Article

Survey on Household Solid Waste Sorting at Source in Developing Economies: A Case Study of Nur-Sultan City in Kazakhstan

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Abstract: The exponential population growth in urban areas makes existing solid waste management policies and strategies challenging. The situation becomes more strenuous in fast-growing cities where increasing waste production can hardly be met by the capacity of existing facilities. Practices like waste prevention, recycling, reuse, and recovery are fundamental elements needed for the reduction of solid waste disposed in landfills, especially in fast-growing cities where more sustainable management practices need to be adopted. This study investigated the behavioral attitudes of citizens of the capital of Kazakhstan, Nur-Sultan (former Astana), towards household solid waste disposal and separation at the source. The survey was conducted through stratified random sampling during April and July of 2018 with the participation of 3281 respondents. It is the first attempt, to our knowledge, of assessing recycling trends in Kazakhstan from the household perspective. The results showed that 24% of respondents were already sorting household solid waste despite the absence of a separation system at the source. The study further demonstrated that separation at source could be effective if the local authorities were to introduce sound public awareness campaigns and install recycling bins in close proximity to residential buildings.

Keywords: household solid waste; recycling; separation at source; survey

1. Introduction

In Kazakhstan and neighboring post-Soviet countries, issues related to household solid waste (HSW) management have become serious concerns [1]. This has been mainly caused by insufficient legislation and regulation [1]. In 2015, there were a total of 4284 landfills and dumps in Kazakhstan, and only 459 met lawful requirements [1,2]. In 2017, there were 546 communal enterprises in total: 55 of them were state owned and 488 privately owned [3]. According to a national report from the Ministry of Energy, 4.3 million tons of municipal solid waste (MSW) was produced in 2018, out of which 3.4 million was delivered to HSW sites [3].

The prevailing management system of HSW in Kazakhstan is unsorted disposal to landfill sites, mainly because of the abundance of ample open space and the relatively low cost of disposal compared to other options [4–6]. However, the environmental impacts are manifold, such as, for instance, the continuous methane emissions and groundwater contamination due to leachate discharge [7,8]. Currently, about 95% of HSW in Kazakhstan is disposed into sanitary landfills, while the entire volume of HSW placed in landfills is estimated to be over 100 Mt [1,9]. The approximate annual production is 4–5 Mt, whereas by 2030 this number is expected to grow up to 7 Mt [10,11]. Under the current urban waste consumption trends, all landfills in Kazakhstan are projected to become saturated within the next decade. The construction of new regional sanitary landfills is required, while the existing ones should be closed and equipped with gas production units that could strongly support the economic sustainability of HSW management [12]. The potential economic opportunities from waste recycling in Kazakhstan has attracted private sector investments, and at present there are more than 130 small and medium sized enterprises dealing with sorting and processing waste of more than 20 types [3]. Promising examples of public–private collaboration are Raduga firm, which processes and manufactures household products from recycled polymers in North Kazakhstan, the Non-Woven Fabric Factory in the Kostanay region, the HILL Corporation in Shymkent, and the KazRecycleService waste recycling plant in Nur-Sultan [3]. In the case of the capital, Nur-Sultan, some private firms have initiated the setup of recycling systems for plastic and glass bottles in some residential buildings [13]. The private initiative in Nur-Sultan advocates the argument that urban waste separation at source could prove to be economically beneficial and environmentally friendly if well managed. Waste separation at source is not a new concept, and various scholars have mentioned the advantages since early 80s [14]. The success of separation methods depends to a great extent on the behavioral aspects of the citizens, whereas separation from mixed waste depends on the availability of technologies [14–17].

The opinions of the public regarding waste management are particularly crucial in developing countries where waste management plans are still in primary stages [18]. Several factors affecting HSW sorting have been investigated in the literature, and results have shown that certain attitudes and perceptions towards environmental concerns and recycling have significantly affected disposal and sorting behaviors [19–22]. Early studies, such as those of Taylor and Todd [23] and Vining and Ebreo [24], have illustrated that factors like cost, time, and the poor conditions of facilities were regarded as hindrances to pro-environmental behavior. Different behavioral models have been proposed since the 1990s in an attempt to understand how a number of different factors affect recycling behavior [25]. For instance, the motivation–ability–opportunity–behavior (MAOB) model showed that even if motivation is present, it is still not enough to support an environmentally friendly behavior. Assessment of sorting attitudes and participation were studied by Nixon and Saphores [26] and Almazán-Casali, Alfaro, and Sikra [17]. The objective of these studies was to identify the factors that may affect the participation of inhabitants in waste sorting schemes. In other studies, in-depth surveys were frequently employed to better comprehend respondents' views on the barriers and success factors affecting HSW management so that relevant awareness campaigns could be adopted. In this regard, a survey carried out in Nigeria has revealed the need for a sustained public education program on waste prevention, promoting the idea of reuse, which could have a substantial effect on waste disposal [27]. Mathematical and causal effect models have also been adopted to stimulate HSW management behavior and promote the potential of adopting recycling schemes [28,29]. These models have shown that the tendency to recycle can be affected by social norms, pro-recycling attitudes, and perceived effectiveness. It was also noted that the tendency to recycle waste was not enough to cause recycling habits. Theoretical models, such as the theory of planned behavior (TPB), have also been employed in order to understand the motivation, intention, and behavior towards HSW sorting practices at the household level [30]. In this regard, the differences and similarities between the determinants of sorting behaviors in two highly developed cities, Singapore and Shanghai, China, have been explored in 2019 by Fan, Yang, and Shen [31]. The findings indicated that specific and general environmental motivations significantly influenced the behavioral intention. Another social

study on HSW management, presented by Meng et al. [32] in Suzhou, China, showed that resident behaviors were highly connected to intrinsic subjective and external objective factors. The authors highlighted four main intrinsic subjective factors: willingness to participate, environmental awareness, social responsibility and behavioral attitudes [32]. As external objective factors, campaign information, accessibility to recycling facilities, influence from neighbors, time spent, economic cost and benefits, and prior knowledge on classification and recycling practices were taken [32]. In addition, the study mentioned that a close distance to recycling services and environmental facilities can be effective at promoting resident participation in HSW classification and recycling.

Based on the abovementioned studies on HSW sorting, it could be concluded that there are different determinants and factors that may impact recycling and sorting behaviors of citizens. Also, literature review points out the need to engage citizens in the recycling of solid waste management as an essential component in the entire process. The surveying of citizens about their solid disposal habits and the potential of sorting waste at source can provide substantial information before the introduction of recycling initiatives. In this regard, this paper aims to evaluate, for the first time in Kazakhstan, the factors that attract citizens to implement separation at source and recycling. The methods of the survey are presented by describing the case study area with statistical data on population age, design of the applied survey, and the targeted participants. Social opinion of proactive and nonactive residents were discussed as well as effects of various factors such as age, income, and education. The results of this study are important for the municipality of Nur-Sultan city, and other municipalities in the region, towards the development of new waste management plans based on separation at source and for the improvement of resident participation within the existing HSW management systems.

2. Materials and Methods

2.1. Description of the Study Area

The capital city of Nur-Sultan is a typical case of a developing city with a rapid increase in HSW generation because of population growth and economic prosperity [33]. In 2018, the city of Nur-Sultan had a population of 1,035,537 [34]. The city has four major administrative districts, namely Yessil, Saryarka, Almaty, and Baiqonyr [35], while the latest administrative district, named Baiqonyr, was created in 2018 (Figure 1). Although relatively smaller in size compared to the other three districts, Saryarqa district is more populated. In 2018, roughly 312,000 people were residing in Saryarqa, 286,000 in Almaty, 218,000 in Baiqonyr, and 213,000 in Yessil. The population in 2016 and 2019 indicates that the age group of 16–62 was the most prevalent in both periods (see Table 1). The three population classification groups used in statistics by the government are the minors group (0–15 years), working active group (16–62 years), and pensioners (58–63 and older—the retirement age for females is 58 and males 62). It should also be noted that the female residents were found to be more than the male residents in the age groups of 16–62 and 58–62 and higher in 2016 and 2019 (see Table 2).

Table 1. Age distribution of Nur-Sultan residents for 2016 and 2019 [34].

Age distribution	Data from 01 January of 2016			Data from January of 2019		
	Total	Male	Female	Total	Male	Female
0–15 years old	242,820	124,790	118,030	326,021	167,370	158,651
16–62 years old	567,491	278,805	288,686	671,977	327,121	344,856
58–62 and higher	62,273	17,100	45,173	80,386	23,131	57,255
Population	872,584	420,695	451,889	1078,384	517,22	560,762
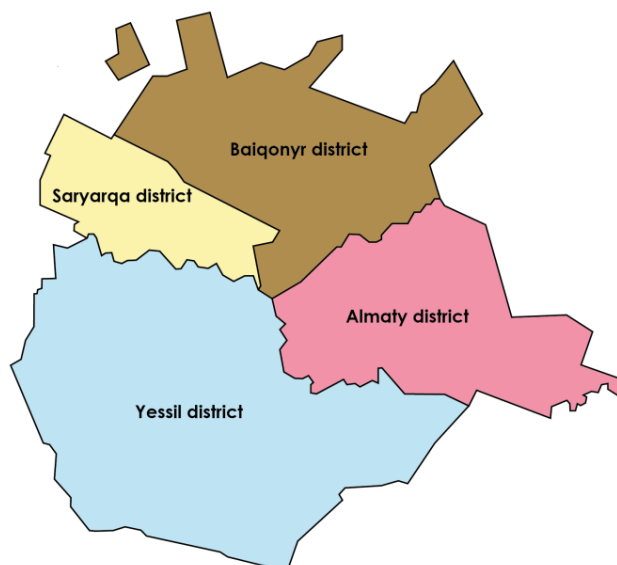
Figure 1. Map of Nur-Sultan city with four administrative districts.

Table 2. Average annual household solid waste (HSW) composition in Nur-Sultan city [36].

Fractions	Annual, % (Standard Deviation)
Organics	47.2 (±1.6)
Plastic	15.4 (±1.4)
Paper	12.5 (±1.1)
Glass	6.2 (±1.2)
Diapers	6.2 (±0.4)
Fine (<12 mm)	3.5 (±0.8)
Textile & Leather	3.4 (±0.6)
Fe Metals	2.0 (±0.3)
C&D	0.9 (±0.4)
Miscellaneous	0.8 (±0.1)
Wood	0.8 (±0.4)
Non-Fe Metals	0.7 (±0.2)
WEEE	0.6 (±0.2)

C&D—construction and demolition waste, WEEE—electrical and electronic equipment waste

Currently, urban solid waste collection in Nur-Sultan city has been undertaken by a private firm named Clean City [13]. Nur-Sultan city has 2565 HSW collection points, which are served by 60 trucks of the Clean City firm [13]. The tariffs of HSW are regulated by the municipality and approved separately for residential and commercial types. Billing is conducted on a monthly basis and delivered to households together with other communal bills. The collected HSW is delivered to the landfill site unsorted and then is forwarded to a primary mechanical and manual sorting plant, where 10% to 13% of initial HSW weight is recycled [13]. Recycled HSW fractions consist mainly of paper, plastic, and metal bottles [4,13]. After the primary recycling process, the HSW stream is then briquetted and transported to the sanitary landfill for disposal. Table 3 presents the average annual HSW composition of Nur-Sultan city [36] for the year 2018. The average annual composition of HSW showed roughly an amount 50% to be organic waste, a major part of which was food residuals. It is then followed by recyclable plastic 15% and paper 12%, while the remaining is combustible and fine fractions [36]. Because of the increase of materials suitable for recycling, the municipality of Nur-Sultan city launched a sorting at source project in August 2018 by placing around 6200 containers for HSW separation near selected residential buildings [37]. In addition, 22 collection points for

recyclable fractions (plastic, paper, and glass materials) as well as free collection services for electrical and electronic equipment waste (WEEE) were setup in the second half of 2018 [13].

**Table 3.** Channels used for distributing the questionnaires.

Channels used During the Survey	Responds	%
Electronic-KSK (Apartment Owner's Association) application (online)	1021	31
Active city groups on Facebook (online)	443	14
Staff of Nazarbayev University (online)[4]	102	3.1
Students of Nazarbayev University (online) [4]	239	7.3
Residents of residential complex "Vienna quarter" (online)	80	2.4
Residents of "BI group" flats (online)	427	13.0
Paper-based survey of city residents (printed and distributed on the back side of bills)	898	27.4
Face-to-face interview (filled in printed questionnaire)	70	2.1
Total	3281	100

[4] Students and staff of the university further discussed as residents of Nazarbayev University

2.2. Design of Survey and Survey Participants

A survey was designed by the authors to evaluate the HSW sorting attitude of Nur-Sultan citizens. Socio-demographic data were collected to identify the profile of the participants, namely age, educational status, family size, and type of housing. Then, the habitual practices on household waste as well as personal preferences were reviewed, such as the average amount of HSW accumulated daily, the level of satisfaction on municipal services, and awareness on waste sorting. Based on the awareness of respondents on HSW separation, the questionnaire provided a follow-up question on the reasoning of this attitude and the motivational or discouraging factors. The selection of different sampling groups was conducted in a stratified manner in order to have representation from different residential zones and types of residents. Commercial areas were excluded, as the survey was focused on residential areas.

The first part of the socio-demographic data was based on close-ended questions. The second part was based on open-ended questions by encouraging respondents to describe their waste management habits. Finally, respondents had an option to express their comments on the improvement of the current waste management system in Nur-Sultan city. A flowchart of the questionnaire is presented in Figure 2.
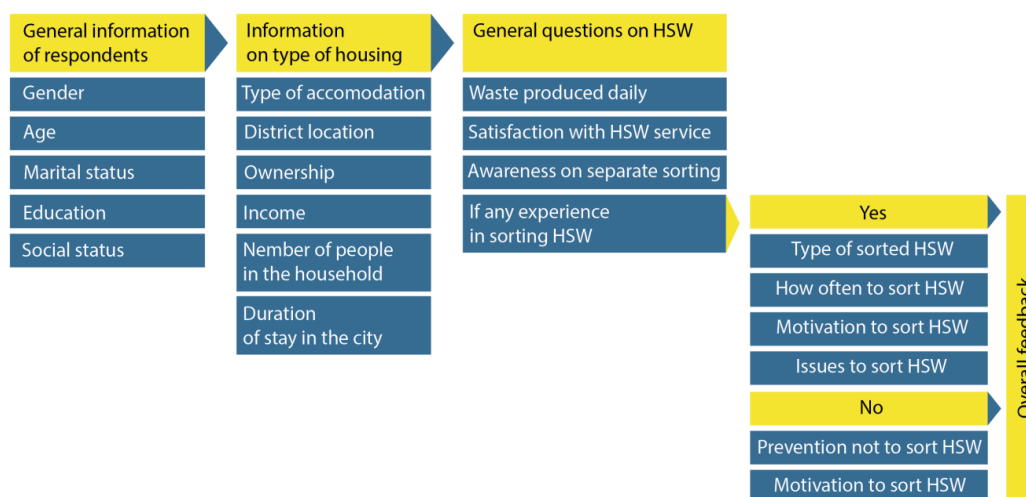
Figure 2. Flowchart of the questionnaire employed during the survey.

The sample size required for the questionnaire was calculated using the following equation:

$$SS = \frac{\frac{z^2 * p(1-p)}{e^2}}{1 + \left(\frac{z^2 * p(1-p)}{e^2 N}\right)},\tag{1}$$

where:

SS	sample size;
z	confidence level (typically z-score equal to 1.96 for 95% confidence level);
e	acceptable level of sampling error (margin of error typically 0.05% ± 5%);
N	population size (p = 1,035,537); and
P	population proportion (50%; i.e., 0.5 by default).

Based on the data obtained from the statistical agency, the population of Nur-Sultan was 1,035,537 as of 1 February 2018 [34]. There is no absolute rule on the number of participants in social surveys as it depends on the desirable margin of error and confidence interval [38,39]. In the present study, 3281 respondents participated in the survey, which corresponds to 1.7% and 2.3% error margins for confidence levels of 95% and 99%, respectively [40].

Different approaches have been applied by scholars to maximize the response rate of the questionnaire, which include online-based interviews, phone conversations, face-to-face interviews, and postal service [41]. In our case, the study was primarily implemented though electronic questionnaires, as presented in Table 3.

The questionnaire was in three languages (i.e., Kazakh, Russian, and English), as some of the targeted areas, such as the university, were inhabited by foreign responders. The study took place during the period from April to July of 2018.

3. Results and Discussion

3.1. Survey Analysis by Gender, Marital Status, and Age

The gender distribution was 43% male and 57% female, where 21% of males and 27% of females reported separating waste material at the source (Figure 3). Gender seemed to play a role in separating intention. Other studies such as Ekere et al. [42] conducted in Uganda, Babaei et al. [43] conducted in Iran, and Padilla and Trujillo [44] conducted in Bogota (Colombia) indicated that gender could influence HSW separation behaviors, as females appeared to be more active in source separation than males.
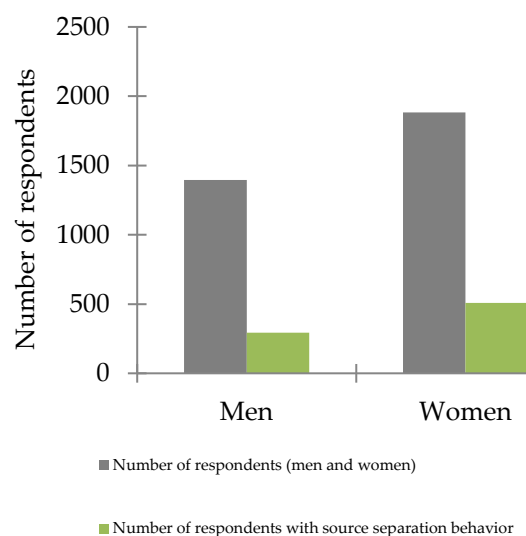

■ Number of respondents (men and women)

■ Number of respondents with source separation behavior

Figure 3. Comparative analysis of HSW sorting behavior by gender.

Of all respondents, 63% were married, and nearly 24% of them participated in recycling initiatives (Figure 4). There was no significant difference between married and unmarried, which is in contrast to the study of Padilla and Trujillo (2018) [44], where married respondents appeared more active in separation at source. In addition, at the time of the survey, 90% of respondents declared higher education degrees, and 11% were students. In total, 364 students participated in the survey, of which 239 were from Nazarbayev University. The results showed that 24.5% of students were separating waste at the source, and the rate slightly increased to 26% in areas where bins for recyclables were installed. This is consistent with the results of other studies, such as Rousta et al. [45].

■ Number of respondents (married and unmarried)

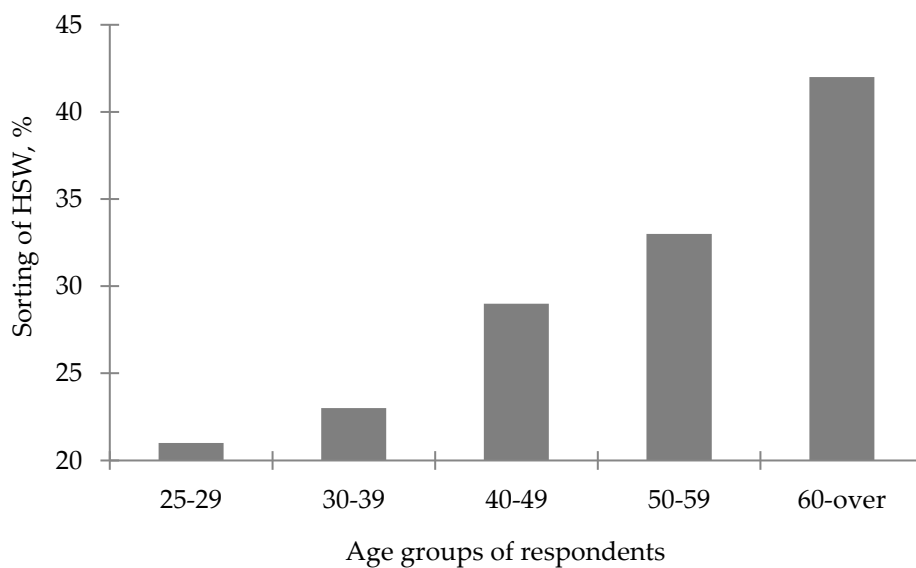■ Number of respondents with source separation behavior

Figure 4. Comparative analysis of HSW source sorting separation behavior by marital status.

As can be seen in Figure 5, the highest number of responders was within the age of 18–49 years, of which 24% separated HSW at source. Also, a trend of increased recycling by age was observed. Roughly one-third of older responders expressed their willingness to separate at source. Studies in the United States have shown that there is a statistically significant relationship between age and source separation, and households with at least one person over 65 years are 1.6 times more likely to separate urban waste [26]. In a survey done in Thailand, Challcharoenwattan and Pharino [46] noted that the older residents tend to sort and manage HSW by themselves, whereas the younger residents let waste management services to do the separation. Chu et al. [47] noted that the retired respondents have relatively more time, and they do not much consider the distance to recycling containers. Padilla and Trujillo [44] observed that in Bogota (Colombia), the older the head of household, the higher their pro-environmental behavior towards source separation. Similar are the results obtained in Abadan, Iran, where respondents more than 45 years of age had an increased attitude towards the development of source reduction programs [43]. The results in Nur-Sultan support these findings as presented in Figure 6.
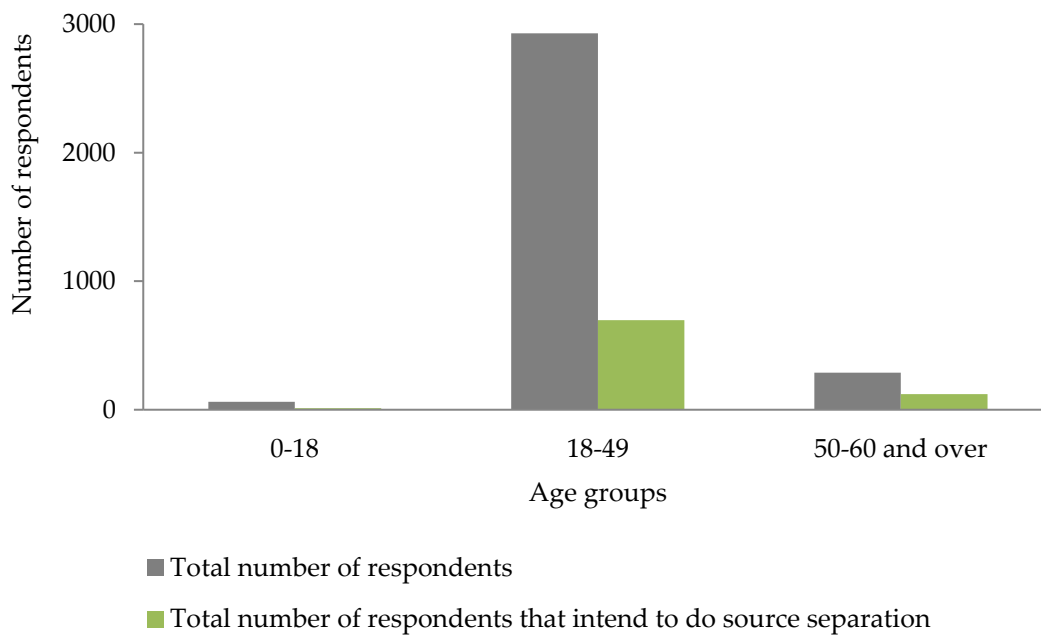
Figure 5. HSW source separation behavior by age group.

Figure 6. Source separation behavior of respondents by age group.

3.2. Social Activity Level of Residents

Figure 7 illustrates the period of residence of respondents in the city. The respondents were divided into those who were born in Nur-Sultan city, those living in the city up to 1 year, 1–5 years, 5–10 years, and more than 10 years. Most of the current residents have been in the city for more than 10 years, while a smaller fraction was born in Nur-Sultan, which indicates the dynamics of population development. No significant differences in the recycling behaviors of residents seemed to occur based on the duration of residence. Within the questionnaire, respondents were also asked to evaluate the current HSW management services they receive on a regular basis. Figure 8 shows the evaluation of the HSW management services divided by the districts of the city. It was found that almost 68% of respondents in urban areas expressed positive feedback for the existing HSW management service, while this number dropped to 28% in suburban areas. The respondents of private houses highlighted the absence of HSW collection systems in suburban areas as a major problem. Few suburban residents indicated that the transfer of HSW from these areas was regular and that HSW collection services were

available. It is evident that there are many suburbs in Nur-Sultan region where waste management is still not well organized.
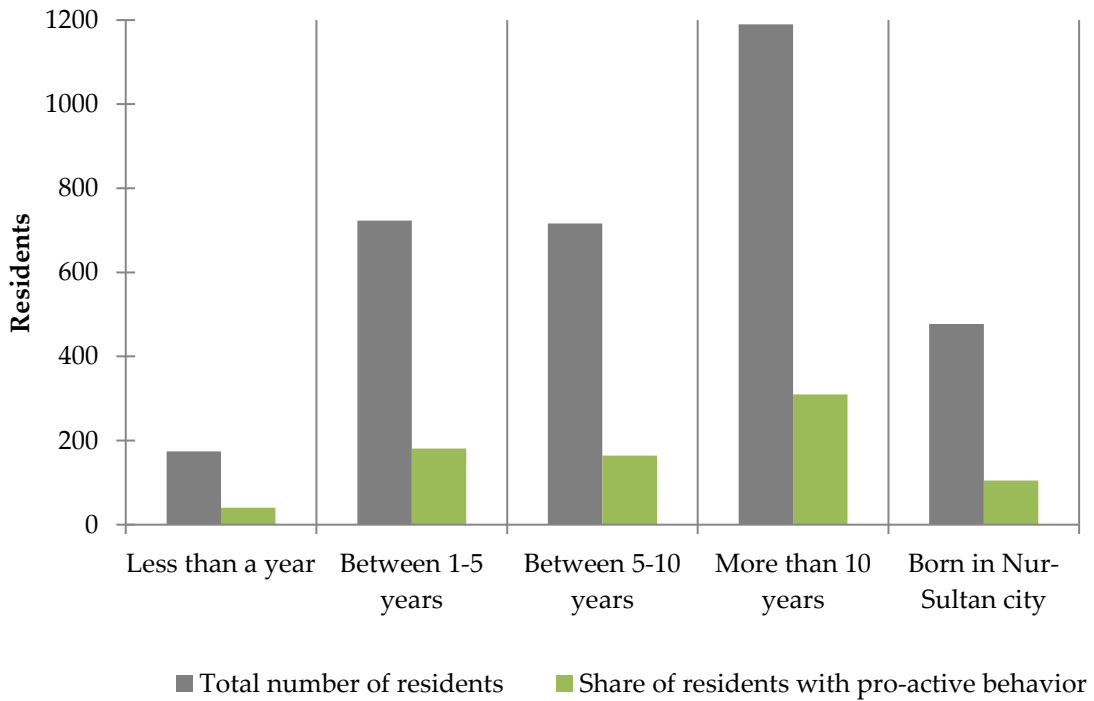

Figure 7. Source separation behavior of respondents by period of residence in Nur-Sultan.
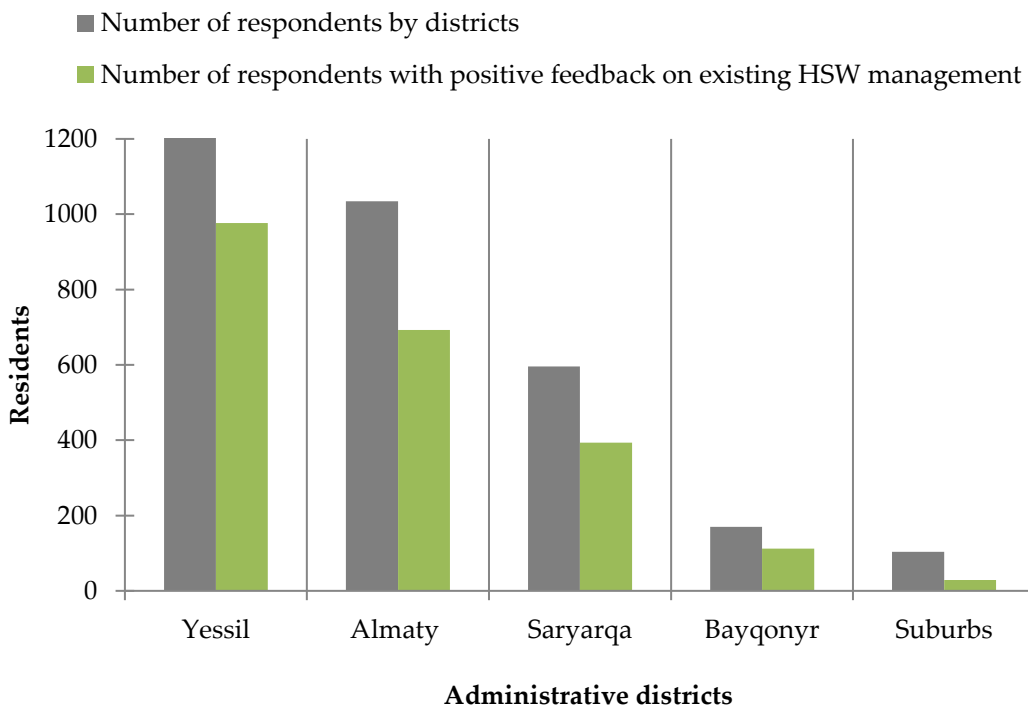

Figure 8. Separation behavior of respondents by district.

The survey data were further analyzed by the type of house where respondents were residing (Figure 9). The highest source separation rate was found at the Nazarbayev University dormitories. In total, 31% of respondents expressed their willingness for source separation, a percentage higher than those residing in private houses (25%) and apartments (24%) (Figure 9). It has to be noted that the university has actively supported separate waste collection. Although not all surveys agree on

the impact of education level on environmental behavior, some results support this assumption [44]. For instance, Kelly et al. [48] investigated on-campus source separation in a New Zealand university community and reported that 49% of all respondents always separated waste when on the campus. Some studies suggest a positive correlation of residence type with recycling habits by explaining that more storage space might encourage recycling behavior [49]. For instance, Lakhan [50] reported that in Canada, multi-residential buildings recycle approximately 90% less than that of single-family households. Rispo et al. [51] argue that higher urban densities imply smaller types of dwellings, which results in the reduced capacity of people to cope with HSW and recycling. Other studies have shown that citizens with high incomes are more likely to perform waste separation in comparison to those with low incomes, as for example in Sri Lanka, Malaysia, Indonesia, and China [15,52,53]. However, in our study it appears that there was no relation between participants' income level and HSW recycling at source, as shown in Figure 10. This agrees with a nation-wide study in the US, where income was not a significant predictor of source separation behavior [26].
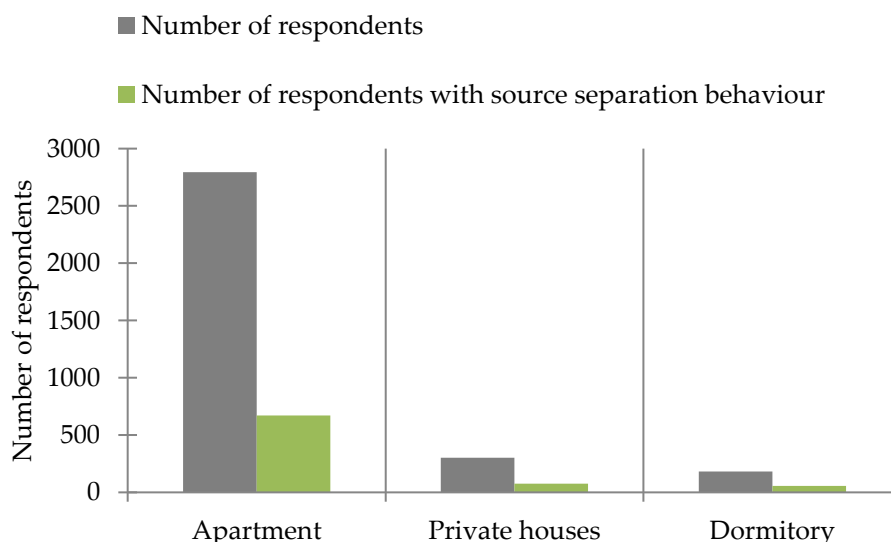
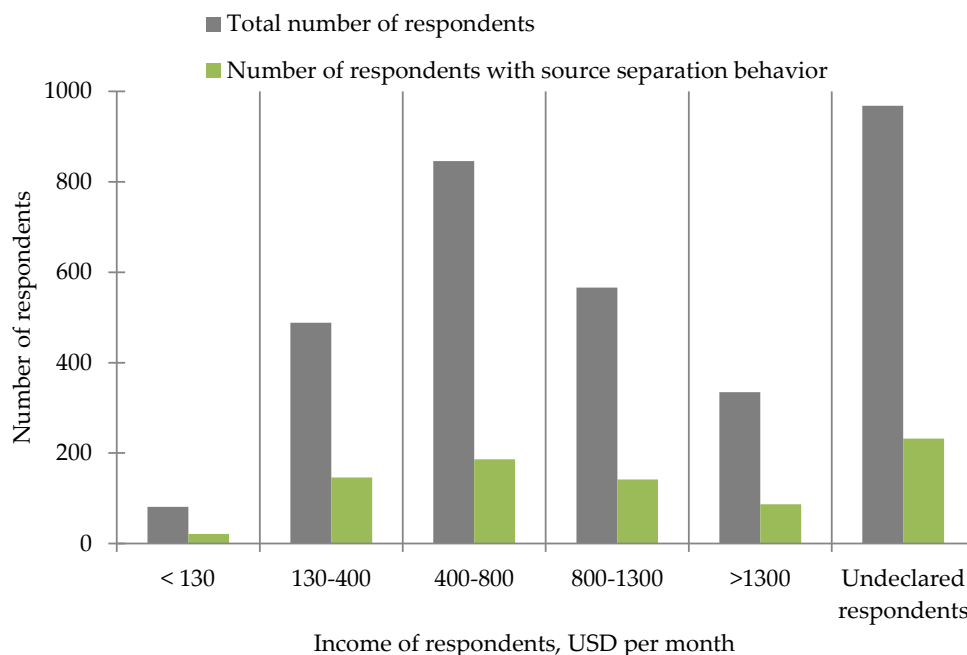**Figure 9.** Comparison of HSW source separation behavior by the type of residential complex.

Figure 10. Waste separation rate by income.

3.3. Sorters versus Nonsorters

The survey results showed that 24% of the responders were separating HSW at source. It should be noted that at the time of survey, there were limited services for separate HSW recycling containers in Nur-Sultan city. A higher source separation rate was observed at Nazarbayev University campus, which could be explained by the recycling bins available on the campus, the initiatives of the university towards separate collection, and the fact that, in general, education has positive effect on HSW separation at source [44]. The average younger age of the university community is probably an additional factor for adopting recycling practices.

The relatively high percentage of source separation trends in the city could be explained by the presence of a few private companies, which collect and recycle plastics and electrical and electronic equipment waste (WEEE) [13]. In the framework of a pilot project, named "Plastic lives here", yellow metal boxes were installed in selected locations of Nur-Sultan city for collecting plastic, orange metal boxes for collecting hazardous waste, and bins for collecting glass and metals [54]. Data from other Asian countries show higher percentages of HSW separation at source, for instance 66% in Bangkok (Thailand) and 49% in Iskandar (Malaysia) [49]. These figures are considerably lower than those reported for developed economies such as in the UK, where in a London suburb, for instance, 80% of the respondents confirmed frequent source separators at home [51]. It should be noted, however, that people tend to overstate their actions when it comes to actual source separation [49].

Considering the source separation of HSW and the factors motivating this behavior, Frey [55] quoted that individuals are prepared to get more actively involved when it costs them less, and this trend reverses when there are higher expenditures. According to Stern [56] and Zhang et al. [57], it is possible to influence individual behavior by making people aware of the consequences of not recycling and by showing them that their personal behavior is significant enough to make a difference. Austin and Hatfield [58] and O'Connor et al. [59] showed that recycling, sorting, and disposal behaviors can be improved with inexpensive and simple methods. The study of Boldero [60] showed that disposal, recycling, and source separation behaviors might also be influenced by situational factors such as the amount of effort involved, access to facilities, and perceived inconvenience. Barr [61] delineated situational factors that may affect personal behavior such as individual characteristics (e.g., socio-demographics), individual experience, and knowledge of the behavioral context (e.g., service provision). Krahe [62] reported that people are more manipulated by external factors than by internal traits. Lehman and Geller [63] stated that it is absolutely crucial to verify that appropriate instructions support the source separation of urban waste. These changes at the individual level can lead to an improvement in source separation and help in minimizing the disposal of materials that can be otherwise reused. However, with the exception of some developed countries such as Belgium, Germany, and Japan, source separation of HSW is rather ineffective and serves to argue for a thorough revision of current policies applied by the local authorities.

3.4. The Overall Feedback and Motivation/Demotivation Factors

Figure 11 shows the overall feedback received from 638 respondents. The absolute majority of respondents (84%) shared their vision and readiness to start source separation of HSW if the authorities employ well-organized services and they receive proper instruction. A considerable number of respondents stressed the importance of making sure that the sorting effort of HSW at home will be ensued by recycling processes in the plant. Vassanadumrongdee and Kittipongvises [49] made a similar observation in a study conducted in Bangkok (Thailand), where 14.6% of respondents stated that the separation at source was meaningless, as they had seen municipal workers mixing residual waste with recyclable materials. The large number of respondents supporting the improvement of the current HSW management system in Nur-Sultan could be another indication for residents' willingness to support recycling practices.
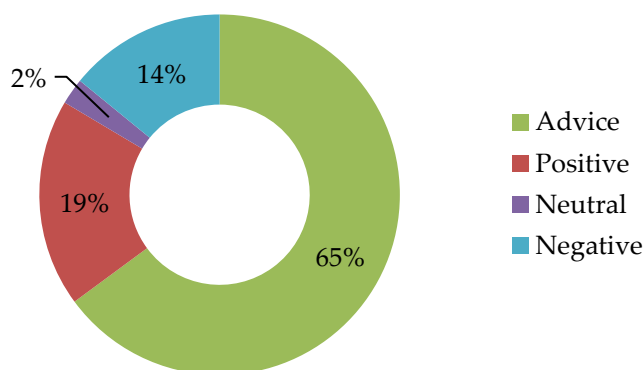
Figure 11. The overall feedback received from active respondents.

Further, the participants were asked to highlight the main reasons motivating or discouraging source separation, as shown in Figures 12 and 13. According to Figure 12, 61% of the respondents who separated waste mentioned that the motivation was active citizenship, while for 26% the motivation was a high degree of environmental awareness. Also, a group of 8% expressed their satisfaction for the current waste management services, while 4% mentioned the need for monetary compensation to further motivate source separation attitudes.
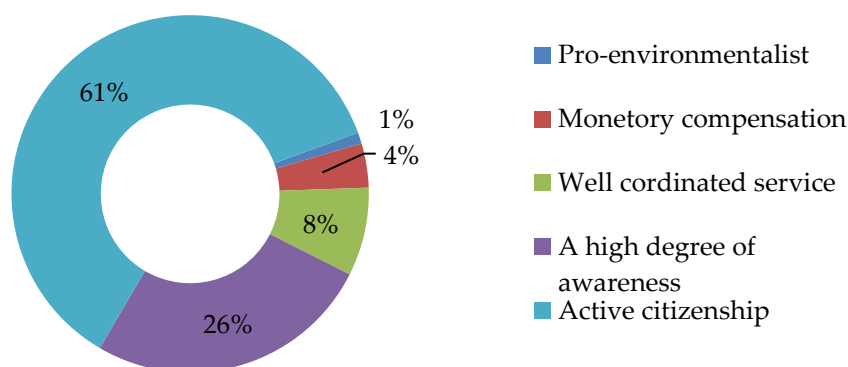
Figure 12. Major reasons of the pro-environmental respondents.
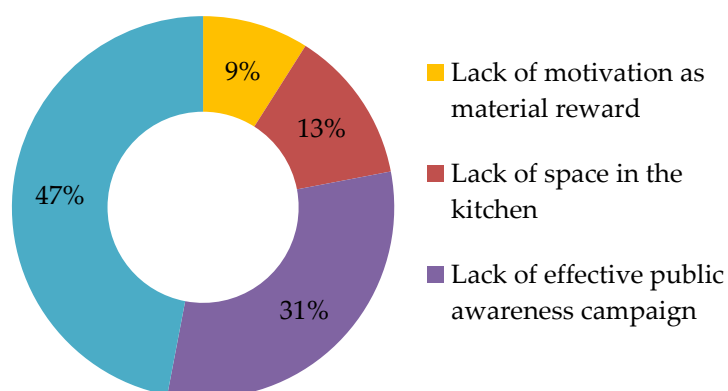
Figure 13. Major discouraging factors noted by non-separating respondents.

In the relevant literature, public awareness is considered as the most effective measure for the enhancement of citizen participation in source separation and recycling plans [64]. According to the study of Hanyu et al. [65], personal attributes like environmental concern, knowledge, and awareness could influence individual behavior. Welfens et al. [66] reported that knowledge is one of the significant key drivers of waste separation and disposal behaviors. There are several other studies underlining the significance of awareness on the effective implementation of HSW on the local level [49,67–69]. On the

contrary, Chen et al. [15] and Zhang et al. [47] have reported that a high awareness and knowledge on HSW management does not necessarily translate into action.

The main barriers to HSW source separation are shown in Figure 13, where 47% and 31% of participants indicated the lack of facilities for separate HSW collection and public awareness programs. The physical proximity of collection containers is a well-known primary determinant of the success of a waste management strategy, and, as rule of thumb, containers should be no more than 100–150 m from households [49]. Rousta et al. [45] concluded that the decreased distance of drop-off points and improved sorting information have improved HSW separation to 28% and decreased the poorly sorted fractions to 70%, respectively. Other studies have highlighted that convenient access to separate HSW facilities was considered as a more determinant factor than the personal beliefs on environmental matters [70–72]. Finally, some of the participants in our study mentioned, as a restraining factor, a lack of space in the kitchen for recycling purposes (13%), while 9% specified the necessity of reward compensation as a motivation factor.

In general, respondents showed a positive attitude to the questions and expressed their readiness for source separate of HSW if relevant city services were provided. In several developing countries, citizens have underlined their willingness to be more involved and actively support waste management solutions [18,73].

4. Conclusions

The results of the survey indicated that, while age plays a significant role, gender, marital status, and income level are not critical factors for HSW source separation behavior. There is a positive attitude and willingness of respondents to perform HSW separation at source, provided that the authorities organize the collection system and employ effective awareness campaigns. Despite the lack of an organized system at the time of the survey, nearly one out four participants already performed source separation of HSW in Nur-Sultan. This shows the positive attitude of citizens as well as the effectiveness of the private sector in recycling initiatives. According to the respondents, important factors for the establishment of HSW sorting practices are the presence of separate containers in close proximity to their residence, effective public awareness campaigns, and clear guidelines from the authorities. Also, it is worth noting that material reward is not critical for separation at source, and the citizens are in favor of supporting recycling initiatives. The study results provide important and useful data for local authorities for the development of an effective source separation HSW system in Nur-Sultan, with wider implications in other urban centers with similar features.

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