



# The Benefit of Biodegradable Plastics for Supporting Sustainable Development: A Case Study of Willingness to Pay in Surakarta City, Indonesia

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## ABSTRACT

Plastic pollution is a global concern affecting water, soil, and air quality. Urgent action is needed to address this issue. This study aims to identify factors influencing the use of biodegradable plastic to reduce its negative impacts. Data were collected from 269 households-129 in Punggawan and 140 in Mojosongo, Surakarta, and analyzed using multiple regression analysis to study the determinants of WTP (*Willingness to Pay*) for biodegradable plastic with STATA software. The results show that the average WTP for biodegradable plastic is IDR 2,214. Most people in Surakarta are already environmentally conscious. Age, knowledge, occupation, interaction of sex and location, education, and marital status influence WTP for biodegradable plastic. It is hoped that the implications of the research will be used as a recommendation for government policies to reduce the amount of plastic waste generation, which is a danger to human beings and the environment.

## INTRODUCTION

In recent years, the issue of environmental pollution resulting from the use of plastic bags has become a matter of great concern (Chandegara et al. 2015, Fischbach et al. 2022, Schuermann & Woo 2022). Researchers in several developed and developing countries have been working hard to reach Sustainable Development Goals (SDGs), especially goal 12 related to sustainable consumption and production (Arora & Mishra 2019, Barcena 2018, Basavaraddi et al. 2012). Data on population and waste generation in Indonesia from 2016 – 2021 shows that the highest population growth rate occurred in 2019, at a rate of 1.08%, from a population of 268 million people in 2018 to a population of 271 million in 2019. The high increase in population in 2019 had a significant influence on the increase in waste generation, which rose from 65.8 million tons per year in 2018 to 67.1 million tons per year in 2019, or an increase in waste generation of 1.99% (Badan Pusat Statistik 2021). The problem of waste is not only a national focus but also the focus of smaller urban areas, including the City of Surakarta. Data from the Surakarta City Environmental Services Department in 2021 shows that the amount of waste produced was 299 tons per day, with the following classification: 185.23 tons per day (61.95%) of organic waste and 113.77 tons per day (38.05%) of inorganic waste (Dinas Lingkungan Hidup Kota Surakarta 2021).

The composition and properties of plastic, which make it difficult to break down, harm the living environment, including soil pollution, water pollution, and air pollution (Gironi & Piemonte 2011, Sharma & Holmberg 2019, Wright et al. 2013). Therefore, progressive environmental policies are urgently needed to achieve

environmental sustainability, even though the improvement of ecological quality is regarded as a luxury for poor people (Song et al. 2022, Suparno et al. 2024). Many researchers are looking for ways to measure the willingness to pay for public goods such as clean air or clean water for personal use by gathering information from property values (Griliches 1971). However, one of the problems with using the Contingent Valuation Method (CVM) is the numerous errors that exist in the different interview methods (Song et al. 2022).

Nowadays, a large number of people are already familiar with various kinds of plastic bags that are made from environmentally friendly materials and can be used instead of single-use (non-environmentally friendly) plastic bags (Ahamed et al. 2021, Angriani et al. 2021, Harijanja et al. 2019, Lad et al. 2024, Lutfi et al. 2017). Numerous studies have found that households with a supportive attitude toward the environment tend to be willing to pay premium prices for environmentally friendly products (Ketelsen et al. 2020, Laroche et al. 2001). Further to this, it is extremely important to discover the household determinants for using environmentally friendly plastic. Caplan (2012) believes that people with a high income often prefer to allocate some of their money to buying more plastic bags rather than carrying reusable bags, even though they have a higher awareness than people with a low income. This is because they dislike the inconvenience of bringing their plastic bags from home. In addition, it has been found that socioeconomic factors of society influence willingness to pay, and income level, in particular, is one of the variables that has a significant impact (Madigele et al. 2017, Nattapat et al. 2019, Schuermann & Woo 2022).

Research by Song et al. (2022) investigates WTP for reducing the use of plastic bags in the district of Linh Nam. This study confirms that 85.29% of households are willing to pay IDR 31,500, with variables of income, education, sex, and willingness to protect the environment having a significant positive influence on WTP. The variables of household size and age have been found to have a significant negative influence on WTP. In addition, Wang & Li (2021) emphasize the importance of awareness in reducing the use of plastic bags. Policies to ban plastic have also been effective in changing consumer behavior significantly. Research by Nattapat et al. (2019) also studies willingness to pay for plastic bag waste management in Bangkok, Thailand. This study confirms that the average willingness to pay for plastic bag waste management in Bangkok is IDR 620, with attitude assessment and support for plastic bag retribution having a significant influence on WTP. The results of research by Madigele et al. (2017) show that the variable with a positive influence on WTP is income, while variables with a negative influence are education, tax offers, and plastic bag recycling.

A study by Mogomotsi et al. (2018) presents an optimistic outcome in reducing plastic bag use. It states that 80.7% of a total of 367 people surveyed agreed that they would reduce plastic bag use and start using other bags that are more environmentally friendly. Research has also shown that plastic tax is not too effective because it is difficult to collect. These are some of the reasons why it is important to increase public awareness about environmental protection.

Based on the discussion above, a study is needed about efforts to reduce non-environmentally friendly plastic bag use in daily life through factors that influence the use of biodegradable plastic, which is more environmentally friendly. This can help to design policies that are adapted to suit the location of the study. Therefore, this study aims to analyze people's behavior and to estimate people's willingness to pay, as well as identify the factors that influence willingness to pay for biodegradable plastic.

## MATERIALS AND METHODS

The data collection used a survey which was carried out in the Districts of Punggawan and Mojosongo. The reason for choosing these two research locations was that Mojosongo is an example of a district in Surakarta with successful plastic waste management, and this district could be compared with Punggawan, a district that has not yet started to implement plastic waste management. The survey was conducted through a questionnaire containing many prepared questions. The study employs the Contingent Valuation Method (CVM), a versatile and straightforward non-market evaluation technique extensively utilized in cost-benefit analysis and environmental impact assessment (Fauzi 2014, Venkatachalam 2004). In this research, the CVM was used to find the willingness to pay for biodegradable plastic in Surakarta. The WTP data were then estimated with multiple linear regression using STATA software. In measuring willingness to pay, however, it was important to make certain during the interview process that all the respondents had correctly understood the information in the questionnaire.

### Data Collection

The total number of households in the two research locations is 1,050 in Punggawan District and 17,712 in Mojosongo District. The sample calculations were made according to the formula of Isaac and Michael (1995) in Vionalita (2020), as follows:

$$s = \frac{X^2 \cdot N \cdot P \cdot Q}{d^2(N - 1) + X^2 \cdot P \cdot Q} \quad \dots(1)$$

Where  $s$  is the number of samples,  $X^2$  is chi-squared, for the degree of freedom=1, level of error 7.5% = 3.17,  $N$  is

the size of the population, P is the chance of being right (0.5), Q is chance of being wrong (0.5), and d is difference between the sample average and population average at 0.05. A random selection of 269 households was chosen, with 129 from Punggawan and 140 from Mojosongo.

**Parametric Design of Willingness to Pay Estimate**

After all the data had been collected, the next step was to analyze each independent variable that would influence the dependent variable (Table 1).

This resulted in an empirical model of willingness to pay (WTP). The empirical model of WTP is as follows:

$$\ln_{wtp} \quad i = \alpha_i + \beta_{1i}sex + \beta_{2i}age + \beta_{3i}educ + \beta_{4i}knowledge + \beta_{5i}occupation + \beta_{6i}income + \beta_{7i}status + \beta_{8i}location + \varepsilon \quad \dots(2)$$

For the equation above:  $\ln\_wtp$  is the Dependent Variable,  $\alpha$  is the constant,  $\beta$  is the coefficient (which may have either positive or negative value), sex, age, education, knowledge, occupation, income, marital status, and location are the independent variables,  $\varepsilon$  is the residual,  $i$  is the individual number. A comprehensive explanation of the research variables is presented below.

Table 1: Explanation of research variables.

Variables	Description
In_wtp	In_wtp is the natural logarithm of the value of the willingness to pay for each household in IDR
Sex	The dummy variable of sex, where 1 means female and 0 means male
Age	The age variable is categorized as a dummy variable with 4 groups: age_1 for the age category 18-25 years, where 1 if 18-25 years, and 0 if another age age_2 for the age category 26-40 years, where 1 if 26-40 years, and 0 if another age age_3 for the age category 41-57 years, where 1 if 41-57 years, and 0 if another age age_4 for the age category over 57 years, where 1 is over 57 years, and 0 if another age
Education	The education variable is categorized as a dummy variable with 6 groups: Elementary school, where 1 if the final education level is Elementary School or the equivalent thereof, and 0 if another education category. Junior high school, where 1 if the final education level is Junior High School or the equivalent thereof, and 0 if another education category. Senior high school, where 1 if the final education level is Senior High School or the equivalent thereof, and 0 if another education category. Diploma, where 1 if the final education level is a Diploma or the equivalent thereof, and 0 if another education category. Bachelor, where 1 if the final education level is a Bachelor's degree or the equivalent thereof, and 0 if another education category. Postgraduate, where 1 if the final education level is a Master's degree or the equivalent thereof and 0 if another education category.
Knowledge	The dummy variable of knowledge where 1 if there is existing knowledge of biodegradable plastic and 0 if there is no knowledge of biodegradable plastic.
Occupation	The dummy variable of occupation, where 1 if work is in the formal or informal sector, and 0 if otherwise (homemaker, student, etc.)
Income	The variable of income, is calculated with a natural logarithm from the income of household members in Rupiah.
Status	The variable of marital status, where 1 if the respondent is married and 0 if unmarried
Location	The variable of location of the respondent's house, where 1 if the respondent is from Mojosongo, and 0 if the respondent is from Punggawan.

**RESULTS AND DISCUSSION**

**Respondent Survey**

The results of the research showed that the total number of respondents was 278, with proportion of 148 (53.24%) from households in Mojosongo and 130 (46.76%) from households in Punggawan (Fig. 1).

Of these respondents, 146 (52.52%) were male and 132 (47.48%) were female. In terms of age, the majority of the respondents were 18-25 years old, with a proportion of 33.09%, followed by 29.14% in the 41-57 age group, 26.98% in the 26-40 age group, and the remaining 10.79% in the age category of 57 and above (Fig. 1a). The majority of the respondents had a Bachelor's degree, with a proportion of 35.61%, followed by 31.29% in the high school category, 16.91% in the diploma category, 8.63% in the junior high school category, 4.32% in the elementary school category, and 3.24% in the postgraduate category (Fig. 1b). In terms of income, almost 32.01% of the respondents earned an income of IDR 1,000,000 to IDR 1,999,999, followed by 23.74% with an income of IDR 2,000,000 to IDR 2,999,999, 14.75% with an income of IDR 3,000,000 to IDR 3,999,999, 7.19% with an income of less than IDR 1,000,000, 6.83% with an income of over IDR 6,000,000, and the remaining 4.68% with an income of IDR 5,000,000 to IDR 5,999,999

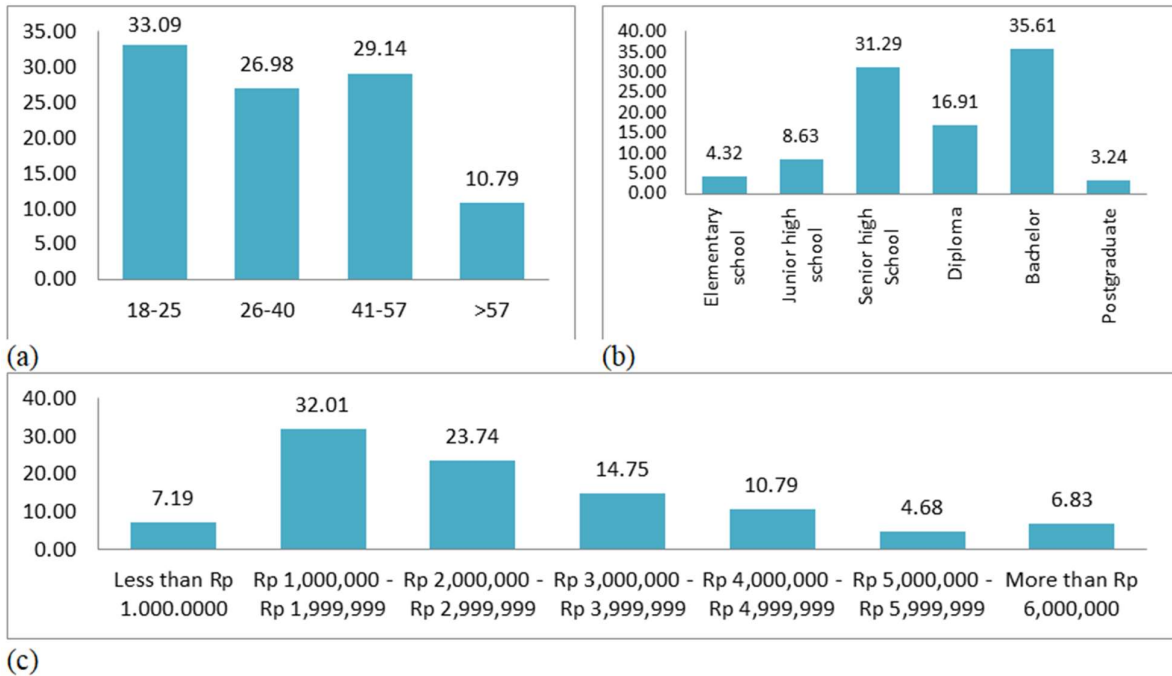


Fig. 1: Distribution of age (a), education (b), and household income (c).

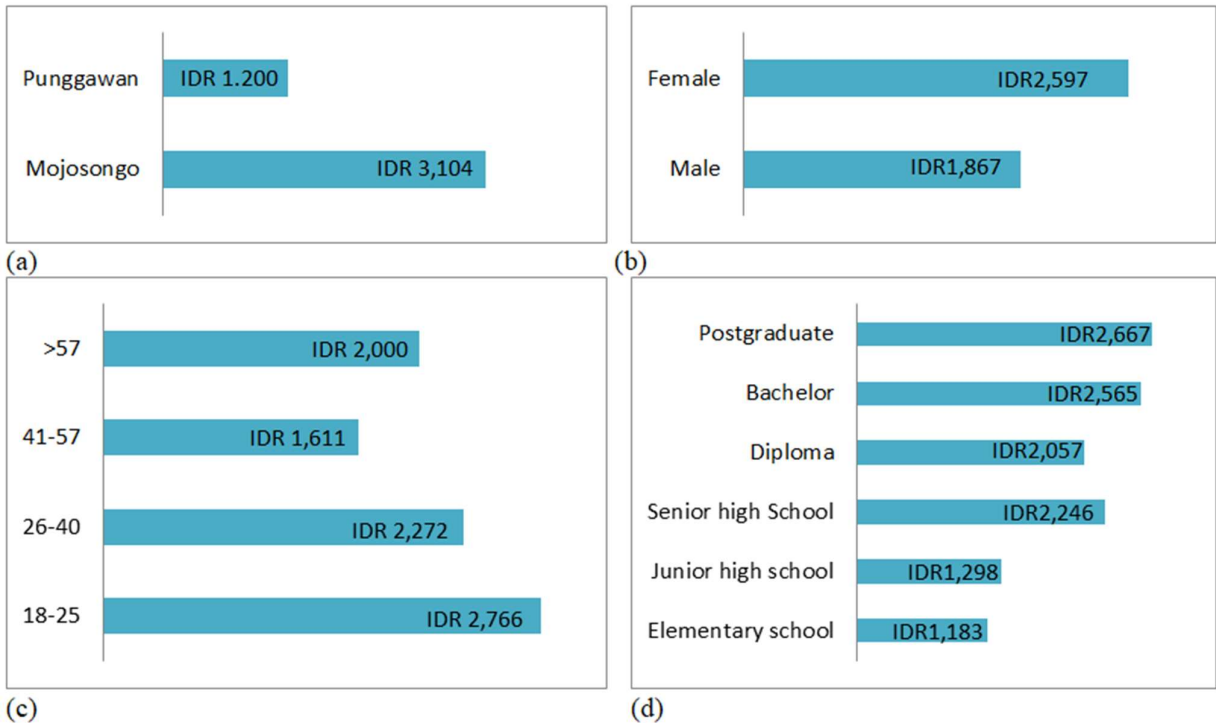


Fig. 2: Respondents' WTP for biodegradable plastic based on location (a), sex (b), and age (c).

(Fig. 1c). Furthermore, it was found that the overall willingness to pay for biodegradable plastic in the two districts was IDR 2,214. If this average Fig. was compared

with the results for the separate locations, the WTP of respondents in Mojosongo was higher, at R 3,104 (See Fig. 2a). Other results showed that females had a higher

willingness to pay (Rp 2,597) than males (Rp 1,867) (Fig. 2b).

It was also found that the older the age of the respondents, the lower the tendency to pay for biodegradable plastic (respondents over the age of 41 years had a WTP less than or equal to IDR 2,000), compared with respondents in the younger age group (respondents below the age of 40 years had a WTP higher than IDR 2,000), as seen in Fig. 2c. In addition, the higher the level of education of the respondents, the higher their willingness to pay. This is shown in Fig. 2d, where it can be seen that respondents with an education level of high school and above had a WTP over IDR 2,000, which is higher than those with an education level of junior high school and below, whose WTP was IDR 1,500.

### Respondents' Behavior

The majority of respondents already had an existing concern for the environment. This is evident from the respondents' behavior, which can be seen by comparing the level of knowledge and use of biodegradable plastic in Surakarta (See Fig. 3).

Fig. 3 shows that a total of 70.86% of respondents were already environmentally conscious, which was indicated by their knowledge of biodegradable plastic and, subsequently, their use of this type of plastic. The next largest group was

the 16.91% of respondents who knew about biodegradable plastic but did not use it, followed by 11.51% of respondents who were not concerned for the environment and showed a minimal response to the existence of plastic waste, and the remaining 0.72% of respondents who already used biodegradable plastic but had no previous knowledge of the existence of this type of plastic before they were told about it when the survey was carried out.

### Willingness to Pay Estimation

The results of the regression analysis show that WTP for biodegradable plastic is influenced by the variables of age, knowledge, and occupation, while the interaction of sex and location, and interaction of education level and marital status (See Table 2). Based on the level of education, respondents with the education level diploma, whether married or unmarried, had the strongest influence on WTP for biodegradable plastic, with a significance of ( $p < 0.05$ ), with an increase of 1.77% for those who were unmarried, and 0.94% for those who were married, compared with other levels of education. Respondents in the education category of junior high school who were married also had a strong influence on WTP for biodegradable plastic with a significance of ( $p < 0.05$ ), with an increase of 0.82% compared with other levels of education. Furthermore, respondents in the education category of senior high school

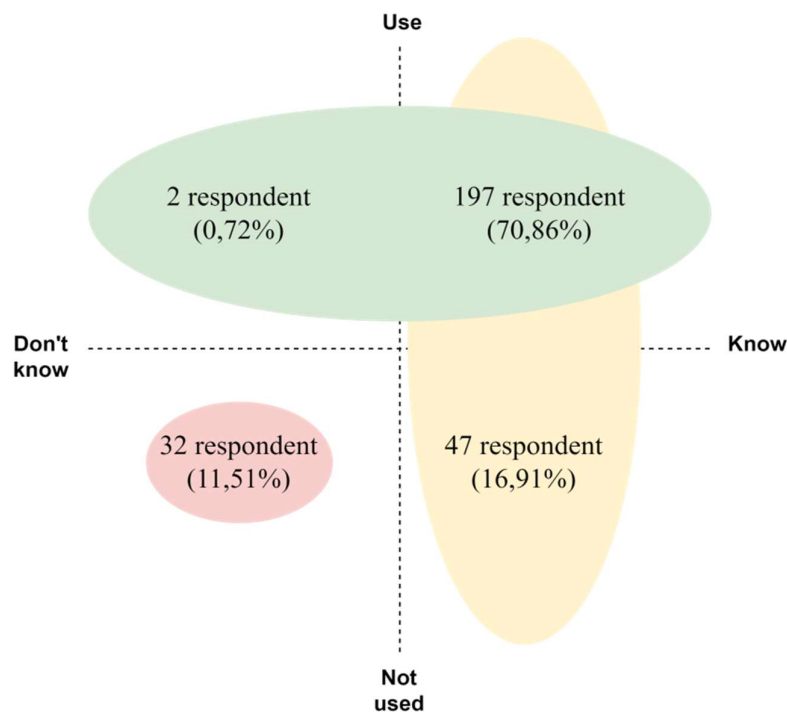


Fig. 3: Mapping of respondents' behavior toward biodegradable plastic.

who were married also had a strong influence on WTP for biodegradable plastic, with a significance of ( $p < 0.10$ ), with an increase of 0.72% compared with other levels of education. Respondents in the education category of Bachelor who were married also had an influence on WTP for biodegradable plastic, with a significance of ( $p < 0.10$ ), with an increase of 0.68% compared with other levels of education.

Females living in Mojoosongo were found to have the most significant influence ( $p < 0.01$ ), with an increase of 0.82% compared with both males living in Mojoosongo

Table 2: Regression results of WTP for biodegradable plastics.

Variable	$\beta$	S.E	Sig.
Constanta	0.46	1.91	0.81
Age			
18-25 years old (age_1)	-1.01	0.62	0.10
26-40 years old (age_2)	-0.81	0.58	0.16
41-57 years old (age_3)	-1.08	0.58	0.06*
More than 57 years old (age_4)	-1.39	0.60	0.06*
Knowledge	0.41	0.14	0.00***
Occupation	-0.39	0.18	0.03**
Income	0.41	0.10	0.00***
Interaction Variable			
Sex#Location			
Male#Mojoosongo	0.63	0.17	0.00***
Female#Punggawan	-0.21	0.19	0.25
Female#Mojoosongo	0.82	0.18	0.00***
Education#Status			
Elementary school#Status			
Elementary school#Marriage	-1.04	1.49	0.49
Other#Single	0.26	1.08	0.81
Other#Marriage	-1.39	1.83	0.45
Junior high school#Status			
Junior high school#Marriage	0.82	0.43	0.05**
Other#Single	1.72	1.23	0.16
Senior high school#Status			
Senior high school#Marriage	0.72	0.39	0.07*
Other#Single	1.43	1.01	0.16
Diploma#Status			
Diploma#Marriage	0.94	0.43	0.02**
Other#Single	1.77	1.04	0.09*
Bachelor#Status			
Bachelor#Marriage	0.68	0.38	0.07*
Other#Single	0.97	1.04	0.34

Note: Coefficient ( $\beta$ ), Standard Error (S.E), Significance (Sig.). A coefficient is statistically significant at either 1 percent (\*\*\*), 5 percent (\*\*), or 10 percent (\*) of the confidence intervals.

and females living in Punggawan. Respondents who had knowledge of biodegradable plastic were willing to pay 0.41% more for this type of plastic, with a significance of ( $p < 0.01$ ). In addition, an increase in income of 1% had an influence on respondents' willingness to pay 0.41% more for biodegradable plastic. Age had a significant negative influence on WTP for biodegradable plastic. This means that the older the respondent was, the lower their willingness to use biodegradable plastic. This is evident from the results of respondents in the 41-57 year age group and the over 57 age group, who showed a decrease in willingness to pay for biodegradable plastic, at a level of 1.08% for the 41-57 year age category and 1.39% for the over 57 age category. Respondents who had a job were 0.39% less willing to pay for biodegradable plastic compared with homemakers, students, and fresh graduates.

## DISCUSSION

Various different models about the importance of biodegradable plastic have confirmed that the preference for strategies for using biodegradable plastic is influenced by socio-economic characteristics and knowledge. From the model used, the explanatory variable estimates have the same signs. Females (seen from the coefficient of "sex") are generally willing to pay "more" for biodegradable plastic compared with males, even though both have an equally significant value. This result is in line with the work of Abate et al. (2020), who state that male respondents have a lower level of concern and attention for environmental issues and are less convinced about the effectiveness of proposed initiatives, which subsequently influences their WTP (Abate et al. 2020). Mainieri et al. (1997) note that this difference in attitude may be because women more frequently shop for household needs than men, and as a result, they are more aware of environmental problems related to various products, including plastic bags, that harm the environment. It is interesting to point out that, in general, the knowledge of females about the environment is usually not as broad as their male counterparts, but females tend to be more emotionally involved, more concerned about environmental degradation, less trusting in technological solutions, and more willing to change or accept environmentally friendly solutions (Kollmuss & Agyeman 2002). This can be linked to their subconscious psychosocial factors, such as emotion, bearing in mind that women are more emotional than males. It has been observed that emotion can also have a significant and direct impact on assessment and choice related to environmental problems (Loewenstein & Lerner 2003).

Age has a negative and significant influence on WTP. This means that the older the respondent, the lower their

wish to pay for newer management strategies, as found in the research of Ojea & Loureiro (2007), which states that older respondents have a lower probability of giving a positive response to WTP compared with their younger counterparts because they have fewer economic resources and, in general, have less concern for the environment (Ojea & Loureiro 2007). Education is expected to have a positive effect on WTP. Education level in relation to environmental management is a strong predictor of the willingness to pay for green, sustainable, and/or environmentally friendly products or initiatives, as found in (Fischbach et al. 2022), a study that focuses on counseling and education efforts as a form of environmental awareness.

Income has a positive and significant influence, and it can be seen statistically that all respondents with similarly high incomes are more inclined to be willing to pay for biodegradable plastic bags than those with a low income. Dunn (2012) believes that respondents with a high income are more willing to pay for new biodegradable plastic rather than have the inconvenience of carrying a reusable bag, even though they have a higher level of environmental awareness than respondents with a low income (Dunn 2012). The fact that a plastic bag is a convenient option, which costs very little when compared with the total cost of the other purchases, makes people more inclined to buy it than to bring their bag from home (Angriani et al. 2021). Therefore, they have no objection to paying for this type of environmentally friendly plastic.

The results of newer research show that knowledge has a positive influence on WTP for biodegradable plastic. This is in line with the findings of Janardan et al. (2023), which state that a high level of general knowledge about plastic pollution influences awareness and knowledge of environmental threats caused by plastic (Coco Chin et al. 2023). In addition, pollution caused by non-environmentally friendly plastic can be reduced by targeting the attitudes of individuals through an educational campaign that aims to improve knowledge and awareness about plastic alternatives and recycling (Oguge et al. 2021). In the same way, an increased understanding and awareness can influence people's convictions concerning the way other people feel about their decision to stop using single-use plastic.

## CONCLUSIONS

Biodegradable plastic is plastic that can help reduce the occurrence of environmental pollution if used on a massive scale by the general public. The findings of this research show that there is a positive result regarding people's willingness to pay (WTP) for biodegradable plastic, with an average amount of IDR 2,214. This can be seen in both of the

samples from the Districts of Mojosoongo and Punggawan. The reason for this is that the majority of people in Surakarta (78.86%) already know about the benefits of biodegradable plastic. Therefore, they do not object to buying and using this type of plastic, even though they have to pay a higher price than for non-environmentally friendly plastic. The results of the analysis show that WTP for biodegradable plastic is influenced by the variables of age, knowledge, and occupation, the interaction of sex and location, and the interaction of education level and marital status. The education level of diploma for both unmarried and married respondents was found to have the strongest influence on WTP for biodegradable plastic. It is hoped that this research can be used as a recommendation for government policies to reduce the amount of plastic waste generation, which presents a danger to human beings and the environment.

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