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Urban garbage classification and environmental pollution: Survey evidences from Chinese cities

Boqiang Lin [1*], Yunming Kuang [2]

1 School of Management, China Institute for Studies in Energy Policy, Collaborative Innovation Center for Energy Economics and Energy Policy, Xiamen University, Xiamen, Fujian, 361005, China. (Corresponding Author)

2 School of Management, China Institute for Studies in Energy Policy, Collaborative Innovation Center for Energy Economics and Energy Policy, Xiamen University, Xiamen, Fujian, 361005, China.

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ABSTRACT

Increasing municipal wastes poses a great threat to public health and further worsening environmental pollution. Urban garbage has become one of the main sources of environmental pollution in Chinese cities, and Urban Garbage Classification (UGC) has become the best option for China. The key to effective implementation of garbage classification lies in the willingness and behavior of residents. We investigate the deviation between willingness to garbage classification (WTC) and behavior of garbage classification (BGC) of residents to the UGC. This study is based on a random survey conducted in China's cities. We find that firstly more willingness to garbage classification do not mean a higher chance of BGC, which indicates a deviation exists between the WTC and the BGC. Second, such a deviation depends mainly on contextual factors and residents' attitudes and knowledge about the UGC. Third, respondents who live in a community with more supporting facilities for the UGC or know more about the UGC, are more likely to participate in garbage classification. Hence, the government should increase the supporting facilities for the UGC and related services to provide a convenient environment for residents to participate in the UGC. Furthermore, strengthening the popularization of knowledge about the UGC to the public can effectively minimize the deviation. This study provides a new perspective for research on alleviating environmental pollution and improving the quality of public health.

Keywords: Environmental pollution, Urban garbage classification, Public participation, Random survey, China

NONMENCLATURE

Abbreviations	
UGC	Urban Garbage Classification
WTC	Willingness to garbage classification
BGC	Behavior of garbage classification

1 INTRODUCTION

The economy of China had the "strongest growth" among the world's major economies in recent years. However, this spectacular economic performance is at the expense of the natural environment and ecological resources, resulting in great consequences [1]. "Garbage Siege" dilemma is one of them, mostly because of the acceleration of urbanization and the boom of urban population. Increasing municipal household waste poses a great threat to public health and further worsening global environmental pollution.

Urban garbage classification (UGC) has been one of the hottest topics in China in recent years. Essentially, it is a kind of household behavior, and residents' participation is an indispensable condition for the effective implementation of the UGC project. Therefore, the key to solve the dilemma of "Garbage Siege" in the future is how to enable residents to participate in the UGC.

Whether to participate in the UGC is an individual's subjective judgment or decision after comprehensive consideration of various factors [4]. There is a variety of factors that influence whether people are willing to classify garbage including macro policies, social moral constraints, and subjective factors at the micro-

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psychological level. The policy-makers usually consider the macro factors more when enacting public policies, but little is known about the micro aspects. Notably, what factors will affect citizens' willingness to garbage classification (WTC)? What factors will affect the behavior of garbage classification (BGC)? Does greater willingness mean higher residents' participation? Is there a deviation between the two responses of residents? Understanding and analyzing such a deviation is of great interest given growing evidence that residents or households have a large impact on the implementation of urban garbage classification and recycling.

In this paper, based on a random survey conducted in the four major cities in China (Beijing, Shanghai, Guangzhou and Shenzhen) in October 2019, we try to answer the above questions. Specifically, we examine factors influencing willingness and behavior of residents to the UGC separately. More importantly, we analyze the deviation between the willingness and behavior.

Our main contributions to existing literature lie in the following three aspects: First, factors influencing both the willingness and behavior of residents to urban garbage classification in metropolises of China are investigated in detail, which contributes to research on household garbage classification. Second, to the best of our knowledge, it's the first study to explore the deviation between willingness and behavior of residents to urban garbage classification in big cities of China using a survey data. Lastly, our study can be helpful for the government to enact targeted policies on how to effectively minimize the deviation between residents' willingness to urban garbage classification and their actual behavior.

2 SURVEY AND DATA

2.1 Survey data

To maintain the quality of the survey, we authorized a professional survey company, named Kaidi Data Research Center (KDRC), to distribute the questionnaires and collect data through "Questionnaire Treasure" in October 2019 in the four most developed cities of China: Beijing, Shanghai, Guangzhou, and Shenzhen. These cities are the pilot cities for implementing waste sorting and recycling policies in China, and their waste removal volume ranks among the top in the country. KDRC, founded in 2010, belongs to the core division of Kaidi Network, which is part of the well-known community of Southern Newspaper Media Group.

The questions in the survey consist of four parts. The first part is to obtain information about Socio-demographic characteristics of the respondents, including age, gender, educational background, income, etc. The second part is designed to inquire about respondents' attitudes towards environment quality, urban garbage classification (UGC), and its environment co-benefit. The third part is used to ask contextual factors influencing the decision of residents on the UGC. The last part is designed to ask the respondent's willingness to garbage classification (WTC) and behavior of garbage classification (BGC), which is the core question of the questionnaire. In this survey, we received 2229 questionnaires, but only 2166 valid questionnaires are used in our study through further filtration. 63 invalid samples are excluded from some irrational reason to ensure the reliability of data.

2.2. Descriptive statistics of variables

Table 1 The percentage of respondents regarding WTC and BGC in each city

DV		City				Total
		Beijing	Shanghai	Guangzhou	Shenzhen	
WTC	0	0.18%	0.32%	1.11%	0.28%	1.89%
	1	19.53%	24.93%	32.41%	21.24%	98.11%
BGC	0	3.46%	0.88%	5.59%	3.83%	13.76%
	1	16.25%	24.38%	27.93%	17.68%	86.24%

Table 2 The explanations of each variable and the descriptive statistics

Variable	Description	Mean	sd	min	max	N
Socio-demographic characteristics						
Gender	Dummy variable (0=female, 1=male)	0.619	0.486	0	1	2166
Age	Age of respondent (1=between 11 and 20. 2=21-30, 3=31-40, 4=41-50, 5=51-60, 6=61-70, 7=71-80)	2.693	0.861	1	7	2166
Edu	Educational background (1=primary school, 2=Junior high school, 3=High school, 4=Technical secondary school, 5=Bachelor, 6=master's degree, 7=PhD)	4.716	0.922	1	7	2166
Income	Average income of household per month (RMB) (1=less than or equal 7000, 2= (7000 10000], 3= (10000 15000], 4= (15000 20000], 5= (20000 30000], 6=more than 30000)	3.315	1.345	1	6	2166
Attitudes and knowledge about UGC						
AUEP	Attention to urban environmental pollution (1=none, 2=lesser, 3=less, 4=more, 5=much more)	3.457	1.002	1	5	2166
IEQ	Attitude towards the argument that UGC can improve urban environment quality (1=absolutely disagree, 2=disagree, 3=neutral, 4=agree, 5=much agree)	3.896	0.818	1	5	2166
AWARE	Knowledge about Urban garbage classification (1=none, 2=lesser, 3=less, 4=more, 5=much more)	3.472	0.749	1	5	2166
Contextual factors						
Pilot	Dummy variable: whether you live in a pilot community for implementing garbage classification? (0=no, 1=yes)	0.718	0.45	0	1	2166
Facilities	How many supporting facilities are there for UGC in your community? (1=none, 2=less, 3=normal, 4=more, 5=much more)	3.284	0.96	1	5	2166

3. METHODOLOGY

Logit Model is adopted in this study since the dependent variables are discrete choice variables (WTC and BGC), which is regarded as the most discrete choice method with simulation. Such generalized linear models

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have been widely used in survey investigation since McFadden [10]. The most attractive feature of this model is that it can generate a linear model for the odds. As can be seen from the aforementioned literature in Section 2, the Logit model is a common regression model for empirical researches based on questionnaire [11-14]. The general form for the binary Logit Model is presented below:

$$\Pr[Y_i = y_i] = \pi_i^{y_i}(1-\pi_i)^{1-y_i}, \quad y_i = 0, 1 \tag{1}$$

$$\text{logit}(\Omega_i) = \ln(\Omega_i) = \ln\left(\frac{\pi_i}{1-\pi_i}\right) \tag{2}$$

$$P(y_i = 1|\mathbf{x}_i) = \pi(\mathbf{x}_i) = \frac{\exp(\mathbf{x}_i'\boldsymbol{\beta})}{1+\exp(\mathbf{x}_i'\boldsymbol{\beta})} \tag{3}$$

$$y_i = \pi(\mathbf{x}_i) + \varepsilon_i = \begin{cases} 1\ ,\ if\ \varepsilon_i = 1-\pi(\mathbf{x}_i) \\ 0\ ,\ if\ \varepsilon_i = -\pi(\mathbf{x}_i) \end{cases} \tag{4}$$

In this empirical study, the Y_i used in the Logit Model includes WTC and BGC, of which both are dummy variables.

4. RESULTS AND DISCUSSION

4.1 Empirical results

Table 3 The results of Logit Model

	WTC			BGC		
	Model 1a	Model 1b	Model 1c	Model 2a	Model 2b	Model 2c
gender	-0.102	0.301	0.298	0.092	0.195	0.159
	(0.359)	(0.383)	(0.383)	(0.130)	(0.140)	(0.148)
age	0.183	0.143	0.148	0.193**	0.192**	0.171*
	(0.172)	(0.185)	(0.190)	(0.085)	(0.095)	(0.094)
edu	0.700***	0.519***	0.444**	0.074	-0.001	-0.056
	(0.162)	(0.174)	(0.175)	(0.077)	(0.077)	(0.083)
income	-0.144	-0.220	-0.228	0.053	-0.005	-0.009
	(0.136)	(0.142)	(0.146)	(0.053)	(0.054)	(0.058)
AUEP		0.505**	0.360*		0.507***	0.438***
		(0.212)	(0.212)		(0.086)	(0.090)
IEQ		0.772***	0.758***		-0.205**	-0.123
		(0.216)	(0.234)		(0.094)	(0.102)
AWARE		-0.035	-0.279		1.106***	0.715***
		(0.392)	(0.376)		(0.146)	(0.154)
Pilot			0.432			1.211***
			(0.356)			(0.160)
Facilities			0.785***			0.684***
			(0.217)			(0.099)
_cons	1.462*	-1.706	-2.353*	0.424	-3.479***	-4.277***
	(0.871)	(1.197)	(1.299)	(0.477)	(0.623)	(0.685)
City-effect	Yes	Yes	Yes	Yes	Yes	Yes
N	2166	2166	2166	2166	2166	2166
r2_p	0.079	0.163	0.202	0.053	0.172	0.266
Fechi2			6.053			27.498
Fechi2p			0.091			0.000

Note: (1) Robust standard errors in parentheses; (2) * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$; (3) City-effect indicates that the regional fixed effect is controlled, and the "Yes" means this fixed effect is controlled. (4) Fechi2 and Fechi2_p denotes the statistics of the LR test and the p-value of this statistics.

Table 4 Odds Ratios of the model coefficients

	WTC	BGC
gender	1.347	1.172
	(0.515)	(0.174)
age	1.160	1.186*
	(0.220)	(0.112)
edu	1.559**	0.946
	(0.272)	(0.078)
income	0.796	0.991
	(0.116)	(0.057)
AUEP	1.433*	1.549***
	(0.304)	(0.139)
IEQ	2.134***	0.884
	(0.499)	(0.090)
AWARE	0.756	2.044***
	(0.284)	(0.315)
Pilot	1.540	3.357***
	(0.548)	(0.537)
Facilities	2.193***	1.982***
	(0.475)	(0.197)
cityeffect	Yes	Yes
N	2166	2166

Note: a) Odds Ratios is based on the Model 1c and Model 2c. b) Standard errors in parentheses. c) * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 5 Average margin effect of Logit regression

Variables	WTC		BGC	
	Estimate	SE	Estimate	SE
gender	0.298	(0.369)	0.159	(0.151)
age	0.148	(0.200)	0.171*	(0.091)
edu	0.444***	(0.160)	-0.056	(0.079)
income	-0.228*	(0.131)	-0.009	(0.055)
AUEP	0.360	(0.249)	0.438***	(0.096)
IEQ	0.758***	(0.225)	-0.123	(0.103)
AWARE	-0.279	(0.297)	0.715***	(0.150)
Pilot	0.432	(0.357)	1.211***	(0.156)
Facilities	0.785***	(0.228)	0.684***	(0.098)
N	2166		2166	

Note: a) the average marginal effect is based on the Model 1c and Model 2c. b) SE is the standard errors. c) * p < 0.1, ** p < 0.05, *** p < 0.01.

Table 6 The results of Probit Model

	WTC			BGC		
	Model 1a	Model 1b	Model 1c	Model 2a	Model 2b	Model 2c
gender	-0.050	0.082	0.078	0.037	0.091	0.068
	(0.142)	(0.154)	(0.160)	(0.072)	(0.079)	(0.084)
age	0.087	0.073	0.063	0.107**	0.093**	0.088*
	(0.080)	(0.088)	(0.089)	(0.044)	(0.047)	(0.049)
edu	0.289***	0.206***	0.182**	0.045	-0.005	-0.028
	(0.064)	(0.070)	(0.072)	(0.038)	(0.041)	(0.043)
income	-0.056	-0.078	-0.092	0.030	0.001	-0.009
	(0.051)	(0.055)	(0.057)	(0.026)	(0.029)	(0.030)
AUEP		0.190*	0.131		0.286***	0.243***
		(0.102)	(0.108)		(0.050)	(0.054)
IEQ		0.338***	0.341***		-0.103*	-0.060

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		(0.098)	(0.102)		(0.054)	(0.058)
AWARE		0.035	-0.098		0.586***	0.362***
		(0.122)	(0.131)		(0.073)	(0.080)
Pilot			0.158			0.671***
			(0.163)			(0.086)
Facilities			0.356***			0.369***
			(0.103)			(0.054)
_cons	0.986**	-0.477	-0.671	0.292	-	-
					1.790***	2.208***
	(0.458)	(0.577)	(0.610)	(0.246)	(0.337)	(0.362)
cityeffect	Yes	Yes	Yes	Yes	Yes	Yes
N	2166	2166	2166	2166	2166	2166
r2_p	0.077	0.161	0.200	0.053	0.174	0.265

Note: (1) Standard errors in parentheses; (2) * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$; (3) City-effect indicates that the regional fixed effect is controlled, and the "Yes" means this fixed effect is controlled.

Table 7 The results of Logit Model without Shanghai

	WTC			BGC		
	Model 1a	Model 1b	Model 1c	Model 2a	Model 2b	Model 2c
gender	-0.198	0.194	0.177	0.176	0.268	0.230
	(0.390)	(0.408)	(0.413)	(0.136)	(0.146)	(0.156)
age	0.002	-0.010	-0.000	0.152*	0.144	0.107
	(0.197)	(0.208)	(0.215)	(0.086)	(0.092)	(0.095)
edu	0.680***	0.520***	0.448**	0.030	-0.017	-0.072
	(0.165)	(0.178)	(0.179)	(0.075)	(0.079)	(0.083)
income	-0.113	-0.179	-0.172	0.043	-0.015	-0.017
	(0.136)	(0.142)	(0.143)	(0.050)	(0.053)	(0.056)
AUEP		0.490*	0.358		0.514***	0.459***
		(0.271)	(0.278)		(0.093)	(0.099)
IEQ		0.831***	0.861***		-0.232**	-0.140
		(0.235)	(0.248)		(0.100)	(0.107)
AWARE		-0.068	-0.254		1.067***	0.684***
		(0.324)	(0.336)		(0.146)	(0.158)
Pilot			0.426			1.192***
			(0.391)			(0.162)
Facilities			0.702***			0.664***
			(0.248)			(0.101)
_cons	2.033*	-1.396	-2.284	0.734	-	-
					3.081***	3.889***
	(1.154)	(1.451)	(1.564)	(0.470)	(0.660)	(0.722)
cityeffect	Yes	Yes	Yes	Yes	Yes	Yes
N	1619	1619	1619	1619	1619	1619
r2_p	0.079	0.168	0.201	0.004	0.125	0.224
Fechi2			5.691			5.940
Fechi2p			0.058			0.051

Note: (1) Robust standard errors in parentheses; (2) * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$; (3) City-effect indicates that the regional fixed effect is controlled, and the "Yes" means this fixed effect is controlled.

4.2 Discussion

As shown in Table 3, education has a positive and significant influence on the WTC, meaning that respondents with higher education seem to be more willing to sort garbage. While the result of model 2c suggests that educational background has no significant influences on the BGC. That is, although educational level may increase respondents' willingness to sort garbage, it has no statistically significant effect on the behavior of garbage classification. But age has a significant and positive impact on the BGC, which suggests that the elder respondents, compared with younger ones, are more involved in sort garbage. The variable "gender" and "income" have no statistically significant influences on the UGC in this study.

In terms of Attitudes and knowledge about the UGC, it includes AUEP, IEQ, and AWARE. Regarding the AUEP, the results of model 2c show that more attention respondents pay to urban environmental pollution, the more likely they are to participate in garbage classification. Furthermore, the influence of respondents' attitudes towards whether the UGC can improve urban environment quality is tested. The result indicates that if the respondent accepts the role of the UGC on the improvement of urban environment quality, he/she is more willing to sort garbage. But it has no significant influence on the BGC. Despite willingness to sort garbage, people who think the UGC can improve urban environment quality do not necessarily participate in garbage classification in their daily life. Indeed, this reflects the deviation between the willingness to garbage classification and its behavior. For instance, the resident who approve the role of the UGC on urban environment quality has more intention to sort garbage, but he/she may be less likely to participate in garbage classification due to the limitation of knowledge about urban garbage classification. knowledge about the UGC has a positive and significant influence on the BGC. Specifically, for those respondents who know more about UGC, the chance of participating in garbage classification is about 2.044 times higher. Having more knowledge of garbage classification can help to reduce the inconvenience or trouble caused by residents' inability to understand the classification knowledge, thereby promoting the behavior of residents' garbage classification.

Regarding the contextual factors, they are all statistically significant and positive impacts on the BGC. The variable pilot has significant and positive influences on the BGC but has no statistically significant impact on the WTC. Specifically, if the interviewee lives in a pilot community for implementing garbage classification, he/she is more likely to participate in urban garbage classification and the odds is about 3.357 times higher. It's reasonable and within our expectations. For the residents living in the pilot community, they are more aware of the UGC project, and thus more responsible for environmental sanitation of the community. Also, as another contextual factor, Facilities has a significant and positive influence on the BGC, which indicates that if the respondents live in a community with more supporting facilities for garbage classification, such as complete assorted garbage containers, the chance of participating in sorting garbage by these residents will be higher about

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98%. Therefore, the contextual factor is an important determinant of the deviation between residents' willingness to urban garbage classification and the behavior.

5. CONCLUSIONS AND POLICY IMPLICATIONS

Major findings are summarized as follows: First, we find that a deviation exists between respondents' willingness and behavior of the UGC in the four metropolises of China. That is, more willingness to classify garbage does not mean higher actual participation of residents. Second, the influencing factors of WTC and BGC are different. Education and income of respondents can significantly affect the WTC. Specifically, education has a positive and significant influence on the WTC, while the income of respondents may generate negative impacts on it. Furthermore, if the respondent accepts the role of the UGC on the improvement of urban environment quality, he/she is more willing to sort garbage. Last but not the least, whether the UGC can be implemented effectively in residents' daily life depends mainly on the contextual factors and residents' attitudes and knowledge about the UGC. For instance, the resident who lives in an area with more facilities, or a pilot community for the UGC, is more likely to classify garbage due to the convenience environment. Those who pay more attention to urban environmental pollution, who know more about UGC are more likely to participate in the UGC in their daily life.

Several policy suggestions can be provided to facilitate urban garbage classification. First, the government should further improve the supply mechanism of facilities and services for the UGC. Enacting scientific and reasonable garbage classification and recycling criterion, providing complete and convenient supporting facilities are the guarantee for the implementation of the UGC. Second, how to enhance residents' knowledge of the UGC and cultivate their sense of responsibility is of great importance to the policy makers. Our results indicate that attitude and knowledge of respondents about the UGC are significant factors in the BGC. This can play a role in the promotion of the UGC, and thus improve urban environmental quality. On the one hand, it is necessary to widely spread the knowledge of the UGC. Some studies suggest that the correlation between specialized classification knowledge and classification behavior is higher than the public's environmental protection knowledge [16, 19]. On the other hand, it is equally important to cultivate the public's sense of responsibility for the UGC. Because public responsibility is a long-term, relatively stable emotion, which is closely related to participating behaviors. It can make the public aware of the environmental and climatic value generated by garbage classification.

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REFERENCE

[1] He J, Lin B. Assessment of waste incineration power with considerations of subsidies and emissions in China. Energy Policy. 2019;126:190-9.

[2] Tonglet M, Phillips PS, Read AD. Using the Theory of Planned Behaviour to investigate the determinants of recycling behaviour: a case study from Brixworth, UK. Resources, conservation and recycling. 2004;41:191-214.

[3] Miliute-Plepiene J, Hage O, Plepys A, Reipas A. What motivates households recycling behaviour in recycling schemes of different maturity? Lessons from Lithuania and Sweden. Resources, Conservation and Recycling. 2016;113:40-52.

[4] Rajapaksa D, Gifford R, Torgler B, Garcia-Valiñas M, Athukorala W, Managi S, et al. Do monetary and non-monetary incentives influence environmental attitudes and behavior? Evidence from an experimental analysis. Resources, Conservation and Recycling. 2019;149:168-76.

[5] Pothitou M, Hanna RF, Chalvatzis KJ. Environmental knowledge, pro-environmental behaviour and energy savings in households: An empirical study. Applied Energy. 2016;184:1217-29.

[6] Song Q, Zhao S, Lam I, Zhu L, Yuan W, Wang C. Understanding residents and enterprises' perceptions, behaviors, and their willing to pay for resources recycling in Macau. Waste Management. 2019;95:129-38.

[7] Lin B, Tan R. Are people willing to pay more for new energy bus fares? Energy. 2017;130:365-72.

[8] Tan R, Lin B. Public perception of new energy vehicles: Evidence from willingness to pay for new energy bus fares in China. Energy Policy. 2019;130:347-54.

[9] Xu M, Lin B. Exploring the "not in my backyard" effect in the construction of waste incineration power plants based on a survey in metropolises of China. Environmental Impact Assessment Review. 2020;82:106377.

[10] McFadden D. Conditional logit analysis of qualitative choice behavior. 1973.

[11] Alhassan H, Kwakwa PA, Owusu-Sekyere E. Households' source separation behaviour and solid

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waste disposal options in Ghana's Millennium City. Journal of Environmental Management. 2020;259:110055.
[12] Matějka F, McKay A. Rational inattention to discrete choices: A new foundation for the multinomial logit model. American Economic Review. 2015;105:272-98.
[13] Papke LE. How are participants investing their accounts in participant directed individual account pension plans? The American Economic Review. 1998;88:212-6.
[14] Mattar L, Abiad MG, Chalak A, Diab M, Hassan H. Attitudes and behaviors shaping household food waste generation: Lessons from Lebanon. Journal of Cleaner Production. 2018;198:1219-23.
[15] Wooldridge JM. Introductory econometrics: A modern approach: Nelson Education; 2016.
[16] Gamba RJ, Oskamp S. Factors Influencing Community Residents' Participation in Commingled Curbside Recycling Programs. Environment and Behavior. 1994;26:587-612.
[17] Liu X, Wang Z, Li W, Li G, Zhang Y. Mechanisms of public education influencing waste classification willingness of urban residents. Resources Conservation and Recycling. 2019;149:381-90.
[18] Vining J, Ebreo A. What Makes a Recycler?: A Comparison of Recyclers and Nonrecyclers. Environment and Behavior. 1990;22:55-73.
[19] Prado LO, Souza HHS, Chiquito GM, Paulo PL, Boncz MA. A comparison of different scenarios for on-site reuse of blackwater and kitchen waste using the life cycle assessment methodology. Environmental Impact Assessment Review. 2020;82.

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