ANALYSIS OF WASTE VOLUME AND TYPE GENERATED IN O.R. TAMBO DISTRICT MUNICIPALITY, SOUTH AFRICA

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ABSTRACT

The volume and varieties of municipal solid waste have increased rapidly because of economic growth, urbanization, and industrialization. The foundations for proper solid waste management planning are quantification and classification of municipal solid waste, but the requirements for collection, transportation, classification, and disposal are grossly under-invested and hardly implemented. As a result, the focus of this research is on the amount and types of waste generated in the O.R. Tambo district municipality. The O.R. Tambo district municipality has implemented a regional recycling program as part of an integrated solid waste management strategy to ensure waste management in its five local municipalities is sustainable. In a 31-month period, the total amount of waste material processed in the five local municipalities was projected to be 2,171.63 tonnes. The types of waste collected in O.R. Tambo district municipality include cardboard (K4), plastic (PET, HDPE, LDPE, and LLEPD), aluminium, and white paper. The study used two-way analysis of variance to compare the means of different waste types that are collected in the study area. The five local municipalities have varying quantities and compositions of waste. The findings of the study demonstrate that different local municipalities were selective in terms of the waste they recycled, which motivated waste pickers to gather certain waste streams from the streets and dump sites. Solid waste generation reduction, proper training, and the implementation of incentive and other fiscal policies were identified as hurdles to effective solid waste management, and recommendations for integrated solid waste management strategies were presented.

Keywords: integrated solid waste management, buy-back centres, recycling, informal sector, street waste picker, job creation.

1 INTRODUCTION

Waste management is a global issue, which confronts several countries due to the rising human population, production, and consumption of waste levels [1]. Poor waste management techniques can harm the environment and impede a country's ability to achieve long-term growth [1]. Waste is a hazard to both human health and the environment, which is why many governments are grappling with it and are developing procedures, policies, and laws to regulate waste management. For example, the United Nations has expressed concerns about environmental protection and the need to adopt policies that support sustainable development [2].

Waste management in South Africa has previously been haphazard and underfunded [3]. Poor waste management include, unlawful dumping, unlicensed waste management facilities, overuse of landfills, insufficient waste minimization and recycling initiatives. Furthermore, a high percentage of human population's lack of information relating to waste management and legislation enforcement, thus waste management remains a major concern. As a result, the South African government has dedicated itself to ensuring environmental preservation through the implementation of many legislations such as the National Environmental Management Waste Act 2008 (Act No. 59 of 2008), Municipal Systems Act (Act No. 32 of 2000) amongst others ensuring that waste management concerns are given the attention they deserve.

WIT Transactions on Ecology and the Environment, Vol 260, © 2022 WIT Press
www.witpress.com, ISSN 1743-3541 (on-line)
doi:10.2495/SC220341

In terms of the regulations and roles allocated to local government, one of the responsibilities of local municipalities is to deal with refuse removal, refuse dumping, and solid waste disposal (Constitution of the Republic of South Africa, 1996) [4]. Each municipality is responsible for developing municipal by-laws that address waste management explicitly, and these by-laws are directed by the National Legal Framework Scholars, such as Fathi et al. [5] who opine that municipalities should emphasize a waste management hierarchy that begins with waste prevention, waste reduction, resource recovery, waste treatment, and the last resort being waste disposal. Municipalities in the performance of their powers and functions related to refuse removal, refuse dumps, and solid waste disposal demands for integrated waste management strategies [6], [7].

Out of the five mentioned waste management strategies, waste minimization is one of the most popular solutions because it entails modifying behaviours and supporting the adoption of the three R's of waste minimization: Reduce, Reuse, and Recycle [8]. In this context the term "recycling" refers to the reprocessing of discarded waste materials for reuse, which includes gathering, sorting, processing, and transforming waste materials into raw materials that can be utilized to make new materials [9]. Furthermore, recycling activities have increased in most countries throughout the world because of their both environmental and economic benefits such as extending the life of raw materials and maximizing the value recovered from them; recycling also lessens the demand for them. It lessens the environmental damage, pollution, and waste that come with the extraction of new materials. Each tonne of recycled glass, for example, prevents around 315 kg of carbon dioxide from entering the atmosphere because of refining procedures. It lowers the costs and emissions associated with moving raw materials and creating new goods. Recycling also helps in combating climate change, whilst on the other hand recycling saves money on waste disposal. When compared to the energy used to produce raw materials, it saves energy during the manufacturing process. Recycling paper, for example, uses 28–70% less energy than producing new paper [10]. It provides job opportunities while also reducing raw material imports [11]–[14]. Recycling involves isolating reusable products from the remainder of the waste stream, and returns commodities to the market. As such, Muzenda [3] claims that recycling is the most visible and achievable waste management method.

2 THE ROLE OF BUY-BACK CENTERS IN THE RECYCLING INDUSTRY

Papers, cardboards, plastic material, and scrap metals are the most often collected recyclables that are sold to buy-back centres (BBCs) [10], [14]. The value of recyclables is determined by the forces of supply and demand in that commodity market. As a result of this circumstance, some recyclables are more valuable in one location than in another. For example, literature has shown that in South Africa the biggest demand for paper and plastic material is in Johannesburg, whereas cardboards are in demand in Durban [15].

According to Viljoen et al. [16] BBCs are also picky about the recyclables they buy from waste collectors. Paper in all forms is the recyclable product purchased by most BBCs; white paper is the most purchased by 82.1%, followed by newspaper (79%), while the magazines and books are sitting at 70.1%, mixed paper 70.1%, and cardboard 71.6% to BBCs. When looking at other recyclables, cans are most purchased (56.7%) by BBCs, followed by glass (46.3%), globes (26.9%), and bottles (32.8%) [16]. BBCs compete for certain recyclables to offer recycling firms with sustainable amounts [16]. If BBCs are close enough to each other, some waste collectors sell all their recyclables to one BBC, while others sell each recyclable to the BBC that provides the highest price because there is great demand for the recyclables. This indicates that the BBCs are competing to attract larger and more sustainable volumes of recyclables. Furthermore, some BBCs, particularly those in locations where there are no other

BBCs nearby, find it difficult to maintain their commitment by purchasing all recyclables from waste pickers, even though some recyclable products may not be profitable to BBCs.

The regional recycling project was initiated and is currently being implemented by the O.R. Tambo district municipality as part of the implementation of its Integrated Waste Management Plan. The establishment of the regional recycling project aimed at linking the informal sector waste management and recycling companies, thereby creating both formal and informal employment in the recycling chain. The regional recycling project helps to minimize unemployment, promote recycling efforts and cooperatives within the region, reduce waste sent to landfills, and boost local economic development.

In all five local municipalities in the O.R. Tambo district municipality there are recycling BBCs. According to Hettiarachchi et al. [17] waste collection via BBCs is crucial for involving the informal sector in the recycling business. BBCs are for-profit businesses where anyone can sell recyclable waste. Types of recyclable waste include paper, cardboard, plastics, aluminium cans, and glass [18]–[20]. Due to limited data, it is difficult to determine the number and the extent of BBCs in South Africa.

BBCs in South Africa rely significantly on the waste collected by waste pickers from the informal sector. BBCs are typically positioned near an industrial and/or commercial hub, making them more accessible to informal waste collectors who lack access to long-distance transportation [20]. Waste pickers are encouraged to deliver the material clean and classify it into various categories to obtain the greatest potential payment. The BBCs sell the recyclables they gather to large recycling firms, making them "middlemen" who serve an essential role as a link between the official and informal sectors [17].

The goal of this study was to determine if there are differences in the amount as well as the type of waste produced in the five local municipalities in the O.R. Tambo district municipality. We hypothesize that the volume and type of waste generation across the five local municipalities of the O.R. Tambo district municipality is the same.

3 MATERIALS AND METHODS

3.1 Study area and site location

The research was carried out in the five local municipalities (Ngquza Hill, Port St Johns, Nyandeni, King Sabata Dalindyebo, and Mhlontlo) of the O.R. Tambo district municipality in the Eastern Cape Province of South Africa (Fig. 1). The overall area of the O.R. Tambo district is approximately 12,095.1 km^2 [21]. The district is designated as a Category C2 Municipality, which denotes a predominantly rural area. At least 80% of the district was once part of the Transkei, and nearly a third of the population lives in scattered homesteads and tiny communities. Except for King Sabata Dalindyebo Local Municipality (KSDLM), all local municipalities in the district are categorised as Category B4 Municipalities, indicating a rural but primarily subsistence economy [21]. The KSDLM is a Category B2 Municipality, which indicates it has a large core town with significant market and business activities and prospects, as well as a relatively fertile agricultural area.

3.2 Sampling

Information about waste volume and different waste types collected in BBCs across the different local municipalities of O.R. Tambo district municipality were solicited using purposive sampling from the O.R. Tambo District Environmental Management Unit.

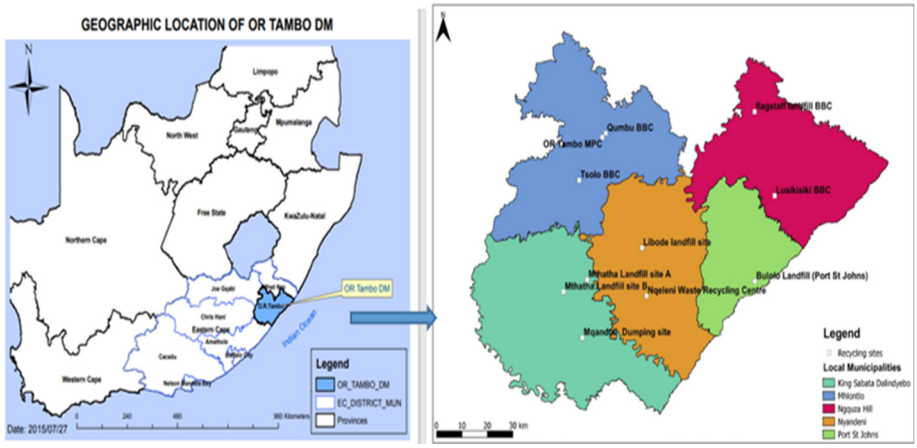

Figure 1: Geographic location of O.R. Tambo district municipality and its BBCs.

3.3 Data analyses

Data entry screens were established in Statistical Package for Social Sciences. We compared the amount and type of waste collected in the BBCs across the five local municipalities using data that were collected over a 31-month period. Using the Statistical Package for Social Sciences (SPSS Version 25), the data was statistically examined. The Kolmogorov–Smirnov and Shapiro–Wilk tests were used to determine whether the data was normally distributed or not. Both tests revealed that the data set was not normally distributed ($p < 0.05$), necessitating the use of a non-parametric test (two-way analysis of variance (ANOVA)). A non-parametric statistic known as the two-way ANOVA was used to compare the mean values of amount and type of waste recycled in O.R. Tambo district municipality. The two-way ANOVA is a substitute to the one-way ANOVA. It is used to see if the means of compared variables have any significant differences. P-values > 0, 05 were considered not to be statistically significant different.

Our analysis employed a two-way ANOVA followed by Tukey's multiple comparison test. ANOVA was used to examine the different types of waste material recycled across the various local municipalities in the O.R. Tambo district municipality and determine which recyclable was more recycled. A value of $p < 0.05$ was considered statistically significant.

4 RESULTS

A total of 2,171.63 tonnes of waste were processed from BBCs. The amount of waste recycled was significantly different for all fixed or independent variables: local municipality ($F = 7.37$, $P < 0.001$), type of waste ($F = 26.94$; $P < 0.001$) and interaction between these factors ($F = 3.63$; $P < 0.001$) as indicated in Table 1. The study findings show that Mhlontlo local municipality had significantly the highest amount of waste compared to other four local municipalities (Table 2 and Fig. 2). However, the amount of recycled waste at KSDLM did not differ from the amount recycled at Nyandeni, Port St Johns local municipality and Ingquza local municipality (Table 2 and Fig. 2). Similarly, the amount of waste recycled at Nyandeni local municipality is like that at Port St Johns and Ingquza Hill local municipality (Table 2 and Fig. 2). Port St Johns and Ingquza Hill local municipality had the same amount of waste recycled (Table 2 and Fig. 2).

Table 1: Tests of between-subjects' effects.

Tests of between-subjects effects					
Dependent variable: Total volume generated					
Source	**Type III sum of squares**	**df**	**Mean square**	**F**	**Sig.**
Corrected model	6391773343897.383[a]	19	336409123363.020	8.177	.000
Intercept	2064022696628.495	1	2064022696628.495	50.168	.000
Type of waste	3324949041884.979	3	1108316347294.993	26.939	.000
Local municipality	1213324951050.458	4	303331237762.615	7.373	.000
Type of waste × Local municipality	1792154904725.186	12	149346242060.432	3.630	.000
Error	24602959829936.953	598	41142073294.209		
Total	33074577309523.816	618			
Corrected total	30994733173834.336	617			
[a] R squared = .206 (adjusted R squared = .181).					

Table 2: Two-way ANOVA multiple comparison test of the different volumes of waste collected for recycling in the five local municipalities of the O.R. Tambo district.

(J) Name of the local municipality	**Mean difference (I–J)**	**Std. error**	**Sig.**	**95% Confidence interval**	
				Lower bound	**Upper bound**
Mhlontlo; KSDLM	107788.64*	25760.082	.000	37305.99	178271.30
Mhlontlo; Nyandeni	134099.79*	25760.082	.000	63617.14	204582.44
Mhlontlo; Port St Johns	81175.87*	25812.387	.015	10550.10	151801.63
Mhlontlo; Ingquzahill	77893.57*	25812.387	.022	7267.81	148519.34
KSDLM; Nyandeni	26311.15	25760.082	.846	−44171.51	96793.80
KSDLM; Port St Johns	−26612.78	25812.387	.841	−97238.54	44012.99
KSDLM; Ingquzahill	−29895.07	25812.387	.775	−100520.83	40730.69
Nyandeni; Port St Johns	−52923.92	25812.387	.243	−123549.69	17701.84
Nyandeni; Ingquzahill	−56206.22	25812.387	.190	−126831.98	14419.55
Port St Johns; Ingquzahill	−3282.29	25864.586	1.000	−74050.88	67486.29

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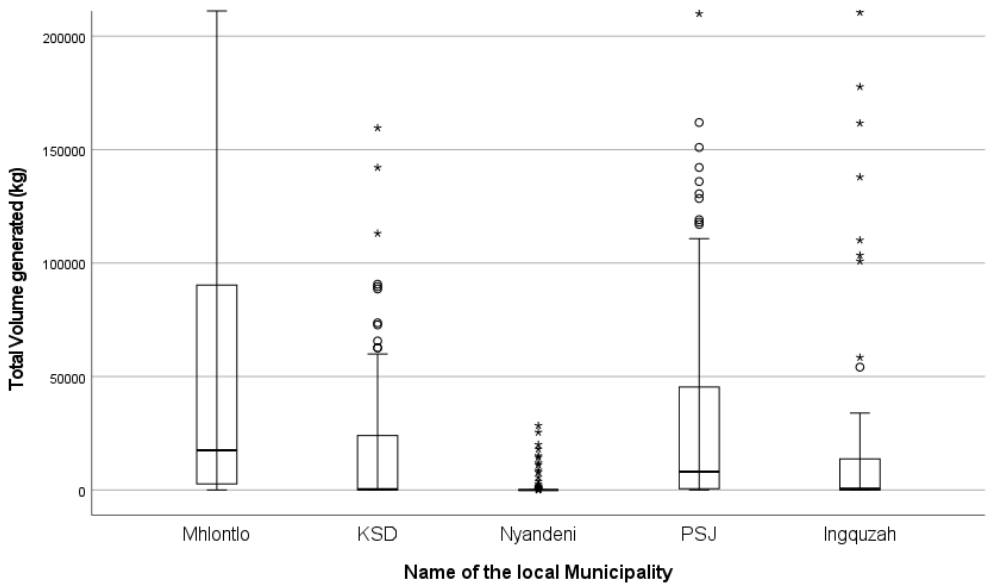

Figure 2: Total volume of waste recycled by location.

In terms of waste recycled by type, the study findings show that cardboard was the most recycled type of waste unlike the other three types of waste (Table 3 and Fig. 3). However, other types of waste (plastic, aluminium, and white paper) did not differ in terms of the amount of waste recycled.

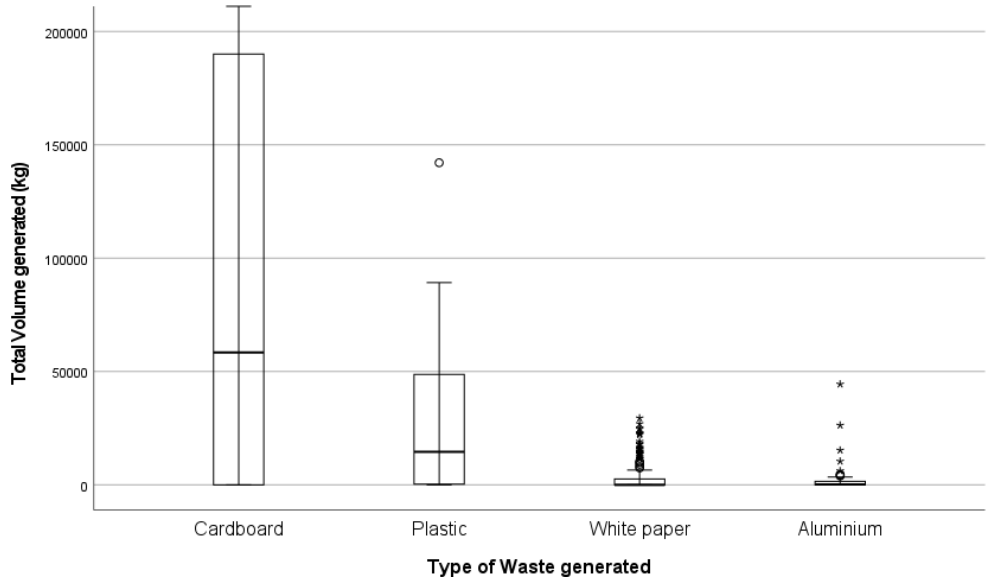

Figure 3: Total volume by type of waste in O.R. Tambo.

Table 3: Two-way ANOVA multiple comparison test of the different types of waste volumes collected for recycling in the five local municipalities of the O.R. Tambo district.

(J) Type of waste generated	Mean difference (I–J)	Std. error	Sig.	95% Confidence interval	
				Lower bound	Upper bound
Cardboard; Plastic	137899.02*	23077.891	.000	78444.16	197353.88
Cardboard; White paper	178436.33*	23040.518	.000	119077.76	237794.91
Cardboard; Aluminium	180716.45*	23077.891	.000	121261.59	240171.31
Plastic; White paper	40537.32	23077.891	.296	−18917.55	99992.18
Plastic; Aluminium	42817.43	23115.204	.250	−16733.56	102368.42
White paper; Aluminium	2280.11	23077.891	1.000	−57174.75	61734.97

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5 DISCUSSION

5.1 Collection by type of waste

5.1.1 Cardboard (K4)

Cardboard was compared across all local municipalities, and the results revealed that the amount of cardboard collected by the local municipalities differed statistically significantly. This is evident in Fig. 3. These findings match those of research done by Schenck and Blaauw [14]. However, these results are contrary to those of Viljoen et al. [20] who discovered that white paper is the most recyclable waste product in Pretoria, whereas the price of white paper is substantially lower in Bloemfontein. This could be attributed to higher transportation expenses because of the BBC's greater distance from recycling companies. Furthermore, PET is sold at the highest price per kilogram in Bloemfontein.

5.1.2 Plastic

According to Viljoen et al. [16], BBCs are discriminating in the recyclables they purchase from waste collectors. There was a statistically significant difference in plastics (PET, HDPE, LDPE, and LLEPD) between the five local municipalities. For example, plastic consumption was higher in three local municipalities: Mhlontlo, King Sabatha Dalindyebo, and Port St Johns. In contrast to what was happening in the Johannesburg metropolitan region, where white paper was in strong demand, steel cans were the most popular [15]. The value of recyclables is defined by the forces of supply and demand in that commodity market, according to Viljoen et al. [16]. As a result, some recyclables are more valuable in different places, resulting in discrepancies in the types of recyclables collected by BBCs.

Pricing discrepancies in recyclable items, according to Schenck and Blaauw [14] incentivize waste pickers all over the world to be selective and collect only waste for which there is a market, therefore supplying the BBCs with higher-value recyclables. Plastics are sold to BBCs in four main types. The findings revealed that waste collectors in Mhlontlo and the KSDLM sold PET (polyethylene terephthalate) at buy-back facilities, and that plastic, particularly PET, is very valuable on the market and produces extra jobs.

According to Hayami et al. [22] one of the reasons why not all BBCs buy PET is that they do not have enough space to store large quantities of PET, especially if there is no bailer, and there are high costs associated with transporting PET over long distances, especially if the recycling companies to whom the BBCs sell are far away, and selling small volumes of plastics makes recycling uneconomical and non-beneficial [16]. Because the O.R. Tambo district's main processing centre, which connects informal recycling to recycling companies, is in Mhlontlo local municipality in this case, more PET was collected in BBCs near the main processing centre due to the ease with which their waste could be transported in large volumes.

5.1.3 White paper

When the white paper's findings are evaluated across all municipalities, statistically significant differences emerge. Mhlontlo and Port St Johns local municipalities collect more white paper. This is most likely since these municipalities have no rivals (private BBCs). The Municipality and Schools in the Municipalities, as well as other government departments such as the South African Police Services, were some of the paper's sources. Because it is the economic core of the O.R. Tambo district municipality and has numerous schools and government departments that use white paper, it is projected that KSDLM BBCs will have

the biggest volumes of white paper collected. Because waste collectors in the local KSDLM operate several buy-back facilities that are not part of the regional recycling program, this is the reason.

5.1.4 Aluminium

The amount of aluminium collected in the five local municipalities differ statistically significantly. However, it is worth nothing that many waste collectors claim that they do not collect aluminium because huge quantities are required to realize the worth of the waste products. Because of space constraints and the fact that the material must be processed before being sold to recycling firms, not all buy-back facilities were able to purchase aluminium from waste collectors. Additionally, there are numerous private aluminium collectors throughout the O.R. Tambo district who collect the material and sell it straight in Durban, thus aluminium has the least recorded waste type in the Municipality records.

5.2 Collection by location

The study findings show that Mhlontlo local municipalities collected more waste than other municipalities followed by Port St Johns local municipality, followed by KSDLM, followed by Ingquza Hill local municipality and then Nyandeni local municipality as the least waste collector in the district as shown in Fig. 2. This is likely because Mhlontlo local municipality has three BBCs, all of which are operational, and there are no competitors in the area. This local municipality also houses the major processing centre, making it easier for collectors to carry their collections to the processing plant.

6 CONCLUSION

The goal of this study was to evaluate the various waste types and volumes collected by the municipality of O.R. Tambo district. The various waste types that are mostly collected in the research locations as well as the overall amount of waste collected by each local municipality are the specific topics that have been examined in this study. According to the study's findings, there are statistically significant differences between the various waste types that were collected in the study area. The volume of waste collected throughout the five local municipalities of O.R. Tambo district municipality also showed statistically significant differences.

ACKNOWLEDGEMENTS

We would like to thank O.R. Tambo district municipality for providing information on different waste generated across its Local municipalities. We would also like to thank NRF for financing the study.

REFERENCES

[1] Mazzanti, M. & Zoboli, R., Waste generation, waste disposal and policy effectiveness: Evidence on decoupling from the European Union. *Resources, Conservation and Recycling*, **52**(10), pp. 1221–1234, 2008.

[2] Davids, I., Theron, F. & Maphunye, K.J., *Participatory Development in South Africa: A Development Management Perspective*, Pretoria Van Schaik Publishers, 2005.

[3] Muzenda, E., Recycling situation in South Africa: A discussion. *International Journal of Biological, Ecological and Environmental Sciences*, **2**(4), 2013.

[4] Constitution of the Republic of South Africa: Act No 108 of 1996.

[5] Fathi, H., Zangane, A., Fathi, H. & Maradi, H., Municipal solid waste characterization and it is assessment for potential compost production: A case study in Zanjan city, Iran. *American Journal of Agriculture and Forestry*, **2**(2), pp. 39–44, 2014.
[6] Draft National Waste Management Strategy, 2010.
[7] National Waste Management Act: Act No 59 of 2008.
[8] Linzner, R. & Salhofer, S., Municipal solid waste recycling and the significance of informal sector in urban China. *Waste Management and Research*, **32**(9), pp. 896–907, 2014.
[9] Williams, P.T., *Waste Treatment and Disposal*, Wiley, 2005.
[10] Magram, S.F., Worldwide solid waste recycling strategies: A Review. *Indian Journal of Science and Technology*, **4**(6), 2011.
[11] Bagchi, A., *Design of Landfills and Integrated Solid Waste Management,* Wiley: New Jersey, 2004.
[12] Waheed, S.A., Adesola, R.O. & Garba, S.M., Biochemistry of wastes recycling. *International Scientific Journal*, **42**, pp. 169–188, 2022.
[13] Challcharoenwattana, A. & Pharino, C., Co-benefits of household waste recycling for local community's sustainable waste management in Thailand. *Sustainability*, 2015. DOI: 10.3390/SU7067417.
[14] Schenck, R. & Blaauw, P.F., The work and lives of street waste pickers in Pretoria: A case study of recycling in South Africa's urban informal economy. *Urban Forum*, **22**(4), p. 411, 2011.
[15] Maphitha, D., *The Role Played by Substance Waste Pickers in Recycling*, University of Pretoria: Pretoria, 2011.
[16] Viljoen, J., Blaauw, D. & Schenk, C., The opportunities and value-adding activities of buy-back centres in South Africa's recycling industry: A value chain analysis. *Local Economy*, **34**(3), pp. 294–315, 2019.
[17] Hettiarachchi, H., Meegoda, J.N. & Ryu, S., Organic waste buyback as a viable method to enhance sustainable municipal solid waste management in developing countries. *International Journal of Environmental Research and public Health*, **15**, p. 2483, 2018.
[18] Ahsan, A., Alamgir, M., El-Sergany, M.M., Shams, S., Rowshon, M.K. & Nik Daud, N.N., Assessment of municipal solid waste management system in a developing country. *Chinese Journal of Engineering*, 2014.
[19] Gela, E., Municipal solid waste management practices for achieving green architecture concepts in Addis Ababa, Ethiopia. *Technologies*, **9**(48), 2021. DOI: 10.3390/technologies 9030048.
[20] Viljoen, J., Schenck, C. & Blaauw, P., The role and linkages of buy-back centres in the recycling industry: Pretoria and Bloemfontein. *Acta Commercii*, **12**(1), pp. 1–12, 2021.
[21] O.R. Tambo District Municipality: Integrated Development Plan Review, 2019/2020.
[22] Hayami, Y., Dikshit, A. & Mishra, S., Waste pickers and collectors in Delhi: Poverty and environment in an urban informal sector. *The Journal of Development Studies*, **42**, pp. 41–69, 2006.