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Is illegal dumping associated with some urban designs? Evidence from Fix My Street data, Brussels.

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Abstract

The design of the urban streetscape influences our way of perceiving the city but also affects behaviour and well-being. In this paper, we analyse if incivilities and more particularly illegal dumping are related to the urban context, at a micro scale (presence of trees, sidewalk width,...) and a meso scale (urban fabric typology: historical, residential, industrial,…). Illegal dumping is costly for the community, is a major inconvenience for residents, and can lead to a feeling of insecurity. To simplify the reporting of nuisances, apps have been developed for citizens such as Fix My Street, launched in Brussels, Belgium in 2013. It enables to report incidents such as broken public lamps or blocked sewer. An 'Illegal dump' category was added in 2017 and has since become the most reported type of incident: between July 2017 and February 2020, 46 744 illegal dumps were reported. We investigate what urban streetscape features are associated with such reports in Brussels. Unfortunately, the use of Fix My Street is not spatially uniform nor exhaustive. To avoid this selection bias, we compare illegal dumps with a control group composed of other types of incidents (n=56,122). Logistic regressions (presence/absence) are performed to explore the association between illegal dumping and some urban morphometrics. Results show that the urban environment is associated with the probability of illegal dumping. On a meso scale, we observe fewer illegal dumps in office neighbourhoods and the green periphery, and many more in the historical fabric. On a micro scale, the typical street where dumping takes place is a narrow, quiet residential street with urban trees. A "broken window" effect is also observed: illegal dumping are more likely to reappear where there has already been a dump.

Keyword: *Illegal Dumping – Urban Morphometrics – Broken Windows Effect - GIS*

Introduction

The design of the urban streetscape influences the way of perceiving the city but also affects behaviour and well-being. Impact of urban environment on well-being is a hot topic on both political and scientific sides: looking for a city that is efficient and sustainable, as well as making the inhabitants and passers-by happy with the surroundings. Many studies have focused on urban context influencing antisocial behaviour and crime; the literature on this topic has often focused on the elements that provide an opportunity for criminal acts (Lorenc *et al.*, 2012). However, it would be interesting to take a broader look at the urban environment beyond specific features and its association with anti-social behaviour.

A broad diversity of methods are nowadays used to study the association between urban environment and human-related phenomena. Field surveys, that have been widely used, allow a very detailed study of an often restricted environment. The development of Geographic Information Systems (GIS) and the increasing

availability of data on the urban environment allow designing studies to a broader extent with limited loss of detail and with a reduced cost. However, this is constrained by the quality and availability of data. The urban environment can be characterised with features operating at various scales. At a *micro* scale, individual elements of the urban environment are identified , such as the presence of a tree or the width of the sidewalk. At a *meso* scale, the urban environment is characterised by classifying and describing the urban fabric as a whole. At the *meso* scale, urban environments have often been characterised either through the experience of inhabitants (Lynch, 1960), based on expert knowledge (Dessouroux, 2008) or automatic methods based on a set of urban environment indicators (e.g. Gil *et al.*, 2012; Hamaina, Leduc and Moreau, 2014). For Brussels, a typology of the street environment has recently been developed (Guyot *et al.*, 2021) based on an automatic method (Araldi and Fusco, 2019). These two scales (*micro* and *meso*) are interesting for studying the association between the urban environment and human-related phenomena: they each allow us to consider this association from a different perspective. On the one hand, it allows to highlight separately which elements of the urban environment are associated with the phenomena considered. On the other hand, it allows an integrated analysis of this association by considering the urban environment as a whole.

Illegal dumping, consisting in disposing of waste without respecting legal provisions (e.g. abandoned furniture, appliances or piles of rubbish), is a recurrent issue in cities. It differs from litter (e.g. cigarette butts, small wastes) in size. Illegal dumping is costly for the community and is a major nuisance for residents, degrading their environment and possibly leading to a feeling of insecurity. In Ghent (Belgium), a survey on the most disturbing forms of urban nuisance places litter and illegal dumping in 1st and 4th place respectively (Heyse, 2014). To simplify the reporting of various nuisances, apps have been developed such as Fix My Street, launched in Brussels (Belgium) in 2013, inspired by MySociety's FixMyStreet launched in 2007 in England. With this app, citizens can freely report incidents such as broken public lamps or blocked sewer. An 'Illegal dump' category was added in 2017 in Fix My Street Brussels and has since become the most reported type of incident.

Urban illegal dumping has scarcely been studied quantitatively. Bruxelles-Propreté (2012) highlights some explanatory factors in its five-year cleanliness plan: social insecurity and the rate of housing changes. They report that dumping is more frequent in neighbourhoods where the population is more mobile. In the outskirts of the city, the problem is less critical, but there is household waste dumped by non-Brussels residents.

In this paper, we analyse whether the urban context is a factor influencing incivilities and more particularly illegal dumping, at a micro scale and at a meso scale.

1. Data and method

1.1. Fix My Street data

Data are obtained via the Brussels Regional Informatics Centre (BRIC, 2020). It includes all incidents reported in Fix My Street by citizens and by professionals (e.g., municipal officers, peace officers, police officers) between July 2017 and February 2020 (inclusive).

Data are divided into two groups. Within the ***Illegal dump*** group (n=46,744 incidents) are the categories *Illegal dumps* and *Abandoned materials - Construction wastes*. The group ***Other*** (n=56,122 incidents) are all the categories of incidents that are neither illegal dumping nor any other incivility. This group includes *Sewer, Public lighting, Public furniture, Vegetation, Coating* and *Signage.*

1.2. Urban environment and "broken window" indicators

The urban environment is characterised at two scales. At the *meso* scale, a typology of the urban fabric is used [**Figure 1**]. This typology highlights the urban environment in which each street is located by taking into account morphological indicators related to the network, buildings and vegetation (Guyot *et al.*, 2021). This typology gives a detailed definition of the urban environment of Brussels, independent of the administrative delineation.

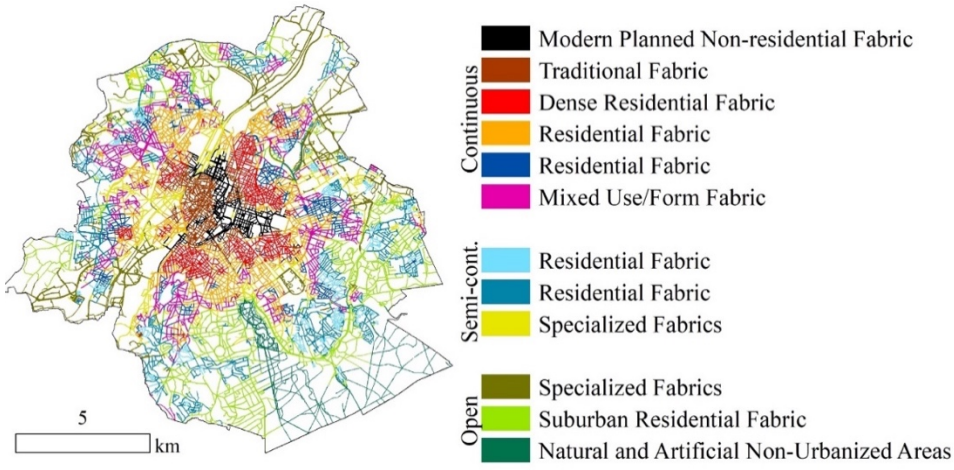

Figure 1*: Urban fabric typology (Source: Guyot et al., 2021)*

We computed a series of indicators at a *micro* scale [Table 1]. Given the lack of literature on the role of urban features on anti-social behaviour, the selection is based on general assumptions such as the availability of space for illegal dumping and the (absence of) informal social control. Proxies for these factors are sought in the available databases. *Tree* and *Recycling bank* are opportunities to drop off dumps at their feet. *Shop* could be a source of waste or the presence of social control. *Road noise* and *Speed limit* constitute a proxy for informal social control. *Vegetation cover*, *Building height*, *Street width*, *Sidewalk width* and *Land cover* highlight the configuration and use of the street.

A “broken window” effect (Kelling and Wilson, 1982) is considered: the dumps would tend to appear in places where there are or have been other illegal dumps. It is measured using two indicators: *Recurrence* and *Time since last* [Table 1].

1.3. Socio-economic indicators

Three indicators are chosen to describe the socio-economic environment: *Household median income*, *Tenant ratio* and *Population density* [Table 1]. The *Municipality* in which the incident took place is also added as an indicator to control for the disparity in the use of the app between municipalities. This last variable is only used as a control variable and will not be analyzed in the results.

Table 1. Computation and source of indicators.

Class	Name	Computation	Data source
Urban environment	Tree	Distance to nearest tree less than 10m [Yes/No].	Urbis (BRIC, 2017)
	Vegetation cover	Ratio of vegetation cover within 100m.	Bruxelles Environnement (Van de Voorde, Canters and Chan, 2010)
	Shop	Distance to the nearest shop less than 20 m [Yes/No].	Atrium.Brussels, 2017
	Recycling bank	Distance to the nearest glass or clothes bank less than 20m [Yes/No].	Bruxelles-Propreté, 2020; Ressources, 2020
	Building height	Average height of buildings in the section of street (between two junctions) in which the incident is located	Urbis 3D (BRIC, 2017)
	Street width	Width of the street at the point of the incident.	Urbis (BRIC, 2017)
	Sidewalk width	Sidewalk width at the level of the incident.	Urbis (BRIC, 2017)
	Speed limit	Speed limit of the street.	Bruxelles Mobilité, 2020
	Road noise	Annual mean road noise level [dB].	Bruxelles Environnement, 2016
	Land cover	Simplification of the Urban Atlas categories into three categories + addition of the office class from the Office Observatory (Brussels) data.	Urban Atlas (European Environment Agency, 2020) Office Observatory (De Beule and Dessouroux, 2011)
Broken window	Recurrence	Number of incidents of the same group within 10m.	Fix My Street (BRIC, 2020)
	Time since last	Time since there were no incidents of the same category within 50m.	Fix My Street (BRIC, 2020)
Socio-economic	Household median income	Value of the statistical sector.	Statistics Belgium, 2017b
	Tenant ratio	Value of the statistical sector.	Census (Statistics Belgium, 2011)
	Population density	Value of the statistical sector.	Statistics Belgium, 2017a

1.4. Method

The use of the Fix My Street App is not uniform across the Brussels Capital Region: it differs across each municipality and is presumably not complete. It is therefore not possible to consider the ***Illegal Dump*** group as an exhaustive inventory. To avoid this selection bias, we compare the ***Illegal Dump*** group with the ***Other*** group, our control group. We assume that users report incidents in the ***Illegal Dump*** group and the ***Other*** group evenly.

To explore the association between urban and socio-economic environment and illegal dumping, logistic (binomial) regressions are performed. This method is widely used in epidemiology. In our case, we took as a dependent variable the fact that an incident in Fix My Street is an ***Illegal dump*** (1) or that it is another incident (***Other***) (0). The explanatory variables used are the urban environment, “broken window” effects and socio-economic indicators. Two outputs of the logistic regressions are extracted: the odds ratios (OR) and the

associated *p*-values (considered significant below 0.05). An OR of 1 means no effect. An OR significantly above 1 means that the explanatory variable increases the probability of the presence of an illegal dump (risk factor) and an OR significantly below 1 means that the explanatory variable decreases the probability of illegal dumping (protective factor). In addition to the sign of the association, we assess the size of the effect: the further the OR value deviates from 1, the larger the effect size.

Three models are applied. The effect of the explanatory variables is computed alone (univariate OR), adjusted with the *Household median income* and *Municipality* variable (adjusted OR) and in a multiple model (multiple OR) to identify the residual effects of a variable, once the other potential explanatory variables introduced into the model have been included. To test the stability of the multiple model, two further analyses are carried out. For the first one, the sample is split in two, according to the date of the incidents. For the second, the model is run for four municipalities (those with the most incidents) separately. For the sake of brevity, the results of these two last analyses will be discussed but not presented.

2. Results and discussion

Significant OR (p<0.5) have been coloured in a gradient of green (protective factor, OR<1) or yellow (risk factor, OR>1) in Table 2 and Table *3*. The darker the colour, the larger the effect size.

2.1. Association between the *meso* urban environment and illegal dumping

Table 2. *Association between the meso urban environment and illegal dumping.*

	OR (univariate)	OR (ajusted)[1]	n
UF1 – Continuous Modern Planned Non-Residential Fabric	0.30 (0.28-0.32)***	0.43 (0.40-0.46)***	5746
UF2 – Continuous Traditional Fabric	Reference	Reference	12393
UF3 – Continuous, Dense Residential Fabric with regular small houses	0.61 (0.58-0.64)***	0.62 (0.59-0.65)***	16180
UF4 – Continuous Residential Fabric with houses and small buildings	0.69 (0.66-0.72)***	0.84 (0.80-0.88)***	21815
UF5 – Continuous Residential Fabric with regular small houses and wide streets	0.68 (0.64-0.72)***	0.90 (0.85-0.96)**	6521
UF6 – Semi-continuous Mixed Use/Form Fabric	0.50 (0.48-0.53)***	0.84 (0.79-0.89)***	11041
UF7 – Semi-continuous Residential Fabric with small houses and small buildings	0.58 (0.53-0.63)***	1.00 (0.91-1.11)	2246
UF8 – Semi-continuous Residential Fabric with houses and average buildings	0.31 (0.29-0.33)***	0.57 (0.53-0.60)***	6193
UF9 – Semi-continuous Specialized Fabrics	0.61 (0.57-0.65)***	0.71 (0.67-0.76)***	6746
UF10 – Open Specialized Fabrics	0.52 (0.49-0.56)***	0.78 (0.73-0.84)***	5239
UF11 – Open Suburban Residential Fabric	0.11 (0.10-0.12)***	0.27 (0.25-0.30)***	4744
UF12 – Open Natural and Artificial Non-Urbanized Areas	0.04 (0.02-0.07)***	0.14 (0.07-0.23)***	221

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 [1]With *Household median income*

For the analysis of the association between the meso urban environment and illegal dumping [*Table 2*], the urban fabric (UF) corresponding to the historical centre of Brussels (UF2) is taken as a reference [see Figure 1]. Compared to UF2, significantly less illegal dumps is observed (protective factor) in all other urban fabrics except for UF7, which is associated with Brussels garden cities. The effect size is larger for the "functional" fabrics UF1 (office spaces), and to a lesser extent for UF9 and UF10 (more industrial or logistic areas). In the residential fabrics, UF3 (dense residential areas) and UF8 (greener areas, also associated with Brussels garden

cities) are relatively more projective than the other residential fabrics (e.g. UF4 and UF5). Finally, the further from the centre to the green periphery of Brussels (UF10, 11, 12), the larger the effect size, even when adjusting with the *Household median income*.

2.2. Association between the *micro* urban environment and illegal dumping

The three socio-economic variables are strongly correlated . We thus only kept *Household median income* in the analysis, which has a larger effect. We kept only one "broken window" effect indicator: *Recurrence*. *Road noise* and *Speed limits* are correlated and conceptually represent the same factor, i.e. traffic. We kept *Road noise* as it is more correlated to *Illegal dump*.

Table 3. *Association between the micro urban environment and the Illegal dump.*

Variable		OR (univariate)	OR (adjusted)1	OR (multiple)[2]	N
Tree	No	Reference	Reference	Reference	62418
	Under a tree	1.08 (1.05-1.11)***	1.15 (1.12-1.19)***	1.27 (1.22-1.31)***	36667
Vegetation	0%	Reference	Reference	Reference	10785
	< 14%	1.69 (1.62-1.77)***	1.8 (1.71-1.89)***	1.88 (1.78-1.99)***	29420
	14-30%	1.16 (1.11-1.21)***	1.96 (1.86-2.07)***	2.14 (2.02-2.27)***	29450
	> 30%	0.67 (0.64-0.70)***	1.56 (1.47-1.65)***	1.80 (1.68-1.92)***	29430
Shop	No	Reference	Reference	Reference	63559
	Yes	1.14 (1.11-1.17)***	0.97 (0.94-1)	0.91 (0.88-0.94)***	35526
Recycling Bank	No	Reference	Reference	Reference	96856
	Yes	1.19 (1.09-1.30)***	1.15 (1.05-1.27)**	1.22 (1.10-1.36)***	2229
Buildings height	< 8m	Reference	Reference	Reference	33015
	8-12m	1.53 (1.48-1.58)***	1.39 (1.33-1.44)***	1.20 (1.15-1.25)***	33042
	> 12m	1.29 (1.25-1.33)***	1.12 (1.08-1.17)***	1.09 (1.04-1.14)**	33028
Street width	< 14m	Reference	Reference	Reference	33022
	14-19m	0.91 (0.88-0.94)***	0.9 (0.87-0.93)***	0.99 (0.95-1.03)	33028
	> 19m	0.69 (0.66-0.71)***	0.63 (0.61-0.66)***	0.82 (0.79-0.86)***	33035
Sidewalk width	<2.5m	Reference	Reference	Reference	33025
	2.5-4m	1.02 (0.99-1.05)	1.09 (1.06-1.13)***	1.01 (0.97-1.05)	33027
	>4m	0.92 (0.90-0.95)***	0.81 (0.78-0.84)***	0.75 (0.72-0.78)***	33033
Road noise	< 49dB	Reference	Reference	Reference	33032
	49-66dB	0.67 (0.65-0.70)***	0.74 (0.72-0.77)***	0.79 (0.76-0.82)***	33016
	> 66dB	0.35 (0.34-0.36)***	0.43 (0.41-0.44)***	0.48 (0.46-0.50)***	33037
Land cover	Residential	Reference	Reference	Reference	81417
	Green	0.61 (0.57-0.66)***	0.62 (0.58-0.68)***	0.92 (0.84-1.00)*	3611
	Industrial	0.76 (0.73-0.79)***	0.57 (0.55-0.6)***	0.72 (0.69-0.75)***	12522
	Office	0.45 (0.41-0.51)***	0.42 (0.37-0.47)***	0.48 (0.42-0.55)***	1535
Recurrence	0 or 1	Reference	Reference	Reference	52854
	More than 1	3.83 (3.73-3.93)***	3.05 (2.96-3.14)***	3.12 (3.02-3.22)***	46231
Household median income	Tertile 1 (low)	5.55 (5.37-5.74)***	-	2.72 (2.60-2.85)***	32506
	Tertile 2	3.47 (3.35-3.59)***	-	1.80 (1.73-1.88)***	33534
	Tertile 3 (high)	Reference	-	Reference	33045

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 [1]With Household median income and Municipality [2]With Municipality

The association between the urban environment indicators and illegal dumping is quite stable in the different models. Only *Shop* and *Vegetation >30%* change sign. The association between illegal dumping and *Shop* is also not stable over time, so it can be said that no stable association is found for this indicator. The association between *Vegetation* and illegal dumping is not linear and is not stable in space: in the municipalities of Anderlecht and Ixelles, vegetation has a protective role, but for the municipalities of Brussels and Etterbeek, it is a risk factor. This demonstrates the different uses and appropriation of green spaces in the different municipalities. *Buildings height* is not a stable factor in space either.

The indicator with the largest effect size in the multiple model is *Recurrence*: if an illegal dump is already observed at a given location, there is a higher probability that another illegal dump will reappear at that location. This effect remains significant even after controlling for the impact of other explanatory variables. This is an effect known to residents who sometimes have to endure illegal dumping on their street. *Household median income* has a larger effect size than *Recurrence* in the univariate analysis but this is no longer the case in the multiple model. It remains high, and this confirms social deprivation as a risk factor, as suggested by Bruxelles-Propreté (2012).

The association between *Recycling banks* and illegal dumping does not seem to be spatially stable and loses some explanatory power when its effect is observed at two different times. It is therefore difficult to conclude for this indicator, contrary to *Tree* where the association is stable (risk factor).

Wide streets (*Street width/>19m*), with a large sidewalk (*Sidewalk width/>4m*) and traffic (*Road Noise*) are associated with a low probability of illegal dumping. These relationships are stable over time and space. Conversely, residential streets (*Land Cover/Residential*) are associated with a high probability of illegal dumping. Therefore, the typical street where a dump takes place could be described as a narrow, quiet residential street.

Conclusion

The numerous occurrences of illegal dumps affect the quality of life and likely well-being in cities and generate additional cleaning costs for the community. We found that illegal dumping is associated with specific urban features. At the *meso* scale, we observed fewer illegal dumps in office neighbourhood and in the green periphery, and many more in the historical fabric. At the *micro* scale, the typical street where a dump takes place could be described as a narrow, quiet residential street with urban trees. A “broken window” effect is also observed: illegal dumps are more likely to reappear where there has already been a dump. This study on a specific instance of degraded urban environment offers perspective on a broader sets of issues pertaining to urban quality of life and well-being, and how to maintain and improve it.

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