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A Study of the Relationship between Environmental Sanitation and Effective Leadership

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Abstract: The annual report issued by the City of Tshwane for the financial year 2016/2017 shows that overall efficiency in the management of municipal solid waste generated by businesses operating in the various parts of Tshwane is undermined by the failure of businesses to comply with municipal bylaws. Businesses that operate in the various parts of Tshwane generate large volumes and varieties of municipal solid waste. The waste generated by businesses is not processed and recycled adequately. Private waste collectors do not play a major role in the processing and recycling of municipal solid waste. The key objective of study was to assess and evaluate the extent to which waste generated by businesses operating in Tshwane was collected, sorted and processed efficiently. The structural time-based model, log-linear analysis and factor analysis were used for identifying and quantifying the top 3 predictors of efficiency in the management of municipal solid waste. The study found that the key obstacle to the efficient management of municipal solid waste was lack of adherence to municipal bylaws on municipal solid waste management. The average time spent at waste collection site by a municipal waste collection truck was 1.22 minutes. The average time spent by a municipal waste collection truck for turning to and from a designated waste collection site to the nearest corner on the street was 0.11 minutes. The average time spent at the nearest intersection outside the business premises that took part in the study by municipal waste collection trucks was 0.23 minutes. The results showed that efficiency in waste management varied significantly by type of waste (23%) and geographical zone (18%).

Keywords: Waste management, Efficiency, Structural time based model, Log linear analysis, Factor analysis

Introduction and Background to Study

The purpose of study was to assess and evaluate predictors of efficiency in the management of municipal solid waste. The study was conducted in the City of Tshwane. According to Statistics South Africa, the population size of the City of Tshwane in 2011 was roughly equal to 3 million. The city is home to over 5, 000 businesses out of which 1, 603 businesses operate within the Central Business District of Tshwane, known as Pretoria (City of Tshwane, 2017). According to the City of Tshwane (2017), about 1, 734, 295 tons of solid waste is collected each year from businesses operating in the city. The solid waste produced by businesses in the city includes trash or garbage such as wood, product packaging, empty bottles, used tyres and car parts, and cans, garden refuse, furniture, clothing, leftover food, newspapers, wires, grease, appliances, paint, pieces of metal, broken containers, sheet metal and expired medicine. These businesses produce massive volumes of solid and liquid waste on a daily basis. Taxi ranks, bus stations, open flea markets, food outlets, and small businesses located in Pretoria are synonymous with litter, uncontrolled solid and liquid waste, as well as lack of capacity in the efficient management of waste. Passengers travelling in buses and taxis throw out trash through widows of moving vehicles. The collection, disposal and processing of waste produced by businesses and households is regulated by legislative policies. The study conducted by Allesch and Brunner (2014) indicates that the use of an integrated municipal solid waste management system is quite beneficial for improving overall efficiency in municipal waste management in almost all developed nations of the world. Chen, Yin, Wang and He (2014) shows that in order for an integrated waste management system to perform efficiently, all relevant stakeholders of the waste chain must play a mutually collaborative role in the collection, disposal, processing and management of waste.

The study conducted by Jambeck, Geyer, Wilcox, Siegler, Perryman, Andrady, Narayan and Law (2015) shows that the use of an integrated solid waste management system is essential for reducing the overall cost of waste management in developing cities worldwide. Lohri, Camenzind and Zurbrugg (2014) have pointed out that the promotion of health education on environmental sanitation and primary health care and a strict enforcement of municipal bylaws are vital for ensuring overall environmental cleanliness and the efficient management of waste in developing cities.

The study was prompted by a host of factors that are known to undermine environmental sanitation, cleanliness and efficiency in waste management in the City of Tshwane. Examples of such factors are poor infrastructural capacity, poor awareness about the benefits of proper waste management, lack of socioeconomic incentives to stakeholders relevant to the waste management chain, failure to adequately utilize modern waste management and processing technology, failure to vigorously enforce municipal bylaws on sanitation and waste disposal, and the absence of an integrated waste management system in Tshwane (Worku, Snyman & Muchie, 2014).

Objectives of Study

The overall objective of study was to assess and evaluate factors that undermine efficiency in the management of municipal solid waste in the City of Tshwane. The specific objective of study was to identify key predictors of efficiency in the management of municipal solid waste generated by businesses that operate in the City of Tshwane.

Methods and Materials of Study

The design of study was cross-sectional and descriptive. Data was collected from 1, 034 businesses on various variables that are known to affect efficiency in the management of municipal solid waste. Efficiency in solid waste management was assessed by using the model proposed by Tchobanoglous, Theisen and Vigil (1993) for estimating the median time required for the collection of solid waste from the businesses that took part in the study. The model measures efficiency in the collection of solid waste from fixed locations and containers based on the mathematical expression shown below in (1):

$$E = 1 - A + B \quad .... (1)$$

In (1), A denotes an off-route factor, and B is a measure of off-route activity time by individuals collecting waste. In cases where $A = B$, the collection of solid waste becomes perfectly efficient. The larger the difference between A and B, the less efficient becomes the waste collection procedure. The time required per trip is given by the expression shown below in (2):

$$t = \frac{t_1 + t_2 + Y}{1 - A} \quad .... (2)$$

In (2),

t is the time required for waste collection from a fixed site per trip

t_1 is equal to pick up time of container at the site of collection

t_2 is equal to on-site time per trip

Y denotes the total haul time during waste collection

X denotes the average round-trip haul distance per trip

Since the relationship between Y and X follows simple linear regression, we have $Y = \beta_0 + \beta X$ .... (3)

In (3), β_0 is the constant term in the simple linear regression of Y on X, and β is the regression coefficient in the simple linear regression of Y on X. In cases where waste is collected from fixed sites, the time required to collect waste per trip follows a stationary model, and is expressed by the expression shown below in (4):

$$t_1 = P + Q + R \quad .... (4)$$

In (4), P is the time taken to pick up a container that is full of solid waste;

Q is the time taken to unload an empty container; and

R is the time taken for driving from one container to the next container.

The number of trips per day is given by the expression shown below in (5):

$$n = Y(1 - A) - \frac{(t_3 + t_4)}{t} \quad .... (5)$$

In (5), variable t is the time required for waste collection from a fixed site per trip; t_3 is the time required to drive from dispatch station to first container location to be served by the day; and t_4 is the time required to drive from the last container location to be served by the day to the dispatch station.

The time taken per trip is given by the expression shown below in (6):

$$t_5 = \frac{t_6 - t}{Y} \quad .... (6)$$

In (6), variable t_6 is the number of trips made in a week. The number of trips made per week is given by the expression shown below in (7):

$$t_6 = \frac{K}{RQ} \quad .... (7)$$

In (7), variable K is a measure of the volume of waste generated in a week in cubic meters per kg; R is the average size of the container in cubic meters per kg; and Q is the weighted average container utilization factor.

Since $t = \frac{t_1 + t_2 + Y}{1 - A}$ as shown above in (2), it follows that

$$t_1 + t_2 + Y = (1 - A)t \quad .... (8)$$

Efficiency can thus be measured by the following relationship:

$$E = \frac{Y + t_1 + t_2 + Bt}{t} = \frac{(t_1 + t_2 + Y) + Bt}{t} = \frac{(1 - A)t + Bt}{t} = 1 - A + B$$

.... (9)

Values of E in the expression $E = 1 - A + B$ were calculated for each of the 1, 034 businesses that took part in the study. Businesses for which values of E fell below the median were used for identifying businesses in which efficiency in waste management was inadequate. Businesses for which values of E were greater than or equal to the median were used for identifying businesses in which efficiency in waste management was deemed adequate. That is,

$$\text{Overall efficiency} = \begin{cases} \text{Inadequate if score is below the median of } E \\ \text{Adequate if score is greater than or equal to the median of } E \end{cases}$$

Crosstab tests of associations (Hair, Black, Babin and Anderson, 2010) were used for screening variables. Log linear analysis (Agresti, 2017) and factor analysis (Pourahmadi, 2017) were used for identifying the top 3 predictors of efficiency in waste management. Multilevel analysis (Leyland and Goldstein, 2011) was used for estimating the extent of variation with regards to efficiency in the management of waste by geographical zone and type of waste generated by businesses that were selected for the study.

The degree of adherence to municipal bylaws and guidelines for the disposal of solid waste was measured by using a 2-point scale. The guidelines used for measuring adherence were the ISO 14000 and ISO 14031 guidelines for environmental management and performance monitoring in the management of waste and the environment (Scheinberg, Wilson & Rodic, 2010). At each of the 1, 034 businesses selected for the study, the degree of adherence to municipal bylaws and procedures recommended for solid waste management by businesses by the City of Tshwane was graded based on ISO 14000 and ISO 14031 guidelines. That is, at each business enterprise, binary grades (Adequate, Not adequate) were allocated as a measure of compliance according to criteria stipulated in ISO 14000 and ISO 14031 guidelines.

Results of Data Analyses

Table 1 shows a comparison between businesses that were efficient with regards to solid waste management with those that were not. It can be seen from the table that 857 of the 1, 034 businesses (83%) were efficient, while the remaining 177 businesses (17%) were inefficient. The table shows that a significant percentage of businesses located in the central and western parts of the city were inefficient, whereas businesses located in the eastern and northern parts of the city were by and large efficient. The table shows that 76% of operators who managed businesses that were efficient with regards to waste management have acquired formal education at college level or better. In general, businesses that are inefficient in the management of waste are relatively younger, poor in personal hygiene and cleanliness of premises, and are by and large commercial. The majority of old businesses (6 years or more) are efficient in waste management. Businesses that are operated by owners are more efficient in comparison with businesses that are operated by employed managers. Utilization of private contractors for waste removal and management, regular inspection of premises by municipal workers, familiarity with the South African White Paper on waste management, source reduction of waste, good perception on the benefits of proper waste management, and adherence to waste management regulations recommended by the municipality are much more common among businesses that are efficient in waste management.

Table 1: Comparison with regards to overall efficiency in waste management

Characteristic	**Efficient (n=857)**	**Inefficient (n=177)**
Category of business	Agricultural: 1% Commercial: 71% Construction: 6% Industrial: 11% Institutional: 2% Municipal: 6% Manufacturing: 3%	Agricultural: 1% Commercial: 83% Construction: 3% Industrial: 3% Institutional: 3% Municipal: 5% Manufacturing: 2%
Geographical location of business in the City of Tshwane	Central: 31% East: 21% West: 19% North: 17% South: 12%	Central: 41% East: 13% West: 23% North: 13% South: 10%
Age of business in years	Less than a year: 5% 1 to 2 years: 6% 3 to 5 years: 29% 6 years or more: 60%	Less than a year: 34% 1 to 2 years: 35% 3 to 5 years: 15% 6 years or more: 16%
Status of business operator	Owner: 76% Manager: 24%	Owner: 31% Manager: 69%
Level of education of operator	College level or better: 76% High school level or less: 24%	College level or better: 39% High school level or less: 61%
Gender of operator	Male: 76% Female: 24%	Male: 73% Female: 27%
Use of private contractor for waste management	Yes: 23% No: 77%	Yes: 16% No: 84%
Sorting waste	Yes: 76% No: 24%	Yes: 45% No: 55%
Adherence to waste management regulations	Yes: 95% No: 5%	Yes: 52% No: 48%

Personal hygiene	Excellent: 9% Very good: 43% Satisfactory: 37% Less than satisfactory: 10% Poor: 1%	Excellent: 0% Very good: 21% Satisfactory: 41% Less than satisfactory: 33% Poor: 5%
Perception on the benefits of proper waste management	Excellent: 3% Very good: 56% Satisfactory: 35% Less than satisfactory: 5% Poor: 1%	Excellent: 1% Very good: 6% Satisfactory: 29% Less than satisfactory: 55% Poor: 9%
Source reduction of waste	Yes: 80% No: 20%	Yes: 52% No: 48%
Amount of waste generated in 1, 000 kg per week	≤ 0.9: 25% 1 to 1.9: 46% 2 to 4.9: 27% 5 to 9.9: 2% ≥ 10: 0%	≤ 0.9: 49% 1 to 1.9: 42% 2 to 4.9: 8% 5 to 9.9: 1% ≥ 10: 0%
Enough trash cans available for customers	Yes: 77% No: 23%	Yes: 46% No: 54%
Regular inspection of premises by municipality	Yes: 84% No: 16%	Yes: 41% No: 59%
Familiarity of operator with White Paper on Waste Management	Yes: 86% No: 14%	Yes: 28% No: 72%

Table 2 shows the time needed for picking up waste from businesses. The speed at which waste was collected from businesses by municipal waste collection trucks was measured in minutes at each of the businesses selected for the study. The results showed that the average deviation from regular pick up time was equal to 8.89 minutes. Deviation represents the difference between the time when waste is regularly picked up by municipal trucks and the earliest or latest time at which waste is actually picked up by the trucks from business premises. The average pickup time per trip (the average time taken by municipal waste collection trucks for picking up waste from waste storage bins, and emptying the waste to the container on the back of the truck) was 1.56 minutes. The average drop down time per trip (the average time taken by municipal waste collection trucks for dropping down waste stored in the container at the back of the municipal truck at designated municipal waste disposal sites) was 1.69 minutes.

Table 2: Time needed for picking up waste from businesses

Task performed by municipal waste collectors in Tshwane	Time required to accomplish task in minutes	Standard Deviation of estimation
Average deviation from regular pick up time	8.89	12.969
Average pickup time per trip	1.56	0.412
Average drop-down time per trip	1.69	0.389
Average at-site time per trip	1.22	0.259
Average time spent at intersections	0.23	0.524
Average time spent at turns	0.11	0.235

The average at-site time per trip (the average time spent at waste collection site by a municipal waste collection truck) was 1.22 minutes. The average time spent at turns (the average time spent by a municipal waste collection truck for turning to and from a designated waste collection site to the nearest corner on the street) was 0.11 minutes. The average time spent at the nearest intersection outside the business premises that took part in the study by municipal waste collection trucks was 0.23 minutes.

Two-by-two Pearson chi-square tests of associations (Hair, Black, Babin and Anderson, 2010) were used for screening valuable predictor variables. Table 3 shows a list of 15 factors that are significantly associated with poor or less than satisfactory waste disposal at the 0.001 level of significance. In each of the tests, the outcome variable of study, Y, was defined as follows:

$$\text{Overall efficiency} = \begin{cases} \text{Inadequate if score is below the median of } E \\ \text{Adequate if score is greater than or equal to the median of } E \end{cases}$$

At the 0.001 level of significance, significant associations are characterized by large observed chi-square values and P-values that are smaller than 0.001. Table 3 provides a list of 15 variables that are significantly associated with inefficient waste management. At the 0.001 level of significance, all 15 variables shown in Table 3 are significantly associated with overall efficiency in the management of waste. It can be seen from the table that the top 5 significant variables are: lack of adherence to municipal bylaws and regulations, wrong perception on the potential benefits of proper waste management, failure of businesses to provide customers with enough trash cans, the status of the business operator (owner or employee), and the frequency at which business premises are inspected by municipal sanitation and health workers, in a decreasing order of strength.

Table 3: List of top 15 significant associations from Pearson's chi-square tests of associations with overall efficiency in waste disposal (P < 0.001)

Variable of study associated with overall efficiency in waste management	Observed chi-square value	P-value
Adherence: Degree of adherence to waste management regulations	716.04	0.0000
Perception: Perception on the benefits of proper waste management	705.99	0.0000
Trashcan: Availability of enough trash cans for customers	701.42	0.0000
Status: Status of person operating business (owener or employee)	469.21	0.0000
Frequency: Frequency at which business premises are inspected by municipality	299.57	0.0000
Hygiene: Personal hygiene of employees at business premises	251.72	0.0000
Maintenance: Degree of maintenance of trash bins and their environment in business premises	167.09	0.0000
Cleanliness: Degree to which business premises are kept clean	139.88	0.0000
Education: Level of education of business operator	127.52	0.0000
Inspection: Regular inspection of premises by municipal workers	115.14	0.0000
Volume: Volume of waste generated	109.59	0.0000
Contractor: Use of private contracors for waste management	104.44	0.0000
White Paper: Familiarity with White Paper on waste management	103.87	0.0000
Implement: Degree to which a waste management plan is implemented	100.11	0.0000
Sort: Sorting waste generated at source	93.12	0.0000

Legend: Significance of association at * P<0.05; ** P<0.01; *** P<0.001

Results Obtained from Log-Linear Analysis

Data analysis was performed by using log-linear analysis (Agresti, 2017) in order to identify key predictor variables that were significantly associated with each other. Log-linear models are hierarchical in nature. In general, there could be an interaction of order k. At k successive steps, interactions of order k (the highest order), k-1, k-2… 3, 2 and 1 (the main effects) are tested for significance step by step. The most useful order is k=2. Table 4 shows results obtained from log-linear analysis.

Table 4: Results obtained from log-linear analysis

Significant interactions of order two with efficiency in waste management	P-value
Poor adherence to municipal bylaws on municipal solid waste management	0.0000
Wrong perception on the benefits of proper waste management	0.0000
Failure to provide trash cans to customers at business premises	0.0000

The above results were tested on interactions of order k=2. It can be seen from the table that at the 0.05 level of significance, all 3 predictor variables in Table 4 are highly significant. That is, overall efficiency in waste management is significantly undermined by 3 factors. These 3 factors are poor adherence to municipal bylaws on municipal solid waste management, wrong perception on the benefits of proper waste management, and failure to provide trash cans to customers at business premises.

Results Obtained from Factor Analysis

Factor analysis (Pourahmadi, 2017) was used for identifying key predictors of efficiency in municipal solid waste management based on principal component analysis. For studies that are based on large sample sizes, factor analysis is ideal for performing data reduction. The method enables researchers to reduce a large number of explanatory variables to a smaller set of underlying factors that significantly account for variability in the dependent variable of study. In this study, factor analysis was based on principal components analysis, computation of Eigen values and the percentage of variance explained by each predictor variable selected for estimation. Influential predictor variables are characterized by Eigen values that differ from the number 1 significantly and a sizeable percentage of explained variation. The predictor variables constituting the fitted factor model should account for at least 75% of the total variability in the dependent variable of study. Factor solutions were rotated and principal components analysis was performed. The procedure produced a 3-factor optimal model in which the predictor variables in the fitted 3-factor model accounted for 84.38% of the total variability in the dependent variable of study. The Cronbach Alpha test was used for ensuring internal consistency and reliability. All Cronbach Alpha coefficients estimated from analysis were above 0.75 in magnitude, thereby showing that the tools used for the measurement of efficiency in municipal solid waste management were theoretically reliable. Bartlett's test of Sphericity was used for testing the adequacy of the correlation matrix, and gave an estimate of 0.859, a figure that was greater than the cut-off point of 0.75, thereby confirming the suitability of factor analysis.

Table 5: Estimates obtained from the Kaiser-Meyer-Olkin and Bartlett's test

Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy	**0.873**
Observed value of chi-square statistic for KMO test	1029.06
Bartlett's Test of sphericity degrees of freedom	279
P-value for Bartlett's Test of sphericity degrees of freedom	0.000

Table 6 shows estimates for the top 3 predictors of efficiency in municipal solid waste management. The table shows Eigen values and percentage of variance explained by each one of the 3 extracted factors. Extraction was done by using principal components analysis. The table shows that each one of the 3 predictor variables is significant at the 5% level. The Eigen value of each of the 3 predictor variables is significantly greater than 1, thereby indicating that each predictor variable is highly valuable in explaining variability in the dependent variable of study (efficiency in the management of municipal solid waste). The percentages of variance explained by each one of the 3 extracted factors is significant. The 3 predictor variables account for 84.38% of the total variability in the dependent variable of study. This figure is above 75%, and shows that the fitted 3-factor model is theoretically reliable.

Table 6: Top 3 predictors of efficiency estimated from factor analysis

C Extracted factor	Eigen value	Percentage of explained variance in viability	Cumulative percentage of explained variance
Poor adherence to municipal bylaws on municipal solid waste management	4.59	32.49	32.49
Wrong perception on the benefits of proper waste management	3.67	27.07	59.56
Failure to provide trash cans to customers	2.91	24.82	84.38%

The results in Table 6 show estimates for the percentage of variance explained by the 3 factors that were extracted by using the principal axis factoring method. Each of the 3 extracted factors has an Eigen value of magnitude greater than 1, thereby indicating its level of importance in terms of accounting for viability in business. The 3 extracted factors collectively account for 84.38% of the total variability in the dependent variable of study (efficiency in municipal solid waste management). Based on the estimates shown in Table 5, it can be concluded that efficiency in the management of municipal solid waste is significantly and adversely affected by 3 factors (lack of adherence to municipal bylaws on municipal solid waste management, wrong perception on the benefits of proper waste management, and failure to provide trashcans to customers in business premises). The 3 factors listed above account for 84.38% of the total variability in the dependent variable of study. This figure is above 75%. As such, the fitted 3-factor model is reliable enough.

Multilevel analysis (Leyland and Goldstein, 2011) was used for estimating the extent of variation with regards to efficiency in the management of waste by geographical zone and category of business enterprise. The results showed that 23.05% of the total variation in efficiency was due to differences among the various types of waste. The results also showed that businesses within the same category of waste and geographical location were equally efficient in the management of solid waste.

Discussion of Results

Results obtained from data analyses indicate that efficiency in the management of municipal solid waste is undermined by failure to enforce municipal bylaws and regulations, and inability to appreciate the potential benefits of proper waste collection and disposal. Similar findings have been reported about developing municipalities in Sub-Saharan African countries (Babatunde, Vincent-Akpu, Woke, Atarhinyo, Aharanwa, Green and Isaacjoe, 2013). The City of Tshwane needs to enforce municipal bylaws on environmental sanitation and proper waste collection and disposal. Private waste collectors should be given an incentive to collect, recycle and sort items such as packages, empty bottles and cans, grass clippings, furniture, clothing, left-over food, newspapers, appliances, paint, batteries and pieces of metals. According to the South African National Department of Environmental Affairs (2017), the disposal and combustion of municipal solid waste is conducted by the use of landfills, the conversion of non-recyclable waste materials into useable heat, electricity, or fuel, combustion, and transfer stations. Although the use of such mechanisms is consistent with the municipal bylaw in the City of Tshwane, the mechanisms have been poorly utilized mostly due to lack of infrastructural development and technical skills (Snyman & Vorster, 2011).

Adelapo, Haris, Alo, Huddersman and Jenkins (2017) have reported that the failure of local municipalities to enforce municipal bylaws on waste collection and disposal is a key obstacle to cleanliness and environmental sanitation in almost all developing nations. Based on a study conducted in Spain, Fernandez-Nava, Del Rio, Rodriguez-Iglesias, Castrillon and Maranon (2014) have proposed a framework that could be used for enhancing efficiency in municipal solid waste management. The framework proposes the provision of economic incentives to private waste collectors and utilisation of modern waste recycling and processing techniques. The results are expected from a typical Sub-Saharan African country in which poverty, unemployment, massive immigration into urban centres prevail (Adeniran, 2015; Nazari, Kalantari, Ghasemi & Jalili Ghazizade, 2017; Park & Lah, 2015; Zen, Subramaniam, Sulaiman, Saleh, Omar, & Salim, 2016; Zhou, Meng, Long, Li & Zhang, 2014). Suburbs of Tshwane such as Mamelodi and Marabastad are characterised by the accumulation of waste and poor service delivery. Generally, awareness and regard for environmental sanitation is poor in black suburbs and townships. Environmental hazard is caused by the arbitrary use of landfill sites. Green waste from landfills produces potentially harmful gasses such as methane and leachates. Such products pollute water reservoirs in the city. The study by Snyman and Vorster (2011) has found that composting and the pre-treatment of municipal waste before landfilling are viable options for the City of Tshwane. A report published by the United States Environmental Protection Agency (2017) shows that composting and pre-treatment of municipal waste before landfilling significantly reduces the volume of solid waste and contributes for overall environmental sanitation. At the moment, the City of Tshwane does not have adequate capacity for large scale composting, and there is an acute need for addressing this shortcoming.

The efficient management of solid waste produced by enterprises that conduct business in the various parts of the City of Tshwane has numerous economic, sanitary and health-related benefits to the inhabitants of the city. Disposing of waste in landfills is much better than using open dumps. Up until recently, emphasis has been placed on waste disposal, and not on management, recycling and composting. Poor management of waste has an adverse impact on the environment and public health, particularly in townships such as Mamelodi, Marabastad, Soshanguve and Attridgeville. In these townships, waste is managed poorly, and landfills are inappropriately sited, designed, managed and operated. Until recently, the management of waste generated by businesses operating in the city has not been given due consideration. The waste management that took place focused mainly on waste disposal and was reactive in that it addressed needs as they occurred. Holistic, integrated waste management planning was poorly done. The low priority that was historically accorded to waste management has resulted in waste impacting detrimentally on the South African environment and on human health. Standards for medical waste incinerators are generally inadequate in comparison with international best practice.

The study conducted by Worku, Snyman and Muchie (2014) has shown that efficient municipal solid waste management requires collaboration with all relevant stakeholders as well as the use of a community based awareness campaign about the potential benefits of proper waste collection and disposal. The authors have shown that the promotion of health, environmental and sanitary education, the provision of incentives to private waste collectors, and a strict enforcement of municipal bylaws are vital for ensuring cleanliness in the various parts of the City of Tshwane. Based on findings obtained from the study, the City of Tshwane must produce and implement an integrated plan for the management of municipal solid waste in collaboration and partnership with the relevant stakeholders in the city so that each of the role players in the waste management chain can investment adequately in basic environmental sanitation. There should be a fresh investment on infrastructure and modern waste management equipment and technology. Adequate capacity must be built for commercial composting.

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