy metal levels in the soil and plants. *Resources, Conservation and Recycling*, 30(2), 95–109. https://doi.org/10.1016/S0921-3449(00)00056-1

Makamte Kakeu-Tardy, R. C. (2018). Secteur informel-formel et espace urbain à Bafoussam (Cameroun) : la récupération des déchets solides municipaux. *L'Espace géographique*. 47. 261-281. 10.3917/eg.473.0261.

Manfredi, S., Tonini, D., Christensen, T. H., & Scharff, H. (2009). Landfilling of waste: Accounting of greenhouse gases and global warming contributions. *Waste Management & Research, 27(8), 825–836*. https://doi.org/10.1177/0734242X09348529

Mathlouthi, O., Ayadi, M., Ghorbel-Abid, I., & Abdallah, N. (2024). Composting and mechanical biological treatment for reducing greenhouse gas emissions in Bizerte, Tunisia. Sustainability, 16(2), 694. https://doi.org/10.3390/su16020694

Mbiba, B. (2014). Urban solid waste characteristics and household appetite for separation at source in Eastern and Southern Africa. *Habitat International*, 43, 152-162. https://doi.org/10.1016/j.habitatint.2014.02.001

Meutchieye, F., & Senge, H. (2006). Etude de faisabilité de la gestion des déchets dans la ville de Dschang. Rapport d’étude. Département de la Coopération Internationale et de l’Aménagement des Milieux Environnementaux et Sociaux *(DICAMES*).

Mfoukou-Ntsakala, A., Bitémo, M., Speybroeck, N., Van Huylenbroeck, G., & Thys, É. (2006). Agriculture urbaine et subsistance des ménages dans une zone de post-conflit en Afrique centrale. *Biotechnologie, Agronomie, Société et Environnement*, 10, 237-249.

Moumbe, JS, Yemmafouo, A., Tsalefac, M., & Fapong, LJ (2020).Municipal Solid Waste Management (MSW) Initiatives: Towards the Emergence of a Green Economy in the City of Dschang, Cameroon, May 2020 *European Scientific Review 16(14)* DOI: 10.19044/esj.2020.v16n14p123

Ngikam E. (2013). Etat de lieu de la gestion des déchets au Cameroun: cas de Yaoundé. Atelier de Lomé du 23 au 29 septembre 2013, Lomé

Ngnikam E, Tanawa E, Rousseaux P, Riedacker A, Gourdon R. (2002). Evaluation of the potentialities to reduce greenhouse gases (GHG) emissions resulting from various treatments of municipal solid wastes (MSW) in moist tropical climates: application to Yaounde. *Waste Manag Res.* 10.1177/0734242X0202000604. PMID: 12549662.

Ngnikam, E, Naquin,P. Oumbe, R, Djietcheu. K. (2017) Evolution of the characteristics of household solid waste in the city of Yaoundé in Cameroon (1995-2015). Environment, Engineering; Development, 2017, No. 74, *pp.1-16.⟨10.4267/waste-sciences-techniques.3654*⟩.⟨hal-03159846⟩DOI: 10.4267/dechets-sciences-techniques.3654

Ngnikam, E., and Tanawa, E., (2006) Les villes d'Afrique face à leurs déchets (*Université de Belfort-Montbéliard*, Ed.; Chantiers). ISBN: 978-2-914279-32-1

Onwosi C.O., Igbokwe V.C., Odimba J.N., Eke I.E., Nwankwoala M.O., Iroh I.N., Ezeogu L.I. (2017). Composting technology in waste stabilization: on the methods, challenges and prospects. *Journal of Environmental Management.* 190, 140-157

Parrot, L., Sotamenou, J., & Dia, B. K. (2009). Municipal solid waste management in Africa: Strategies and livelihoods in Yaoundé, Cameroon. *Waste Management*, 29(2), 986-995

Pereira, G., Araújo, L., Wenneck, G., Saath, R., Ghuidotti, G., Bertolo, R., (2022). Physicochemical characterization of fermented Bokashi compost produced on-farm in southern Brazil. REVISTA DE AGRICULTURA NEOTROPICAL. 9. e6926. 10.32404/rean.v9i2.6926.

Pokhrel, D., & Viraraghavan, T. (2005). Municipal solid waste management in Nepal: Practices and challenges. *Waste Management*, 25(5), 555-562. https://doi.org/10.1016/j.wasman.2005.01.020

Richard, M., Shehu, İ., & Audu, A. (2020). The Role of Solid Waste Composting in Mitigation of Greenhouse Gas Emissions in States of Northeastern Nigeria. *International Journal of Environmental Pollution and Environmental Modelling*, 3(4), 147-154.

Ruggieri, L., Cadena, E., Martínez-Blanco, J., Gasol, C., Rieradevall, J., Gabarrell Durany, X., Gea, T., Sort, X., Sánchez, A., (2009). Recovery of organic wastes in the Spanish wine industry. Technical, economic and environmental analyses of the composting process. *Journal of Cleaner Production - J CLEAN PROD.* 17. 830-838. 10.1016/j.jclepro.2008.12.005.

Sakijege, Tumpale & Lupala, John & Sheuya, Shaaban. (2012). Flooding, flood risks and coping strategies in urban informal residential areas: The case of Keko Machungwa, Dar es Salaam, Tanzania. Jàmbá : *Journal of Disaster Risk Studies*. 4. 10.4102/jamba.v4i1.46.

Sharholy, M., Ahmad, K., Mahmood, G., Vaishya, R.C. and Gupta, R. (2007) Municipal Solid Characteristics and Waste Management in Allahabad, India. *Waste Management*, 27, 490-496. http://dx.doi.org/10.1016/j.wasman.2006.03.001

Shove, E., & Spurling, N. (Eds.). (2013). Sustainable practices: Social theory and climate change. *Routledge*.

Skordilis A. (2004). Modelling of integrated solid waste management systems in an island. *Resources Conservation & Recycling.* Vol. 41, 243-254.

Sotamenou, J. (2010) LE COMPOSTAGE : UNE ALTERNATIVE SOUTENABLE DE GESTION PUBLIQUE DES DECHETS SOLIDES AU CAMEROUN. Université de Yaoundé II.

Sotamenou, J. (2012). Les facteurs d'adoption du compost en agriculture urbaine et périurbaine au Cameroun. *Terrains & travaux*, n° 20(1), 173. https://doi.org/10.3917/tt.020.0173

Sotamenou, J., & Parrot, L. (2005). Les déterminants de la récupération et du recyclage des déchets ménagers dans les bas-fonds de Yaoundé au Cameroun. In L. Parrot & R. Kahane (Eds.), Rapport final de l'Atelier international "Agriculture et développement urbain en Afrique de l'ouest et du centre" (pp. 39). CIRAD. http://agritrop.cirad.fr/529963/

Srivastava, V., Ismail, S. A., Singh, P., & Singh, R. P. (2015). Urban solid waste management in the developing world with emphasis on India: Challenges and opportunities. *Reviews in Environmental Science and Bio/Technology,* 14, 317–337. https://doi.org/10.1007/s11157-014-9352-4

Temgoua, E., Ntangmo, H., Njine, T. H., Serve, A., (2012). Vegetable production systems of

swamp zones in urban environment in west Cameroon: Case of Dschang city. Univ. J. *Environ. Res. Technol.* 2(2), 83-92

Temgoua,E. Ngnikam, E, .Dameni.H &. Kouedeu Kameni, GS (2014) "Recovery of household waste through composting*"* *Tropicultura*, 2014, 9p.https://www.tropicultura.org 04/05/2024

Topanou, A. (2012). Management of household solid waste in the city of Abomey-Calavi (Benin): Characterization and recovery tests by composting (Doctoral dissertation, Aix-Marseille).https://theses.fr/2012QIXM4807 02/05.2024

UNFCCC (United Nations Framework Convention on Climate Change), (2015). Paris Agreement

United Nations Framework Convention on Climate Change. (1997). *Kyoto Protocol to the United Nations Framework Convention on Climate Change*. United Nations. Retrieved from https://unfccc.int/kyoto_protocol

UN-Habitat. (2012). State of the world's cities 2012/2013: Prosperity of cities. United Nations Human Settlements Programme. https://unhabitat.org/state-of-the-worlds-cities-20122013-prosperity-of-cities

United Nations Population Fund (UNFPA). (2008). State of world population 2008: Reaching common ground – culture, gender and human rights. United Nations Population Fund. https://www.unfpa.org/publications/state-world-population-2008

USAID (2015). Greenhouse gas emissions in East Africa. *https://www.climatelinks.org/sites/default/files/asset/document/GHG%20Emissions%20Factsheet%20East%20Africa_12%2031%202015_edited_rev08-19-2016_Clean.pdf,*

Vergara P., & Silver W., (2023). Assessing the climate change mitigation potential from food waste composting. *Sci Rep 13, 7608*. https://doi.org/10.1038/s41598-023-34174-z

Viaene, J., Van Lancker, J., Vandecasteele, B., Willekens, K., Bijttebier, J., Ruysschaert, G., De Neve, S., & Reubens, B. (2015). Opportunities and barriers to on-farm composting and compost application: A case study from northwestern Europe. *Waste Management, 48, 92–103.* https://doi.org/10.1016/j.wasman.2015.09.021

Weitz, K., Thorneloe, S., & Jambeck, J. (2002). Moving from solid waste disposal to materials management in the United States. *Environmental Science & Technology*, 36(23), 5108–5116. https://doi.org/10.1021/es025643d

World Bank Solid Waste Management. 2018. [(accessed on 9 November 2024)]. Available online: http://www.worldbank.org/en/topic/urbandevelopment/brief/solid-waste-management [Ref list]

Yarboro, S. A., Chiron, S., & Han, J. (2021). A review of quantitative and qualitative methods for material flow analysis in municipal solid waste management. *Resources, Conservation & Recycling*, 161, 99-117.

Yeo D., Dongo K., Mertenat A., Lüssenhop P., Körner I., Zurbrügg C., (2020). Material Flows and Greenhouse Gas Emissions Reduction Potential of Decentralized Composting in Sub-Saharan Africa: A Case Study in Tiassalé, Côte d'Ivoire. *Int J Environ Res Public Health*. doi: 10.3390/ijerph17197229. PMID: 33023240; PMCID: PMC7579658.

Zurbruegg, C. (2003) Solid Waste Management in Developing Countries: A Sourcebook for Policy Makers and Practitioners: EAWAG/SANDEC

Appendixes

Appendix 1

QUESTIONNAIRE

I am Berinyuy Emmanuela Chem a student from the Pan African University Institute of Water and Energy Sciences including Climate Change at the University of Tlemcen Algeria and this is a structured questionnaire designed to collect information from compost users and staff workers of AMGED (Agence Municipal De Gestion Des Déchets) at the Ngui composting facility on municipal solid waste composting in Dschang, Cameroon. This questionnaire is intended to obtain data for my thesis research on the topic "**Climate Change Mitigation Through Municipal Solid Waste Composting in Dschang, Cameroon".**

The information collected will be used strictly for this purpose only.

Section A: General Information

1). Demographics

a) Name (optional): _______________

b) Age:

Under 18 years ☐ old 18 to 30 ☐ years old 31 to ☐ 50 years old ☐ Over 50 years old

c) Sex:

Male ☐ Female ☐ Other ☐

d) Profession: _______________

e) Level of education:

None ☐ Primary ☐ Secondary ☐ Higher education ☐

2). Residence details

a) How long have you lived in Dschang?

1

Less than 1 year ☐ 1 to 5 years ☐ More than 5 years ☐

Section B: Waste Management Practices

3). Production and disposal of waste

a) How do you dispose of your household waste?

Municipal Collection ☐ Open field dumping ☐ Burning ☐ Composting ☐

Others (specify): ____________

b) Do you understand the concept of composting?

Yes ☐ No ☐

4). Awareness and participation in composting

a) Do you practice composting?

Yes ☐ No ☐

b) If yes, how often?

Daily ☐ Weekly ☐ Occasionally ☐

5). Individual composting initiatives

a) Do you have a personal composting facility at home or in your the farm?

Yes ☐ No ☐

b) If yes, what do you compost?

Food waste ☐ Garden/yard waste ☐ Animal waste ☐

All degradable waste ☐

Others (specify): __________

c) How long have you been composting individually?

Less than 6 months ☐ 6 months to 1 year ☐ More than 1 year ☐

d) What composting method do you use?

Open air (aerobic) composting ☐ Bin composting ☐ vehement composting ☐

Others (specify): _______

Section C: Environmental Awareness

6). Perception of climate change

a) Are you aware of the impact of waste on climate change?

Yes ☐ No ☐

b) Do you think composting can reduce waste-related emissions?

Yes ☐ No ☐ I don't know ☐

7). Methane sequestration

a) Have you heard about methane emissions from waste?

Yes ☐ No ☐

b) Do you believe that composting can help reduce methane emissions?

Yes ☐ No ☐ I don't know ☐

Section D: Socio-economic aspects

8). Economic opportunities

a) Do you think that composting creates job opportunities in Dschang?

Yes ☐ No ☐ I don't know ☐

b) Would you be willing to purchase compost for gardening or agricultural purposes?

Yes ☐ No ☐

9). Impact of compost on agricultural products

a) Have you used compost on your farm or garden?

Yes ☐ No ☐

b) If yes, which crops or plants benefited from the compost?

Vegetables ☐ Fruits ☐ Cereals ☐ all crops ☐

Others (specify): ____________

c) What improvements have you observed after using compost?

Increased yield ☐ Better soil quality ☐ Reduced use of chemical fertilizers ☐

Pest resistance ☐

Others (specify): ____________

10). Motivation and support for individual composting

a) What motivated you to start composting?

Environmental awareness ☐ Cost savings ☐ Better agricultural production ☐ I buy compost ☐

Others (specify): ____________

b) What support would help you maintain or improve your composting initiative?

Access to training ☐ Equipment or materials ☐ Financial incentives ☐

Others (specify): ____________

11). Community Benefits

a) Do you believe that composting improves the cleanliness of the community?

Yes ☐ No ☐

b) Would you participate in a community composting program if it were available?

Yes ☐ No ☐

Section E: Obstacles and Opportunities

12). The challenges of composting

a) In your opinion, what is the biggest challenges to composting?

Lack of awareness, ☐ financial constraints, ☐ limited space, ☐

cultural practices ☐

Others (specify): ____________

13) Intensify composting efforts

a) What would encourage you to start composting?

Financial incentives ☐ free training ☐ Access to composting materials ☐

Community programs ☐ Other (specify): ____________

14). Recommendations

a) What suggestions do you have for improving composting practices in Dschang?

Questionnaire

Section F: For AMGED employees

15. Operational details

a) What is your role in the composting process? ________________

b) How much waste does your company process daily? ______________

16). Methane management

a) Do you use any other method to reduce methane emissions during composting?

Yes (specify): ________________

No ☐

17) Intensify efforts

a) What challenges does your company face in expanding its composting operations?

____

b) What possibilities for improvement do you see?

________________ ________________

Appendix 2

Internship letter

RÉPUBLIQUE DU CAMEROUN
Paix –Travail–Patrie
RÉGION DE L'OUEST
DÉPARTEMENTDE LA MENOUA
COMMUNE DE DSCHANG
SECRÉTARIAT GÉNÉRAL
SERVICE DES AFFAIRES GENERALES
B.P.169 DSCHANG; Tél.:00237.233.45.11.38 677.74.29.06
SiteWeb : www.commune-dschang.org
E-mail : info@commune-dschang.org

DSCHANG

REPUBLIC OF CAMEROON
Peace –Work–Fatherland
WEST REGION
MENOUA DIVISION
DSCHANG COUNCIL
GENERAL SECRETARY
GENERAL AFFAIRS DEPARTEMENT
PO Box169 DSCHANG; Phone:00237.233.45.11.38 677.74.29.06
Website: www.commune-dschang.org
E-mail : info@commune-dschang.org

Programme de Stage de Mme Berinyuy Emmanuela Chem.

Mlme Berinyuy est appelée à suivre un stage académique à la Commune de Dschang pour une période de deux (02) mois allant du **13 janvier 2025 au 13 mars 2025.**

PERIODE	SERVICES	OBSERVATIONS
13 jan 2025	Secrétariat Général	- Prise de contact
14 janvier 2025 au 12 mars 2025	AMGED	- Présentation de la Commune de Dschang (Historique, structure) - Déroulement du stage
13 mars 2025	SAG	- Fin du stage

L'intéressée est priée de prendre attache avec le Secrétariat Général de la Commune de Dschang pour les modalités pratiques inhérentes à son stage. /-

Copie à :

- Secrétaire Général ;
- SAG ;
- BRH ;
- Intéressée ;
- Services concernés ;
- Chrono &Archives.

Dschang, le 13 JAN 2025
Le Maire

RÉPUBLIQUE DU CAMEROUN ★ COMMUNE DE DSCHANG ★

Prof. TEMGOUA Emile
1er Adjoint au Maire

RÉPUBLIQUE DU CAMEROUN
Paix –Travail–Patrie
RÉGION DE L'OUEST
DÉPARTEMENTDE LA MENOUA
COMMUNE DE DSCHANG
SECRÉTARIAT GÉNÉRAL
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DSCHANG

REPUBLIC OF CAMEROON
Peace –Work–Fatherland
WEST REGION
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E-mail : info@commune-dschang.org

N° 05 /L/C.Dcs/SG/SAG

Dschang, le 13 JAN 2025

Le Maire
À
Mme Berinyuy Emmanuela Chem,University Institute of Water and Energy Sciences including Climate change Algeria.

Objet **: a/s** ***Votre demande de stage académique Du 12 Decembre 2024.***

Monsieur,

J'accuse réception de votre demande dont l'objet est repris en marge.

Y faisant suite, je marque mon **accord de principe** pour un stage non rémunéré d'une période de 02 mois allant du ***13 janvier au 13 mars 2025.*** Vous voudrez bien prendre attache avec le Secrétariat Général de la Commune de Dschang pour les modalités pratiques y afférentes.

Veuillez agréer Monsieur, l'assurance de ma parfaite considération.

Copie à :

- Secrétaire Général ;
- SAG ;
- Intéressé ;
- Chrono & Archives.

POUR LE MAIRE ET PAR DELEGATION
Le 1er Adjoint au Maire

RÉPUBLIQUE DU CAMEROUN ★ COMMUNE DE DSCHANG ★

Prof. TEMGOUA Emile
1er Adjoint au Maire

Appendix 3

Research supervisor and Internship supervisor

Appendix 4

The Ngui compost facility Staffs