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RESEARCH ARTICLE

Study of littered wastes in different urban land-uses: An 6 environmental status assessment

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Abstract

Littered waste is a severe environmental problem. Although there have been many studies on wastes littered in the environments like beaches and seas, there is insufficient information on littered wastes in the urban settings. In this research, employing visual survey by the field litter counts method, littered wastes in six urban land uses in Qazvin, Iran were studied. The results showed that administrative and recreational land uses, by an average of 5.22 and 9.59 items per 100 m, respectively, had the lowest pollution, while low-density commercial land use had the maximum pollution by 185.96 items per 100 m. Urban littered waste ratios were not the same in various land uses: cigarette waste and paper and cardboard accounted for higher than 80% of the whole littered wastes in most studied land uses. The cigarette butt was also the most frequently litter in the city. In terms of environmental status, administrative and recreational areas can be defined as places with good conditions, while low-density commercial land use had bad conditions. Consequently, urban land use was acknowledged as a significant factor in the density of littered waste. More attention to cleaning the commercial land use to reduce the density of littered waste, and also finding methods to decrease littering waste by citizens, is a need in urban environment.

Keywords Litter · Waste management · Urban environment · Land-use · Environmental status

Introduction

Solid waste management is a significant issue in today's world with many health, environmental, and financial aspects [1–3] that cause several effects on environment, even climate change [4]. Among municipal solid wastes, litters have prominent importance in terms of the environment as well as waste management. Litter is waste that discharged directly or indirectly into the environment and can be observed in various areas, including beaches or urban streets [5]. Studies on different classifications of litters indicate that plastic, paper, and tobacco waste, such as cigarette butts, account for the most considerable number of them [6–9].

littered wastes have adverse impacts on various local to global scales on the environment and organisms in different terms of health, aesthetics, and economy. These wastes are known as a prevalent problem globally [8] and need serious efforts to the collection and management. Serious challenges have been highlighted in studies of different types of littered waste such as cigarette butts in different environments such as beaches, urban environments, and marine areas. These challenges include high collection costs [8], unpleasant sceneries [10], toxicity to organisms [11, 12], environmental pollution leaks [13, 14], and the inefficiency of the current collection systems [10, 15]. Given that appropriate knowledge about the properties of littered wastes plays a basic role in the management of these wastes, as well as better identification of sources and effects of them [16], thus, the study of littered wastes in different environments is a necessity. Many studies have been conducted over the years in the area of coastal and marine

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litters [6, 7, 9, 16]; nevertheless, very few studies have been performed about urban litters hitherto. In addition, studies on urban litters have often been conducted on one type of littered wastes. Therefore, the aim of this research was to study the quantitative and diversity of littered wastes in the urban environment. Also, the study of spatial variation of urban litters was a significant aim of this study. Furthermore, considering the limitations of similar studies and the lack of an index, with some modifications in the environmental status index, which had previously been used for the evaluation of pollution status in environments like coastal areas, this index was utilized to evaluate pollution status of urban environments.

Method

A visual survey method was selected for this study [17]. Furthermore, based on this method, data related to wastes littered in urban environment were collected by field litter counts [18, 19]. In this research, items such as leaves, branches and remains of pruning activities, and broken parts from the sidewalk surface were not consider as a litter [8]. This study was carried out in Qazvin (Fig. 1), which is one of the provincial centers in Iran. With an area of 64,132 km2, the city consists of 19 districts (http://fava.qazvin.ir), and according to the newest official statistics has a population of 402,748 inhabitants (https://www.amar.org.ir).

The same survey protocol was defined for the environments studied. The study was conducted in six months, from April 2019 to September 2019. Also, the studies were conducted on workdays, including 5 days (excluding Thursdays and Fridays), from 5 to 8 p.m, as during these hours, observations could be made using daylight and in the same conditions, also, street cleaning schedules affect the amount of urban waste [18] that performs in Qazvin in the last hours of the night. The selected time for this study was similar to the time of the earlier researches in the evening [19–21]. The scope of study specified in each location included the entire sidewalk and extended up to 1 m into the street [8, 18]. The length between the two intersections was considered as the study distance. After counting the litters, their quantity was expressed per observation length [5, 6, 22]. Then, the coefficient mentioned in Table 1 was applied to calculate the environmental status index [5, 23] of each group of city streets. We classified the urban environment into six categories in terms of land use: residential (C1), recreational (C2), administrative (C3), dense commercial, (C4) low-density commercial (C5), and Non-dominant land use (diverse) (C6). non-dominant land use included areas of the city that has commercial, recreational, and residential uses in the uniform ratio.

Taking into data displayed in Table 1, the environmental status of each urban land use was determined by multiplying the number of observed litter in the corresponding weights (Eq. 1) and defined as Table 2:

$$EnvironmentalStatus = \frac{\sum_1^n (\mathrm{Wi} \times \mathrm{N})}{L} \quad (1)$$

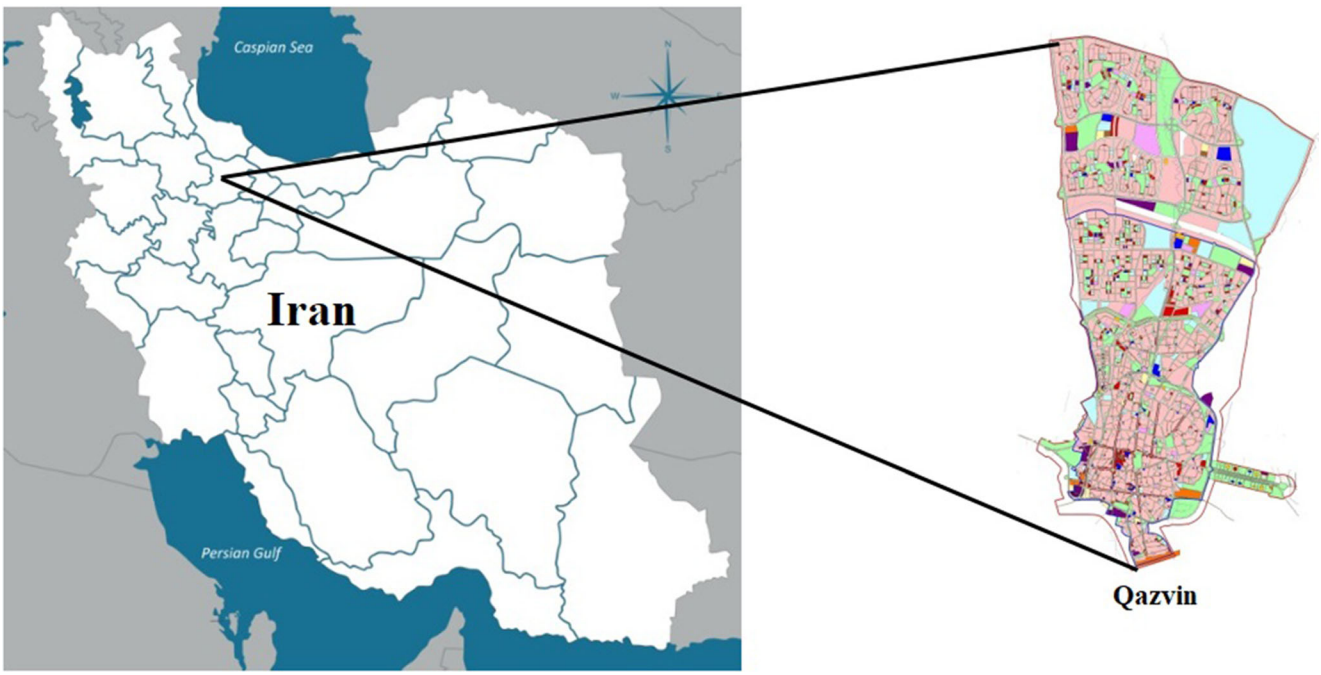

Fig. 1 Location of the studied city

Table 1 Classification and corresponding weights of different litters [5, 23]

Litter type	Urban environment classification (number of items per 100 m)				corresponding weights*
	Good	Mediocre	Unsatisfactory	Bad	
Cigarette butt	0–9	10–15	16–30	more 30	2
Cigarette pocket	0–1	1–2	2–4	more 4	1
ATM receipt**	0–9	10–15	16–30	more 30	1
Paper***	0–1	1–2	2–4	more 4	1
Juice packet	0–1	1–2	2–4	more 4	1
Other packets	0–1	1–2	2–4	more 4	1
Candy wrap	0–9	10–15	16–30	more 30	1
Biscuit wrap	0–1	1–2	2–4	more 4	1
Disposable dish	0–1	1–2	2–4	more 4	1.5
Disposable glass	0–1	1–2	2–4	more 4	1.5
Drinking straw	0–1	1–2	2–4	more 4	1.5
PET bottle	0–1	1–2	2–4	more 4	1.5
Bottle door	0–1	1–2	2–4	more 4	1.5
Nylons****	0–1	1–2	2–4	more 4	1.5
Juice Bottle	0–1	1–2	2–4	more 4	1
Bottle door [metal]	0–1	1–2	2–4	more 4	1
Glass bottle	0–1	1–2	2–4	more 4	1.5
Wood	0–1	1–2	2–4	more 4	1
Facial tissue	0–1	1–2	2–4	more 4	2

*__1__ if the litter type cause indirect damage, __1.5__ if the litter type causes a direct impact, and __2__ if the litter type has a toxic or infectious agent

**Includes bank receipts, purchase invoices, and like that

***Include office papers, brochures, and newspapers in sizes less than A4

****Plastic bags, freezer bags and like that

where, Wi are corresponding weights, N is number of litter, and L is length of the area studied.

Results and discussion

The results of this research for the observed littered wastes in six land uses have been included in Table 3. The results showed that the minimum number of urban litter was in administrative land use; while the maximum number of urban litter was in low-density commercial land use. The number of litters observed in dense commercial land use was more than 6.12 times greater than that in residential land use. Also, as Fig. 2 illustrates, the ratios of the counted littered wastes in each studied category differs. Nevertheless, cigarette butt, ATM receipt, and candy wrap can be defined as the most prevalent urban littered wastes, respectively. In total, these litters account for more than 80% of urban litters.

According to the litters observed in this study and considering the coefficients given in Table 1, the environmental status for administrative and recreational urban land uses were calculated as 17.84 and 9.16, respectively. However, low-density commercial land use with an environmental status score of 311.1 had the highest score among urban land uses (Fig. 3a). The important point here is the high impact of cigarette butts and facial tissue on determining the environmental status, because these litters are the most prevalent urban litters and have corresponding weights of 2 in Table 1. In fact, the presence of chemicals and toxins in cigarette butts and their leakage into the environment, as well as the facial tissue pollution and its infectious potential have a significant effect on the environmental status of the different urban environments. On the other hand, in some

Table 2 Defined environmental status based on calculated index

Calculated Index	Less than 25	26–100	101–250	higher than 250
Environmental Status	Good	Mediocre	Unsatisfactory	Bad

Table 3 Frequency and the ratio of litters in urban land uses studied

Land-use/ item		Relative abundance (item/ 100 m)			% total
		Min	Max	Mean	
Residential (n = 5)*					
Cigarette waste	Cigarette butt	18.2	21.5	20.04	80.97
	Cigarette pocket	0.1	0.9	0.52	2.10
Paper and cardboard	ATM receipt	0	1.1	0.3	1.21
	Paper	0	0.2	0.08	0.32
	Juice packet	0	0.2	0.06	0.24
	Other packets	0	0.1	0.08	0.32
Plastic	Candy wrap	0.9	3.7	1.9	7.68
	Biscuit wrap	0.2	1.3	0.68	2.75
	Disposable dish	0	0	0	0.00
	Disposable glass	0	0.4	0.14	0.57
	Drinking straw	0	0.4	0.14	0.57
	PET bottle	0	0	0	0.00
	Bottle door	0	0.5	0.15	0.61
	Nylons	0.1	0.5	0.22	0.89
Metal	Juice Bottle	0	0.1	0.02	0.08
	Bottle door	0	0	0	0.00
Others	Glass bottle	0	0.1	0.02	0.08
	Wood	0	0.4	0.1	0.40
	Facial tissue	0	0.6	0.3	1.21
Total		-	-	24.75	100
Official (n = 3)					
Cigarette waste	Cigarette butt	3.2	12.6	3.56	68.20
	Cigarette pocket	0	1	0.3	5.75
Paper and cardboard	ATM receipt	0.64	0.75	0.69	13.22
	Paper	0	0.5	0.17	3.26
	Juice packet	0	0	0	0.00
	Other packets	0	0	0	0.00
Plastic	Candy wrap	0	0.1	0.03	0.57
	Biscuit wrap	0	0	0	0.00
	Disposable dish	0	0	0	0.00
	Disposable glass	0	0	0	0.00
	Drinking straw	0	0	0	0.00
	PET bottle	0	0	0	0.00
	Bottle door	0	0.5	0.17	3.26
	Nylons	0	0	0	0.00
Metal	Juice Bottle	0	0	0	0.00
	Bottle door	0	0	0	0.00
Others	Glass bottle	0	0	0	0.00
	Wood	0	0	0	0.00
	Facial tissue	0	0.6	0.3	5.75
Total				5.22	100
High density commercial (n = 5)					
Cigarette waste	Cigarette butt	58.6	99.67	58.6	38.65
	Cigarette pocket	0.16	2.93	1.77	1.17
Paper and cardboard	ATM receipt	27.27	96.82	45.65	30.11
	Paper	2.5	4.21	3.14	2.07

Table 3 (continued)

Land-use/ item		Relative abundance (item/ 100 m)			% total
		Min	Max	Mean	
	Juice packet	0.38	2.24	1.15	0.76
	Other packets	0	0.52	0.46	0.30
Plastic	Candy wrap	6.5	11.36	9.37	6.18
	Biscuit wrap	2.83	9.15	6.05	3.99
	Disposable dish	0	3.06	1.43	0.94
	Disposable glass	0.83	2.97	2.08	1.37
	Drinking straw	0.78	2.45	1.79	1.18
	PET bottle	0.5	0.97	0.73	0.48
	Bottle door	1.62	10.26	4.85	3.20
	Nylons	4.5	7.14	4.74	3.13
Metal	Juice Bottle	0	0.1	0.03	0.02
	Bottle door	1.16	4.88	2.47	1.63
Others	Glass bottle	0	0.13	0.02	0.01
	Wood	0.23	4.48	2.55	1.68
	Facial tissue	4.16	5.81	4.73	3.12
Total				151.61	100
Low density commercial (n = 4)					
Cigarette waste	Cigarette butt	68.02	229.1	115.7	62.22
	Cigarette pocket	0.1	3.35	1.15	0.62
Paper and cardboard	ATM receipt	21.8	38.3	35.6	19.14
	Paper	0	2.41	0.9	0.48
	Juice packet	0	1.32	0.46	0.25
	Other packets	0	0.24	0.1	0.05
Plastic	Candy wrap	7.2	22.47	11.13	5.99
	Biscuit wrap	0.2	5.1	3.62	1.95
	Disposable dish	0	6.23	1.94	1.04
	Disposable glass	0	2.94	1.53	0.82
	Drinking straw	0.66	5.05	1.81	0.97
	PET bottle	0	0.64	0.18	0.10
	Bottle door	0.35	5.4	1.74	0.94
	Nylons	0.7	5.7	3.04	1.63
Metal	Juice Bottle	0	0.11	0.04	0.02
	Bottle door	0.5	2.41	0.95	0.51
Others	Glass bottle	0	0.11	0.04	0.02
	Wood	0.8	3.58	1.73	0.93
	Facial tissue	1.71	8.41	4.3	2.31
Total				185.96	100
Recreational (n = 4)					
Cigarette waste	Cigarette butt	0.85	24.2	7.91	82.48
	Cigarette pocket	0	0.03	0.01	0.10
Paper and cardboard	ATM receipt	0.86	0.2	0.56	5.84
	Paper	0	0.07	0.02	0.21
	Juice packet	0	0.3	0.1	1.04
	Other packets	0	0.11	0.02	0.21
Plastic	Candy wrap	0.2	0.75	0.37	3.86
	Biscuit wrap	0	0.03	0.01	0.10
	Disposable dish	0	0	0	0.00

Table 3 (continued)

Land-use/ item		Relative abundance (item/ 100 m)			% total
		Min	Max	Mean	
	Disposable glass	0	0.05	0.02	0.21
	Drinking straw	0	0.01	0.01	0.10
	PET bottle	0	0.04	0.04	0.42
	Bottle door	0.05	0.25	0.11	1.15
	Nylons	0	0.26	0.11	1.15
9Metal	Juice Bottle	0	0. 1	0.02	0.21
	Bottle door	0	0.1	0.04	0.42
Others	Glass bottle	0	0	0	0.00
	Wood	0.02	0.07	0.04	0.42
	Facial tissue	0.1	0.24	0.2	2.09
Total				9.59	100
Non-dominant land use (diverse) (n = 4)					
Cigarette waste	Cigarette butt	49.31	96.54	69.54	41.93
	Cigarette pocket	1.93	4.6	3.53	2.13
Paper and cardboard	ATM receipt	28.5	41.2	35.05	21.14
	Paper	0.9	2.39	2.03	1.22
	Juice packet	0.4	1.22	0.85	0.51
	Other packets	0.24	1.2	0.57	0.34
Plastic	Candy wrap	10.1	31.5	20.23	12.20
	Biscuit wrap	4.11	22.11	8.99	5.42
	Disposable dish	0.54	2.12	1.47	0.89
	Disposable glass	2.12	6	3.36	2.03
	Drinking straw	0.47	2.34	1.48	0.89
	PET bottle	0.29	2.3	1.08	0.65
	Bottle door	1.85	4.36	2.97	1.79
	Nylons	2.44	8.1	4.8	2.89
Metal	Juice Bottle	0.06	0.2	0.11	0.07
	Bottle door	1.2	2.72	1.18	0.71
Others	Glass bottle	0	0.2	0.05	0.03
	Wood	1.17	3.7	2.66	1.60
	Facial tissue	4.31	7.67	5.88	3.55
Total				165.83	100

*Number of studied street in each category

items such as ATM receipt, although the number of counted litters in some areas was high, according to the corresponding weights 1 for these litters, they had less effect than cigarette butts and facial tissue in the environmental status index.

Calculated environmental status scores for studied land uses ultimately led to two land uses in good condition, two in unsatisfactory status, one in mediocre status, and one in bad condition. As presented in Fig. 3b, administrative and recreational land uses were assessed as in good condition in terms of environmental status. Moreover, the pollution of the residential areas by different types of littered waste was determined as mediocre. As shown in Fig. 2, cigarette butts are the most important littered waste in various land uses. However, in residential and recreational areas, cigarette butts include more than 80% of the littered wastes, but in commercial areas, its ratio was between 40 and 60%. In commercial areas due to the existence of shopping centers, bank branches, cafes, and restaurants, other types of littered waste such as paper and plastic increased compared to residential, administrative, and recreational areas. The effect of different urban land uses on the composition of litters was significant, so that in non-

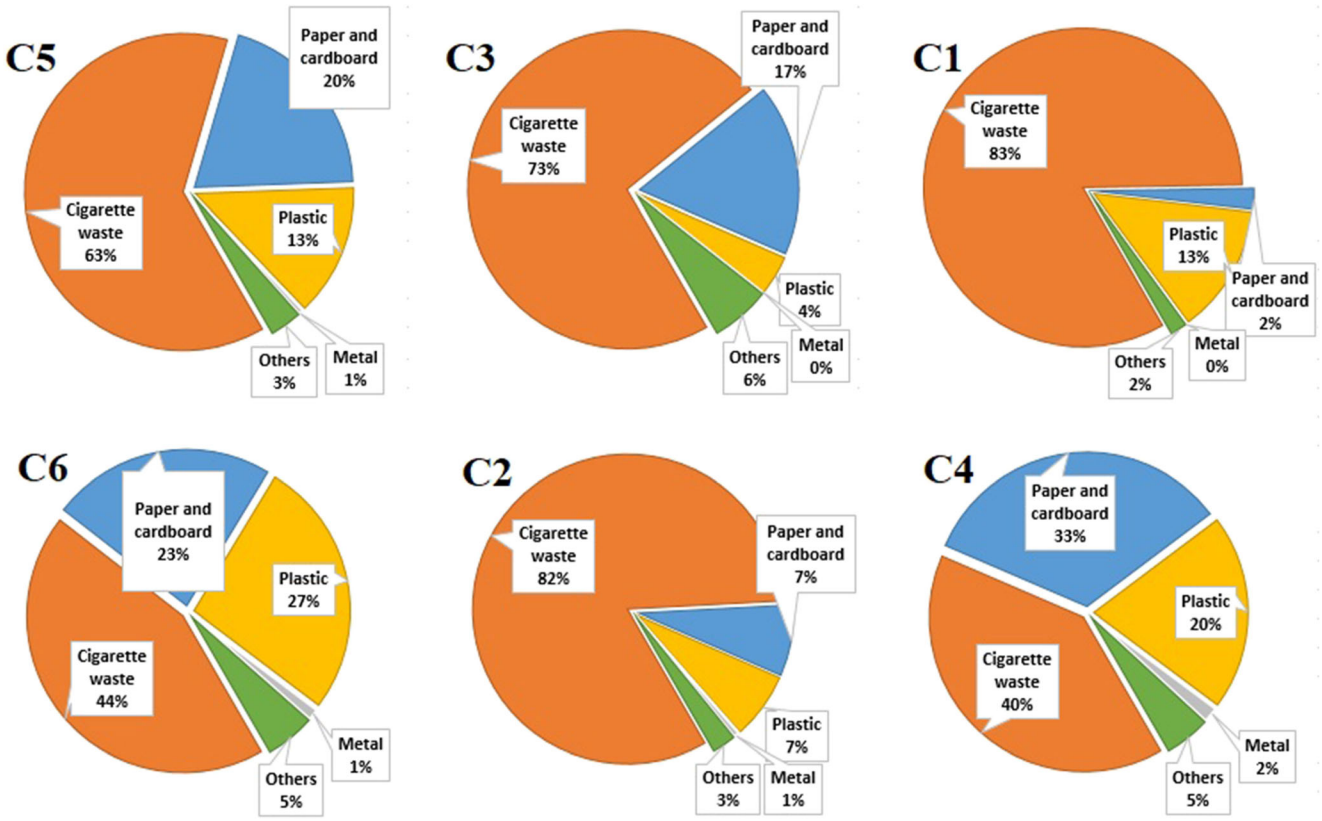

Fig. 2 Ratio of litter categories in different urban land uses

dominant land use (C6) the diversity of social activity leads to the proportional composition of urban litters compared to areas with specific and dominant land uses.

Before this study, very few studies have been performed on littered waste in urban areas. Therefore, there is not much comparable information with the results of this study. However, in a study performed in an Argentina's cities by Pon and Becherucci, urban litters were studied with results comparable to our findings [8]. Studying four urban areas: predominantly commercial and dense, residential, seaside resort, and industrial land uses in the city of Mar del Plata, they counted a total of 20,336 litters. Of these, cigarette butts, paper, and plastics accounted for 33, 31, and 22 percent, respectively. In our study, by studying six land uses in various areas of the city, 38,368 litters were counted, the most abundance of which was 25,837 cigarette butts. In the Pon and Becherucci study, the percentage of commercial and high-density, residential, seaside resort, and industrial areas of the sum of litters counts were 26.33, 12.75, 23.92, and 39.92 percent, respectively [8]. While the share of commercial, residential, administrative and recreational land uses in our research were 48.11, 5.28, 0.68, and 22.66 percent, respectively. The results of our study and its comparison with the data from Mar del Plata study prove that urban land use affects the density of urban litter. This is also obvious in the study of cigarette butts as a significant urban litter in the results of many studies [15, 18, 19].

Many reasons can alter the difference in the number of litters in diverse urban areas. Population density can be

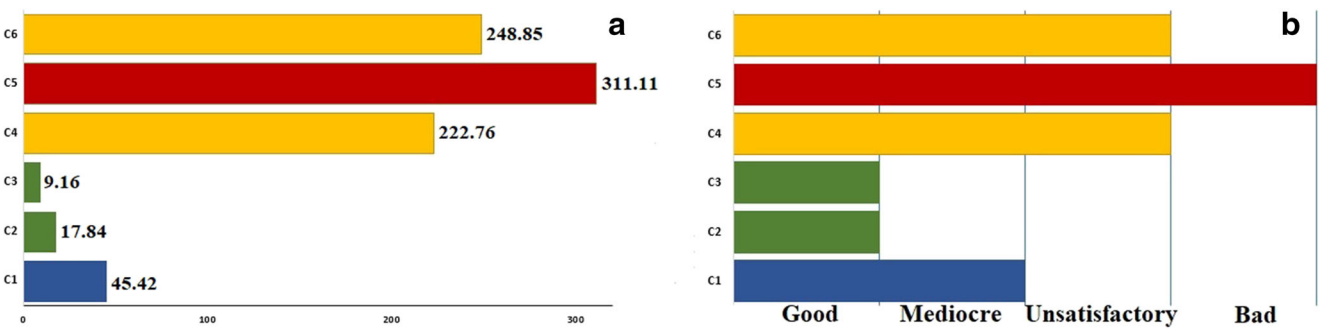

Fig. 3 Score of environmental status calculated for urban land uses studied (**a**), Environmental status calculated for urban land uses studied (**b**)

considered as a significant factor affecting the number of urban litter [8, 19, 24]. That is, an increased number of people on urban streets raises the per capita littering, and ultimately, the number of littered wastes in crowded urban areas, which are often in the commercial areas of the city. For this reason, in our study, the lowest number of litters was observed in administrative areas due to the lowest number of people and only during the office hours' activity. Another factor that influences the number of litters in the passages is their sweeping rate. Insofar as one reason for the difference in the number of cigarette butts, thrown in several urban areas of Madrid, is the difference in urban sweepings in different areas of the city [19]. That being said, the type and quantity of passage sweeping are the same in all areas in the city we are studying. Thus, it cannot be the reason for the difference we have observed. Also, we have noticed some business owners sweeping the front of their shops daily in commercial land uses, like in the Green's Study in Berlin [15]. At first glance, this may appear to decrease the number of litters in the city. Nonetheless, because places such as tree pits and open curbs besides the passages are regarded as low access points for sweeping, the transfer of litters to them by business owners can cause litters to swell there.

A significant factor in the quantity of litters in various urban land uses can be mentioned as the presence of centers with high litter potential in different land uses. For illustration, cigarette butts, one of the most important urban litter can be seen around sales centers; and smoking is more prevalent around supermarkets and urban transportation stations such as buses [15, 18, 19]. Our observations in this study showed that the most litter of paper is around bank branches and ATMs, as well as commercial centers. Also, the most littered disposable dishes were found around cafes and fast foods. Since these places were seen in commercial land use and the city center more than other land uses, an important reason for the high number of litters in commercial land use compared to

Table 4 Results of related studies on littered wastes in urban environment

Location and date of sampling	Litter type	Remarks	Reference
Mar del Plata city, Argentina; April 2008 to March 2009	Whole of litters	√ The number and composition of littered wastes vary in different land uses. √ Cigarette butts, paper, and plastic were the most abundant litters, respectively. √ Residential areas have the lowest littered wastes and industrial areas have the highest littered wastes.	[8]
Madrid, Spain; May 2019 to September 2019	Cigarette butt	√ One of the reasons for the difference in the density of urban litters (cigarette butt) in different areas is the difference in urban services such as sweeping. √ Some places in cities, such as urban transport stations and cafes have a high potential for cigarette butt littering. √ Population density is directly related to the number of littered cigarette butts in the city	[19]
Berlin, Germany; May 2012 to February 2013	Cigarette butt	√ Littered cigarette butts were more abundant around cigarette sale centers and cafes. √ Cleaning activities by business owners is a reason for the difference in the density of littered cigarette butts. √ Low access to places such as bicycle stations and tree pits for sweeping increases the duration of littered cigarette butts and increase the density of this waste in these places.	[15]
Qazvin, Iran; April 2019 to September 2019	Whole of litters	√ The number and composition of littered wastes vary in different land use lead to different environmental status in different land uses. √ Cigarette butts was most abundant observed litter in urban environment. √ Administrative areas have the lowest littered wastes and commercial areas have the highest littered wastes. √ In areas such as around bank branches, supermarkets, cafes, and intersections, most litters were seen, although in different waste composition.	This study

other urban land uses is the existence of centers with high potential for more waste littering in these areas (Table 4).

Environmental status of urban land uses shows that cigarette butts and plastics are the most important litters. Cigarette butts are a prevalence litter in the world, which are regarded as a hazardous waste owing to the presence of many chemicals in them and their leakage into the environment [10]. The toxic impacts of this litter on organisms [25–27] as well as water pollution by it [15] have been reported in previous studies. In urban settings, in addition to toxicity, another risk of cigarette butt disposal is the probability of being eaten by household animals and children [28], which moreover highlights the consequence of this litter in the urban environment. On the other hand, cigarette butts are a durable waste in the environment for months [15, 24, 28]. Due to the high leakage rate of some of its pollutants [10], cigarette butts can be a source of hazardous pollution in city areas. Earlier studies have determined that the high number of littered cigarette butts is not associated with the lack of bins in the passages, because the number of littered cigarette butts was notable in areas where there an ample amount of trash bins [15]. This point was also visible in our study of cigarette butts and other litters, which was still easily observed, despite a high number of trash bins in the city. Also, the usage of plastic in daily activity has been growing since previous decades owing to characteristics such as persistence, lightweight, resistance properties, flexibility, and low cost [29–31]. A major part of it used as disposable containers and packaging, was seen in our research as litter in city areas. Since plastic is recognized as an environmental hazard [32, 33], its littering in urban streets can challenge the collection and management of this waste. On the other hand, the management of plastics and other municipal wastes is economically significant, and littered waste management can inflict costs on the waste management system and residents [34].

Conclusion

The density of urban litters in the city of Qazvin was studied. Urban land use is an effective factor in the number of urban litter. The six studied land uses were ranked as C5 > C6 > C4 > C1 > C2 > C3. Of the 38,368 counted items, cigarette butts, ATM receipt, and candy wrap were the most prevalent urban litters. Many factors such as population density, type of urban services, low access points such as tree pits, high potential waste littering centers such as cigarette sales centers, ATMs, and cafes are efficient in the different numbers of litters in diverse urban land uses. In crowded areas, more shopping centers, bank branches, restaurants, and cafes lead to more littering. Also, in low access places such as tree pits and surface water canals, as well as in areas where urban services are poor, the density of littered waste is higher. In terms of litter pollution and considering the environmental status, the condition in Qazvin was determined as unsatisfactory. The existence of a few studies on the urban litter is a gap in waste management knowledge. Consequently, due to the aspects of urban litter, including toxicity, durability, and dispersion, it is essential to provide appropriate methods for the management of these wastes. Quantitative and qualitative index should also be defined to evaluate and compare wastes littered in different cities and urban areas.

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Compliance with ethical standards

Conflict of interest The authors declare that there is no conflict of interest.

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