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Regional Variations in Urban Trash: Connections between Litter Communities and Place

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Abstract: In this study, data analysis methods from ecology were applied to litter surveys to evaluate patterns among urban litter items found in two types of streets in England (High Streets and Central Business Districts). Results indicate that sites characterised as a High Street (predominantly leisure activities such as shopping and dining) contained lower densities, less variety, yet featured items with higher potential for environmental contamination than sites categorised as Central Business District (identified by high numbers of professional workers and transport links). Although litter were significantly different between sites, the litter community structure was not. Our results suggest that litter typologies and associated activities can lead to specific knowledge of key influential items in a site and inform future evidence based and sustainable mitigation systems.

Keywords: litter; waste management; sustainability; community parameters; litter impact index

1. Introduction

Over half of the global population lives in an urban setting [1]. By congregating in a specific area, participants are benefited with symbiotic support between various working parts of a city. Like an ecosystem, urban spaces provide a singular point where complex security, education, employment, transport and social networks are built. Designed to make life easier, the luxuries of living in an urban ecosystem are plenty. Although the importance of the urban area is universal, purpose and characteristics are unique to each - variations can be observed both between and within urban areas. These variations are often characterized by their primary use type, such as designations of business, leisure and residential zoning.

Like any ecosystem, the urban ecosystem itself is vulnerable to stressors that threaten its wellbeing, one of these threats is the presence of litter. Litter is a generalized term that encompasses a wide array of items, despite distinguishable variations in typology, and is commonly accepted to be the byproduct of littering, a human behaviour [2]. In truth, the connection between litter and littering is not straightforward; where a considerable portion of non-cigarette litter items are generated via unintentional means [3]. Equally, specific activities produce different litter typologies, and the material composition of litter items determines the level of associated negative impact [4]. One constant, however, is that litter within a space is a significant driver in the generation of more litter [5].

Generally, litter mitigation efforts in urban spaces have focused on the individual, typically seeking to influence littering behaviour [2,6]. As the connection between *litter* and the act of *littering* is not linear [3], this approach does not consider individual spaces or the micro-variations between their use type.

Due to the systematic and continuous negative effects that litter poses, both locally and globally, it is vital that the cleanliness of urban spaces not only be standard [7], but more importantly, are approached in a sustainable manner to avoid societal and environmental impacts as well as financial stress.

Based on the understanding of litter and littering in urban spaces, and the lack of critical empirical evaluation of this, this study seeks to evaluate how different street types in different cities affect accumulation and litter typology. Through systematic litter surveys, this study is designed to explore differences in litter profiles between regions and further grouping study sites by their purpose within the urban structure. Litter profiles will be compared in four ways, individual typology, prevalence, source activity and impact. It is theorized that the function of a street can influence methods of littering; and if litter generating activities within specific urban spaces can be predicted, a better understanding of targeted approaches can emerge.

2. Materials and Methods

2.1. Study Sites

To gain insight on regional variations in litter typology profiles, a series of systematic litter surveys were conducted in four sites located in the three largest cities in England. Specific sites within cities were chosen by local participating councils who identified their most problematic areas in terms of littering. Sites consisted of two London locations, Central: London Bridge (LBL) and South: Sutton High Street (SHS), Birmingham New Street (NSB) and Manchester Oxford Road (OXM) (Figure 1). The four sites fit into two distinct urban street types, the High Street (HS) and the Central Business District (CBD) and are all considered high intensity of use in government land type indices [8].

Both the HS (SHS and NSB) and the CBD (OXM and LBL) are centrally located and highly connected in terms of transport, but the two serve very different roles in the lives of those who patronize them. The HS is a socio-economic hub, providing communal outdoor space for socializing, as well as a destination for food, shopping and entertainment [9]. Whereas the distinguishing factor of a CBD is its role as host to corporate office spaces and headquarters; often attracting healthcare and higher education institutions, and is patronized by a large population of highly skilled workers [10,11].

Figure 1. The 4 cites and locations of study streets.

2.2. Litter Survey

Prior to data collection sessions, sample sites were canvassed, and an inventory of present litter was taken. This inventory was used to inform templated data collection forms and ensure that as

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many litter typologies as possible were included, whilst being cognisant that for ease of reporting the form should fit on a single page. This was done with the intention of reducing the portion of data in the sample classified as 'other'.

During data collection sessions, each sample site was divided in sectors, allowing for multiple individuals to act as counters, simultaneously collecting data while eliminating any potential for duplicate counts. Sites varied in size and the number of sectors depended on number of counters available to conduct the survey simultaneously. Additional requirements for sectors were that they could each be surveyed in their entirety within a similar and reasonable timeframe, approximately 30 minutes. To ensure consistency across all counters, prior to data collection sessions, each counter was walked through the extent of their sector and trained in litter identification. In training exercises, data collection forms were reviewed to guarantee counters were familiar with and understood the meaning of each litter typology. Observers were often local to each study site (i.e., observers in London did not collect data in Manchester etc), therefore emphasis on comprehension of, and consistency in data collection methods was paramount.

Counters were provided with data collection forms that included 32 different litter typologies (Appendix A), allowing for a high-resolution tally method of data. Typologies were borrowed from previous studies e.g. Keep Britain Tidy, 2020 [8] allowing both consistency within the field of research and comparative analysis if desired. Additionally, counters were provided with detailed maps of their designated counting areas which included notes on physical markers such as lamp posts and changes in pavement tiles to aid in identifying area boundaries. As the health and safety of counters was of the upmost concern, instructions were to never count littered items located on a roadway and to only count litter items present in pedestrian designated areas.

Depending on the number of sectors in the study site, 2 to 4 counters collected data simultaneously. During data collection sessions, counters were instructed to systematically canvas the entirety of their sector, tallying each item of litter encountered in their data collection form. Each sector took no more than 30 minutes to canvass in its entirety. To remain within research budgets, each site was counted on 4 separate occasions.

2.3. Analysis

Modelling approaches from community ecology were applied to surveyed litter items and their Litter Impact Index values (LIIV) [4]. Community parameters are generally considered indicative measurements of the strength and diversity of an ecosystem [12], and are used here in the context of understanding the structure and diversity of litter typologies within the study sites. These parameters not only include measurements of volume, a traditional approach to litter analysis, but analyse variety in typologies present and identifies dominant typologies within each site.

Litter items were recorded by typology within each subsector from 4 separate counting sessions. Subsectors by session were considered independent sampling units and, except for areas designated as roadways, were surveyed in their entirety.

A series of indices on typology were calculated for each sampling unit and are considered community parameters. Community parameters (CP) include, abundance (total number of litter items found), richness (number of litter typologies present), density (abundance divided by subsector area), evenness (richness divided by abundance) and impact (mean LIIV of counted items). Due to the nature of the sampling units, the summary count of the data were assumed non-parametric and were not transformed for normality.

To measure the influence of sessions on community parameters, a one-way ANOVA was run for each in SigmaPlot 14.5, comparing means with the Tukey Test [13,14]. As the size of subsectors were not consistent, abundance was not included in community parameter analysis, and analysis of density was considered as an appropriate indicator of levels of litter present. Once it was determined that sessions had no influence on the data, regional influences on community parameters (richness, density, evenness and impact) were analysed using a Kruskal-Wallis Test between cities (SHS, OXM, NSB and LBL). When significant differences were observed, a Dunn's method pairwise comparison procedure was employed to further investigate. The influence of street types (HS and CBD) on

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community parameters were analysed using, a Wilcoxon Test. In all comparison analysis, differences were considered statistically significant when P<0.05. Violin plots to represent community parameters by city and street type were built in R Studio using the ggplot2 (version 3.3.6) package.

Overall diversity by city and street type were calculated in Excel using the Shannon Diversity Index then transformed for ease of comprehension to the Shannon Equitability Index [15].

Data on litter typology and source activity were normalized by area and modelled in R Studio using the vegan (version 2.6-2) and cluster (version 2.1.3) software packages. An Analysis of similarity (ANOSIM) was run to test for similarities in litter composition among city and street type groupings [16,17] and the Similarity Percentage analysis (SIMPER) procedure was employed to identify particular typologies and activity groupings that were responsible for these similarities [16,18]. Finally, A non-metric multidimensional scaling (nMDS) model was performed using Bray-Curtis distances to illustrate community structures within test sites [19].

3. Results

During four separate data collection sessions in each of the four sites, a total of 26,209 items of litter were counted within 132 subsectors. Data were on the following dates: SHS: 04, 05, 11, 12 March 2016; OXM: 19, 20, 25, 27 May 2016; NSB: 03, 04, 10, 11 June 2016; LBL: 06, 08, 20, 22 April 2017. Litter items were categorized into 32 typologies and 8 source activities (Appendix 2). Note that due to construction, a small portion of OXM (sector 7, subsector 45) on 25 May, 2016 (session 3) was inaccessible and therefore not counted.

3.1. Influence of Sessions

The influence of sessions on community parameters (CP) has been considered inconsequential in similar studies [20]. A Kruskal-Wallis one-way ANOVA on ranks was run to determine the influence of sessions on CP. Results identified differences in richness (P=<0.001), yet none by density (P=0.051), evenness (P=0.489), or impact (P=0.515). Given the similarity in richness medians and evidence from prior research, it was decided to discount the influence of sessions.

3.2. Community Parameters

For the purposes of this study, each litter typology was considered a separate species. Results of CP both by city and pooled by street type are seen in Figure 2. The overall shape of violin represents the distribution of data while individual dots represent actual data points. Box and whisker plots within violin represent interquartile intervals. With the exception of the richness parameter, general violin shapes indicate higher levels of distribution among CBD sites (OXM and LBL) with a concentrated pattern among HS sites (SHS and NSB).

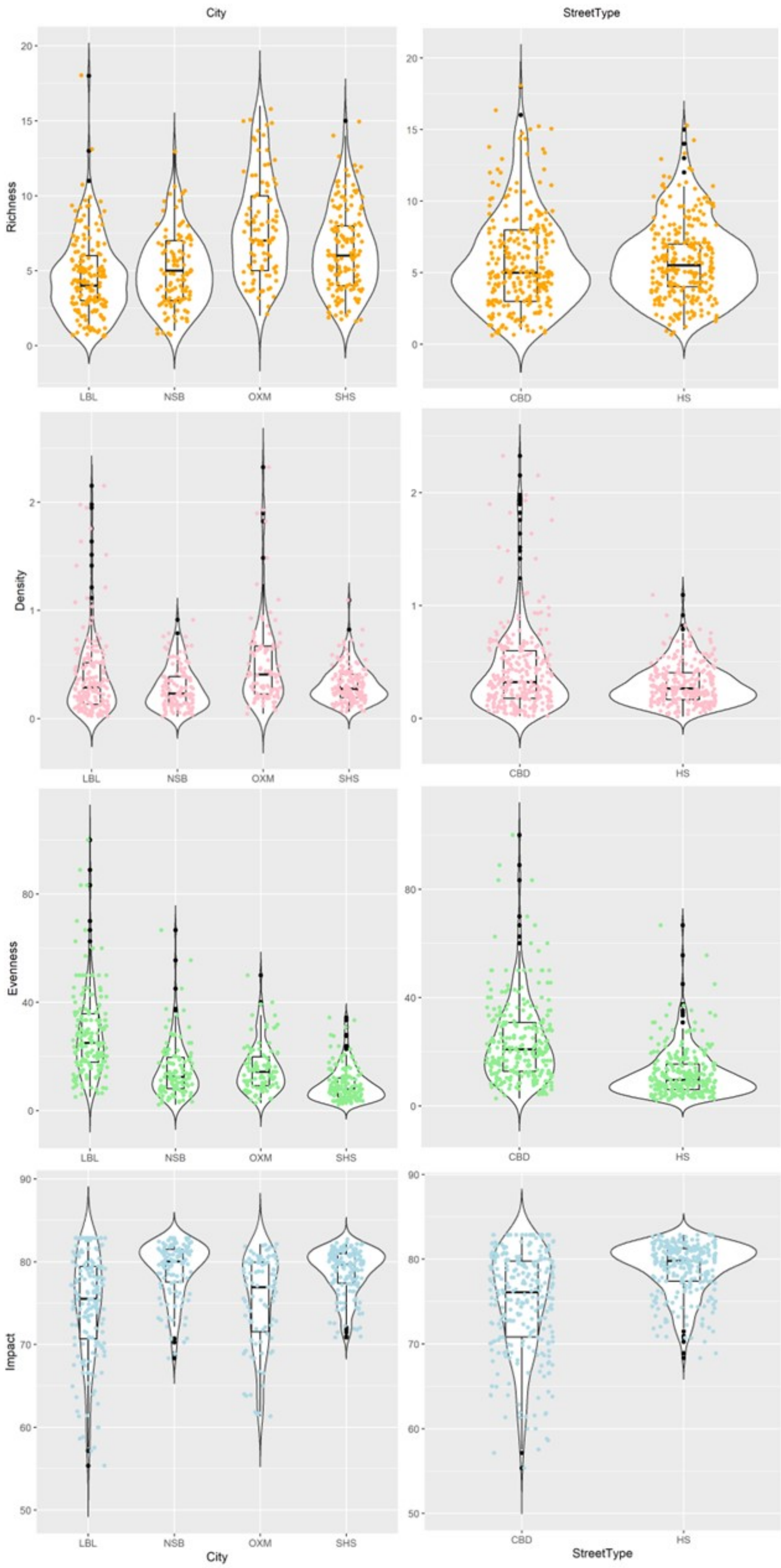

Figure 2. Community parameter distribution pooled by city and street type.

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3.3. Regional Influence

A one-way ANOVA between community parameters and sites tested for regional differences (Table 1). It was found that all parameters were significantly different between cities, however when pooled by street type, there were similarities within the parameters of richness and density.

Table 1. One-way ANOVA of community parameters between cities (Kruskal-Wallis) and street type (Wilcoxon).

Parameter	City	Street type
Richness	P<0.001	**P=0.427**
Density	P<0.001	**P=0.003**
Evenness	P<0.001	P<0.001
Impact	P<0.001	P<0.001

An all pairwise means comparison analysis was run between parameters within city pairings (Table 2). Strong city groupings were found within the density parameter between both London locations (SHS and LBL); within the evenness parameter between both locations outside of London (OXM and NSB); and within the impact parameter between HS locations (SHS and NSB) and CBD locations (OXM and LBL).

Table 2. Dunn's method all pairwise means comparison of parameters between cities.

Parameter		SHS	OXM	NSB
	OXM	P=0.023	-	-
Richness	**NSB**	P=0.002	P<0.001	-
	LBL	P<0.001	P<0.001	**P=0.915**
	OXM	P<0.001	-	-
Density	**NSB**	**P=0.712**	P<0.001	-
	LBL	**P=1**	P<0.001	**P=0.617**
	OXM	P<0.001	-	-
Evenness	**NSB**	P<0.001	**P=1**	-
	LBL	P<0.001	P<0.001	P<0.001
	OXM	P<0.001	-	-
Impact	**NSB**	**P=1**	P<0.001	-
	LBL	P<0.001	**P=1**	P<0.001

3.4. Diversity

To establish diversity of litter typologies, the Shannon’s Equitability Index (Q) vales were calculated (Figure 3). Diversity within cities clearly show higher diversity in CBD (OXM and LBL) while HS (SHS and NSB) feature lower diversity scores.

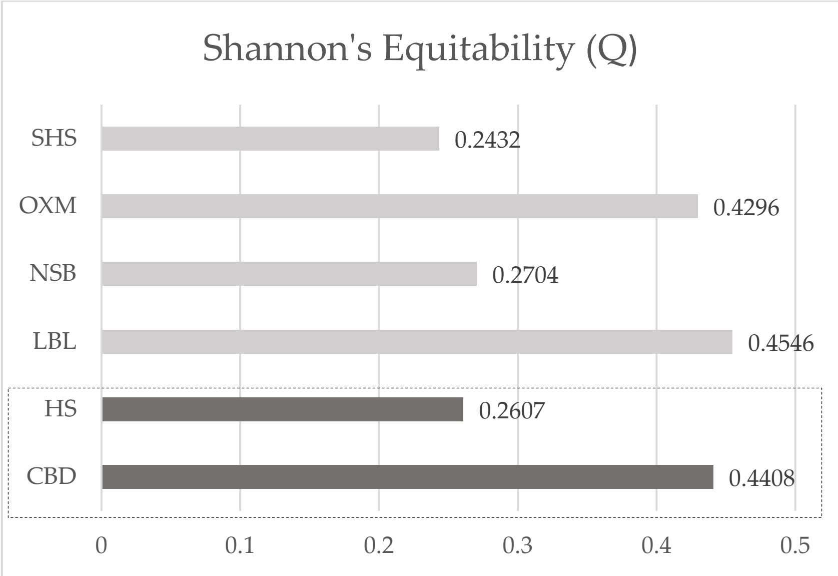

Figure 3. Shannon's Index of Equitability values depicting diversity of litter typology by city (light grey) and street type (dark grey). Results range from 0-1, where lower values represent communities with the fewer species.

3.5. Litter Composition

The Analysis of Similarity (ANOSIM) results in an R value that is measured on a scale of 0-1 where a high value represents greater differences in litter typology composition between sites [17]. Values were exceptionally low in comparisons of litter typologies between cities ($R=0.04263$, $P<0.001$) and street types ($R=0.03735$, $P<0.001$), implying high similarities between typology composition. Equally, low values were observed in comparisons of litter activity groupings between cities ($R=0.04172$, $P<0.001$) and street types ($R=0.04449$, $P<0.001$), implying high similarities between activity grouping composition.

The Similarity Percentage analysis (SIMPER) output in Table 3, represents similarity in litter typology and activity groups by city pairings and street types. In terms of typologies, similarity values were highest between CBD sites, LBL and OXM (58.57%) while the lowest similarities were found between the HS sites SHS and NSB (46.02%) The overall percentage of litter typology similarity explained by street types (HS-CBD) was 53.05%. When grouped by activity, similarity values were again highest between CBD sites LBL and OXM (53.93%) and LBL and NSB (52.38%) and lowest between HS sites SHS and NSB (42.89%). The overall percentage of similarity of activity groupings explained by street types (HS-CBD) was 49.59%.

Table 3. SIMPER percentage of litter typology and activity groupings similarity between cities and street types.

Parameter	City	SHS	OXM	NSB	HS
Litter Typology	**OXM**	49.38%	-	-	-
	NSB	**46.02%**	54.18%	-	-
	LBL	52.54%	**58.57%**	55.86%	-
	CBD	-	-	-	**53.05%**
Activity Groupings	**OXM**	45.71%	-	-	-
	NSB	**42.89%**	50.25%	-	-
	LBL	49.40%	**53.93%**	52.38%	-
	CBD	-	-	-	**49.59%**

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To better understand which litter typologies and activity groupings contributed towards similarity values between street types, Table 4 lists typologies in order of greatest influence. Unsurprisingly cigarette ends were the most influential litter typology (58%), followed by chewing gum (6%). Cigarettes again were the most influential activity grouping (63%), followed by eating (10%).

Table 4. Influence of litter typology and activity groupings towards similarity between street types HS and CBD (SIMPER analysis).

Parameter	Item	Contribution
Litter Typology	Cigarette end	58%
	Gum	6%
	General	3%
	Sweet bag	3%
	Tissue	3%
	Flyers & leaflets	3%
	Till receipts	2%
	Cigarette packaging	2%
	Cash point receipts	2%
	Food	2%
	Bus or train ticket	2%
	Plastic bottle	1%
	Cellophane food wrap	1%
	Takeaway box	1%
	Utensil	1%
	Can	1%
	Cigarette rolling paper	1%
	Unsure	1%
	Sandwich pack	1%
	Paper cup	1%
	Other drink	1%
	Newspaper & magazine	1%
	Paper bag	1%
	Cardboard box	1%
	Lighter & matches	1%
	Hot drink cup	0%
	Crisp bag	0%
	Glass bottle	0%
	Polystyrene box	0%
	Bagged litter	0%
	Plastic bag	0%
	Textile	0%
Activity Group	Cigarette	63%
	Eating	10%
	Shopping and Entertainment	7%
	Gum	6%
	Other	5%
	Drinking	4%
	Smoking	4%
	Transport	1%

Activity groups were analysed between city pairs to identify those with greatest influence (Table 5). Similarly to street type comparisons, cigarette ends were most influential across all pairings followed by eating.

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Table 5. Activity grouping contribution towards similarity between pairs of cities (SIMPER analysis).

LBL-OXM overall similarity: 53.93%		**LBL-SHS overall similarity: 49.40%**	
Cigarette	58%	Cigarette	63%
Eating	11%	Eating	11%
Shopping and Entertainment	9%	Gum	6%
Other	5%	Shopping and Entertainment	7%
Gum	6%	Other	5%
Drinking	5%	Drinking	4%
Smoking	4%	Smoking	4%
Transport	2%	Transport	0%
LBL-NSB overall similarity: 52.38.25%		**OXM-SHS overall similarity: 45.71%**	
Cigarette	62%	Cigarette	62%
Eating	12%	Eating	10%
Shopping and Entertainment	7%	Shopping and Entertainment	8%
Gum	6%	Other	7%
Drinking	5%	Drinking	4%
Smoking	4%	Gum	3%
Other	3%	Smoking	3%
Transport	1%	Transport	3%
OXM-NSB overall similarity: 50.25%		**NSB-SHS overall similarity: 42.89%**	
Cigarette	62%	Cigarette	72%
Eating	10%	Eating	7%
Shopping and Entertainment	9%	Shopping and Entertainment	7%
Other	5%	Other	4%
Drinking	5%	Gum	4%
Smoking	3%	Smoking	3%
Gum	3%	Drinking	3%
Transport	3%	Transport	0%

3.6. Community Structure

The non-metric multidimensional scaling model (nMDS) is interpreted in stress values, where those >.3 suggest clustered patterns and <.2 imply a weak random relationship [16]. The analysis on litter typology resulted in a stress value of 0.11, and the data are therefore considered random. Figure 4 illustrates the output, where HS are mostly clustered within the centre, while CBD sites exhibit a wider spread.

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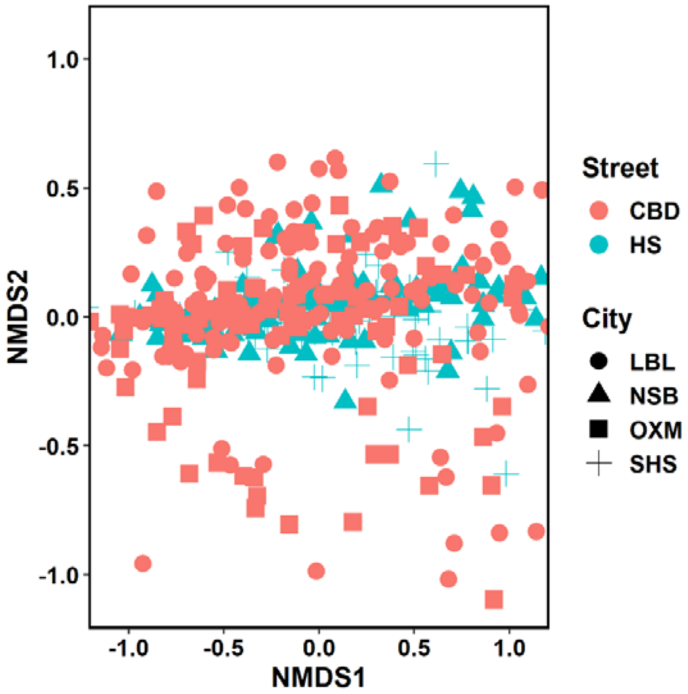

Figure 4. NMDS on litter typology is considered random.

The nMDS on activity groupings resulted in a stress value of 0.1, and the data are therefore considered random. Figure 5 illustrates the output and no clearly defined community clusters are apparent, with sites exhibiting wider spreads from the centre.

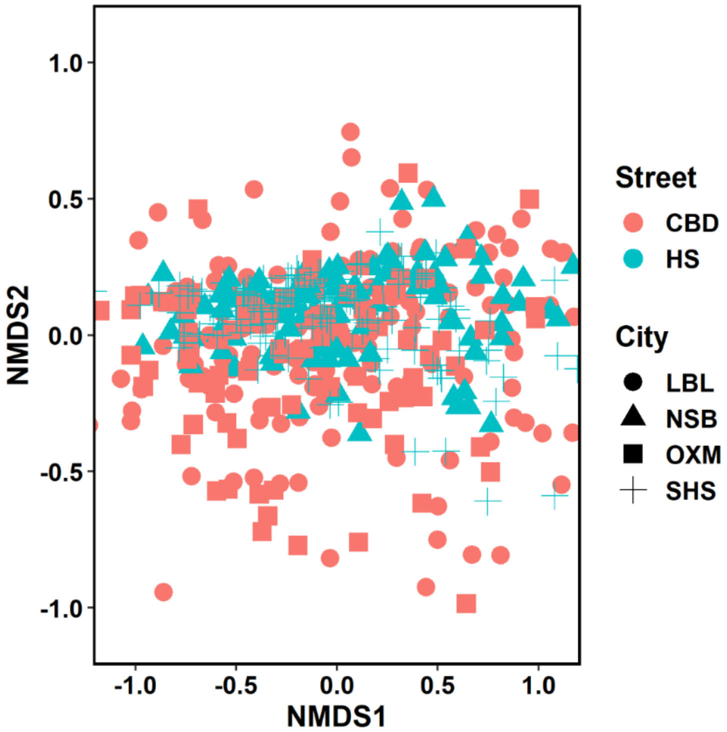

Figure 5. NMDS on litter activity groupings is considered random.

3.7. Summary of Results

This study examined patterns in litter typology and source activity between 4 English cities (SHS, OXM, NSB, LBL) as well as within two street type groupings, the high street (HS, SHS and NSB) and the central business district (CBD, OXM and LBL). Data were collected in each site during four sessions, and in line with previous research, sessions were considered to have no influence on litter patterns [20].

Violin plots on density and impact indicate strong similarities in data distribution between street type groupings, while richness and evenness violin plots suggest the same yet to a lesser degree. Generally, results suggested community parameters (CP) were influenced by street type, with CBD sites exhibiting higher densities of varied items with lower impact values, and HS sites featuring fewer items of higher impact values with specific typologies dominating the sample.

Significant differences ($P<0.001$) were found by city within all CP. In pairwise means comparisons, similarities were found in richness between NSB-LBL, in density between NSB-LBL, SHS-NSB and LBL-SHS, in evenness between OXM- NSB, and in impact between SHS-NSB and OXM-LBL. When pooled by street type, no difference was found in richness ($P=0.427$) yet significant differences were found in density ($P=0.003$), evenness ($P<0.001$) and impact ($P<0.001$). Results suggest that there are some connections between street type and CP regarding volumes of litter and the level of impact of items present.

Diversity is highly influenced by factors of richness and evenness and the results of the Shannon's Equitability Index were in line with observations on community parameters. Both the HS (0.26) sites, SHS (0.24) and NSB (0.27), scored low on diversity while the CBD (0.44) sites, OXM (0.45) and (0.43) LBL were considerably higher. Results suggest a more varied and equal distribution of litter typologies in CBD.

Generally, litter composition was similar across sites in both typology and activity groupings. Highest similarities were found between LBL-OXM (CBD sites) in both litter typology (54.57%) and activity groupings (53.93%), while the lowest similarities were found between SHS-NSB (HS sites) in both categories (typology 46.02%, activity 42.89%). In typology the largest contributor to similarity was unsurprisingly cigarette ends (58%) followed by chewing gum (6%), while in activity groupings cigarette ends and eating were highest contributors to similarity. When grouped by street type, similarities in typology (53.05%) were higher than that observed in activity groupings (49.59%). Results suggest that cigarette ends were the most influential species, and although CBD sites had similarities in composition, HS sites did not. Data suggests that cigarette ends were more frequently observed in HS sites where leisurely activities were taking place. Cigarette ends are an item that are not only littered more frequently, but are disposed of in uniquely specific ways [21,22].

No distinguishable typology or activity groupings community structure were found, although the nMDS indicated spread was wider among CBD sites than HS.

4. Discussion

As is seen all over the world, urbans areas have a set of unique and distinguishable characteristics. This applies not only to the language and aesthetics of places, but can apply to cultural and individual values, particularly in relation to consumption and post-consumption behaviour. Societal, environmental and economic problems associated with littering are plenty, however quantitative studies to evaluate numbers in urban spaces are limited.

This study found that the density, diversity and impact of litter is influenced by the purpose of a street, and to a lesser degree, the items that are present. Sites that were designated CBD typically contained a wider range of items where HS were characterised specifically by dominant items. This can mostly be attributed to the overwhelming influence of cigarette ends, which led to high comparative similarities in litter composition.

Aspects of uncertainty are present in the use of evaluation parameters such as richness, evenness and diversity, where specifics of community structure can be overlooked through quantification of individual traits [12]. This study avoids this pitfall through the inclusion of Litter Impact Index values, lending weight to parameters and signaling differences in regional communities. Through the impact weighting of litter typologies, opportunities arise to establish mitigation systems that specifically target places with highly toxic litter profiles. For example, similarity in richness between HS and CBD coupled with higher density rates in CBD would suggest that the CBD be the focus for environmental enhancement initiatives. However, despite the CBD containing more litter items by density, impact values were significantly higher in HS, thus targeted initiatives in HS would lead to greater reductions in associated environmental ramifications.

A comparison of litter profiles between areas of high intensity of use has the potential to lend clues to local litter trends and highlight sources of contention to inform tailored solutions. Although the litter composition of a site does not appear to be predictable, there is merit in the influence of street type towards density and impact value. As the use of direct cues and tailored approaches has considerably higher success than generalised campaigns [23–25], a baseline understanding of litter profiles of a site can inform targeted mitigation initiatives and governing cleansing strategies.

By framing litter as a product of place and not one of human behaviour, this study argues that sustainable waste management systems can be established on a local level. Given the current concerns about litter, understanding regional variations in composition and abundance is important to establish targeted solutions.

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Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A. Litter Typology Data Collection Form

	Name, date, time, sector, weather					
	Subsector					
	Litter type	*Count*				
Cigarette material	Cigarette end					
	Cigarette pack, cellophane wrap, foil paper					
	Cigarette papers, filters					
	Matches, lighters					
	Gum - 3D					
Drinks	Plastic bottle					
	Tin or can container					
	Hot drinks cup					
	Hot drink insulating wrap					
	Paper cup (cold drink)					
	Glass bottle					
	Other drink items					
Food packaging	Crisp packets					
	Sweet wrappers & bags					
	Takeaway box: card, plastic, aluminium					
	Polystyrene food boxes					
	Sandwich packs or wrap					
	Tissue or napkin					
	Paper bag					
	Utensils					
	Food					
	Cellophane wrapping					
	Other food items					
Shopping & Ent	Train/bus tickets					
	Cash point receipts					
	Till receipts					
	Flyers and leaflets					
	Cardboard box					
	Newspaper & magazines					
	Plastic bags					
Other	Textiles					
	General litter (other)					
	Unsure					
	Bagged litter					
	TOTAL COUNT OF LITTER:					

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Appendix B. Results of Data Collection Sessions, Including Litter Typologies and Activity Groupings

Item	Activity	Total	%	SHS	%	OXM	%	NSB	%	LBL	%
Cigarette end	Cigarettes	20640	78.75%	9919	84.20%	4279	70.44%	4063	82.85%	2379	68.96%
Cigarette packs, cellophane wrapping and foil paper	Smoking	323	1.23%	53	0.45%	88	1.45%	115	2.35%	67	1.94%
Cigarette rolling papers, unsmoked filters	Smoking	103	0.39%	30	0.25%	34	0.56%	0	0.00%	39	1.13%
Lighters and matches	Smoking	77	0.29%	34	0.29%	15	0.25%	2	0.04%	26	0.75%
Gum - 3D	Gum	561	2.14%	215	1.83%	129	2.12%	52	1.06%	165	4.78%
Plastic bottle	Drinking	149	0.57%	36	0.31%	52	0.86%	25	0.51%	36	1.04%
Tin or aluminium drink can	Drinking	106	0.40%	21	0.18%	42	0.69%	12	0.24%	31	0.90%
Paper cup	Drinking	92	0.35%	40	0.34%	25	0.41%	20	0.41%	7	0.20%
Hot drink and insulating wraps	Drinking	86	0.33%	21	0.18%	31	0.51%	4	0.08%	30	0.87%
Glass bottle	Drinking	54	0.21%	7	0.06%	31	0.51%	4	0.08%	12	0.35%
Other drink	Drinking	58	0.22%	7	0.06%	3	0.05%	33	0.67%	15	0.43%
Crisp packets	Eating	85	0.32%	17	0.14%	45	0.74%	8	0.16%	15	0.43%
Sweet wrappers and bags	Eating	470	1.79%	200	1.70%	108	1.78%	67	1.37%	95	2.75%
Takeaway boxes: card, plastic, aluminium etc	Eating	160	0.61%	43	0.37%	86	1.42%	19	0.39%	12	0.35%
Polystyrene food boxes or trays	Eating	42	0.16%	10	0.08%	12	0.20%	5	0.10%	15	0.43%
Sandwich packs or wrap	Eating	93	0.35%	11	0.09%	40	0.66%	23	0.47%	19	0.55%
Tissues and napkins	Eating	376	1.43%	159	1.35%	80	1.32%	54	1.10%	83	2.41%
Paper bags	Eating	44	0.17%	10	0.08%	17	0.28%	3	0.06%	14	0.41%
Utensils	Eating	89	0.34%	16	0.14%	12	0.20%	29	0.59%	32	0.93%
Food	Eating	185	0.71%	23	0.20%	79	1.30%	41	0.84%	42	1.22%
Cellophane wrapping - food	Eating	128	0.49%	42	0.36%	28	0.46%	8	0.16%	50	1.45%
Train and bus tickets	Transport	155	0.59%	6	0.05%	117	1.93%	11	0.22%	21	0.61%
Cash point receipts	Shopping Entertainment	272	1.04%	93	0.79%	39	0.64%	120	2.45%	20	0.58%
Till receipts	Shopping Entertainment	468	1.79%	276	2.34%	74	1.22%	69	1.41%	49	1.42%
Flyers and leaflets	Shopping Entertainment	374	1.43%	55	0.47%	212	3.49%	45	0.92%	62	1.80%
Cardboard box	Shopping Entertainment	52	0.20%	19	0.16%	22	0.36%	3	0.06%	8	0.23%
Newspapers and magazines	Shopping Entertainment	50	0.19%	4	0.03%	25	0.41%	3	0.06%	18	0.52%
Plastic bags	Shopping Entertainment	39	0.15%	5	0.04%	27	0.44%	2	0.04%	5	0.14%
Textiles	Other Unsure	18	0.07%	4	0.03%	3	0.05%	4	0.08%	7	0.20%
General litter (other)	Other Unsure	702	2.68%	363	3.08%	247	4.07%	44	0.90%	48	1.39%
Unsure	Other Unsure	86	0.33%	6	0.05%	41	0.67%	11	0.22%	28	0.81%
Bagged litter	Other Unsure	72	0.27%	35	0.30%	32	0.53%	5	0.10%	0	0.00%
Total		**26209**		**11780**	**44.95%**	**6075**	**23.18%**	**4904**	**18.71%**	**3450**	**13.16%**

References

1. The World Bank. Urban population (% of total population). 2022 [cited 2022 May 19]. Urban population. Available from: https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS?name_desc=false
2. Schultz P W, Bator R J, Brown Large L, Bruni C M,, Tabanico J J. Littering in Context: Personal and Environmental Predictors of Littering Behavior. Environ Behav. 2013;45:35–59.
3. Kachef RL, Chadwick MA. Not all litter is littered: An exploration of unintentional means of public waste generation. Environ Chall. 2023 Dec 1;13:100756.
4. Kachef RL. The Geography of Litter: An investigation into the sources, deposition, transfer dynamics, impact, and regional variations of anthropogenic waste debris in England [Internet] [Doctorate of Philosophy]. [London, UK]: King's College London; 2023. Available from: https://kclpure.kcl.ac.uk/portal/en/studentTheses/the-geography-of-litter
5. Reiter SM, Samuel W. Littering as a function of prior litter and the presence or absence of prohibitive signs. J Appl Soc Psychol. 1980;10(1):45–55.
6. Al-mosa Y, Parkinson J, Rundle-Thiele S. A Socioecological Examination of Observing Littering Behavior. Vol. 29, Journal of Nonprofit & Public Sector Marketing. 2017. p. 235–53.
7. Luan Ong I L,, Sovacool B K,. A comparative study of littering and waste in Singapore and Japan. Resour Conserv Recycl. 2012;61:35–42.
8. Keep Britain Tidy. Litter Composition Analysis [Internet]. Department for Environment, Food and Rural Affairs; 2020 [cited 2021 Oct 12]. Available from: https://sciencesearch.defra.gov.uk/ProjectDetails?ProjectID=20212&FromSearch=Y&Publisher=1&SearchText=eq0121&SortString=ProjectCode&SortOrder=Asc&Paging=10#Description
9. Mayor of London. High Streets for All [Internet]. 2017. Available from: https://www.london.gov.uk/sites/default/files/high_streets_for_all_report_web_final.pdf
10. Greater London Authority. London's Central Business District: Its global importance [Internet]. Greater London Authority; 2008. Available from: https://www.london.gov.uk/sites/default/files/gla_migrate_files_destination/londons-cbd-jan08.pdf
11. Deloitte. Oxford Road Corridor Strategic Regeneration Framework Guidance. 2019.
12. Barrantes G, Sandoval L. Conceptual and statistical problems associated with the use of diversity indices in ecology. Rev Biol Trop. 2009;57(3):451–60.
13. Winer B. Design and analysis of single-factor experiments. In: Statistical principles in experimental design [Internet]. New York, NY: McGraw-Hill Book Company; 1962. p. 46–104. Available from: https://psycnet.apa.org/doi/10.1037/11774-003
14. Zar JH. Biostatistical analysis. Pearson Education India; 1999.
15. Allaby M. A dictionary of zoology. OUP Oxford; 2014.
16. Clarke KR. Non-parametric multivariate analyses of changes in community structure. Aust J Ecol. 1993;18(1):117–43.
17. RDocumentation. anosim: Analysis of Similarities [Internet]. 2022 [cited 2022 Apr 7]. Available from: https://www.rdocumentation.org/packages/vegan/versions/2.3-5/topics/anosim
18. RDocumentation. simper: Similarity Percentages [Internet]. 2022 [cited 2022 May 9]. Available from: https://www.rdocumentation.org/packages/vegan/versions/2.3-5/topics/anosim
19. Ebner J. Non-metric multidimensional scaling (NMDS): What? How? [Internet]. Archetypal Ecology. 2018 [cited 2022 Feb 11]. Available from: https://archetypalecology.wordpress.com/2018/02/18/non-metric-multidimensional-scaling-nmds-what-how/
20. Becherucci ME, Seco Pon JP. What is left behind when the lights go off? Comparing the abundance and composition of litter in urban areas with different intensity of nightlife use in Mar del Plata, Argentina. Waste Manag. 2014 Aug 1;34(8):1351–5.