



The Effect of Population Density on the Level of Public Awareness in 3R-Based Domestic Waste Management: A Study in the Densely Populated Settlements of Sangkrah Village, Surakarta City

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Abstract

The increasing population in Surakarta City, particularly in the densely populated Sangkrah Village, has contributed to an increase in the volume of domestic waste, or what we better know as household waste. Although the importance of waste management based on 3R (Reduce, Reuse, Recycle) has been frequently voiced, we still face problems such as lack of infrastructure and low community participation. Therefore, this study aims to see whether population density affects residents' awareness in managing household waste with the 3R principle in Sangkrah Village. This study used a quantitative method with a survey approach, involving 100 respondents from Sangkrah Village who were randomly selected (accidental sampling). The data obtained were analyzed using the Pearson correlation test and simple linear regression. The results show that most respondents have a fairly good understanding of the 3R concept. However, waste recycling practices in the field are still relatively ordinary. Our statistical analysis also shows that population density has no significant relationship with the level of community awareness in managing 3R waste (P-value 0.958; correlation coefficient 0.005).

INTRODUCTION

The population of a city increases every year. This growth also leads to increased consumption and urban activity. Every human activity inevitably produces waste or garbage (Damanhuri et al., 2009). Surakarta, for example, has fostered the formation of densely populated residential areas, particularly in strategic areas close to the city center. As a cultural hub and a city with stable economic growth in Central Java, Surakarta has experienced relatively high population growth year after year (Surakarta, 2024; Buchori et al., 2020; Setyono et al., 2016).

One area reflecting this population density is Sangkrah Village, located in Pasar Kliwon District. This village has a relatively high population density compared to other villages in Surakarta, as evidenced by the Sangkrah Village map, which highlights the close proximity of residential areas, limited open space, proximity to rivers, and high levels of domestic activity. This situation can illustrate the various

environmental problems that can arise, one of which is the increasing volume of domestic household waste generated daily (PURBOLAKSITO, 2014).

According to data from the Surakarta City Environmental Agency, the volume of waste entering the Final Processing Site (TPA) from the Surakarta City area has been increasing annually, including five sub-districts in Surakarta City, including Sangkrah District (Sari et al., 2025). Unfortunately, not all domestic waste is managed optimally by either the government or the local community. Frequently complained about issues include the limited number of waste collection vehicles, the lack of adequate waste management facilities and infrastructure, and low public awareness of the importance of sorting, processing, or recycling waste independently (Shekdar, 2009; Kwakye et al., 2024).

If domestic waste is not managed properly, it can lead to various other environmental problems, such as water and air pollution, the emergence of disease, and the deterioration of residential areas' aesthetics (Ompusunggu et al., 2025; Ifyalem & Jakada, 2023; Siddiqua et al., 2022). Therefore, in the context of this problem, a 3R-based waste management concept (Reduce, Reuse, Recycle) is needed, specifically reducing, reusing, and recycling waste as a method for managing waste, especially household waste. This concept can shift the public's paradigm in waste management, shifting from mere disposal to reuse. The simplest management approach can be achieved by separating organic and inorganic waste, which is the key to implementing the 3R concept (Trisnawati & Khasanah, 2020; Samiha, 2013; Brunner & Rechberger, 2015; Ludwig et al., 2012).

For example, research conducted by Fitriansyah et al. (2020) in the Cicadas Village of Bandung City, a densely populated area, showed that 70% of total municipal waste comes from domestic waste, with a daily generation reaching 6.14 tons in the Cicadas Village alone. In this study, the 3R-based approach was deemed important, but its implementation is highly dependent on community participation. In line with the issues in the Cicadas area, this indicates that in densely populated areas, public awareness of waste management tends to be low because their primary focus is solely on basic needs, often neglecting environmental issues such as waste management.

Based on various issues from previous research, this study is crucial, aiming to explore and analyze the influence of population density on public awareness of 3R-based domestic waste management. We chose Sangkrah Village as the study location because it is a concrete example of a densely populated settlement with environmental challenges that require attention. The results of this study are expected to directly contribute to the local community's participation, understanding, and sustainability in waste management in residential areas, especially in their own residential areas.

METHODS

Research Location

This research was conducted in a densely populated settlement in Sangkrah Village, Surakarta City, with 6 neighborhood units (RW) and 22 neighborhood units (RT) covering an area of 0.46 km². It has a population of 12,756, with a population density of 27,730.43 per km² (Central Statistics Agency of Surakarta City, Pasar Kliwon District In Figures, 2024).

Approach

This study used a quantitative approach with a survey method. Quantitative research is a scientific approach that emphasizes the collection of data in numerical form (Zulfikar et al., 2024). Quantitative research is based on and rooted in the positivist paradigm, where human behavior is studied through observation and

reasoning (Su, 2018). This study aims to explore the initial picture of the relationships between variables in Sangkrah Village. The minimum required sample size was calculated using the Cochran formula, with a 10% margin of error due to the large population size. The Cochran formula is commonly used in surveys or cross-sectional studies when researchers estimate a large population (Ahmed, 2024).

Cochran's Formula for Large (Infinite) Populations:

$$n = \frac{z^2 pq}{e^2}$$

Description:

n = Sample size

z = Confidence level (90% = 1.65; 95% = 1.96; 99% = 2.58)

p = Proportion value obtained from previous research (literature). If the proportion is unknown, the estimated proportion is 50% (0.5)

q = 1-p

e = Estimated error rate (10%)

N = Population size

$$n = \frac{1,96 \times 0,5 \times (1 - 0,5)}{0,1^2}$$

$$n = 96,4$$

Correction for Finite Population (Finite Population Correction):

$$n = \frac{n_0}{1 + \frac{n_0 - 1}{N}}$$

$$n = \frac{96,4}{1 + \frac{96,4 - 1}{12.756}} n = \frac{96,4}{1 + \frac{95,4}{12.756}} n = \frac{96,4}{1 + 0,00745} = \frac{96,4}{1,00745} = 95,3$$

Based on calculations using the Cochran formula with a finite population correction, a sample size of 95 respondents was obtained. However, in research practice, it is often recommended to round the sample size to a more accessible and safer number, 100 respondents, to anticipate the possibility of non-response. The calculation results indicate that for smaller populations, the number of subjects (sample size) can be smaller to provide researchers with sufficient confidence in their findings (Ionas, 2019). The data collection technique in this study was a questionnaire collected using the accidental sampling method. Accidental sampling is a sampling technique in which subjects are selected based on ease of access, such as people encountered by chance (Subhaktiyasa, 2024). However, the accidental sampling technique has a drawback: the sample obtained may not represent the characteristics of the entire population (Fauzy, 2022). Therefore, the findings of this study need to be interpreted with caution, especially when generalizing to the entire population of Sangkrah Village or other densely populated areas.

Quantitative data calculations and analysis techniques were performed statistically using MiniTab statistical software (Sofwatillah et al., 2024). To examine the relationship between population density and public awareness of 3R-based domestic waste management, we used the Pearson correlation test to measure the strength and direction of the linear relationship, and simple linear regression analysis to identify the effect of one variable on another.

RESULTS AND DISCUSSION

Condition of Sangkrah Village Settlement

The condition of settlements in Sangkrah Village was determined through community perceptions of the densely populated environment in which they live, using a scale of 1-5, with 1 = strongly disagree and 5 = strongly agree. Densely populated settlements are residential areas lacking green open spaces, with very high building and population density (Maharani et al., 2022).

The analysis showed that cumulatively, 68% of respondents gave a score of 4 or 5, indicating that the majority of residents felt they lived in a densely populated environment. Nine percent of respondents gave a score below 3, indicating that their neighborhood was not densely populated. Meanwhile, 23% of respondents gave a score of 3, indicating a neutral perception, indicating that community perceptions were still relative or situational.

Respondent Characteristics

This research was conducted by distributing questionnaires directly and online to residents in Sangkrah Village regarding the level of public awareness in managing 3R domestic waste, this study requires 100 respondents with various age ranges (Artham, 2020). This study uses a survey questionnaire with a Google Form application that is distributed in two ways, namely direct interviews on location and distributing through social media for those who live in Sangkrah Village. After collecting the data, I processed it using Excel and MiniTab, which later the respondents will be a sample representing the population of this study, an overview of the respondents who will be used as research samples is taken based on gender characteristics and age range.

Gender

The first characteristic of respondents is their categorization by gender. The sample is categorized by male and female, as shown in the following table.

Table 1. Respondent Characteristics by Gender

Gender	Total	Presentation
Male	32	32%
Female	68	68%

Based on Table 1 above, it can be seen that the majority of respondents in this study were female. Women made up 68%, or 68 people, of those who completed the questionnaire. Conversely, men made up 32%, or 32 people. This finding suggests that women have a greater understanding and awareness of domestic waste management, particularly among housewives. This difference is also influenced by the use of accidental sampling as a data collection technique, which is also based on ease of access during interviews (Artham, 2020).

Age

This study involved 100 respondents with a diverse age range between 12 to 76 years, based on descriptive analysis, the following statistical values were obtained.

Table 2. Statistical Results of Respondents by Age

Variable	N	N*	Mean	SE Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Age (Example: 20)	100	0	36.98	1.62878	16.2878	12	22	35	51.75	76

Based on Table 2 above, the average age (mean) is 37 years, with a minimum age of 12 years and a maximum age of 76 years. The age distribution of respondents obtained from the interview survey results varies widely, spanning from young people to the elderly. This suggests that perceptions of 3R waste management may be influenced by age. Most respondents aged 22-52 (Q1 and Q3) are in the productive age group, or descriptively, the most active in social activities and have relatively good access to information (Soetanto, 2017). The data in Table 2 above also shows the standard deviation, indicating age variation, which can provide an opportunity for further analysis to determine whether certain age groups may influence the level of awareness or active participation in 3R practices compared to others.

Respondents in this study were then categorized by age range. Respondents were divided into 12-20 years, 21-30 years, 31-40 years, 41-50 years, and over 51 years. The following table shows respondent characteristics by age range.

Table 3. Respondent Characteristics by Age

Age	Total
>12-20	19
21-30	22
31-40	19
41-50	14
>50	26

Based on table 3 above, it can be seen the number of each respondent from various age ranges, with the result that the age group >50 years dominates in filling out the survey, while the age group 41-50 years has the least contribution in filling out the survey. Based on the table it can also be seen that the level of awareness and understanding of 3R domestic waste management and the level of participation in implementing waste management cannot be measured only through the level of age maturity, although the table above shows that the majority of respondents are in the age range >50 years, it is certainly the presence of other driving factors, for example knowledge of domestic waste and 3R management, individual level of awareness, individual initiative in managing waste (Wang te al., 2017).

Level of understanding of 3R and level of implementation of waste recycling behavior

This analysis is based on data from 100 respondents covering their level of understanding of the differences between the 3Rs (Reduce, Reuse, Recycle) and the level of implementation of waste recycling behavior. With a scale of 1-5 (assuming 1 = Very Poor Understanding to 5 = Very Understanding) for the variable Level of Understanding of the 3Rs and a scale of 1-5 (assuming 1 = Never/Very Rarely to 5 = Very Often) for the variable level of implementation of waste recycling behavior.

Table 4. Understanding of 3R

Scale (1-5)	Count	Percent (%)	Cumulative Percent (%)
1	14	14.0	14.0
2	18	18.0	32.0
3	14	14.0	46.0
4	39	39.0	85.0
5	15	15.0	100.0
Total (N)	100		

Table 5. Implementation of Waste Recycling

Scale (1-5)	Count	Percent (%)	Cumulative Percent (%)
1	16	16.0	16.0

2	21	21.0	37.0
3	31	31.0	68.0
4	22	22.0	90.0
5	10	10.0	100.0
Total (N)	100		

Based on the data in Table 4, the majority of respondents (39%) were at level 4 on the scale, indicating a good understanding. This was followed by level 2 (18%), scale 1 and 3 (14% each), and scale 5 (15%). This indicates that residents in Sangkrah Village have a good understanding of the differences between 3R-based waste management.

Regarding the level of recycling implementation (Table 5), 31% of respondents were at level 3, indicating a moderate level of implementation. This was followed by level 4 (22%), scale 2 (21%), scale 1 (16%), and scale 5 (10%). This scale indicates that the level of implementation of waste recycling among residents in Sangkrah Village is at a moderate level. This finding aligns with the research by Hutabarat et al. (2015), which revealed that low waste management attitudes among some respondents were influenced by their level of knowledge. Some respondents in the study did not understand the negative impacts of poor solid waste management on the environment and still believed that waste management responsibility rests solely with the city government.

Waste management has the potential to provide significant benefits to the community and the environment. Therefore, active community participation in the waste management process is essential (Rahman et al., 2020). The results of this study's analysis, as seen in Table 3, show that the level of community participation in waste management activities in Sangkrah Village tends to be moderate. The majority of respondents (29%) scored 4 on the scale, indicating fairly active participation. This was followed by 22% of respondents scoring 3 and 21% on the scale, indicating moderate to low participation. Nineteen% of respondents scored 1, indicating that they were not or very rarely involved in waste management activities. Meanwhile, only 9% of respondents indicated a very high level of participation, at a scale of 5.

It should be clarified that "participation" in this context encompasses various activities, such as sorting organic and inorganic waste at home, participating in individual and community-scale waste recycling programs such as waste banks, reusing usable items, and attending 3R-based waste management outreach activities. Referring to Presidential Regulation Number 97 of 2017, the government has set targets for the National Policy and Strategy (Jakstranas) for Waste Management, namely a 30% waste reduction and 70% waste management by 2025 (wapresri.go.id, 2024). However, the results of Sangkrah residents' participation in waste sorting activities, which mostly fell within levels 3 and 4 of the participation scale, indicate that this involvement has not yet fully met the established national targets. For comparison, a similar study conducted in Cicadas Village, Bandung, showed lower levels of participation. This is due to economic pressures and the lack of supporting infrastructure for waste management (Fitriansyah et al., 2020), which makes these findings relevant as a benchmark in assessing the effectiveness of community participation in similar contexts.

Table 6. Waste Management Participation

Participation in waste management activities	Count	Percent	CumPct
1	19	19,00	19,00
2	21	21,00	40,00
3	22	22,00	62,00

4	29	29,00	91,00
5	9	9,00	100,00
N =	100		

The questionnaire inquiring about the attendance of the villagers in the process of waste management activity revealed a significant amount of variation in their participation. Among the 100 respondents, 19 percent said the level of participation was very low implying that it was seldom or nonexistent. This lowest category can be described as lacking knowledge, have little motivation or be lacking facilities to manage wastes.

The number of respondents who were categorized under the low participation variable was 21 % and this represents periodic but inconsistent engagement in activities related to wastes. The addition of the lowest group casts a worrying note on the effect of 40 percent of residents who had minimal interactions with attendant to their domestic wastes which is a vivid indicator of the behavioral and structural hindrance which forms a major retardant to household involvement in the 3R model.

On the other hand, 29 % of the respondents indicated that they had quite a high level of participation followed by the 22 % who controlled towards the center where the level of participation was identified. All these numbers indicate that more than fifty percent of the population (51 %) are relatively active in terms of waste management including sorting and reuse or attending group waste programs. Nevertheless, only 9 percent of them answered that they are engaged on a very high level, thus previous illustrating that fully committed people are a minority in the community.

The overall findings illustrate that although most residents can be said to have some level of engagement in managing their waste, the majority were classified as moderate, as opposed to very high levels of engagement and this is evidence that the community is only generally aware, insofar as it has not resulted consistently into engagement practices. Further development of the supporting infrastructure, provision of incentives, and ongoing education campaigns are thus key enablers to transitioning residents out of low and medium participation levels into the next stage of higher and more sustainable waste management participation.

The relationship between population density and the level of public awareness in managing domestic waste based on 3R

The analysis in this study was conducted using a correlation test using the Pearson correlation method with MiniTab software. The Pearson correlation test is used to measure the strength and direction of the linear relationship between two variables assumed to have a normal distribution (Figures 1 and 2). The results of the correlation test between the variables Population Density and Public Awareness Level in 3R-Based Domestic Waste Management indicate that there is no significant relationship between the two.

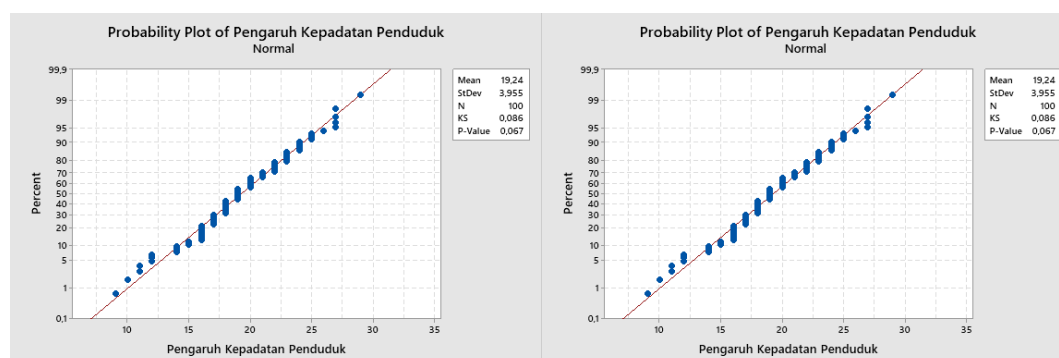


Figure 1. Normalitas

This is indicated by the P-value of 0.958 (Figure 3), which far exceeds the significance limit of 0.05. Referring to the Statistics book (Septin, 2023), a correlation value of 0.005 (Table 4) falls into the category of very weak correlation, or almost no correlation. Therefore, it can be concluded that population density has no significant relationship with the level of public awareness of 3R-based domestic waste management. Although there is no direct linear relationship between population density and 3R awareness, the interpretation of these results requires further study, possibly taking into account demographic factors.

Tables 2 and 3, considering age, can examine the relationship. When the correlation test data (Figures 1 and 2) are compared by age group, it is found that respondent participation is dominated by the productive age group, particularly those aged 21-30. However, not all age groups show the same level of participation or awareness of 3R. In several groups in the age range as seen in Table 3, respondents from the 41-50 years and >50 years age groups may potentially have different perceptions and habits in managing waste due to several factors, for example, experience factors, habitual values, and understanding of exposure to environmental information (Soetanto, 2017).

Table 7. Effect of Population Density

Variable	Correlation Coefficient (r)
Level of Public Awareness	0.005

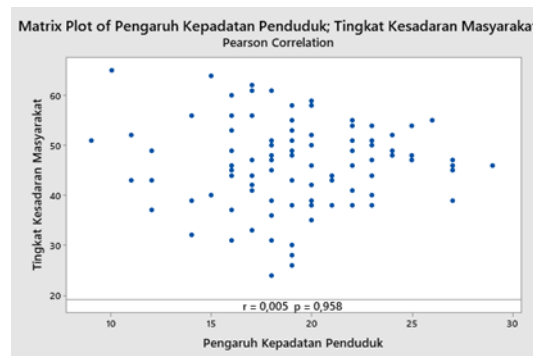


Figure 2. Pearson Correlation

In this study, we conducted a simple linear regression analysis between population density scores and the level of public awareness of 3R-based domestic waste management. Regression analysis was conducted to detect the relationship between the two variables (Astuti, 2023). In the regression analysis conducted between the two variables, although there was no significant relationship between density and public awareness, it does not immediately mean that population density has no effect at all. A very weak correlation statistically only indicates the context of the analyzed data. However, in direct field research, the two variables can have a variable relationship when viewed from each individual's perspective regarding their level of awareness of their household waste.

Table 8. Regression Coefficients

Term	Coef	SE Coef	T-Value	P-Value	VIF
Constant	45,88	4,26	10,76	0,000	
The Effect of Population Density	0,011	0,217	0,05	0,958	1,00

The results of regression analysis also extend the evidence presented that the population density does not take a central role in determining the public knowledge on 3R-based domestic waste management. The p-value corresponding to the population density variable is $p = 0.958$, the regression coefficient is 0.011. The effect is not significant since the p value represents more than the standard significance level ($\alpha = 0.05$). Therefore, population density differences do not make a significant change in predicting differences in the degree of awareness of the citizens in relation to waste management practices. It suggests that other determinants e.g. ease of access to infrastructure, provision of waste management, or community activities are probably more decisive in determining levels of awareness than density in itself.

Bridging the Knowledge Action Gap in 3R Waste Management

Based on the current research, the population density is not sufficiently connected to the magnitude of community awareness on the subject of a 3R-based domestic waste management in Sangkrah Village in terms of a statistically significant correlation. Such a finding makes the usual assumption that the density of population automatically takes a certain influence over environmental awareness and waste management behaviour among urban communities difficult to withhold. The Pearson correlation coefficient $r = 0.005$, and the non-significant p-value 0.958 were observed, which serves to demonstrate a very weak relationship between these variables and the fact that factors other than the density in isolation influence public attitudes and practices concerning 3R waste management to a large degree.

An interesting inference of the discovery is the disparity between knowing and practicing. Although most of the respondents reveal sufficient conceptual knowledge of the 3R framework, the practical level is middle. Such incongruence is reminiscent of the so-called gap between knowledge and action as addressed at length in environmental behaviour literature (Hutabarat et al., 2015). It can be supported by empirical studies that have found that, even though awareness efforts can lead to improved levels of conceptual understanding, this does not necessarily manifest into a change in behaviour, unless a fully developed infrastructure, incentive programmes, and socially-established norms are also present (Rahman et al., 2020; Fitriansyah et al., 2020). The current statistics thus indicate that population density in Sangkrah Village is not the biggest obstacle; institutional limitations, such as insufficient waste management facilities and governmental and waste-recording mechanisms are more decisive.

A further clue comes with comparative analysis to related studies. Case studies were conducted on Cicadas Village, Bandung, and factors such as low scores of 3R practice with high population density were found to be largely affected by socio-economic statuses and poor infrastructure. Cumulatively, these insights reveal that despite the possible correlation between population density and the level of public awareness in various contexts, other structural factors are bound to become the key determinants in driving the change in waste management behaviour, especially within the urban communities (Fitriansyah et al., 2020). Ompusunggu et al. (2025) argue that the failure to manage household waste depicts a more robust correlation with health conditions and infrastructural deficiencies as compared to population density. Such comparisons are important to explain that urban waste management is multi-dimensional, with awareness, infrastructure, and socio-economic pressures co-shaping the outcomes.

Another essential aspect is the contribution of demographical variables and especially age and sex. The current research observation suggests that the target respondents are mostly women, which is an essential practice of housewives in domestic waste. This gender disparity conforms to the study conducted by Hutabarat et al. (2015) that noted that women have a larger burden when it comes to waste

management and through that, women exert an influence on levels of awareness. Age is also an important factor: respondents of the productive age category (21-50 years) have shown a slightly higher awareness and engagement and the respondents who are older respondents have further established existing habits that might inhibit their behavior change. The results indicate that intervention strategies should be demographically-oriented, and the focus of the campaign be aware of intergenerational disparities in knowledge gains, information access, and daily schedules (Soetanto, 2017).

Theoretically, the finding that density and awareness are not strongly related calls the ecological assumption that higher density must worsen the waste behavior by lack of space and larger waste production, under the urban setting. Rather, the findings speak to behaviorism-infrastructure models, which focus on the idea that the mediators of awareness are the enabling conditions and social capital, and not density in and of itself (Damanhuri et al., 2009). Such an orientation promotes combined socio-environmental scaffolding in which institutional provision, cultural norms and what is commonly termed collective efficacy are deployed to explain awareness and practice per 3R waste management.

Despite the useful impact that the current study has on global knowledge in the field of household waste production and disposal preferences within high-density urban environment, several limitations can be mentioned. To begin with, the applications of accidental sampling might have been biased, specifically, by providing excessive representation of the female and elderly population, which might have framed the supposed generalisability. Second, cross-sectional design elicits perceptions at one point in time, thus it is inimical to knowledge about the dynamics of awareness and change in behaviour over time. Third, the research is conducted based on self-reported questionnaires, which makes it vulnerable to social desirability bias since respondents might overreport awareness and their participation rates in order to fit the socially desirable standard. These shortcomings highlight the need in future research to utilize sampling methods of greater strength, utilize longitudinal designs, and ensure that mixed methods approaches allow a combination of survey and direct observation of the behavior of those generating household waste.

These results imply two things. The first is operational; in policy directions in Surakarta and other striking city conditions, shifting can no longer proceed with a concentration on minimizing density and urban planning; rather urban policy should seek to reinforce rubbish management processes. Direct promotion of the behavioural change is possible through concrete interventions like the adequate availability of waste bins, guarantees constant collection, and the creation of waste banks. In complement, the design of public education campaigns should not only aim at informing, but also at motivating behaviours such as waste sorting based on economic incentives (such as recycling programs). The engagement of local leaders and the community based organisations might even strengthen the participation because it creates collective responsibility.

The study contributes theoretically to the body of urban environmental studies research by showing that density as a variable is not enough to be explanatory to waste awareness and behaviour in urban studies. Instead, awareness has to be examined along with socio-economic, cultural, and institutional contexts. This observation is a challenge to reductionist notions and in favor of more holistic environmental policy and planning.

CONCLUSION

Based on the results of research in the densely populated settlement of Sangkrah Village, Surakarta City, it can be concluded that although the community has a good level of understanding regarding the 3R concept (Reduce, Reuse, Recycle), the

implementation of waste recycling behavior in the field is still quite adequate. This indicates a gap between knowledge and real actions. Furthermore, analysis using the Pearson correlation test and simple linear regression revealed that population density does not have a significant relationship with the level of community awareness in 3R-based domestic waste management. With a very high P-value (0.958) and a very weak correlation coefficient (0.05), it can be statistically concluded that population density is not the main determining factor for the high or low level of community awareness in domestic waste management. Therefore, efforts to increase community awareness and participation in 3R-based waste management in densely populated areas such as Sangkrah Village need to focus more on other more influential factors, such as the provision of adequate infrastructure, more intensive and attractive socialization programs, and strong community support.

Suggestion

Improve waste management facilities, such as separate bins (organic and inorganic) in various strategic locations, and increase the number of waste collection vehicles to make the collection process more efficient.

Conduct ongoing public awareness campaigns based on the 3Rs (Reduce, Reuse, Recycle). This outreach can be conducted through various media and community activities to increase public awareness and participation in waste reduction.

Establish a waste bank community in each neighborhood unit (RW). This program will encourage people to sort and exchange waste for economically valuable waste, while simultaneously creating a clean environment.

The government needs to ensure a regular and periodic waste collection schedule from house to house. This will help maintain environmental cleanliness and prevent waste accumulation.

REFERENCES

- Ahmed, S. K. (2024). How to choose a sampling technique and determine sample size for research: A simplified guide for researchers. *Oral Oncology Reports*, 12(September), 100662. <https://doi.org/10.1016/j.oor.2024.100662>
- Artham, S. (2020). *Pengaruh persepsi keadilan (justice) dalam service recovery terhadap loyalitas konsumen Shopee* [Undergraduate thesis, Universitas Dian Nuswantoro]. Repository.
- Astuti, S. P. (2023). *Statistika* (Edisi kedua). Gerbang Media Aksara.
- Brunner, P. H., & Rechberger, H. (2015). Waste to energy – Key element for sustainable waste management. *Waste Management*, 37, 3–12. <https://doi.org/10.1016/j.wasman.2014.02.003>
- Buchori, I., Pangi, P., Pramitasari, A., Basuki, Y., & Wahyu Sejati, A. (2020). Urban expansion and welfare change in a medium-sized suburban city: Surakarta, Indonesia. *Environment and Urbanization ASIA*, 11(1), 78–101. <https://doi.org/10.1177/0975425320902367>
- Damanhuri, E., Wahyu, I. M., Ramang, R., & Padmi, T. (2009). Evaluation of municipal solid waste flow in the Bandung metropolitan area, Indonesia. *Journal of Material Cycles and Waste Management*, 11(3), 270–276. <https://doi.org/10.1007/s10163-009-0241-9>
- Fauzy, A. (2022). Konsep dasar teori sampling. *Antimicrobial Agents and Chemotherapy*, 58(12), 7250–7257.
- Fitriansyah, H., Pringadi, B. H., & Nurwulandari, F. S. (2020). Pengelolaan persampahan pada permukiman padat penduduk di Kelurahan Cicadas

Kota Bandung. *Plano Madani*, 9(1), 73–86.

- Hutabarat, B. T. F., Ottay, R. I., & Siagian, I. (2015). Gambaran perilaku masyarakat terhadap pengelolaan sampah padat di Kelurahan Malalayang II Kecamatan Malalayang Kota Manado. *Jurnal Kedokteran Komunitas dan Tropik*, 3(1), 41–47.
- Ifyalem, K. J., & Jakada, Z. A. (2023). The influence of housing and waste management facilities on public health. *Journal of Materials and Environmental Science*, 14(1), 62–81.
- Ionas, I. G. (2019). *Quantitative research by example* (Version 1.0.0 {β}).
- Kwakye, S. O., Amuah, E. E. Y., Ankoma, K. A., Agyemang, E. B., & Owusu, B. G. (2024). Understanding the performance and challenges of solid waste management in an emerging megacity: Insights from the developing world. *Environmental Challenges*, 14, 100805. <https://doi.org/10.1016/j.envc.2023.100805>
- Ludwig, C., Hellweg, S., & Stucki, S. (Eds.). (2012). *Municipal solid waste management: Strategies and technologies for sustainable solutions*. Springer Science & Business Media.
- Maharani, A., Mawardah, R., Tarigan, R. P., & Tambunan, W. (2022). Analisis permukiman padat dan implementasi terhadap kesesuaian lahan permukiman padat di Kawasan Petisah Hulu. *Journal of Laguna Geography*, 1(1), 32–36. <http://journal.moripublishing.com/index.php/joulage>
- Ompusunggu, A. R. I., Safinatunnaja, E. N., Ridwan, R. M., Khaerina Ramdani, T. C., Ana, A., & Achdiani, Y. (2025). Pengelolaan sampah rumah tangga dan dampaknya terhadap kesehatan keluarga. *Health & Medical Sciences*, 2(3), 10. <https://doi.org/10.47134/phms.v2i3.43>
- Purbolaksito, D. (2014). *Pola komunikasi keluarga dalam menanamkan nilai-nilai pendidikan karakter anak (Studi kualitatif penerapan pola komunikasi keluarga dalam pendidikan karakter anak pada keluarga Jawa di Kelurahan Sangkrah Kecamatan Pasar Kliwon Kota Surakarta)* [Undergraduate thesis, Universitas Sebelas Maret]. UNS Institutional Repository.
- Rahman, R., Sididi, M., & Yusriani, Y. (2020). Pengaruh pengetahuan dan sikap terhadap partisipasi masyarakat dalam pengelolaan sampah di Kampung Nelayan Untia. *Jurnal Surya Muda*, 2(2), 119–131.
- Samiha, B. (2013). The importance of the 3R principle of municipal solid waste management for achieving sustainable development. *Mediterranean Journal of Social Sciences*, 4(3), 129–135.
- Sari, D. N., Djumiarti, T., & Yuniningsih, T. (2025). Manajemen pengelolaan sampah di TPA Putri Cempo Kota Surakarta. *Journal of Public Policy and Management Review*, 13(3), 266–271.
- Setyono, J. S., Yunus, H. S., & Giyarsih, S. R. (2016). The spatial pattern of urbanization and small cities development in Central Java: A case study of Semarang–Yogyakarta–Surakarta region. *Geoplanning: Journal of Geomatics and Planning*, 3(1), 53–66. <https://doi.org/10.14710/geoplanning.3.1.53-66>
- Shekdar, A. V. (2009). Sustainable solid waste management: An integrated approach for Asian countries. *Waste Management*, 29(4), 1438–1448. <https://doi.org/10.1016/j.wasman.2008.08.025>
- Siddiqua, A., Hahladakis, J. N., & Al-Attiya, W. A. K. (2022). An overview of the environmental pollution and health effects associated with waste landfilling

- and open dumping. *Environmental Science and Pollution Research*, 29(39), 58514–58536. <https://doi.org/10.1007/s11356-022-21015-3>
- Soetanto, J. (2017). *Pengaruh kepercayaan, kemudahan, kualitas informasi dan persepsi resiko terhadap keputusan pembelian melalui situs jejaring sosial di Semarang* [Doctoral dissertation, Universitas Katolik Soegijapranata]. Unika Repository.
- Sofwatillah, Risnita, Jailani, M. S., & Saksitha, D. A. (2024). Teknik analisis data kuantitatif dan kualitatif dalam penelitian ilmiah. *Journal Genta Mulia*, 15(2).
- Su, N. (2018). Positivist qualitative methods. In C. Cassell, A. L. Cunliffe, & G. Grandy (Eds.), *The Sage handbook of qualitative business and management research methods* (pp. 17–32). Sage Publications Ltd. <https://doi.org/10.4135/9781526430236.n2>
- Subhaktiyasa, P. G. (2024). Menentukan populasi dan sampel: Pendekatan metodologi penelitian kuantitatif dan kualitatif. *Jurnal Ilmiah Profesi Pendidikan*, 9(4).
- Trisnawati, O. R., & Khasanah, N. (2020). Penyuluhan pengelolaan sampah dengan konsep 3R dalam mengurangi limbah rumah tangga. *Jurnal Cakrawala: Studi Manajemen Pendidikan Islam dan Studi Sosial*, 4(2). <http://ejournal.iainu-kebumen.ac.id/index.php/cka/index>
- Wang, H., Liu, X., Wang, N., Zhang, K., Wang, F., Zhang, S., & Matsushita, M. (2020). Key factors influencing public awareness of household solid waste recycling in urban areas of China: A case study. *Resources, Conservation and Recycling*, 158, 104813. <https://doi.org/10.1016/j.resconrec.2020.104813>
- wapresri.go.id. (2024). Penuhi target pengurangan sampah dan emisi, Wapres minta program penghargaan Adipura lebih inovatif dan adaptif. <https://www.wapresri.go.id/penuhi-target-pengurangan-sampah-dan-emisi-wapres-minta-program-penghargaan-adipura-lebih-inovatif-dan-adaptif>
- Zulfikar, R., Permata Sari, F., Fatmayati, A., Wandini, K., Haryati, T., Jumini, S., Annisa, S., Budi Kusumawardhani, O., Mutiah, A., Indrakusuma Linggi, A., & Fadilah, H. (2024). *Metode penelitian kuantitatif (teori, metode dan praktik)* (E. Damayanti, Ed.). Widina Media Utama.