Computational forecast of municipal waste in Lagos: What may happen in 2025?

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Abstract. Lagos is the commercial hub of Nigeria with almost the highest population in Nigeria. The municipal waste of Lagos is currently huge with existing health threats to residence around the landfills. Thirty-seven years (1980-2017) dataset for municipal waste in Lagos was projected to 2025 using computational analysis i.e., moving averages and excel forecast tool. It was discovered that the averages of all the forecast show that the municipal waste in Lagos will be fairly stable between 2020-2025 with an addition of 12 million tonnes by 2025. It is recommended that waste management authorities in Lagos should step-up with the establishment of municipal waste processing companies in all the five landfill sites because the land fill leachates is expected to pollute more ground water sources in Lagos metropolis.

1. Introduction

In the country Nigeria, the law forbids indiscriminate dumping of plastic waste, e-waste and other forms of waste [1]. However, the enforcement of the law is overwhelmingly impossible because of the inadequacies of regulating bodies. Public awareness on the dangers of indiscriminate dumping of waste is very low, thereby exposing over 100 million people to dangerous substances that cause defects in human organs such as the skin, nose lungs, eye and brain [2-6]. Ultimately, this danger leads to loss of lives. Due to the high level of poverty, the importation of used goods from developed world is a big business in Africa and beyond [7]. Due to the Nigeria population the patronage of imported used goods is high, thereby necessitating her ranking as the top for waste generation [8]. Still in the sub-Saharan Africa, Ghana is also recognized for its huge importation of used goods. Most of the used-goods are electronics, clothes and automobiles. Unfortunately, most of the imported goods are near expiry and becomes waste. Out of this wastes, the electronics waste is more worrisome because high level of heavy metals such as copper, lead. The e-waste also is made-up of plastic, which is an additional cause for caution to marine lives [9].

Lagos state, Nigeria, is believed to have large amount of e-waste because it is the commercial capital of Nigeria. The heap of wastes in landfill across is unimaginably large as presented in Figure 1. With an estimated 21 million residents, waste management is a huge task, hence the dumping of refuse along water bodies may not be eradicated. There are 3 major landfills and 2 temporary sites serving Lagos State. The two largest land fill i.e. Olushosun Landfill and Abule-Egba Landfill sites. Olushosun Landfill receives approximately 40% of the total waste deposits from Lagos [10]. The size is 42.7 hectares and it has a residual life span of 20 years. Abule-Egba Landfill occupies a land of about 10.2 hectares and receives waste from the densely populated area. The residual life span is approximately 8 years.
Basel Action Network (BAN) conducted a research that maps the distribution of e-waste over Lagos State. The research shows that there are huge e-waste in Lagos, which includes central processing units (CPU), Dell CPU, Dell computer (made in Ireland), Pentium II computer, Toshiba computer, gateway computer, computer monitor, TV monitor, used computers, CTX computer monitor, Hewlett Packard scanner, Compaq CPU, electronic equipment, Hewlett Packard printer, Hewlett Packard fax, Hewlett Packard copier, OPUS technology computer equipment, old computer, computer keyboard, UTAX C123, IBM computer, used printerPanafax UF-160, refrigerator, NEC computer, AGFA copy machine, XEROX copy machine, RICOH copy machine, EPSON, and Macintosh CPU (BAN, 2005)

2. Methodology
Lagos State is located on longitude 2° 42’E and 3° 22’E and between latitude 6° 22’N and 6° 42’ N [12-13]. It is bounded in the south by Atlantic Ocean. This research thirty-five years dataset was used (1980-2014) was used to forecast the volume of municipal waste by 2025. The municipal waste dataset for all the landfill in Lagos for 2012 was gotten from Lagos Waste Management Authority (LAWMA) [14]. The dataset covers the refuse dumping of private and government operators in the State. The cubic meters of refuse deposited was calculated according to the number of trucks that deposits waste per day. The source error may likely occur via manual counting system. Constructing computational systems that automatically counts truck coming in and out of the dumpsite can minimize this error. Opejin [15] had reported that organic waste accounts for 45% of the total wastes in Lagos. The computational tool that was moving averages and excel forecast tool. The techniques have been reported to be very reliable in understanding both the trend and anomalies of dataset [15-16]. The excel forecast was particularly chosen because most professionals and students appreciate the tool.

The dataset ranges from 1980-2017. The 92% of the dataset was used to forecast and 8% was used to test the validity of the dataset. The forecast technique are two moving averages, excel forecast tool and the averages of all forecast.

3. Results and Discussion
The municipal waste in Lagos generally dwindled between two highest outputs i.e., 1991 and 2010. Though the significant decrease between 1991 and 2010 is quite questionable since it is believed that the population over Lagos has been increasing with respect to opportunities that abound in the city. World population review believes that as of 2012, about 17.5 million people live in Lagos [17]. Beyond 2010, the municipal waste keeps reducing even when there are no clear evidence that population had decreased. There are two broad explanations, i.e., first, some people have their private
landfills; second, residence living at the outskirt of the state patronize the waste management system of neighboring states. The forecast of the municipal waste in Lagos is presented in Figure 2.

![Figure 2: Forecast of municipal waste (2020-2025)](image)

The forecast extended in 2025. 92% of the dataset was used for the prediction while the remaining 8% of the dataset was used to test the accuracy of the forecast. The prediction of the moving averages show that the annual municipal waste will be fairly stable and may not go beyond 2.2 million tons. The excel forecast tool predicted that the municipal waste would linearly increase to 2880285.15 in 2025. The averages of all the forecast show that the municipal waste in Lagos will be fairly stable and will not go beyond 2.3 million tons in 2025.

The validity of the prediction was carried out using 8% of the dataset i.e., 2015-2017 with a degree of confidence given as 95%. It was observed that the outcome shows that the moving averages were near accurate in that the dataset was fairly stable. The correlation between the forecast and the test dataset is shown in Table 1 below. Corrl. 1 is the correlation between the first moving average and the test dataset; Corrl. 2 is the correlation between the first moving average and the test dataset; Corrl. 3 is the correlation between the excel forecast tool and the test dataset; and Corrl. 4 is the correlation between the averages of all forecast and the test dataset. The second moving average showed high correlation while the excel forecast tool showed a negative correlation, i.e., meaning that there is an inverse relationship between two variables - when one variable decreases, the other increases.

### Table 1: correlation between forecast and 8% test dataset

| Corrl. 1 | Corrl. 2 | Corrl. 3 | Corrl. 4 |
|----------|----------|----------|----------|
| 0.736    | 0.999    | -0.941   | 0.972    |

The inter-variable covariance of the two averages and the original dataset is presented in Table 2. Also, the inter-variable covariance of the excel forecast tool, averages and the original dataset is presented in Table 3.
Table 2: Inter-Variable Covariance for moving averages

| Original Data | Moving average 1 | Moving average 2 |
|---------------|------------------|------------------|
| X: 509596226721.99 | 48651054866.189 | -20930871482.474 |
| Y: 397977001951.01 | 229187557686.53 | |
| Z: 195821000780.64 | 195821000780.64 | |

The inter variable covariance, which describes the extent random variables vary together show that original data/moving average 1 had the highest covariance while the original data/moving average 1 had the lowest covariance. Hence, though the moving average 2 showed the highest correlation for 8% test dataset (Table 1), the order of accuracies using the trained dataset i.e., 92% follow in descending order i.e., moving average 1, forecast average, moving average 2 and excel forecast tool.

Table 3: Inter-Variable Covariance excel forecast

| Original Data | Excel forecast Tool | Averages of all forecast |
|---------------|---------------------|--------------------------|
| X: 509596226721.99 | -16206994259.884 | 3837729707.9433 |
| Y: 105666088951.68 | 71473854302.215 | |
| Z: 152816683885.15 | 152816683885.15 | |

This result show that there will an addition of over 12 million metric tons of municipal waste will be added to the Lagos landfill between 2020 and 2025. This result means the estimated e-waste may also rise to about 40%. Hence, the local waste management authorities in Lagos have a herculean task to prevent high heavy metals contaminations that can increase diseases to dumpsite workers and neighbouring communities. It is recommended that waste management authorities in Lagos should step-up with the establishment of municipal waste processing companies in all the five landfill sites, as the land leachates is expected to pollute more ground water sources in Lagos metropolis. In other words, public awareness is important to educate populace on waste management [18].

4. Conclusion

The study reveals that the municipal waste would increase between 2020 and 2025 by 12 million tons. The undocumented municipal waste would also increase within the city with high risk of outbreak of airborne diseases. It is expedient that the waste management authorities in Lagos should urgently incorporate waste processing plants that would help reduce the weight of the waste on the surface geology of the landfill. When the depth of the leachate increases, there is a high possibility that deep ground water sources around the landfill will be polluted. It is recommended that the waste disposal laws be enforced via large campaign awareness and stricter law concerning the disposal of waste.

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