THE JOURNAL OF CARIBBEAN ENVIRONMENTAL SCIENCES AND RENEWABLE ENERGY presents

the OPEN ISSUE 2020

July, Volume 3: Issue 1
doi.org/10.33277/cesare/003.001

Examining Solid Waste Practices and Littering at the University of the West Indies, St. Augustine Campus

by authors Vaughn-Xavier Jameer, Ambika Mallian, Trina Halfhide

THE OPEN ISSUE **2020**
Volume 3, Issue 1

Online Resource: www.cesarejournal.org/publications-v3i1

Journal of Caribbean Environmental Sciences and Renewable Energy

Examining Solid Waste Practices and Littering at the University of the West Indies, St. Augustine Campus

Authors: Vaughn-Xavier Jameer, Ambika Mallian, Trina Halfhide
Department of Life Sciences, University of the West Indies, St. Augustine Campus, Trinidad and Tobago, W.I

Corresponding author: Trina Halfhide, PhD, Lecturer, Department of Life Sciences, University of the West Indies, St. Augustine Campus, Trinidad and Tobago, W.I

The Journal of Caribbean Environmental Sciences and Renewable Energy
Vol. 3, Issue 1, 2020 doi.org/10.33277/cesare/003.001/02

ABSTRACT

Littering is a rampant problem and rooted in human behaviour. This study aims to record, categorise, and examine spatial patterns between pieces of litter and trash and recycling bins across the University of the West Indies, St. Augustine Campus. The geographic location of pieces of litter and bins (trash and recycling) were recorded and georeferenced to a campus base-map. A total of 10, 889 pieces of litter were recorded over the 7-day survey. The majority of litter was plastic (47.6%) and cigarettes (24.1%). The litter on campus was not evenly distributed. The kernel density estimation demonstrated that there was an obvious hotspot in the south-east of campus at the student activity centre (SAC), where there were more than 5 pieces of litter per sq. meter. The total of 182 bins were recorded and the mean distance between bins was 13.0 meters. Most of the bins were clustered in the southwest end of the hotspot, near the SAC. In addition, there were no recycling bins placed in this location. A recycling bin should be located in the SAC, as there are the most littering offenses, and recycling success with plastic items can be improved. Using a uniform colour for trash bins may increase proper solid waste disposal and reduce littering.

Keywords: Geographic information systems, kernel density estimation, environmental behaviour, littering, solid waste management

1.0 INTRODUCTION

Municipal solid waste management is particularly important in small island developing states (SIDs), such as Trinidad and Tobago. With a fixed area and an increasingly urban population, socio-economic and environmental impacts are reliant on land and waste management trends. Treated and untreated solid waste deposition at government-owned disposal sites and illegal dumping are the primary methods of waste management in Trinidad and Tobago. Most of the solids waste facilities are operational for approximately 70 years, surpassing their 20-year lifespan. Additionally, leachate produced contaminates its environs as there is improper drainage in some of these areas. The application of a national integrated solid waste management system would benefit the country as there are inefficiencies in both the private and public sectors.

Studies showed that the average Trinbagonian citizen-generated 1.4 kg of waste daily **[1]**. A 2009 solid waste characterization study assessed four of the country's landfills **[2]**. The study revealed that of the 700,000 tonnes of solid waste that was recorded at the landfills in Trinidad; Approximately 84.0% of all items were recyclable or compostable. Similarly, the landfill in Tobago contained 52.0% recyclable or compostable materials. More recently, surveys conducted between 2013 and 2015 indicated that many citizens generated

Authors: Vaughn-Xavier Jameer, Ambika Mallian, Trina Halfhide
Department of Life Sciences, University of the West Indies,
St. Augustine Campus, Trinidad and Tobago, W.I

The Journal of Caribbean Environmental Sciences and Renewable Energy
Vol. 3, Issue 1, 2020 doi.org/10.33277/cesare/003.001/02

between 0 to 50 kg or litres of waste including organics, paper, or beverage containers annually [3,4]. When considering the recycling programmes alone, approximately 321 million dollars was invested in facilities management, and extra labour was required for sorting and cleaning recyclables items and then transporting these items. As most waste in Trinidad and Tobago is recyclable or compostable, there are many opportunities for waste recovery [5].

A few studies have examined solid waste on university campuses. There are many reasons for examining solid waste in this niche environment. Universities and colleges typically have young adults between the ages of 18 to 23, with different demographic, social, and environmental ideals. Armijo de Vega et al., 2008 notes that "colleges and universities have the moral and ethical obligation to act responsibly towards the environment, they would be expected to be leaders in the movement for environmental protection". The university environment is one that is geographically small and adoption of potential ideals, such as recycling and 'waste to energy' opportunities are easier than in a municipality or cooperation. One study conducted at Mexicali I campus estimated that approximately 1 ton of solid wastes is produced per day, with more than 65% of these wastes were recyclable or potentially recyclable [6]. It was determined that during the 2007–2008 academic year, the Prince George campus of the University of Northern British Columbia (UNBC), Canada produced between 1.2 and 2.2 metric tonnes of solid waste per week, the majority (70%) were recyclable or compostable materials [7]. In many cases, it would take little effort to separate waste or implement changes as the solid waste is usually concentrated. At the University of Ghana, the mean distance between litter and trash bins was 50 meter, with most of litter was clustered in student activity areas and food courts [8].

This study characterises the improperly disposed solid waste or litter at the University of the West Indies, St. Augustine Campus. The geographic location of the trash and recycling bins and each piece of litter within the perimeter of the campus was recorded. Hub distance and nearest neighbour analyses were then conducted to examine the clustering of litter and infer patterns pertaining to littering behaviour.

2.0 METHODOLOGY

The methodology employed comprised of data collection, georeferencing and cluster analyses.

2.1 DATA COLLECTION

Solid waste surveys were done over a 7-day period in March 2019 at the University of the West Indies, St. Augustine Campus. The mobile application, Litterati was used to photograph, record the geographic location and metadata. A dataset was then imported into excel and each entry comprised an identification number, geographic coordinates, the time recorded, and category of litter. There were eight categories of litter (Table 1). Two other datasets were also completed for the trash and recycling bins. The three datasets were then saved as CSV files.

Authors: Vaughn-Xavier Jameer, Ambika Mallian, Trina Halfhide
Department of Life Sciences, University of the West Indies,
St. Augustine Campus, Trinidad and Tobago, W.I

The Journal of Caribbean Environmental Sciences and Renewable Energy
Vol. 3, Issue 1, 2020 doi.org/10.33277/cesare/003.001/02

Table 1: *Survey of the relative number of pieces of litter and percentage (%)*

Category	Number of Pieces of Litter	Percentage (%)
Textile	51	0.5
Organic	68	0.7
Glass	102	1.0
Other	110	1.1
Metal	414	4.1
Paper	2111	20.9
Cigarette	2429	24.1
Plastic	4804	47.6
TOTAL	10089	100

2.2 GEOREFERENCING

The litter, trash, and recycling bins datasets were imported in QGIS (QGIS 3.4.6 'Madeira'), then georeferenced to a campus base-map retrieved from OpenStreetMap. All layers were then saved in World Geodetic System (WGS84) reference coordinate system.

2.3 CLUSTER ANALYSES

The mean distance between the pieces of litter and trash bins was determined in a preliminary analysis to see if the littering behaviour was consistent throughout campus. Then three additional tools were used: the nearest neighbour analysis, nearest hub algorithm, and the distance matrix analysis. The nearest neighbour analysis measured the distance between pieces of litter in the same category. This computation was also done to examine the distance between adjacent trash and recycling bins on campus. The nearest hub algorithm created thyessen polygons for the trash and recycling bins. The pieces of litter were then weighted per polygon. A kernel density estimation was then used to examine the density of litter and hotspots, where the maximum litter is found. Heat maps were used to illustrate the hotpots relative to the location of trash and recycling bins. The distance layer analysis determined the distance between pieces of litter and trash and recycling bin on campus. All results are expressed in meters.

3.0 RESULTS AND DISCUSSION

Pieces of litter during the 7 days in March 2019 were recorded and classed into eight categories (Table 1). A total of 10,889 pieces of litter were recorded during the time period. Textiles (0.5%) and organic (0.7%) categories accounted for less than 1.0% of the total litter. Glass (1.0%), other miscellaneous items (1.1%) and metal (4.1%) accounted for a small portion of the litter. The majority of litter was paper (20.9%), cigarettes (24.1%) and plastic (47.6%). Plastics were visually dominant (Figure 1). Although plastics dominated the St. Augustine Campus, it was the fifth most abundant at Trinidad's landfills in 2010 **[2]**.

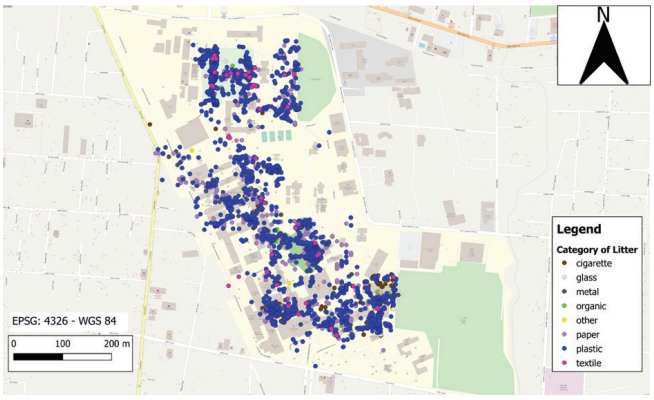

Figure 1: *Individual pieces of litter recorded during the 7-day survey at the University of the West Indies, St Augustine Campus.*

Authors: Vaughn-Xavier Jameer, Ambika Mallian, Trina Halfhide
Department of Life Sciences, University of the West Indies,
St. Augustine Campus, Trinidad and Tobago, W.I

The Journal of Caribbean Environmental Sciences and Renewable Energy
Vol. 3, Issue 1, 2020 doi.org/10.33277/cesare/003.001/02

Litter on campus was not evenly distributed (Figure 2). There was the highest number of pieces of litter in the south of campus, where numbers were greater than one thousand. A total of 2,569 pieces of litter were recorded at the student activity centre (SAC). In the general area of the JFK quadrangle, 1,133 pieces of litter were recorded. The football playing field was the only place in the north end of campus that had greater than one thousand pieces of litter (Figure 2).

The 10,889 recorded points were observed to be 0.60 meters from each other, where the expected mean distance if the litter was uniformly distributed was 3.0 meters. The kernel density estimation demonstrated that there was an obvious hotspot in the south-east of campus, where there were more than 5 pieces of litter per sq. meter (Figure 3). There were a total of 182 recorded bins and the mean distance between bins was 13.0 meters. From the nearest hub analysis, the mean distance from a piece of litter and a bin was 21.8 meters. The minimum distance of solid waste from the bin was 0.0 meters while the maximum was 102.2 meters. Most of the bins were clustered in the southwest end of the hotspot, at the SAC. There were no bins in the north or east ends of campus (Figure 4). In addition, there were no recycling bins placed in this location. A recycling bin should be located in the SAC, as there are the most littering offenses, and recycling success with plastic items should improve.

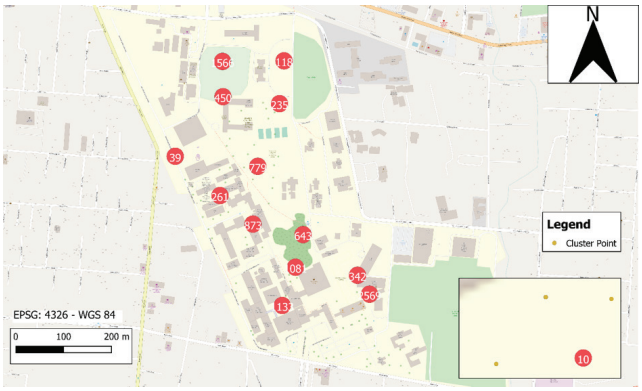

Figure 2: *Clusters generated based on the 7-day survey at the University of the West Indies, St Augustine Campus*

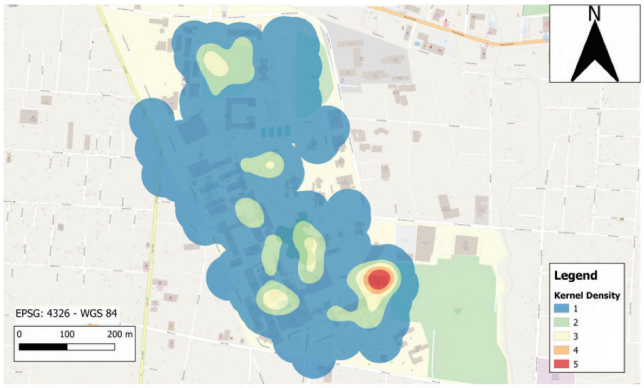

Figure 3: *Clusters generated based on kernel density estimation*

Most of the campus' trash bins were green coloured in the sports areas and high traffic areas. However, black and red general trash bins were observed in the food court and student activity centre. Indiscriminate use of colours may confuse passers-by and not facilitate easy appropriate disposal of litter. Other studies showed that solid waste management improved with having uniform coloured trash bins **[9]**. Bins should be redesigned to consider aesthetics, daily capacity, and utility. A colour-coded bin system would allow the seamless management of recycling and composting without the risks of contamination.

The factors influencing the littering behaviour at the University of West Indies, St Augustine Campus were not examined and outside the scope of this study. However, many other studies have established aesthetics, positioning, the use of graphics and video games increase appropriate litter disposal **[10, 11, 12, 13]**. Incorporating video gaming and increasing signage should increase success, especially in a campus environment, where most students are young adults. Education is also an important part of any long-term litter prevention and solid waste management strategy.

Authors: Vaughn-Xavier Jameer, Ambika Mallian, Trina Halfhide
Department of Life Sciences, University of the West Indies,
St. Augustine Campus, Trinidad and Tobago, W.I

The Journal of Caribbean Environmental Sciences and Renewable Energy
Vol. 3, Issue 1, 2020 doi.org/10.33277/cesare/003.001/02

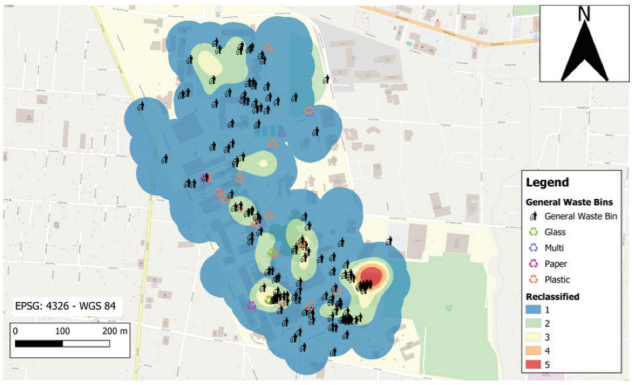

Figure 4: *Clusters generated based on kernel density estimation and trash and recycling bin locations*

4.0 CONCLUSION

A total of 10,889 pieces of litter were recorded during the 7-day survey on the campus of the University of the West Indies, St Augustine. Plastic (47.6%) and cigarettes (24.1%) accounted for the majority of litter. This litter was not evenly distributed. The density of litter was highest in the south of campus. Most of the bins were clustered in the southwest end of the hotspot, at the SAC. There were no recycling bins in the SAC, where most of the plastic litter is generated. Indiscriminate use of colours may confuse passers-by and not facilitate easy appropriate disposal of litter. Incorporating video gaming and increasing signage should increase successful disposal on campus settings.

Authors: Vaughn-Xavier Jameer, Ambika Mallian, Trina Halfhide
Department of Life Sciences, University of the West Indies,
St. Augustine Campus, Trinidad and Tobago, W.I

The Journal of Caribbean Environmental Sciences and Renewable Energy
Vol. 3, Issue 1, 2020 doi.org/10.33277/cesare/003.001/02

REFERENCES

OPEN SOURCE CLOSED SOURCE

[1] Dhalai, R. (2018). SWMCOL: TT producing 700,000 tonnes of waste per year. Retrieved from: https://newsday.co.tt/2018/06/27/tt-producing-700000-tonnes-of-waste-per-year/. Last retrieved April 25, 2020.

[2] Singh, K., Kelly, S. O., & Sastry, M. K. (2009). Municipal Solid Waste to Energy Potential for Application in Trinidad and Tobago. The Journal of the Association of Professional Engineers of Trinidad and Tobago, 38(1), 42-49.

[3] Egarr & Associates (2013). INTEGRATED SOLID WASTE MANAGEMENT POLICY. Retrieved from https://rdlg.gov.tt/wp-content/uploads/TT-MOLG-SWM-Policy-Final-Document-12-04-233-with-revisions-7.pdf

[4] Government of Trinidad and Tobago (2015). NATIONAL WASTE RECYCLING POLICY - planning.gov.tt. Retrieved from https://www.planning.gov.tt/sites/default/files/WASTE RECYCLING POLICY 2015 Final.pdf Last retrieved

[5] Litter Act. Ministry of the Attorney General and Legal Affairs. (2015). Retrieved from https://rgd.legalaffairs.gov.tt/laws2/Alphabetical_List/lawspdfs/30.52.pdf

[6] de Vega, C. A., Benítez, S. O., & Barreto, M. E. R. (2008). Solid waste characterization and recycling potential for a university campus. Waste management, 28, S21-S26.

[7] Smyth, D. P., Fredeen, A. L., & Booth, A. L. (2010). Reducing solid waste in higher education: The first step towards 'greening'a university campus. Resources, Conservation and Recycling, 54(11), 1007-1016.

[8] Dery, F. A., Kuusaana, E. D., & Owusu-Sekyere, E. (2018). Solid Waste Characterization and Recycling Potential for University Campuses in Ghana: Case Study of Two Ghanaian Universities. J Waste Recycl, 3(1), 3.

[9] Chung, D., Muda, A., Omar, C. M. C., & Manaf, L. A. (2012). Residents' perceptions of the visual quality of on-site wastes storage bins in Kuching. Procedia-Social and Behavioral Sciences, 49, 227-236. Dhar, S., Ordonez, V., & Berg, T. L. (2011, June). High level describable attributes for predicting aesthetics and interestingness. In CVPR 2011 (pp. 1657-1664). IEEE.

[10] Dhar, S., Ordonez, V., & Berg, T. L. (2011). High level describable attributes for predicting aesthetics and interestingness. In CVPR 2011 (pp. 1657-1664). IEEE.

[11] Evans, D. L. (1997). High-luminance LEDs replace incandescent lamps in new applications. In light-emitting diodes: research, manufacturing, and applications (Vol. 3002, pp. 142-153). International Society for Optics and Photonics.

[12] Huang, S., Scurati, G. W., Elzeney, M., Li, Y., Lin, X., Ferrise, F., & Bordegoni, M. (2019). AIM: An Interactive Ashtray to Support Behavior Change through Gamification. In Proceedings of the Design Society: International Conference on Engineering Design (Vol. 1, No. 1, pp. 3811-3820). Cambridge University Press.

[13] Calderon Pradilla, L. (2013). Videogames and sustainability: how gaming actions can potentially contribute to less waste actions. Master Thesis Series in Environmental Studies and Sustainability Science.

CESaRE - The Journal of Caribbean Environmental Sciences and Renewable Energy

www.cesarejournal.org