Journal of Environment and Earth Science
ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online)
Vol 2, No.4, 2012

Using Person Product Moment Correlation to explore the relationship between different categories of Municipal solid waste in Kano Metropolis, Northwestern Nigeria

Aliyu Baba Nabegu[1] Adamu Mustapha[2*]

1. Department of Geography, Faculty of Earth and Environmental Sciences, Kano University of Science and Technology, Wudil. Kano State, Nigeria.
2. Department of Environmental Sciences, Faculty of Environmental Studies, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia.
*E-mail of the corresponding author: amustapha494@gmail.com

Abstract
This study explores the relationship between different categories of Municipal solid waste in Kano Metropolis with Person-Product Moment Correlation. Data for the study was obtained from Samples of Municipal solid waste from dumps located within three residential zones of Kano metropolis. The samples were collected and segregated into their various classifiable categories based on standard procedures. The data analyses showed a positive correlation between food scrap, ash and vegetable (r = 0.852, 0.752) and negative correlation between food scrap, paper cardboard, rubber, metals, plastic and glass (r = -0.847, -0.793, -0.853, -0.833 and -0.776). Based on these results, it can be concluded that a waste management strategy for the area should focus on managing biodegradable organic waste, considering this constituent has the potential to impact the environment, type of collection equipments, transport mode and frequency of collection. Furthermore, the amounts of waste generated per households can be used to predict the total amount of vegetable waste generated within the municipality.
Keywords: Biodegradable Solid, waste management. Waste generation, Waste composition, Recycling

1. Introduction

Population growth, urbanization, economic development and the associated rising living standards and changing life style towards consumerism have led to increases in the quantity and complexity of municipal solid waste in cities in developing countries leading to severe environmental and human health consequences. The management of the growing volume of municipal solid waste poses formidable challenges to most of these countries. In the developed countries of the world, the characterization of waste forms the basis for management and intervention, since, a data base on the characteristics of the municipal solid waste being generated is a key component in the development of robust and cost-effective solid waste management policy and from such data models are available to predict waste generation patterns (Daskapoulous et al. 1998).

However, very little research has been done so far to develop models applicable in developing countries. Models are available to predict the gross waste generation capacity of countries and regions. But, these are not adequate for developing integrated waste management plans for municipalities, since waste generation patterns are unique to specific situations in the respective countries and regions. There is an urgent need for waste prediction models for suburban municipalities in developing countries, like Kano metropolis. Such cities are fast growing and lack basic infrastructure for waste management. Once developed, such information could be extrapolated to other communities with similar socio-economic conditions.

To develop models that will help in developing countries, information on the composition of municipal solid waste is required for understanding the pattern of generation but also, due to the need to estimate material recovery potential and identify sources of component generation, (Beukering *et al.,* 1999), choice of appropriate equipments the frequency of collection as well as the potential risks to the environment and human health (Nabegu, 2008a). Available data on the types of solid waste generated in most developing countries are incomplete, inconsistent and unreliable due to wide variations in data recording, definitions, collection methods and seasonal variations. This paper used the Person Product Moment Correlation to explore relationship between the components of the waste and the possible implication in formulating models that will guide the formulation

of sustainable waste management strategies.

2. Materials and Methods

2.1 Description of the Study Area

Kano is the largest city in the Sudan Region of West Africa. It is located between latitude 12^{o} 25 to 12^{o} 40N and longitude 8^{o} 35N to 8^{o} 45E. Kano city has for centuries been the most important commercial and industrial nerve centre attracting millions from all parts of the region and beyond. Immigration and natural growth rate of 3%, and increase economic activities is expected to continue to increase the population and waste stream in the years to come. Today Kano metropolis generates about 1, 0805,000 tons of solid waste per year or approximately 3050 metric tons per day (Nabegu, 2008b). By 2025, this figure is expected to increase to 1,825,000 tons per year, or 5000 metric tons per day. These are estimates and the real values are probably more than these quantities. The climate of the study area is the tropical wet and dry Aw by Koppen's classification. Climatic factors play a crucial role in the municipal waste management of the study area. For example, during the wet season, heat and humidity cause the municipal solid waste to be of higher moisture content thus increasing the weight of the refuse (Nabegu, 2008c). In addition, high humidity with heat causes the organic portion of the waste to decompose quickly leading to problems in handling and disposal, which directly affects the environmental health of the waste workers and the inhabitants (Kurupran, et. al., 2003).

2.2 Methods

The study was undertaken between March and May 2007 and was organized in stages as follows:

Stage 1: This stage involved a desk study in which documents and records relating to municipal solid waste management in Kano metropolis, by the Refuse Management and Sanitation Board (REMASAB) were studied to obtain archival as well as data on existing municipal solid waste composition in the city.

Stage 2: Twenty five residents each from three identified residential zones selected randomly. To determine sample locations within Kano metropolis, a basic knowledge of the urban area of Kano was helpful, guided by the assertion of Gordon (1983) that an urban area is usually defined to comprise of three levels within which data could be collected: - The city proper (in this study the old walled city): - Metropolitan transition area (in this study the G.R.A.) and urban agglomeration (in this study suburban area). Identified residential zones were subdivided into equal grids using Kano metropolis as base map. Table of Random Numbers was used to choose the study areas. These represented various residential, commercial, market, and industrial areas.

Stage 3: The general principles outlined by ASTM (1999) were followed. Trucks were randomly sampled at the main landfill situated on Court Road, and refuse was hand sorted into component categories.

Stage 4: The waste from identified bins in the households used in the study was thoroughly mixed. 100 kg of sample was collected. A quartering technique based on NEERI (Report, 1997) was used to obtain 12.5 kg. Using the quartering technique, the total waste mass was divided into four parts and waste from two diagonally opposite portions was taken and mixed. The other two portions were discarded. This procedure was repeated until a waste sample of approximately 12.5 kg weight was obtained.

Stage 5: Various components from the 12.5 kg sample, such as plastics, paper, metal, organic fractions, etc., were segregated and weighed, and these were expressed as a percentage of the total weight.

3. Results and Discussion

Table 1 shows the descriptive statistics of different categories of waste observed in the three residential zones of Kano metropolis. From the table, the skewness ranged from -0.714 to 0.744 showing data is normally distributed. From the samples of solid wastes collected in the three zones, eight different types of wastes were categorized. These are food scarp, paper cardboard, textile and rubber, plastic material, glass, metal, ash and dirt and vegetables. Analysis of waste type shows that Kano metropolis's solid waste consists to a large extent of organic and biodegradable matter (66 %) and the 34% non biodegradable typical of low income developing country (Ramachandra and Bachanda,2007). Thus, a waste management strategy for the city should focus on managing biodegradable organic waste, considering this constituent has the potential to impact the quality of leachate and gas generation if deposited in a unsanitary landfill as is the case now. The choice of equipments and frequency of

collection will also be impacted by the high organic content of the waste (Nabegu, 2008c).

3.1 Pearson Product Moment Correlation

Person Product Moment Correlation was employed to explore the relationship between different categories of solid waste in Kano Metropolitan. Preliminary analyses were performed on the raw data to ensure no violation of the assumption of normality and linearity, further, the equality of variance (homogeneity of variance) was checked using Levene test of homogeneity and revealed significant value greater than alpha value showing all variance are equal. Since there were eight bivariate pairs, Bonfereni adjusted alpha of 0.000625 (0.05/8) was used to test the null hypothesis of the bivariate pairs.

As depicted in table 2, there is strong positive relationship among the solid waste materials. There is positive correlation between food scrap, ash and vegetable (r = 0.852, 0.752). This shows that increase in food scrap waste may enhance the increase in ash and vegetable waste. This observation can be explained by the fact in developing countries there is a direct correlation between income and type of food consumed. The poor who are predominant in Kano metropolis consume fresh vegetables hence the predominance of food scrap this observation has been made in similar cities notably by AbuQadis, et.al.,(1997), Bandera,et.al.,(2007) among others and it is generally accepted that food scrap is typical of developing countries. Also, in Kano metropolis like similar areas in developing countries there is a direct correlation between income and type of energy use. Due to dearth and non availability of conventional urban energy sources the vast majority of residents in Kano use wood and charcoal as main energy sources leading to high content of ash . This has also been reported elsewhere by (Kurupatan et.al.,2003, Buerostro, et.al., 2008).

There is negative correlation between food scrap, paper cardboard, rubber, metals, plastic and glass (r = -0.847, -0.793, -0.853, -0.833 and -0.776). The negative correlation between food /vegetable and cardboard and other recyclable material is due to the fact that residents of Kano metropolis are typical of developing countries different from those of developed high income countries living in the modern semi-detached houses, which denoted the high prosperity level that generate far more waste per household. These households produced more packaging materials due to higher consumption of comestibles (Banar and Ozkar, 2008, AbuQadis et.al., 1997). Furthermore, the negative correlation between food/vegetable and other recyclables in Kano is due to high rate of recycling. In Kano metropolis, recycling and reuse is an important factor in waste. Though informally organized recycling is said to account for 40% of the waste stream in Kano metropolis (Nabegu,2009). The recycling and reuse takes place at different levels. Most of the materials do not even get to the waste stream – they are given to poorer and needy neighbors for reuse, or sold as high level recyclable and only the bad items are sent to the dust bin which are collected by the scavengers (ibid).

Although this study was not designed to determine, whether, an increase in one variable caused an increase in the value of a second variables. It would seem logical that to say that vegetables and ashes are more likely to increase when food scrap increase, due to the fact it has been shown that urban poverty continues to increase due in part to rapid immigration which is mainly by poor leaving derelict rural areas for the city. Kano metropolis is said to be increasing by 40% annually. The poor condition of the immigrants would suggest that the consumption pattern and energy use would remain fairly as it is which would mean increase in vegetable matter would translate in to more ash in the waste. Thus, the organic waste generation per household in Kano metropolis can be considered as a surrogate for living standards of occupants of the household. Also, according to (US EPA 1999), the composition of municipal solid waste varies significantly across a city and differences in the characterization and reporting of waste types also differ with some municipal authorities including construction and demolition waste and industrial waste as part of the municipal waste stream. Clearly this is the case in Kano where, the absence of physical planning means industrial, commercial and residential land uses are mixed and often it is difficult to separate sources and types of waste from these mixed land uses .Construction and demolition waste in Kano metropolis goes for recycling and reuse and is therefore hardly accounted in the waste stream. Also, basic infrastructure brings other variations in cities with unpaved or poorly paved streets that have large amounts of dust and dirt from street sweeping this is reflected in the suburban and city areas of Kano metropolis. Also, high amounts of organic waste in the GRA part of Kano metropolis was due to the number of trees and plants in the area.

4. Conclusion

To develop an effective waste management strategy for a given city, it is imperative to have an idea of the current and future composition of the waste stream. In this study, the data analyses showed that there is positive

correlation between food scrap, ash and vegetable (r = 0.852, 0.752). This shows that increase in food scrap waste may enhance the increase in ash and vegetable waste. There is negative correlation between food scrap, paper cardboard, rubber, metals, plastic and glass (r = -0.847, -0.793, -0.853, -0.833 and -0.776). Based on the study it can be concluded that a waste management strategy for the area should focus on managing biodegradable organic waste, considering this constituent has the potential to impact the environment, type of collection equipments, transport mode and frequency of collection. Also, the amounts of waste generated ash per households can be used to predict the total amount of vegetable waste generated within a municipality.

References

ASTM. (1999) Standard test method for determination of the composition of unprocessed municipal solid waste. *D 5231-92*, West Conshohocken, Pa.

Abu Qdais, H., Hamoda, M. F. & Newham, J. (1997). "Analysis of residential solid waste at generation sites". *Waste Management & Research, 15* (4), 395-406.

Banar, M. & Özkan, A. (2008). "Characterization of the municipal solid waste in Eskisehir City, Turkey". *Environmental Engineering Science, 25* (8), 1213-1219.

Bandara, N. J., Hettiaratchi, J. P., Wirasinghe, S. C. & Pilapiiya, S. (2007). "Relation of waste generation and composition to socio-economic factors: a case study". *Environmental Monitoring and Assessment, 135* (1-3), 31-39. 94

Buenrostro, D. O., Márquez-Benavides, L. & Pinette, G. F. (2008). Consumption patterns and household hazardous solid waste generation in an urban settlement in México. *Waste Management, 28* (1), S2-S6.

Beukering, P. V., Sehker, M., Gerlagh, R. and Kumar, V. (1999). Analysing Urban Solid Waste in Developing Countries: A Perspective on Bangalore. Collaborative Research in the Economics of Environment and Development (*CREED) and Environmental Economics Programme (IIED)*

Daskapoulos, E., Badr, O. & Probert, S. D. (1998). Municipal solid waste: A prediction methodology for the generation rate and composition in the European Union countries and the United States of America. *Resources, Conservation and Recycling, 24* (2), 155-166.

Gordon H.S. (1983) The Economic Theory of Common Property Resource. In R.K Dorfman (eds) *Economics of the Environment.* Methuen, London.

Kuruparan, P., Tubtimthai, O., Visvanathan, C. and Tränkler, J. (2003). Influence of Tropical Seasonal Variation, Operation Modes and Waste Composition on Leachate Characteristics and Landfill Settlement. *Proceedings of the Workshop on Sustainable Landfill Management, December 3-5, 2003, Centre for Environmental Studies,* Anna University, Chennai, India.

Nabegu, A. B. (2008a) An assessment of refuse management and sanitation board (REMASAB)s waste management in Kano metropolis. *Techno science Africana journal Vol.1, June.*

Nabegu , A.B (2008b) Municipal solid waste characteristics in three residential zones of Kano metropolis. *Maidugri Journal of Arts and Social Sciences. Vol. 6 pp199-210*

Nabegu, A.B (2008c)The organization of plastic waste recycling in Kano metropolis. *Techno science Africana journal Vol.2, pp89-9*

Nabegu, A.B. (2009) An Explanation of the informal plastic waste recovery process in Kano metropolis, Nigeria, using Gidden's Structuration theory. *Bayero Journal of Interdisciplinary Studies volume 1 Number 2 June 2009*

NEERI Report, 1997. Strategy Paper on Solid Waste Management in India.

Ramachandra, T.V. and Bachamanda, S. (2007) 'Environmental audit of Municipal Solid Waste Management',

Int. J. Environmental Technology and Management, Vol. 7, Nos. 3/4, pp.369–391.
USEPA. (1999) "Characterization of municipal solid waste in the United States: 1998 update." *Rep. No. 530-R-98-007*, U.S. Environmental Protection Agency Office of Solid Waste, Washington, D.C.,

Table 1 Descriptive Statistics of Variables under study

	Mean	SE	SD	Variance	Skewness	Kurtosis
Areas	2	0.15162	0.83045	0.69	0	-1.554
Food scrap	27.6	2.97136	16.2748	264.869	-0.736	-1.553
Paper Cardboard	15	2.49597	13.67101	186.897	0.742	-1.554
Textile Rubber	7	0.45486	2.49136	6.207	0	-1.554
Metals	9.3333	1.40878	7.71623	59.54	0.706	-1.554
Plastic materials	11	0.84418	4.62378	21.379	0.336	-1.554
Glass	6.6667	0.83506	4.57379	20.92	-0.117	-1.554
Ash	13	1.58296	8.6702	75.172	-0.714	-1.554
Vegetable	10.3333	1.52627	8.35973	69.885	0.252	-1.554

Table 2 Pearson Product Moment Correlation of Municipal Solid Waste

	Foodscrap	PaperCardboard	Rubber	Metals	Plastics	Glass	Ash	Vegetable
Areas								
Foodscrap	1							
PaperCardboard	-.847**	1						
Rubber	-.793**	.881**	1					
Metals	-.853**	.997**	.915**	1				
Plastics	-.833**	.944**	.988**	.966**	1			
Glass	-.776**	.855**	.999**	.892**	.978**	1		
Ash	.852**	-.998**	-.910**	1.000**	-.963**	-.887**	1	
Vegetable	.752**	-.821**	-.993**	-.862**	-.963**	-.998**	.856**	1

**. Correlation is significant at the 0.01 level (2-tailed).