How Waste Is Managed in Urban and Rural Areas: Evidence from China

Zeyi Pan
555 Chenhui Rd, Pudong New District, Shanghai
panzeyi@hsefz.cn

Abstract. Waste disposal method has long been one of the severe environmental problems in China. A few previous researches suggest that the waste disposal method may related to the awareness, education and the willingness of participation of people. However, an overview of the waste disposal of China from the community level is lacked. As a result, China Health and Retirement Longitudinal Study (CHARLS) is used in this research to show the correlation between waste disposal method demographical information. In the research, we find that communities/villages with denser population tend to adopt the cleaner waste disposal method. We also find that fundamental socioeconomic factors such as education and income are closely related to waste management. Communities/villages with higher average education level and higher average income are more likely to adopt a cleaner waste disposal method.

1. Introduction
China, as a developing country during a long period of time, has been experiencing severe environmental problems. Among them, waste problem is one of most serious issues that affect the living conditions, environmental quality, and welfare of Chinese people. Organic waste takes up a high percentage of the municipal solid waste (MSW), which is about 25% higher than the proportion in the higher which as a result causes domination of landfilling (60.16%) in Chinese municipal solid waste management (MSWM) [1]. Thus, it is necessary to study how various waste disposal methods are applied in China. It is estimated that the awareness of waste disposal and the communities’ influence accounts for the differences of waste disposal in urban areas in China [2] and the villagers’ ethnicities, the infrastructure and income sources accounts for the differences of waste disposal in rural areas [3]. However, these estimates are based on regional results while an overview of waste management of China is lacked. Agwu [4] studied waste disposal method in Port-Harcourt and pointed out that more males are aware of waste disposal than the female. A study [5] on waste management in developing countries suggests that household education, household economics, MSWM personnel education, MSWM plan, local recycled-material market, contributes to the waste disposal method. These studies suggest that the waste disposal method adopted by some urban community or rural village not only depends on the infrastructure, municipal services, and policies at the community and city levels, but is also influenced by socioeconomic factors of the households and the community/village(C/V).

This paper focuses on how waste is managed in urban and rural China and discusses the relationship between waste disposal method and socioeconomic factors at the community level, such as population, average age, average income, average years of education, percentage of female residents, and etc. It is
organized in the following way. We start with the background of waste management in China and relevant existing research in the introduction part. It is followed by explaining the data and methods that we used in this study. We then state the results of our analysis along with the discussion. We end up with conclusions, summarizing the findings.

2. Data and Methods

We utilize data of China Health and Retirement Longitudinal Study (CHARLS) in this study. CHARLS focuses on a nationally representative sample of Chinese residents ages 45 and older in 28 provinces around China. It is carried out every two years after the baseline national wave in 2011. We mainly use the data of wave 3 of CHARLS. The survey was in the year of 2015. There are about 21000 individual observations and 450 urban communities and rural villages in this wave. Table 1 shows the detailed demographic distribution of CHARLS wave 3 sample.

| Age Group | Percent | Male (%) | Female (%) | Urban (%) | Rural (%) |
|-----------|---------|----------|------------|-----------|-----------|
| <50       | 23.65   | 10.27    | 13.38      | 9.80      | 13.84     |
| 51-55     | 16.65   | 7.93     | 8.72       | 7.01      | 9.64      |
| 56-60     | 14.98   | 7.38     | 7.60       | 6.07      | 8.91      |
| 61-65     | 14.98   | 8.08     | 8.58       | 6.76      | 9.90      |
| 66-70     | 11.72   | 6.01     | 5.71       | 4.42      | 7.30      |
| 71-75     | 7.80    | 3.93     | 3.86       | 3.07      | 4.72      |
| 76-80     | 4.94    | 2.56     | 2.37       | 2.15      | 2.78      |
| >80       | 3.61    | 1.58     | 2.03       | 1.44      | 2.17      |
| Total     | 20705   | 9885     | 10820      | 8435      | 12270     |

Notes: Most of the ages of the respondents in CHARLS 2015 are from 45 to 65. The number of female samples is slightly greater than that of male samples. There are more respondents living in rural areas than those living in urban areas, which is consistent with the trend of urbanization in modern China. Data source: CHARLS 2015.

CHARLS data contains a wide array of information about the community/village and the respondents such as demographics, education, health, income, and etc. In the community/village survey, it collects information on how waste is managed in this community/village. In the questionnaire, the provided answers to this question include (1) moved away by truck, (2) buried in this village, (3) burn away, (4) put into nearby river, and (5) do not manage. We construct a dummy variable “waste disposal method” based on this information, with 1 representing moving the waste away for centralized processing, and 0 representing disposing locally.

In the community/village survey data, besides waste disposal method, we also construct variables based on the population of the community/village, whether there are minorities in the community/village, and whether there were natural disasters (e.g. earthquake, flood, typhoon, etc.) occurred in the community/village in the past 5 years. We include these variables are included in the analysis to account for their potential influence on waste management. For example, communities/villages with a large population may not have the capacity to dispose the waste locally. For another example, communities/villages having natural disasters may have better local infrastructures so they might tend to dispose waste locally.

We draw information on age, gender, years of education, and income of individual respondents from the individual survey data of CHARLS 2015. Details about the variables constructed is in Table 2 below.
Table 2 Variables Constructed

| Variables                        | Description                                                                 |
|--------------------------------|-----------------------------------------------------------------------------|
| Waste disposal method (Y)       | Dummy variable, with \( \begin{cases} 1 & \text{move away} \\ 0 & \text{dispose locally} \end{cases} \) |
| Urban                           | Dummy variable, with \( \begin{cases} 1 & \text{urban community} \\ 0 & \text{rural village} \end{cases} \) |
| Population                      | Continuous variable indicating number of residents in the C/V                |
| Minorities                      | Dummy variable, with \( \begin{cases} 1 & \text{has minorities} \\ 0 & \text{does not have} \end{cases} \) |
| Natural disaster                | Dummy variable, with \( \begin{cases} 1 & \text{natural disasters} \\ 0 & \text{does not have} \end{cases} \) |
| Average age                     | Continuous variable indicating average age of the C/V                        |
| Female percentage               | Continuous variable indicating percentage of female residents of the C/V     |
| Average education years         | Continuous variable indicating average years of education of residents in the C/V |
| Average income                  | Continuous variable indicating average annual income of households in the C/V |

After constructing the aforementioned variables and deleting the duplicated and missing values, we end up with 439 communities/villages in the sample. To probe waste management in urban and rural China, we first show fraction of each disposal method in the sample. We then relate the constructed Y variable with the socioeconomic variables shown above. To further study the ceteris paribus relation of each factor with Y, we utilize the following regression model:

\[
Y(\text{waste disposal method})_i = \beta_0 + \beta_1 (\text{urban})_i + \beta_2 (\text{population})_i + \beta_3 (\text{minorities})_i + \beta_4 (\text{natural disasters})_i + \beta_5 (\text{average age})_i + \beta_6 (\text{female percentage})_i + \beta_7 (\text{average education years})_i + \beta_8 (\text{average income})_i + u_i
\]

Since the Y variable is a dummy, so we perform logistic regression instead of the regular OLS regression in the analysis.

3. Results and Discussion

Figure 1 shows the waste disposal methods found in our national-representative sample. It suggests that the wastes of nearly half of communities/villages (C/V) are moved away for further disposal. However, there are another 41% of C/V where wastes are not managed at all. Among the rest disposal methods, burying locally dominates burning away and putting into rivers.

![Figure 1 Composition of Waste Disposal Methods in Urban and Rural China.](image)
Next, we divided the 439 C/V in the sample based on whether wastes are moved away or disposed locally (check the construction of waste disposal method variable in the data and methods section). We calculated the mean of the socioeconomic variables shown in Table 2 within each of the two groups, and the results are displayed in Figures 2 and 3.

Figure 2 shows the percentage of urban communities in each of the two groups. They clearly suggest that moving away is the major method adopted by urban communities, while disposing locally is more widely used in rural villages. It also suggests that there is almost no difference between the two groups of C/V in terms of average age and percentage of female residents while education and average income differ greatly between these two groups. This is consistent with the fact that waste disposal is more of a collective choice influenced by local infrastructures and local policies than an individual behaviour. As discussed in the above, moving away is a more environment-friendly approach, therefore, waste problems may impose higher threat to rural environment than it does to its urban counterpart. In a policy perspective, this difference also suggests a direction of policy design to improve rural environments in terms of waste management. We performed logistic regression analysis taking all the variables shown in Table 2 into consideration. The results are shown in Table 3. The results of logistic regression (column (1) in Table 3) shows that the variable urban is positively correlated with Y, moving the waste away (Y=1, p<0.01). This indicates that urban communities are much more likely to adopt the clean method i.e. moving the waste away than rural communities. We find that after controlling for whether it is an urban community or a rural village, the correlations between Y and the variables population, whether there were natural disasters in the past 5 years, average years of education, and average income in a year, are still statistically significant, suggesting that these correlations are not merely a result of urban-to-rural difference.
Table 3 Regression Table

| Variables                                      | (1) Main Regression | (2) Robustness Check |
|------------------------------------------------|---------------------|----------------------|
| Urban or rural                                 | 1.349***            | 1.244***             |
| Population                                     | (0.298)             | (0.310)              |
| Whether the C/V has minorities                 | 0.131               | 0.0814               |
| Whether there were natural disasters in the    | -0.558**            | -0.988***            |
| past 5 years                                   | (0.273)             | (0.295)              |
| C/V average age                                | 0.0646              | 0.00363              |
| Percentage of female in the C/V                | 2.734               | 1.286                |
| C/V average years of education                 | 0.392***            | (3.494)              |
| C/V average income in a year                   | 3.65e-05**          | 2.89e-05**           |
| C/V percentage of high school and above        | (1.52e-05)          | (1.43e-05)           |
| Constant                                       | -8.973***           | -3.458               |
| Observations                                   | 439                 | 387                  |

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Thus, the positive correlation between Y, moving the waste away and population may reflect that C/V with a large population generates a large amount of waste every day and it exceeds the environmental capacity if it is disposed locally. The negative correlation between Y and whether there were natural disasters in the past 5 years is due to the fact that the population of C/V with natural disasters in the past 5 years is smaller than that of C/V without. This is evident from Figure 10 shown below. It is clearly shown that the population of C/V without natural disasters in the past 5 years is greater.
Table 3 suggests that average years of education and average income in a year are positively correlated with $Y$, indicating that the adoption of a cleaner waste management policy is closed related to good fundamentals such as education and high income of the local environment. The three demographic variables minorities, average age, and percentage of female residents are not statistically significant, suggesting that they play a less important role in influencing waste management than fundamental socioeconomic variables such as education and income.

To check whether the regression results are robust to how variables are constructed, we further performed robustness check by replacing the variable average years of education with percentage of residents with an education of high school and above in the same regression. The results are shown in Table 3 column (2). We find that neither the signs nor the significant variables change due to this replacement. This suggests that the aforementioned regression results are robust to how variables are constructed such education.

Our findings of great urban-to-rural difference in terms of waste management and the significant influence of socioeconomic fundamentals such as education and income are consistent with previous studies.

Disposing waste locally, which is not an environment-friendly way, may cause many health problems such as increasing the chance of the spread of epidemics [6]. To improve the situation and to change the habit of a community on waste management, education may be a promising approach, especially in rural areas where the education level is far from its marginal to affect the waste management. Besides, it is also crucial to increase the average income of a community so that more and more community can dedicate on the construction of better waste management infrastructures.

Some results from other researches can be used in improving the condition of waste management in China. Smart Dustbins [7], for example, can be deployed in both rural and urban areas. As mentioned in a study [8], the increase of accessibility to the recycle bins enables the people in rural areas to improve their waste disposal methods. Besides, a study in South Africa [9] shows that the MSW can also be used as a new kind of fuel which provides energy at an approximate value of 19 MJ/kg so that the use of fossil fuels will decrease. As a result, the MSW in urban areas can be used to generate energy to meet the huge amount of need in big cities.

4. Conclusions
We find that in China there is a great urban-to-rural difference in terms of waste management in China. That is to say, the adoption of cleaner management method i.e. moving the waste away instead of disposing locally is much more widely spread in urban communities than in rural villages. We also find that communities/villages with denser population tend to adopt the cleaner waste disposal method. This might be because the large amount of waste produced at these communities/villages with dense population exceeds their local environmental capacity. Besides, we find that fundamental socioeconomic factors such as education and income are closely related to waste management.
Communities/villages with higher average education level and higher average income are more likely to adopt a cleaner waste disposal method.

References
[1] Mian M M et al. 2017 Municipal solid waste management in China: a comparative analysis. J. of Matl. Cycl. and Waste Mgmt. 19.3 p 1127-1135
[2] Li X et al. 2019 Garbage source classification performance, impact factor, and management strategy in rural areas of China: A case study in Hangzhou. Waste Mgmt. 89 p 313-321.
[3] Hamer G 2003 Solid waste treatment and disposal: effects on public health and environmental safety Biotech. Adv. 22.1-2 p 71-79
[4] Agwu M O 2012 Issues and challenges of solid waste management practices in Port-Harcourt City, Nigeria-a behavioural perspective Am. J. of Soc. and Mgmt. Sci. 3.2 p 83-92
[5] Troschinetz A M and James R M 2009 Sustainable recycling of municipal solid waste in developing countries," Waste Mgmt. 29.2 p 915-923.
[6] Suresh, K., S. Bhuvanesh, and B. Krishna Devan. "ARDUINO MICROCONTROLLER BASED SMART DUSTBINS FOR SMART CITIES."
[7] Sin-Yee, Tee, and Low Sheau-Ting. "Attributes in Fostering Waste Segregation Behaviour." International Journal of Environmental Science and Development 7.9 (2016): 672.
[8] Hlaba, A., A. Rabiu, and O. A. Osibote. "Thermochemical Conversion of Municipal Solid Waste- An Energy Potential and Thermal Degradation Behavior Study." International Journal of Environmental Science and Development 7.9 (2016): 661.
[9] Romin, Husna, and Pensiri Akkajit. "A Study of Knowledge, Attitude, and Practice (KAP) of Personnel in Clinic Regarding Infectious Waste Management Case Study: Mueang Phuket District, Phuket." International Journal of Environmental Science and Development 9.6 (2018).