Amity Journal of Management Research

Efficient Integrated Solid Waste Management System for MC Municipality in Zimbabwe

Ruth Nedziwe & Stanley Murairwa
Africa University, Mutare, Zimbabwe

Abstract

The increasing population, booming economy, rapid urbanisation and the rise in community living standards have greatly accelerated the generation of municipality solid waste. The developments have created challenges in the management of solid waste in most poorly resourced municipalities in many underdeveloped and developing economies. The research evaluated the effectiveness of the MC municipality solid waste management system (MC-MSWMS) in Zimbabwe. The MC municipality solid waste management system collects, sorts and disposes the solid waste. The Voluntary sampling design was used to select the respondents for the research. The research discovered that the current MC municipality solid waste management system was ineffective due to budget constrains which were hindering the acquisition of new sophisticated solid waste management equipment and employment of competent staff members. The other factors affecting the solid waste management system's efficiency were lack of collection routines, disintegrated solid waste management sub-systems and lack of skilled human capital to cope with the increasing generation and accumulation of solid waste due to rapid increase in population. The research advocates for the adoption of an integrated municipality solid waste management system (IMSWMS), prioritisation of collection of most produced solid waste and increasing of the solid waste collection frequencies in high solid waste generation sources. The adoption of the development would enable the participation of all relevant stakeholders in enhancing the performance of the MC municipality solid waste management system.

Key words: Solid Waste Management System, Municipality, Efficient Solid Waste Management System, Integrated Solid Waste Management System, Solid Waste

JEL: Q5, Q52

Paper classification: Research Paper

Introduction

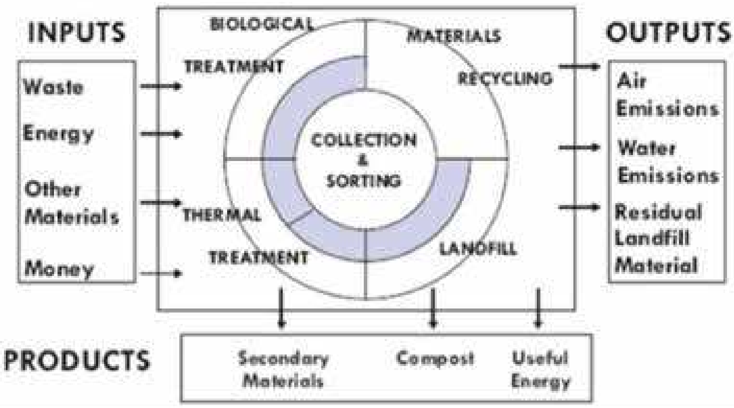
Throughout history, solid waste has been generated by humans (Barbalace, 2013). Solid waste is any solid material that is discarded from the household, commercial, institutional and industrial processes arising from human activities which no longer have value to those who possess it and is rendered useless. In the early stages of life, solid waste was not a major threat to human life as land was sparse and plentiful. However, following the onset of industrialisation and the sustained urban growth of large populations, the volume of solid waste has increased immensely globally and it has posed aggressive environmental and health impacts. Shafiul and Mansoor (2003) stated that solid waste became problematic due to the rise of cities and towns where large numbers of people started to congregate in relatively small areas in pursuit of livelihoods. While the cities' population densities per capita increased, the generation of solid waste increased likewise, hence, solid waste management emerged as an essential specialised sector in an attempt to keep the cities healthy and clean. The four common basic means of dealing with solid waste that have been used repeatedly in history are recycling, burning, landfilling and compositing. The municipality solid waste management (MSWM) refers to source separation, storage, transportation and final disposal in an environmentally sustainable manner. This brought the idea of the MSWM system (MSWMS) which has been evolved into different models for example, the waste management pyramid (McDougall, White, Franke, & Hindle, 2001). In light of all this, the research viewed the MSWM as an important environmental system that is an integral part of the basic urban service. This is because the environmental and health impacts of poor or inefficient MSWMS are very damaging to people exposed to unhealthy conditions. Diseases such as typhoid, cholera, dysentery and malaria, are all associated with poor solid waste management. The MSWM has emerged to be a major challenge to most urban and rural local authorities in Zimbabwe as evidenced by the outbreak of cholera in 2007 (Tsiko & Togarepi, 2012).

The increasing population, booming economy, rapid urbanisation and the rise in community living standards, have greatly accelerated the rate of generation of solid waste in developing countries such as Zimbabwe. For instance, the MC municipality had a living population of about 1 755 000 people (ZimStats, 2012) which constituted about 13.5% of the country's total population. It had an average household of 4.2 persons and putting this in line with the average solid waste produced by one person per day, a municipality household produces an estimate of 6.3 kilograms of garbage per day and thus, a population of 1 755 000 gives an insight of the solid waste accumulation rate. This excludes the Small and Medium Enterprises that have rapidly increased due to high unemployment caused by closing of formal companies in Zimbabwe. The increased generation of solid waste is not the problem but it is the management of the generated solid waste. The rapid urban population growth during the last decade, coupled with hyperinflation, economic decline and a fall in both capital and recurrent real budgets of local authorities, among other factors, placed considerable strain on local authorities' resources, resulting in the failure to provide adequate services to their residents and areas under their jurisdiction. Kaseke (2005) stated that solid waste management was a major problem in Zimbabwe's towns and cities and the problem was increasing due to urbanization, population growth, industrialisation and increased use of non-biodegradable plastics and bottles. Mangundu, Makura, Mangundu and Tapera (2013) traced the mismanagement of the municipality solid waste back to the attainment of Zimbabwe's independence in 1980. This resulted in the easing of colonial policies which were restrictive in terms of population movements from rural to urban areas. Most of these people settled in high density suburbs which were characterised by illegal dumping due to irregular solid waste collection schedules. This has raised questions in the functionality of the MSWM systems that are being harnessed to deal with massive volumes of waste being generated both at local and national levels. Zimbabwe as a nation is producing an estimated average of 2.5 million tonnes of municipality solid waste per annum (TARSC & CFH, 2010). Of the produced solid waste, the quantity collected by municipalities was reported to have decreased from 80% of total solid waste across different municipalities in the mid-1990s to as low as 30% of total solid waste in some large cities and small towns in 2006 (TARSC & CFH, 2010). As a result, the 70% of the 2.5 million tonnes of solid waste ended up being dumped in residential areas and at undesignated areas which caused other problems such as leachate, air and land pollution and major environmental, economic and health related problems. An example of health issues include cholera outbreaks in 2008 (Tsiko & Togarepi, 2012) and typhoid cases in Mutare (Zuze, 2017). The objectives of the research were to ascertain the types and sources of solid waste that are managed by the MC municipality, the sub-systems of the MC municipality solid waste management system (MC-MSWMS) and the effectiveness of the sub-systems of the MC-MSWMS.

Literature Review

An individual produces almost half a tonne of the municipality waste annually in the European Union (Sinkevicius, 2020). The waste management systems should be optimised (Brunner & Stanisavljevic, 2020). The anchor theory of this research is the integrated system in Figure 1 by McDougall, *et al*. (2001) and revised by Nordone, *et al*. (2007).

Figure 1: Integrated Solid Waste Management (McDougall, White, Franke, & Hindle, 2001)



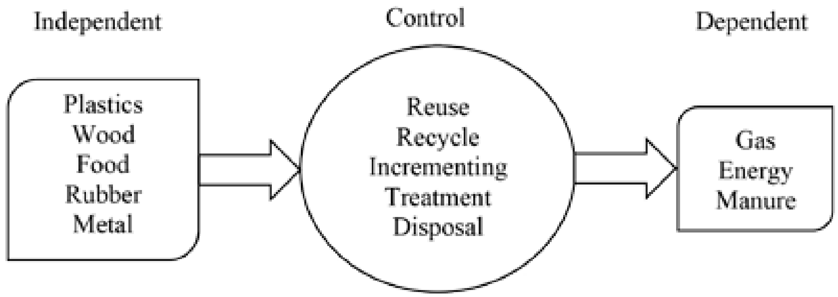
The shaded area in Figure 1 shows the region where energy is produced. The idea behind this framework was to show the three major parts of a typical integrated SWMS which are the inputs, processing and outputs. According to Nordone, *et al*. (2007), the processing stage has been combined with many other theories in the past to form a more comprehensive system. For instance, the idea of combining the prototype with the life cycle assessment was to evaluate a city or nation's future MSWMS options. A number of researchers such as Tallentire and Steubing (2020) have recently adapted Figure 1. The main objective of developing an integrated solid waste management system is to reduce the impact of the challenges caused by cumulating solid waste which (Dao-Tuan, Nguyen-Thi-Ngoc, Nguyen-Trong, Bui-Tuan and Dinh-Thi-Hai (2018) described as worsening. Awuchi, Awuchi, Amagwula and Igwe (2020) presented a waste hierarchy with three main aspects, namely, reduce, reuse and recycle. The different types of industrial waste are listed in Awuchi and Awuchi (2019a; 2019b).

Methodology

(a) Research Type: A descriptive survey method was used since only the staff members of one municipality participated in providing the research data. The research used both qualitative and quantitative data to address the research objectives.

(b) Research Variables: The variables and their interaction in this research are presented in Figure 2.

Figure 2: Interaction of the Research Variables



(c) Research Population: The MC municipality's Health and Housing department had 864 staff members. The target population was the sub-department of Refuse Collection which had 64 staff members. The sub-department was purposively selected because it is the sub-department that is mandated to manage the MC-MSWMS and the sustainability of its environment.

(d) Research Sample: The research selected a large sample of 32 staff members from the MC municipality's Refuse Collection sub-department.

(e) Sampling Technique: The research applied Voluntary sampling design (Murairwa, 2019; 2015) to select 32 volunteered MC municipality's Refuse Collection sub-department staff members for providing the research data.

(f) Data Collection Method: A questionnaire was distributed to volunteered MC municipality's Refuse Collection sub-department staff members to complete and return while the researchers were waiting. This was followed up by face to face interviews in order to understand in detail how the MC-MSWMS works.

(g) Data Analysis Tools: The research used the performance percentage score to rank the performance of the MC-MSWM sub-systems. The performance score (*PS*) was calculated with:

$$PS = \frac{x_i}{N} \times 100, \qquad (1)$$

where x_i is the number of the MC municipality staff members who selected the question's i^{th} response and N is the total number of staff members who responded to the question. The difference of two proportions test was applied to test the hypothesis H_0: The effective and ineffective vote proportions are statistically not different versus H_1: The effective and ineffective vote proportions are statistically different. Murairwa (2019; 2016) computed the test value for the difference between two proportions with:

$$Z = \frac{(\hat{p}_1 - \hat{p}_2) - (\pi_1 - \pi_2)}{\sqrt{\frac{1}{n_1} + \frac{1}{n_2}\left(\bar{p}(1 - \bar{p})\right)}}, \qquad (2)$$

where π_1 is the hypothesised first population proportion, π_2 is the hypothesised second population proportion, $\hat{p}_1$ is the effective response proportion, $\hat{p}_2$ is the ineffective response proportion, $\bar{p}$ is the pooled effective and ineffective response proportions, n_1 is the number of respondents who voted effective (sample 1) and n_2 is the number of respondents who voted ineffective (sample 2). The pooled research vote proportion ($\bar{p}$) is calculated with:

$$\bar{p} = \frac{x_1 + x_2}{n_1 + n_2}, \quad (3)$$

where, $x_1 = \hat{p}_1 n_1$, $x_2 = \hat{p}_2 n_2$, n_1 is the number of respondents who voted effective (sample 1) and n_2 is the number of respondents who voted ineffective (sample 2). A Pearson's Chi-square test was implemented to test the hypothesis H_0: The MC-MSWMS was effective versus H_1: The MC-MSWMS was ineffective. Murairwa (2010) calculated the Pearson's Chi-square test value with:

$$\chi^2_{calc} = \sum \frac{\left(O_{ij} - E_{ij}\right)^2}{E_{ij}}, \quad (4)$$

where *E* and *O* are the expected and observed frequencies respectively. The *i* and *j* index the row and column of the contingency table of the research data.

Data Analysis

The questionnaire's response rate is presented in Figure 3.

Figure 3: Questionnaires' Response Rate

Figure 3 shows a questionnaire return rate of 73.33%. Of the 73.33% questionnaires returned, 71.11% were fully completed and these were analysed for this research. The 2.22% questionnaires were incomplete and could not be analysed for this research. About 26.67% of all the questionnaires distributed were not retained. Of the 71.11% respondents, 46.88% and 53.12% were females and males respectively. The percentage distribution of the respondents by gender and marital status is presented in Table 1.

Table 1: Respondents' Percentage Distribution by Gender and Marital Status

Marital Status	Gender		
	Female	Male	Total
Single	6.25	12.50	18.75
Married	34.38	34.38	68.75
Divorced	3.13	6.25	9.38
Widowed	3.13	0.00	3.13
Total	46.88	53.13	100.00

Table 1 shows the percentage distribution of the respondents by gender and marital status. Of all the respondents who completed the questionnaires, 12.50% of males were single, 34.38% of females and 34.38 of males were married; 3.13% of females and 6.25% of males were divorced while 3.13% of females were widowed. It should be noted however that the differences between the gender distributions are statistically insignificant. Therefore, males and females were equally represented at all marital status levels in this research. The distribution of the respondents by gender and education is presented in Table 2.

Table 2: Respondents' Percentage Distribution by Gender and Education

Education	Gender		
	Female	Male	Total
O Level	12.50	6.25	18.75
A Level	6.25	12.50	18.75
Diploma	12.50	15.63	28.13
Degree	9.38	9.38	18.75
Masters	6.25	9.38	15.63
Total	46.88	53.13	100.00

Table 2 shows that 12.50% of females had "O" level certificates, 12.50% of males had "A" level certificates as compared to 6.25% of female respondents. Of all the respondents, 15.63% of males and 12.50% of females had diplomas. The respondents who had degrees and masters qualifications were 18.75% and 15.63% respectively. The percentage distribution of the respondents by gender and position is presented in Table 3.

Table 3: Respondents' Percentage Distribution by Gender and Position

Position	Gender		
	Female	Male	Total
Clerk	9.38	15.63	25.00
Manager	3.13	12.50	15.63
Secretary	3.13	0.00	3.13
CEO	0.00	3.13	3.13
Operations	31.25	21.88	53.13
Total	46.88	53.13	100.00

Table 3 shows that 25.00% of the respondents were clerks and 15.63% were managers who were directly involved in the day to day running of the MC-MSWMS. Of all the respondents, 3.13% were secretaries, 3.13% were CEOs and 53.13% respondents were in the Operations section of the Refuse Collection sub-department. The percentage distribution of the respondents by age and marital status is presented in Table 4.

Table 4: Respondents' Percentage Distribution by Age and Marital Status

Marital status	Age range			
	18 – 25	26 – 35	36 – 55	Total
Single	18.75	0.00	0.00	18.75
Married	6.25	28.13	34.38	68.75
Divorced	3.13	3.13	3.13	9.38
Widowed	0.00	0.00	3.13	3.13
Total	28.13	31.25	40.63	100.00

Table 4 shows that 18.75% of the respondents were single while 6.25% of the ages 18-25 years were married. Of the ages 26 – 35 years, 28.13% were married and 34.38% of the ages 36 – 55 years were married while 3.13% of the ages 18 – 25 years and 36 – 55 years were divorced. Of all the respondents, 3.13% were widowed and were of the ages 36 – 55 years. The research investigated the percentage distribution of the respondents by age and position and presented the results in Table 5.

Table 5: Respondents' Percentage Distribution by Age and Position

Position	Age range			
	18 – 25	26 – 35	36 – 55	Total
Clerk	6.25	15.63	3.13	25.00
Manager	0.00	6.25	9.38	15.63
Secretary	0.00	0.00	3.13	3.13
CEO	0.00	0.00	3.13	3.13
Operations	18.75	9.38	25.00	53.13
Total	28.13	31.25	40.63	100.00

Table 5 shows that 6.25%, 15.63% and 3.12% of the respondents of the ages 18-25, 26-35 and 36-55 years respectively were clerks. Of all the respondents, 15.62% were managers who were working in the Refuse Collection sub-department. On the other hand, 6.25% and 9.38% of the managers (15.62%) were of the ages 26-35 and 36-55 years respectively. Among the respondents, 3.25% were secretaries of the ages 18-25 years and 3.25% were CEOs of the ages 36-55 years. Of all the respondents from Operations section 53.12%, 18.75%, 9.37% and 25.00% were of ages 18-25, 26-35 and 36-55 years respectively.

Research results and discussions

The research established the types of solid waste that the MC-MSWMS was managing and presented the results in Figure 4.

Figure 4: Types of Solid Waste Collected by the MC-MSWMS

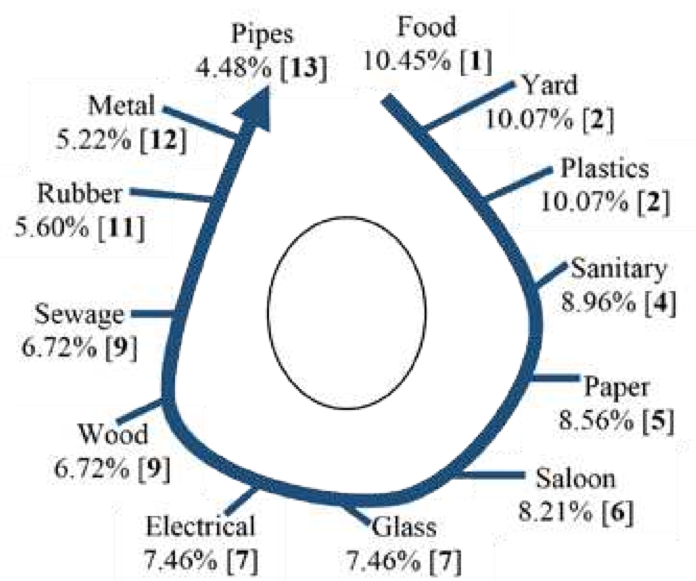


Figure 4 shows thirteen types of solid waste that were generated by the MC municipality residents. Figure 4 also shows the ranking of the types of the solid waste by the votes of the respondents. The most generated solid waste was Food (10.45%), followed by both Yard (10.07%) and Plastics (10.07%). The least generated solid waste was pipes (4.48%). The results confirm some of the findings by Brunner and Stanisavljevic (2020), Awuchi and Awuchi (2019a; 2019b) and Tallentire and Steubing (2020) on the types of industrial waste. The research established the sources of the municipality solid waste and presented the results in Table 6.

Table 6: Sources of MC Municipality Solid Waste

Solid waste source	Score	Rank
Multiple family	10.20	1
Single family	8.63	2
Hotels	8.63	2
Restaurants	8.24	4
Stores	7.45	5
Markets	7.45	5
Schools	7.45	5
Office buildings	7.06	8
Saloon	7.06	8
Government buildings	7.06	8
Street cleaning	6.67	11
Prisons	6.27	12
Parks	3.92	13
Landscaping	3.14	14
Recreational areas	0.78	15

Table 6 shows the solid waste sources and the estimated percentage of daily quantities that were generated from each of the solid waste sources. The research ranked the solid waste sources from the one which produces the most solid waste to the one which produces the least solid waste per day. The MC municipality should introduce penalty for producing extra volume of solid waste to a predetermined volume. The suggestion supports the practice in other areas such as Taipei (Awuchi, Awuchi, Amagwula, & Igwe, 2020). The MC municipality should devise appropriate methods of collecting the solid waste in order not to spread the COVID-19. The MC municipality solid waste sources are presented in Table 7.

Table 7: Sources of MC Municipality Solid Waste

Sources	None	Very little	Some	Quite a bit	Very much	Score	Rank
Street cleaning	0.00	9.38	31.25	25.00	25.00	10.89	1
Markets	0.00	6.25	21.88	28.13	18.75	10.21	2
Government buildings	0.00	0.00	28.13	25.00	21.88	10.21	2
Hotels	0.00	6.50	31.25	28.13	15.63	9.54	4
Prisons	3.13	0.00	28.13	28.13	15.63	9.54	4
Saloon	6.25	0.00	6.25	25.00	12.50	8.17	6
Office buildings	0.00	6.25	31.25	15.63	18.75	7.60	7
Schools	3.13	9.38	28.13	21.88	9.38	6.81	8
Multiple family	3.13	9.38	37.50	15.63	12.50	6.13	9
Restaurants	12.50	3.13	12.50	15.63	12.50	6.13	9

Parks	6.25	3.13	18.75	12.50	12.50	5.45	11
Stores	0.00	12.50	43.75	15.63	6.25	4.77	12
Landscaping	3.13	0.00	9.38	12.50	5.25	3.87	13
Recreational areas	15.63	0.00	3.13	0.00	3.13	0.68	14
Single family	6.25	6.25	15.63	0.00	0.00	0.00	15

Table 7 shows the estimated percentage of daily quantities of solid waste that were managed by the MC-MSWMS. The MC municipality solid waste sources were ranked from the one which produces the most daily quantity solid waste to the one which produces the least daily quantity solid waste. The most municipality solid waste were coming from street sweeping. The most quantity of solid waste per day came from street sweeping (10.89%), followed by markets 10.21%), government buildings (10.21%), hotels (9.54%) and prisons (9.54%), saloons (8.17%), office buildings (7.60%), schools (6.81%) and restaurants (6.13%) and multiple families (6.13%). The bottom four on the ranking list are stores (4.77%), landscaping (3.87%), recreational areas (0.68%) and single families (0.00%). Although there is no evidence to support or reject the notion that an efficient or inefficient waste management system can or cannot cause the spread of coronavirus (COVID-19), the accumulation of solid waste in developing economies is worrisome and demands attention of researchers and policy makers. The results support the arguments by Tallentire and Steubing (2020) and Sinkevicius (2020). The research measured the effectiveness of the MC municipality solid waste management sub-systems and presented the results in Figure 5.

Figure 5: MC Municipality Solid Waste Management Sub-Systems

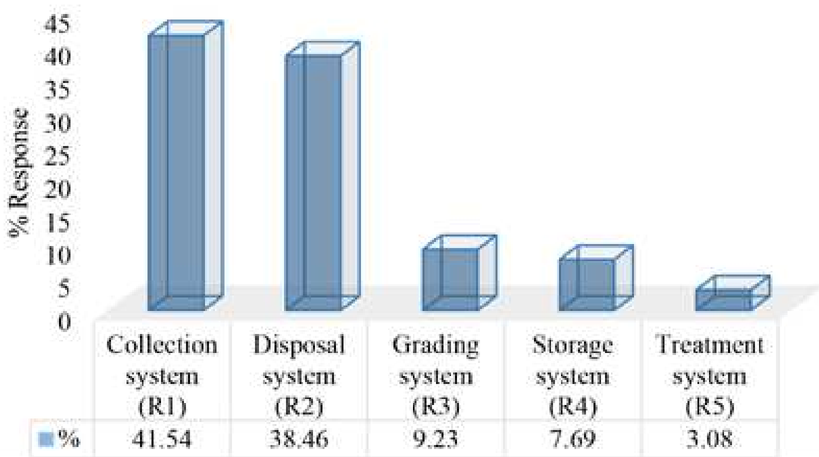


Figure 5 shows that the most effective MC municipality solid waste management sub-system was the Collection system that was ranked first with 41.54% of the votes. The general results tend to suggest that the MC-MSWMS is imbalanced measuring by the frequency variations from one system to the other. It can be concluded that the overall MC-MSWMS was ineffective. The perceptions of the respondents on the MC-MSWMS are presented in Figure 6.

Figure 6: Effectiveness of the MC-MSWMS

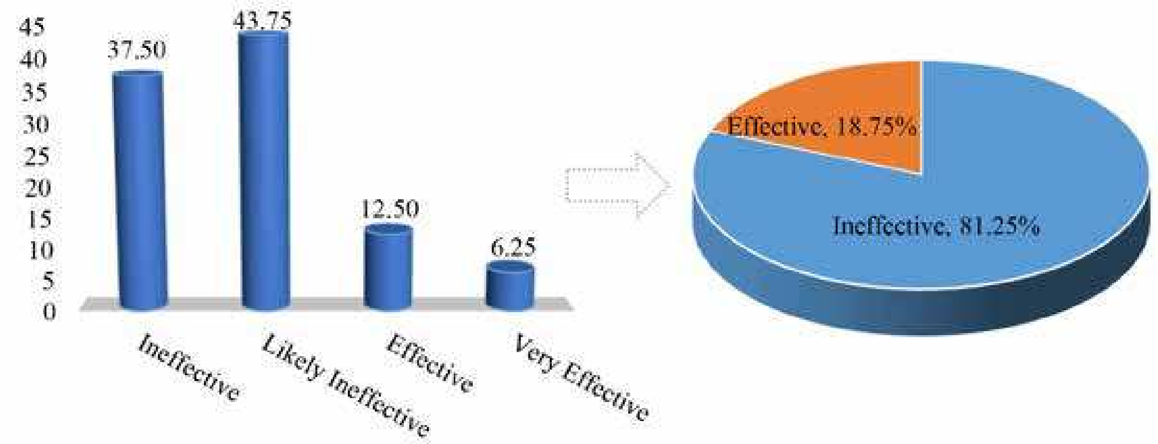


Figure 6 shows that 37.50% of the respondents voted that the MC-MSWMS was ineffective while 43.75% voted that it was likely ineffective. The respondents who voted that the MC-MSWMS was effective and very effective were 12.50% and 6.25% respectively. Thus, of all the respondents, 18.75% and 81.25% voted that the MC-MSWMS was effective and ineffective respectively. As stated by Brunner and Stanisavljevic (2020), there is room for optimising the MC-MSWMS. The research investigated the significance of the difference between the effective and ineffective vote proportions. The results of the difference of the two vote proportions test are presented henceforth.

$H_0: \mu_1 - \mu_2 = 0$ versus $H_1: \mu_1 - \mu_2 \neq 0$.

$\pm Z_{(0.025,\infty)tab} = \pm 1.96$. The null hypothesis is rejected if and only if $|Z_{calc}| > |Z_{tab}|$.

$$Z_{calc} = \frac{(0.1875 - 0.8125) - (0)}{\sqrt{\left(\frac{1}{32} + \frac{1}{32}\right)(0.5(0.5))}} = -5.00.$$

Since $|Z_{calc}| = 5.00 > |Z_{tab}| = 1.96$, the null hypothesis H_0 is rejected and the conclusion is that the difference between effective and ineffective response proportions is statistically significant. Therefore, the MSWMS requires serious upgrading and innovation in order to be effective. According to McDougall *et al*. (2001), an effective integrated municipality solid waste management system (EIMSWMS) should have interconnected solid waste management sub-systems. A Chi-square test was implemented to verify the findings of the difference of the two response proportions test with the hypothesis that, H_0: The MC-MSWMS was effective versus H_1: The MC-MSWMS was ineffective. The computed Chi-square test results are presented in Table 8.

Table 8: Chi-square Test Results

Difference	62.500%
95% Confidence Interval	39.082% to 76.445%
Chi-squared	24.609
Degrees of Freedom	1
Significance level	P < 0.0001

Since $\alpha = 0.05 > p = 0.0001$, the null hypothesis (H_0) is rejected and the conclusion is that the MC-MSWMS was ineffective. The Chi-square test of 24.609 is greater than the Chi-square tabulated of 3.841, therefore, the null hypothesis (H_0) is also rejected. This is confirming the results of the difference between the two response proportions test of effective (18.75%) and ineffective (81.25%) of the MC-MSWMS.

Conclusion and Recommendations

The MC municipality solid waste management department should prioritise the collection of food, yard, plastic and sanitary wastes. These are the first three high ranked types of solid waste that were collected by the MC-MSWMS. The MSWM department should constantly visit households and industries to collect generated solid waste. The composition of the solid waste shows that some are biodegradable while others are non-biodegradable hence the MC municipality should come up with multiple management sub-systems for proper disposal of both biodegradable and non-biodegradable solid waste.

The MC municipality should increase the collection frequency of solid waste from identified sources (such as multiple and single families, restaurants and hotels) that generate more solid waste. The MC municipality should also employ more competent staff members who should be deployed in the sources that produce high solid waste. In order to be efficient and effective, the MC municipality should purchase and use heavy equipment for collecting solid waste from multiple families, single families, restaurants and hotels. There is need to modify the MC-MSWMS. Instead of dividing their jurisdiction into sections, the municipality could consider having their collection trucks divided by sources of generation so as to generate data on how much solid waste is generated from each of the identified sources. This would help the MC municipality to distribute their focus by demand hence a more effective management of the municipality solid waste, for example, more attention where more solid waste is generated.

The current MC-MSWMS is not a complete integral municipality solid waste management system (IMSWMS) hence the municipality should consider developing or establishing the solid waste management processes. The MC municipality should establish an efficient IMSWMS (EIMSWMS). For example, the MC municipality should develop the grading, treatment and storage facilities to accommodate the enhancement of the current MC-MSWMS. The research proposed an efficient IMSWMS (EIMSWMS) that is presented in Figure 7.

Figure 7: Efficient Integrated Solid Waste Management System

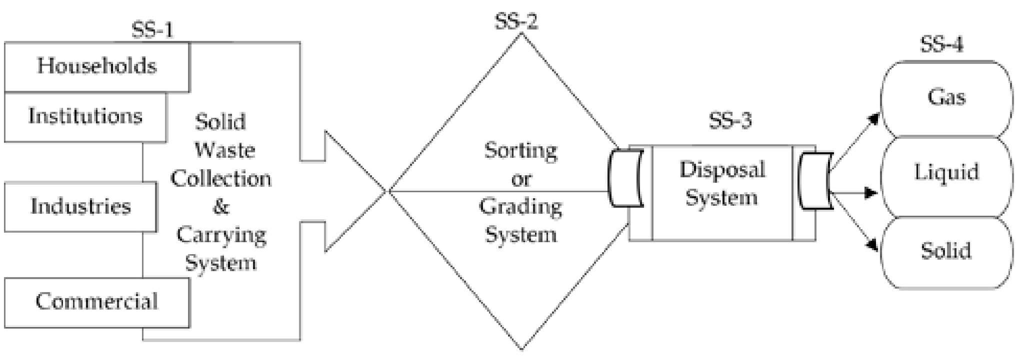


Figure 7 shows the proposed efficient integrated municipality solid waste management system (EIMSWMS). The whole EIMSWMS should be automated in order to be efficient. The proposed EIMSWMS is composed of four continuum sub-systems (phases) and these continuum sub-systems (SSs) are:

SS-1: Collection of solid waste from generation sources such as households, industries, commercial, institutions and open spaces.

SS-2: Sorting or grading of the collected municipality solid waste. The process involves the pigeonholing of food, plastics, wood and rubber in different storage containers for disposal in Phase 3.

SS-3: Identifying the appropriate disposing method for the graded and grouped solid waste.

SS-4: Disposing and packaging for domestic and commercial use of the outputs from the solid waste disposal processes. Figure 7 shows three common products that are coming from many solid waste disposing processes, namely, burning, Kraft, deposition, sublimation, carpentry, forging, burnishing, extrusion, composing and digestion among many others.

Areas of further research

The research could be done to investigate the factors affecting the establishment of an effective municipality solid waste management system, and the advantages of having a private organization overseeing the operations of the MC municipality solid waste management system. A research could also be done to assess the impact of accumulating solid waste to the spreading of coronavirus (COVID-19).

References

Awuchi, C. G., & Awuchi, C. G. (2019a). Physiological Effects of Plastic Wastes on the Endocrine System. *International Journal of Bioinformatics and Computational Biology, 4*(2), 11 - 29. Retrieved from http://www.aascit.org/journal/archive?journalId=809

Awuchi, C. G., & Awuchi, C. G. (2019b). Impacts of Plastic Pollution on the Sustainability of Seafood Value Chain and Human Health. *International Journal of Advanced Academic Research, 34*(12), 2466 – 2486.

Awuchi, C. G., Awuchi, C. G., Amagwula, I. O., & Igwe, V. S. (2020). Industrial and Community Waste Management: Global Perspective. *American Journal of Physical Sciences, 1*(1), - 16.

Barbalace, R. C. (2013). *Improving Municipal Solid Waste Management Through Recycling in Urban Settlements of Thailand.* Chulalongkorn University.

Brunner, H. P., & Stanisavljevic, N. (2020). The user – beneficiary or victim of modern waste management systems? *Waste Management & Research, 38*(6), 597 – 598.

Dao-Tuan, A., Nguyen-Thi-Ngoc, A., Nguyen-Trong, K., Bui-Tuan, A., & Dinh-Thi-Hai, V. (2018). Optimizing Vehicle Routing with Path and Carbon Dioxide Emission for Municipal Solid Waste Collection in Ha Giang, Vietnam. (Y. Chen, & T. Q. Duong, Eds.) *Industrial Networks and Intelligent Systems, 221*, 212 – 227.

Kaseke, M. (2005). The use of deposit refunds as pollution control policy in urban areas: the case of Zimbabwe. *Accounting for Urban Environment Workshop.* Arusha.

Mangundu, A., Makura, E. S., Mangundu, M., & Tapera, R. (2013). *The Importance of Intergrated Solid Waste Management In Independent Zimbabwe: The Case of Glenview Area 8.* Harare.

McDougall, F. R., White, P. R., Franke, M., & Hindle, P. (2001). *Integrated Solid Waste Management: a Life Cycle Inventory* (2nd ed.). Blackwell Science.

Murairwa, S. (2010). Sustainable Continuous Production Improvement Strategies: A Framework for Reviving Failing Companies in Zimbabwe. *Amity Journal of Operations Management, 1*(1), 21 – 47.

Murairwa, S. (2015). Voluntary Sampling Design. *International Journal of Advanced Research in Management and Social Sciences, 4*(2), 185 – 200.

Murairwa, S. (2016). *RESEARCH AND STATISTICS with application procedures in statistical package for social sciences.* Uttar Pradesh-201010, India: Research Foundation, Publishers and Subscription Agents of International and Indian Journals.

Murairwa, S. (2019). *RESEARCH AND STATISTICS with application procedures in statistical package for social sciences* (1st ed.). Harare, Zimbabwe: Media Essentials.

Nordone, A. J., White, P. R., McDougall, F., Parker, G., Garmendia, A., & Franke, M. (2007). Waste Management And Minimization Integrated Waste Management. *Encyclopedia of Life Support Systems (EOLSS).*

Shafiul, A. A., & Mansoor, A. (2003). *Partnerships for solid waste management in developing countries: Linking theories to realities. Institute of Development Engineering, Water and Development Centre.* England: Loughborough University.

Sinkevicius, V. (2020, April 14). Waste management in the context of the coronavirus crisis. European Commission. Retrieved June 6, 2020

Tallentire, C. W., & Steubing, B. (2020). The environmental benefits of improving packaging waste collection in Europe. *Waste Management , 103*, 426 – 436.

TARSC, & CFH. (2010). *Assessment of solid waste management in three local authority areas of Zimbabwe.* Harare: Community Based Assessment: Discussion paper TARSC . Retrieved June 6, 2020, from http://www.tarsc.org/publications/documents/TARSC%20CFH% 20SWM%20report%20Feb2010

Tsiko, R. G., & Togarepi, S. (2012). A Situational Analysis of Waste Management in Harare, Zimbabwe. Journal of American Science. *Journal of American Science, 8*(4), 692 – 706. Retrieved from http://www.americanscience.org

ZimStats. (2012). *Population Census National Report 2012.* Harare: Zimbabwe National Statistics Agency (ZimStats).

Zuze, T. (2017). Typhoid is here, watch out. Harare, Zimbabwe. Retrieved June 4, 2019, from https://www.manicapost.co.zw/typhoid-is-here-watch-out/

Author's Profile

Ruth Nedziwe is a monitoring and evaluation assistant. She obtained a B.Sc. in Public Administration from Africa University in Zimbabwe where she is currently studying a master in International Relations and Diplomacy. She is passionate about programme impact evaluation, peace building, mediation and negotiation, governance and human rights.

Stanley Murairwa is a Senior Lecturer at Africa University (AU) in the College of Business, Peace, Leadership and Governance (CBPLG) in Zimbabwe. He is the Head of Business Sciences Department. He obtained a Ph.D. degree in Decision Science from Universiti Utara Malaysia (UUM), Malaysia, M.Sc. degree in Operations Research (Distinction) from National University of Science and Technology (NUST), Zimbabwe, B.Sc. Special Honours degree in Statistics from University of Zimbabwe (UZ), Diploma in Statistics from University of Zimbabwe (UZ), Diploma in Management Information System from The Institute for the Management of Information Systems (IMIS), United Kingdom and a two year In-House Statistical Training Programme (ISTP) Part-A and Part-B certificates from Zimbabwe National Statistics Agency (ZIMSTAT). His areas of research interest include Heuristics, Production/Operations Management and Applied Statistics. He has published number of research papers in International and National Journals of repute.