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Greenhouse gas reduction and cost-benefit through improving municipal solid waste management in Ouagadougou

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Waste management is one of the major challenges of urban management in Sub Saharan African countries. The current difficulties in the management of solid waste are the result of poor mastering of concepts, approaches, and techniques. This paper aims to study the Greenhouse gas reduction and cost-benefit through improving municipal solid waste management in Ouagadougou. Since the site location is important for collection optimization, the paper was focused on the research of the technique to achieve this goal with two identified methods, the gravity method and the Quantitative System for Business software (WinQSB). The result showed that both methods got the same coordinate system (12.36943601; -1.513841578) which corresponds to street 3.22, Dapoya, Ouagadougou, Burkina Faso. The new site offers more benefits, especially in terms of cost reduction as well as greenhouse gas reduction. For example, ten million FCPA or twenty thousand 20,000 USD a year could be saved up. CO₂ emissions in the transport sector pose a key problem along with particle and NOx emissions. Also, 30 m³ of gasoline is needed per week per truck to transport urban waste, which is released around 3,801.6 Kg of CO₂ per year by using an old transfer station. By considering the new transfer station because of the proximity of collection points, around 2,500.8 Kg of CO₂ per year is released which is less than CO₂ released in the old station.

Key words: Municipal solid waste, site optimization of transfer station, greenhouse gas reduction, solid waste landfill.

INTRODUCTION

Greenhouse gas (GHG) emissions resulting from urban waste services are a major cause of climate change. Climate change poses a major threat to sustainable urban development in Africa. Changes in the frequency, intensity, and duration of climate extremes (droughts, floods, and heatwaves, among others) will affect the livelihoods of the urban population, principally the poor and other vulnerable communities who live in slums and marginalized settlements (Kumssa et al., 2015) The number of GHG emitted due to waste management in the
cities of developing countries is predicted to rise considerably soon (Friedrich and Trois, 2011); however, these countries have a series of problems in accounting for and reporting these gases (Cheyne, 2002). Some of these problems are related to the lack of a coherent framework for accounting and reporting of greenhouse gases from waste at the municipal level (Achankeng, 2003).

The condition of the municipal solid waste management (SWM) of Africa is critical. Under the general expansion of the human population and rapid urbanization in Africa, the amount of municipal solid waste is increasing drastically. However, the public authority capacity to implement the municipal SWM service in each country is limited. As a result, many municipal solid wastes are not collected or treated/disposed-off appropriately, which has caused public health issues and environmental problems. The urban population of Africa plays an indispensable role in the amelioration of the city sanitation environment, which is likely to triplicate in 2050 from about 450 million people (40% of the total population) and was linked with various kinds of economic infrastructure buildings. However, the current condition of the municipal SWM of African countries was reported that Municipal waste management is the responsibility of each municipality (city) or local government, but its implementation capacity is often weak, facilities and equipment are insufficient, and maintenance, management, and waste disposal are often not carried out properly. The central government or the provincial government's guidance, coordination, and management system for instructing the municipality are not in place appropriately.

As the cities are expanding and population increases, the existing capacity, and trend of waste management do not perform the desired level of service. The existing service of waste management is primitive and follows the collection-transportation-disposal hierarchy. Dumpsites in the city are increasingly difficult to obtain and trucking of wastes out of the city is growingly expensive. Local community-based waste collection schemes are a shining light but the secondary collection points are again gloomy. The disposal site is an uncontrolled dumping threads to surface and groundwater pollution. Proper handling and managing of waste have value if the 4 R principles: reduce, reuse, recovery, and recycling is followed. Large numbers of people are supported by waste picking and recycling activities, which may be unsanitary but important in terms of economics and reducing the quantities of waste requiring disposal.

Municipalities have to strengthen institutional capacity and financial management. The de-mountable container system is good but costly due to misleading with the actual concept (Amarie et al., 2009). The strong monitoring and incentive mechanism along with the possibility of installation of weigh-bridge at the dumpsite can make the system efficient. The crude way of waste disposal should be avoided as surface and groundwater are being polluted (Das and Bhattacharyya, 2015). The best option is the controlled management of dumpsite with compacted clay liner for the protection of ground intrusion and recirculation back of the leachate to the landfill allowing faster decomposition and reduction. Landfill gas can be controlled by installing vent pipes for releasing gas to the atmosphere or contracting out to any private company for the generation of energy (Burhantoro et al., 2012).

Burkina-Faso, located in West Africa, has an area of 274,120 Km² where Ouagadougou is the capital located in the center of the country between the parallels 12° 20 and 12° 25 of latitude North and the meridians 1° 27 and 1° 35 of longitude West (Carling and Håkansson, 2013). On the administrative level, Ouagadougou is a decentralized territorial collectivity and led by a mayor elected by popular vote by municipal councilors. The demographics are difficult to appreciate by the divergent searchable and controversial sources of data, because of the lack of coordination of the actors involved in urban management in Ouagadougou.

For the present study, the demographic data available at the National Institute of Statistics and Demography was taken into account (Chang and Desai, 2003). According to this source, the city covers an area of about 21,000 ha and includes more than 50% of the urban population of the country. The current population of Ouagadougou is estimated at 1 500 000 inhabitants. The average household size was 5.6 people, ranging from 5 to 7 people (Beğen, 2002). The urban density is between 3458 and 4600 inhabitants per square kilometer or about 40 inhabitants per hectare (Zi-xia and Wei, 2010).

This research looks at the case of Ouagadougou indeed, piles of garbage and waste litter the streets and this has become a common sight in other Burkina cities as well. Municipalities are facing increasing difficulty in providing adequate services. The country legislation acknowledges the need to move away from landfill as the absolute solution. The legislation aims to clean up the city while limiting the wild dumps by adequate standards. To this end, the municipality of Ouagadougou has created an operational structure named "Direction de la property" in charge of the management of the waste. This paper analyzes the current state of solid waste management systems in Ouagadougou, improve the collection systems of the municipal solid waste management, and estimate greenhouse gas released from waste.

CURRENT STATE OF SOLID WASTE MANAGEMENT SYSTEM IN OUAGADOUGOU

Waste collection systems of the city of Ouagadougou

The city urban waste grows rapidly from year to year as
shown in Figure 1. Solid Management in Ouagadougou has organized in three (02) stages (pre-collection collection, and transportation) (Botello-Álvarez et al., 2018). This organization requires the existence of two structures equipped with facilities to carry out this work, the existence of waste management infrastructures and the financial means necessary to ensure their operation. The solid waste collection is concerning every street according to the government plan (SDGD), which consist to divide the town into 12 areas; each area is led by one private enterprise (Ferronato et al., 2019). In Ouagadougou, the common method of the solid waste collection suggested is the door-to-door system, where waste is sourced separately and disposed of in fraction-specific containers that are located typically in outdoor waste sheds in inner courtyards of residential blocks (Feng et al., 2009). The MSW collection is carried out using private waste collection enterprises at a fixed cost, varied from 500 FCFA (1 USD) to 1000 FCFA (2 USD) with the level of standing.

Pre-collection and collection

Pre-collection from households in the collection by the producer of waste using the bin. It should be noted that in our cities, pre-collection is done without a minimum of sorting at source. This job is provided by small enterprises and associations. The Environmental Services Department of Ouagadougou is responsible for urban technical management, including urban waste management. It is primarily responsible for collecting and transporting waste to a landfill (Das and Bhattacharyya, 2015). There are several collection routes along which each of the bins must be lifted twice a week. Each engine makes a maximum of 12 trips a day, five workdays a week (Ding et al., 2011). It consists of bringing the waste from the source of production to the collection or collection point (garbage bin or collection center). The collection of waste can be done either by the voluntary contribution of the users, or door to door by the small enterprise, associations, or the municipality. In the precollection and collection system in Ouagadougou, we have zero CO₂ emission from engines. The city used engines such as charts that emit no waste products that pollute the environment or disrupt the climate.

Transport

Transport is an operation that consists of recovering waste from the transfer station to final disposal. In the city of Ouagadougou, it is provided by the sustainable development department. The cost of transport is quite high and difficult to support communities that have difficulty in acquiring transport equipment but also to ensure their maintenance (Fei-Baffoe et al., 2014). As an example for the commune of Ouagadougou, transporting one cubic meter of waste to transfer station costs 4,500 FCFA (10 USD), the truck can transport up to thirty cubic meters. Transport from households to the landfill is carried out by private-public companies under the direction of the cleaning bureau (Cao et al., 2011).

CO₂ emissions in the transport sector pose a key
problem along with particle and NOx emissions. If long-term climate protection targets are to be met, the transport sector must play its part by reducing its absolute CO2 emissions. When it comes to the application of technical measures at source, part of the emissions reduction target could be achieved through greater use of alternative fuels and another part by reducing specific CO2 emissions in conventional vehicles. 30 m3 of gasoline is needed per week per truck to transport urban waste, which is released around 3,801.6 kg of CO2 per year by using an old transfer station. By considering the new transfer station because of the proximity of collection points, around 2,500.8 kg of CO2 per year is released which is less than CO2 released in the old station. That means there are only two ways to reduce specific CO2 emissions:

(i) By reducing fuel consumption in vehicles with conventional through reducing the distance of the trip.
(ii) By using renewable, low- CO2 fuels – partly in conjunction with new engine technologies.

Landfill situation in Ouagadougou

In the city, the landfill is essentially dumping grounds. It covers an area of 70 ha. They lack the basic infrastructure that defines a landfill, such as membrane lines, impermeable liners, daily covers, and methane extraction infrastructure. The traditional method of landfills was to directly wad wastes in valleys and watercourses that are naturally formed or in artificial pits and pounds without any treatment to prevent wastes from diffusion and transference, which is called an informal landfill compared with the modern sanitary landfill. Since its opening in April 2005, Polesgo landfill receives most of the household waste produced in Ouagadougou. It has a capacity of 6.1 million cubic meters of waste and offers an operating capacity of 20 years. The landfill is located about ten kilometers north of the city and has two main charges: firstly, solid waste burial and secondly, solid waste valorization (composting, plastic recovery, etc.).

The two most important problems with our landfill are leachate, and greenhouse gases. Leachate is the liquid formed when waste breaks down in the landfill and water filters through that waste. This liquid is highly toxic and can pollute the land, groundwater, and waterways. Improper management of sanitary landfills will become a huge problem for the environment. The main pollution that occurs by the sanitary landfill is the generation of leachate which will affect groundwater, ecosystem, and human health because of the high content of organic compounds. Greenhouse gas constitutes a big challenge in the city. Organic material such as food scraps and green waste is put in a landfill; it is generally compacted down and covered. This removes the oxygen and causes it to break down in an anaerobic process. Eventually, this releases methane, a greenhouse gas that is 25 times more potent than carbon dioxide. The implications for global warming and climate change are enormous. Methane is also a flammable gas that can become dangerous if allowed to build up in concentration. Composting food scraps and green waste in a compost bin eliminates many of these problems. Another solution is to build a landfill lined with a membrane that is specially designed to catch methane in liquid form and prevent it from escaping into the air (Peidong et al., 2006).

Methane emission estimation from solid waste disposal

The calculation of methane emission will be estimated by using IPCC default method. This method is based on the main equation which is:

\[ \text{Methane (Gg/yr)} = \frac{\text{MSWT} \times \text{MSWF} \times \text{MCF} \times \text{DOC} \times \text{DOCF} \times F \times 16}{12-R} \times (1-\text{OX}) \]  

Where:  
MSWT is the total MSW generated (Gg/yr),  
MSWF is the fraction of MSW disposed to solid waste disposal sites,  
MCF is the methane correction factor (fraction),  
DOC is the degradable organic carbon (fraction) (kg C/kg SW)  
DOCf is the fraction DOC dissimilated,  
F is the fraction of CH4 in landfill gas,  
R is the recovered CH4 (Gg/yr),  
OX is the oxidation factor.

On average 0.52 kg per person per day of Waste was generated in the capital of the country. The total amount of waste generated per year was estimated at 330 Gg/yr, therefore the city disposed of only 52% of municipal solid waste into the landfill site so the methane emission released was about 3,545 Gg/year. The method assumes that all the potential CH4 emissions are released during the same year the waste is disposed of.

MATERIALS AND METHODS

It is needed to improve collection systems because the collection is the most important in solid waste system cost. Therefore, a little percentage improvement in the collection operation can produce an important saving in the overall cost. Two methods were identified as the center of gravity method and Quantitative System for Business (WinQsb), Figure 2 shows the study area. The map displayed the delimitation of the city in terms of the number of districts, villages, natural resources such as lakes, dams, etc.

Center of gravity

The gravity method is a geophysical technique that measures differences in the earth’s gravitational field at specific locations. The
Figure 2. Location of the study area: Ouagadougou Commune.

Gravity method is a relatively cheap, non-invasive, non-destructive remote sensing method. Gravity data in engineering and environmental applications should be collected in a grid or along with a profile with stations spacing five meters or less. Using the highly precise locations and elevations plus all other quantifiable disturbing effects, the data are processed to remove all these predictable effects. The most commonly used processed data are known as Bouguer gravity anomalies, measured in mGal. An accurate determination of the source usually requires outside geophysical or geological information (McDougall et al., 2008; Sheahan and Barrett, 2017).

In addition to obtaining a gravity reading, a horizontal position and the elevation of the gravity station must be obtained. The horizontal position could be either latitude and longitude or the x and y distances (meters or feet) from a predetermined origin. The required elevation accuracy for detailed surveys is between 0.004 and 0.2 m as well as to obtain such accuracy requires performing either an electronic distance meter (theodolite) survey or a total-field differentially corrected global positioning survey (GPS) (Simões et al., 2009). This method requires two steps, locate each of the existing collection points with (X; Y) coordinate system and find out the (X; Y) coordinate system of the new area by taking the average (X; Y) coordinate of all existing area.

\[
x_0 = \frac{\sum x_i L_i \times Q}{\sum L_i \times d_i} \quad y_0 = \frac{\sum y_i L_i \times Q}{\sum L_i \times d_i}
\]

(2)

Where \((x_0, y_0)\) is the coordinate of the new transfer station, \((x_i, y_i)\) is the coordinate of the existing transfer station. \(L_i\) is the Load to be transported between the old and the new area. \(d_i\) is the distance between collection point and transfer station and \(Q\) is the shipping rate. In the case of Ouagadougou according to the formula, a barycenter coordinate was gotten as the initial solution, recorded as \((x_1, y_1)\). The initial coordinate \((x_1, y_1)\) was set into the formula and calculate the results as \((x_2, y_2)\). Then the coordinate \((x_2, y_2)\) was placed into the formula, calculate the results recorded as \((x_3, y_3)\), and so on, and repeated until the results of two identical iterations (Sruthi et al., 2018). An optimum solution was gotten after 13 iterations.

WinQSB overview

The package of informatics programs, Quantitative System for Business (WinQSB) is a software system developed and maintains by Chang Yih from Georgia Institute of Technology (Tai et al., 2011), functioning under Windows, which is composed of 19 modules, each module is composed of others sub modules. The launching of a certain module allows processing the input data, obtaining the results, analysis, and interpretation. The extensions of the saved files are particular to each appealed module. The QSB (Quantitative Systems for Business) contains the most widely used problem-solving algorithms in Operations Research and Management Science (OR/MS).

The goal is to present a way to solve the facility location problem by using WinQSB software. The main question is where must we put a facility or a service to be able to minimize the total time and cost. Despite its simple description, the problem contains some of the most interesting and difficult notions of applied mathematics and especially of optimization theory. Using this software in practice has a real contribution to the development activities efficiency, ensuring a high economy of time by eliminating routine activities tied to the classic way of solving the problem. This program Facility Location and Layout, solve three facility design problems: facility
RESULTS AND DISCUSSION

Selecting of the new transfer station location with gravity method

The selection of a site for any waste-related facility can be a sensitive issue, particularly for those living nearby. So identifying a good site for a waste transfer station can be a challenging process. Site suitability depends on numerous technical, environmental, economic, social, and political criteria. When selecting a site, a balance needs to be achieved among the multiple criteria that might have competing objectives. The center-of-gravity, or weight center, the technique is a quantitative method for locating a facility such as a warehouse at the center of the movement in a geographic area based on weight and distance (Tchobanoglous, 2009). Using this method to an existing collection point, a new location, more advantageous, was found. The result shows that (12.36943601; -15.13841578) is the best coordinate’s location for the transfer station building. Figure 3 represents the location of the old and new transfer station based on the calculation as well as landfill location.

Location result with WinQSB

The facility location Model, also known as location analysis, is a branch of operations research and computational geometry concerned with the optimal placement of facilities to minimize transportation costs. The facility location problem can be classified as several new facilities to be located, the solution space, the size of facilities, the criteria used to determine the location, the distance measured, and so on. Based on these problems, the software can do some statistical analysis and find out the best site, in the case of Ouagadougou, the new coordinate system is corresponding to street 3.22, Dapoya, Ouagadougou, Burkina Faso. Table 1 recaps the cost between both transfers’ stations using trucks. It shows that using the new transfer station is more beneficial to the municipalities. So the new transfer station is the most useful in general, and the profit is more and more important compared to old station.

Benefits of the new location

Communities need transfer stations to move their waste efficiently from the point of collection to distant, regional landfills. By consolidating solid waste collection and disposal points, transfer stations help communities reduce the cost of hauling waste to these remote disposal sites. The main benefit of the new transfer station is the reduction in transportation costs. Indeed, there is saving on the consumption of the fuel and as such, the cost of the garbage transport is minimized (Sun et al., 2009). The transfer station offers citizens facilities for average are located 20 km away from the center of the city. This saves travel time and the fleet can be better utilized for making extra trips resulting in ineffective cleaning and
Table 1. Cost result between both transfer stations using truck.

| Collections points | Distance to the new transfer station (km) | Distance to the old transfer station | Waste generated (kg) | Qi | New transfer cost (FCFA) | Old transfer cost (FCFA) |
|---------------------|------------------------------------------|-------------------------------------|----------------------|----|--------------------------|--------------------------|
| 1                   | 15                                       | 20                                  | 16304.22             | 0.35 | 85597.16                 | 114129.5                 |
| 2                   | 4.6                                      | 4.2                                 | 25821.72             | 0.35 | 41572.97                 | 37957.93                 |
| 3                   | 4.7                                      | 3.6                                 | 30969.54             | 0.35 | 50944.89                 | 39021.62                 |
| 4                   | 2.4                                      | 8.8                                 | 27254.34             | 0.35 | 22893.65                 | 83943.37                 |
| 5                   | 8.3                                      | 6.5                                 | 30619.62             | 0.35 | 88950                    | 69659.64                 |
| 6                   | 8.3                                      | 5.2                                 | 16752.96             | 0.35 | 48667.35                 | 30490.39                 |
| 7                   | 3.4                                      | 6.8                                 | 14587.56             | 0.35 | 17359.2                  | 34718.39                 |
| 8                   | 3.4                                      | 8.4                                 | 19145.16             | 0.35 | 22782.74                 | 56286.77                 |
| 9                   | 16                                       | 20                                  | 12587.94             | 0.35 | 70492.46                 | 88115.58                 |
| 10                  | 6.6                                      | 6.1                                 | 37962                | 0.35 | 87692.22                 | 81048.87                 |
| 11                  | 17.1                                     | 9.3                                 | 33095.52             | 0.35 | 198076.7                 | 107725.9                 |
| 12                  | 10.4                                     | 9.2                                 | 24369.12             | 0.35 | 88703.6                  | 78468.57                 |
| 13                  | 20                                       | 21                                  | 32257.98             | 0.35 | 225805.9                 | 237096.2                 |
| 14                  | 13.8                                     | 7.3                                 | 33720.3              | 0.35 | 162869                   | 86155.37                 |
| 15                  | 8.2                                      | 8                                   | 36392.76             | 0.35 | 104447.2                 | 101899.7                 |
| 16                  | 7.5                                      | 9.4                                 | 38679.12             | 0.35 | 101532.7                 | 127254.3                 |
| 17                  | 4.3                                      | 13.9                                | 34934.76             | 0.35 | 52576.81                 | 169957.6                 |
| 18                  | 21                                       | 21                                  | 9745.38              | 0.35 | 71628.54                 | 71628.54                 |
| 19                  | 3.8                                      | 11.6                                | 41563.26             | 0.35 | 55279.14                 | 168746.8                 |
| 20                  | 14.3                                     | 16.1                                | 11187.72             | 0.35 | 55994.54                 | 63042.8                  |
| 21                  | 9                                        | 12.2                                | 15705.9              | 0.35 | 49473.59                 | 67064.19                 |
| 22                  | 2.9                                      | 10.6                                | 10860.48             | 0.35 | 11023.39                 | 40292.38                 |
| 23                  | 22                                       | 22                                  | 23148.18             | 0.35 | 178241                   | 178241                   |
| 24                  | 6.7                                       | 14.3                                | 25262.82             | 0.35 | 59241.31                 | 126440.4                 |
| 25                  | 6.9                                       | 14.5                                | 21364.02             | 0.35 | 51594.11                 | 108422.4                 |
| 26                  | 12                                       | 15                                  | 22913.82             | 0.35 | 96238.04                 | 120297.6                 |
| 27                  | 8.3                                       | 15.4                                | 23397.66             | 0.35 | 67970.2                  | 126113.4                 |
| 28                  | 8.7                                       | 15.7                                | 16880.94             | 0.35 | 51402.46                 | 92760.77                 |
| 29                  | 9.9                                       | 16.9                                | 21847.86             | 0.35 | 75702.83                 | 129230.1                 |
| 30                  | 10.5                                      | 17.4                                | 48449.88             | 0.35 | 178053.3                 | 295059.8                 |
| 31                  | 21                                       | 22                                  | 6787.8              | 0.35 | 49890.33                 | 52266.06                 |
| 32                  | 11.2                                      | 6.8                                 | 16607.16             | 0.35 | 65100.07                 | 39525.04                 |
| 33                  | 7.7                                       | 14.7                                | 13354.74             | 0.35 | 35991.02                 | 68710.14                 |
| 34                  | 10.8                                      | 17.8                                | 8159.4              | 0.35 | 30842.53                 | 50833.06                 |
| 35                  | 22                                       | 22                                  | 28702.08             | 0.35 | 221006                   | 221006                   |
| 36                  | 18.2                                      | 15.3                                | 2792.88              | 0.35 | 17790.65                 | 14955.87                 |
| 37                  | 25.5                                      | 26                                  | 20733.84             | 0.35 | 185049.5                 | 188677.9                 |
| 38                  | 26                                       | 26.5                                | 47613.96             | 0.35 | 433287                    | 441619.5                 |
| Total               |                                           |                                     |                      |     | 3511764                   | 4208863                   |

sweeping. It can also be noticed that the wear and tear of the tires and other components of vehicles are minimized by avoiding long trips and adverse conditions at landfill sites. Waste transfer station may be the most cost-effective when it is located convenient drop off waste as well; we have more abilities in waste handling and disposal alternatives. The small dumper placer vehicles need not have to travel long distances up to the landfill site, which on near a collection area (Tinmaz and Demir, 2006). The use of transfer station lowers collection costs, as crews spend less time traveling to and from distant disposal sites and more time collecting waste; this
reduces costs for labor, fuel, and collection vehicle maintenance.

To understand how sensible it is to spend money on these emissions reductions, we can compare them to estimates of carbon's social cost, which quantifies the incremental damage resulting from emitting a ton of carbon dioxide and other greenhouse gases into the atmosphere. The long residence time of CO₂ in the atmosphere makes climate change a long-term problem. As a result, the key to reducing emissions in the future is to have low-cost alternatives to fossil fuels that are zero or low-carbon. The true total cost of investments or interventions today therefore must contain both their static, or face-value cost, and any spillovers those investments have for future costs of emissions reduction. The importance of a dynamic perspective is hardly new (Newell, 2017), but it is often neglected both in the public debate and in the literature on costs of abatement. Yet, the welfare benefits of even small growth rates in the efficiency of clean technologies may be large, as suggested by simulations in Hassler (Lazard, 2017).

**DISCUSSION**

To improve the collection system, site selection is important. There are many methods for choosing the best location; we have studied the center of gravity approach, and another method using WinQSB. With both methods, we have found the same result for implementing the new transfer station. However these methods have some limitations, but the WinQSB is more advantageous because of the ease of use of the software. It can find some solutions in very little time. This software is very useful for everyone and we even do not need any programming skills. The new site offers no doubt more benefits, especially in terms of cost reduction. For example, ten million FCFA (local currency) or twenty thousand 20,000 USD can be saved a year.

Of all municipal responsibilities, waste management remains one of the most complex, noble, and exciting for elected officials and their staff. Since it is a versatile field that requires taking into account a multitude of themes related to the environment, sanitation, economy, law, sociology, communication. Waste transfer station may be the most cost-effective when it is located near a collection area. The use of transfer station lowers collection costs, as crews spend less time traveling to and from distant disposal sites and more time collecting waste; this reduces costs for labor, fuel, and collection vehicle maintenance. The present results provide evidence that the new site has the potential to achieve emission from vehicles. To our knowledge, no previous study has calculated the potential savings within the transport sector in the city. Providing alternatives vehicles can contribute to CO₂ emission reduction.

**Conclusion**

This paper examines the greenhouse gas reduction and cost-benefit through improving municipal solid waste management in Ouagadougou. The waste is designated as a nuisance related to the growth of the city. This paper shows the problems and challenges related to municipal solid waste management; however, the difficulties encountered today in Ouagadougou in this area are also aggravated by the economic handicap of the country and the behavior of the people. Observation through the distribution of garbage piles in the capital of Ouagadougou is an opportunity to examine the collection system.

Since the site location is important for collection optimization, the paper was focused on the research of the technique to achieve this goal. Two main methods were identified, the gravity method and the Quantitative System for Business software (WinQSB). The result showed that both methods got the same coordinate system (12.36943601; -1.513841578) which is corresponding to street 3.22, Dapoya, Ouagadougou, Burkina Faso. The new site offers more benefits, especially in terms of cost reduction. For example, we could save up to ten million FCFA or twenty thousand 20,000 USD a year. All the difficulty will lie in finding a strategy reconciling technique-economic efficiency and socio-economic realities. One of the answers to this question already lies in the reduction of waste both in terms of production and collection.

CO₂ emissions in the transport sector pose a key problem along with particle and NOx emissions. In the case of Ouagadougou to transport urban waste, around 3,801.6 Kg of CO₂ is released per year by using an old transfer station. By considering the new transfer station because of the proximity of collection points, around 2,500.8 kg of CO₂ per year is released which is less than CO₂ out in the old station. As a preventive measure, a considerable reduction of the mobility of hazardous substances in landfills is then needed, even if the former and current practice have not yet resulted in serious damages. The landfill and its environmental impacts will be part of every country during the next generations.

**CONFLICT OF INTERESTS**

The authors have not declared any conflict of interests.

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REFERENCES

Achankeng E (2003). Globalization, urbanization and municipal solid waste management in Africa. In Proceedings of the African Studies Association of Australasia and the Pacific 26th Annual Conference. pp. 1-22.

Amarie OI, Frunzaverde D, Popovic G, Hamat CO (2009). WinQSB simulation software—a tool for professional development. Procedia-Social and Behavioral Sciences 1(1):2786-2790.

Begn NN (2002). Optimal locations of landfills and transfer stations in solid waste management (Doctoral dissertation, Bilkent University).

Botello-Álvarez JE, Rivas-García P, Fausto-Castro L, Estrada-Baltazar A, Gomez-Gonzalez R (2018). Informal collection, recycling and export of valuable waste as transcendent factor in the municipal solid waste management: A Latin-American reality. Journal of Cleaner Production 182:485-495.

Burhamtoro AW, Bisni M, Soemamo (2012). Model of Municipal Solid Wastes Transportation Costs Type Dump Truck (Case Study at The Malang City, Indonesia). International Journal of Engineering and Technology 13(3):34-40. Available at: http://www.ijens.org/Vol_13_L_03/136303-5757-IJENSPDF.pdf

Cao L, Guan W, Lu L (2011). Study on the landfill leachate pretreatment based on coagulation and MAP precipitation. International Conference on Electronics, Communications and Control (ICETCC).2011. pp. 2324-2327.

Carling K, Håkansson J (2013). A compelling argument for the gravity model applied to recycling. European Journal of Operational Research 226(3):658-660.

Chang YL, Desai K (2003). WinQSB: Software and manual. New York, itd: Wiley, version, 2.

Cheyne I (2002). The definition of waste in EC Law. Journal of Environmental Law 14(1):61-73.

Das S, Bhattacharyya BK (2015). Optimization of municipal solid waste collection and transportation routes. Waste Management 43:9-18.

Ding Z, Tan F, Li Q, Qiu J (2011). Research on Fenton oxidation treatment of landfill leachate by microwave. In 2011 International Conference on Electric Technology and Civil Engineering (ICETCE). pp. 1468-1471.

Fei-Baffoe B, Nyankson EA, Gorkeh-Miah J (2014). Municipal Solid Waste Management in Sekondi-Takoradi Metropolis, Ghana. Journal of Waste Management 2014:1-9.

Feng S, Ma Y, Jiang Y (2009). Economic cost-benefit analysis on urban solid waste categorized collection of China. In 2009 International Conference on Energy and Environment Technology 16(3):279-281.

Ferronato N, Ragazzi M, Portillo MA, Lizarazu EG, Viotti P, Torretta V (2019). How to improve recycling rate in developing big cities: An integrated approach for assessing municipal solid waste collection and treatment scenarios. Environmental Development 29:94-110.

Friedrich E, Trois C (2011). Quantification of greenhouse gas emissions from waste management processes for municipalities—A comparative review focusing on Africa. Waste Management 31(7):1585-1596.

Kumssa A, Mosha AC, Mbeche IM, Njeru EHN (2015) Climate Change and Urban Development in Africa. In: Leaf Filho W (eds) Handbook of Climate Change Adaptation. Springer, Berlin, Heidelberg.

Lazard (2017). "Lazard's Levelized Cost of Energy Analysis Version 11.0" Report.

McDougall FR, White PR, Franke M, Hindle P (2008). Integrated solid waste management: A life cycle inventory. John Wiley & Sons.

Newell RG (2017). Unpacking the Administration's Revised Social Cost of Carbon. Available at: https://www.resourcesmag.org/common-resources/unpacking-the-administrations-revised-social-cost-of-carbon/

Peidong M, Chuan H, Liao W, Xiao mei D (2006). Economic Rationality of Transfer Station of MSW. Environmental Sanitation Engineering 6:5. Available at: http://en.cnki.com.cn/Article_en/CJFDTotal-HJWS200606005.htm

Sheahan M, Barrett CB (2017). Food loss and waste in Sub-Saharan Africa: A critical review. Food Policy 70:1-12.

Simões LF, Pais TC, Ribeiro RA, Jonniaux G, Reynaud S (2009). Search methodologies for efficient planetary site selection. In 2009 IEEE Congress on Evolutionary Computation, pp. 1981-1987.

Sruthi T, Gandhimathi R, Ramesh ST, Nidheesh PV (2018). Stabilized landfill leachate treatment using heterogeneous Fenton and electro-Fenton processes. Chemosphere 210:38-43.

Sun X, Sun Y, Wang H, Lu W (2009). Effects of recirculation parameter on leachate from fresh municipal solid waste. In 2009 International Conference on Environmental Science and Information Application Technology 2:269-272.

Tai J, Zhang W, Che Y, Feng D (2011). Municipal solid waste source-separated collection in China: A comparative analysis. Waste Management 31(8):1673-1682.

Tchobanoglous G (2009). Solid waste management. Environmental engineering: Environmental health and safety for municipal infrastructure, land use and planning, and industry. Wiley, New Jersey. pp. 177-307.

Timmaz E, Demir I (2006). Research on solid waste management system: To improve existing situation in Corlu Town of Turkey. Waste Management 26(3):307-314.

Zi-xia C, Wei H (2010). Study and application of Center-of-Gravity on the location selection of distribution waste. In 2010 IEEE International Conference on Logistics Systems and Intelligent Management (ICLSIM), pp. 981-984.