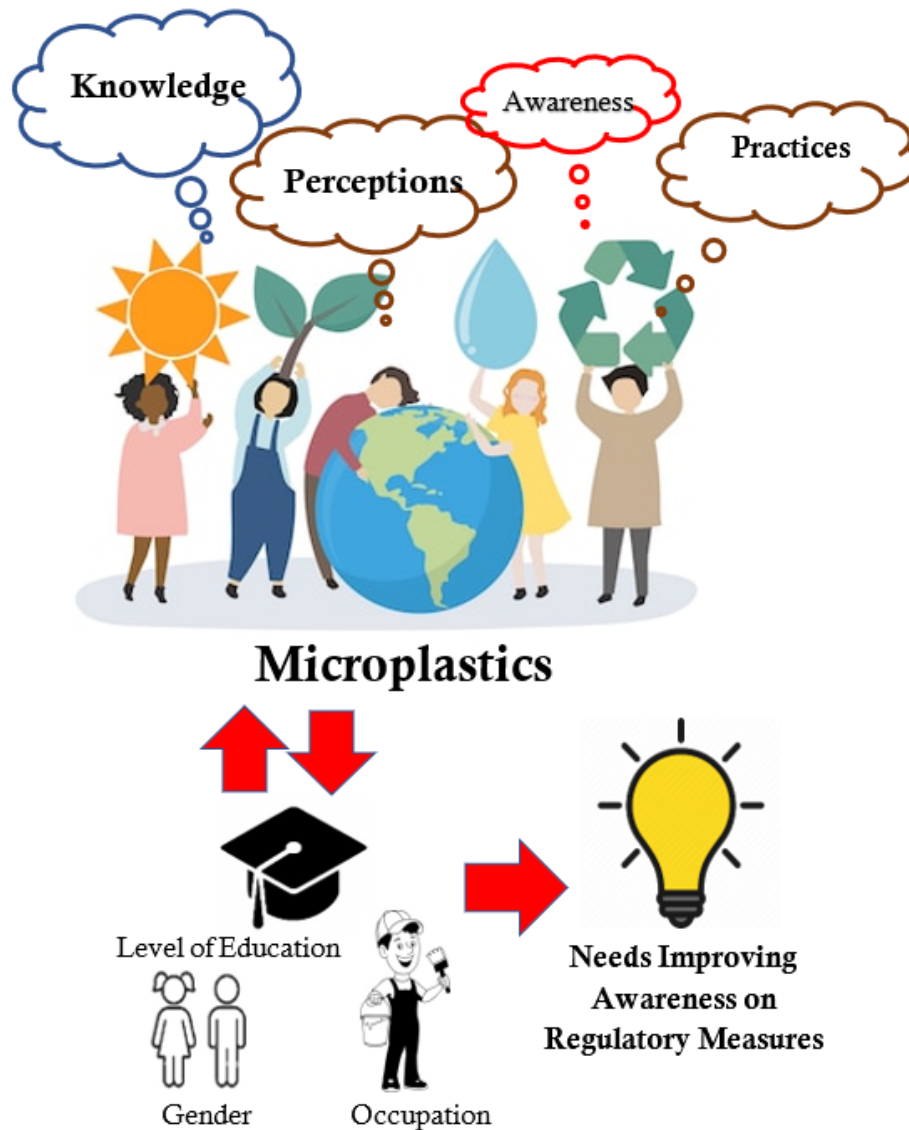**RESEARCH ARTICLE**

Community awareness and perceptions on microplastics: a case study from Sri Lanka

K. Premarathna, S. P. Abeysundara, A.M.T.A. Gunaratne and H.M.S.P. Madawala*

Highlights

- Microplastics (MPs) are known as a major pollutant in the environment.
- The study evaluates community perceptions and awareness on this emerging pollutant and its immediate impacts.
- Public awareness of impacts of MPs is higher, though their alertness on regulatory measures is rather poor.
- Public awareness, perceptions and practices are related to their gender, education level, age and occupation.
- Improving public awareness on regulatory measures is highlighted.

RESEARCH ARTICLE

Community awareness and perceptions on microplastics: a case study from Sri Lanka

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Abstract: Microplastic (MP) pollution is a global issue due to its unprecedented impacts on the environment and human health. However, its place as a potential pollutant and possible impacts on plant and human health are less understood among the general public. The study was conducted to investigate the level of awareness of MP pollution and its impacts and to evaluate their practices and perceptions of plastic usage, and their awareness on regulatory measures in Sri Lanka. The convenience sampling method was employed to select the study population representative of both rural and urban areas. A questionnaire was distributed among 166 respondents belonging to the age group of 20 - 40 years. Nearly 67% and 68% of respondents were aware of MPs and their harmful impacts, respectively. Nevertheless, most respondents (66 %) were not aware of the regulatory measures introduced by the authorities to control the usage of plastic products. About 66% of respondents discarded plastic items on a daily or weekly basis indicating their widespread usage among the general public in Sri Lanka. However, a majority (85%) were unaware that burning of plastics is a prohibited action in the country. The results revealed that the awareness of MPs and their impacts were significantly linked to the gender, level of education, and occupation of respondents, though their awareness on regulatory measures did not show any relationship with the tested demographic characteristics. Unemployed respondents (98.4%) were more mindful of the non-biodegradable nature of plastics than that of students and employed respondents, indicating that the level of education has no link with their awareness of plastics and their characteristics. Despite reasonably high awareness on MPs, the study highlights the necessity of introducing effective strategies to enhance the awareness of regulatory measures to control plastic usage and safe disposal mechanisms among the general public to manage MP pollution in Sri Lanka.

Keywords: Microplastics; Perceptions; Practices; Regulations; Sri Lankan Community

INTRODUCTION

Plastics are materials of low-cost, lightweight and durable, thus making them an excellent raw material for a wide range of applications (Andrady and Neal, 2009). As a result of these user-friendly properties and their many commercial applications, the plastic production has increased markedly over the last few decades (Hopewell *et al.,* 2009). In 2019, the global production of plastics was estimated at 368 million metric tons, with a forecast of increasing it to 33 billion tons by 2050 (Horton *et al.,* 2017). According to Geyer *et al.* (2017), around 6,300 million metric tons of plastic waste has been generated globally of which only 9% is recycled, 12% incinerated and 49% ended up in landfills. In Sri Lankan context, it annually imports 160,000 metric tons of plastic raw material and another 100,000 metric tons of finished and intermediate plastic products (Gunarathna *et al.,* 2010). With no proper mechanism in place for recycling plastic waste and/or any other environmentally-friendly disposal mechanism, most of this plastic-based waste eventually end up in landfills causing pollution and other environmental hazards in the island. Due to the non-biodegradable nature, the discarded end-of-life plastics accumulate in landfills and in natural habitats (Hopewell *et al.,* 2009), causing potentially serious environmental consequences. Once plastics disintegrate into small pieces (less than 5 mm) known as microplastics (MPs), they can become a serious environmental pollutant (Machado *et al.*, 2018). These tiny plastic particles tend to accumulate in terrestrial and aquatic environments over time, thereby altering soil properties and water dynamics, and eventually affecting plant performance (Raab and Bonger., 2021). Furthermore, MPs have shown a strong ability to adsorb pollutants due to their large specific surface area and hydrophobicity (Wang *et al.*, 2020), transforming them into pollutant carriers (Deng *et al.*, 2020). According to recent findings, trophic transfer and biomagnification provide a potential route for MPs to end up in humans (Yee *et al.*, 2021; Elizalde-Velázquez *et al.*, 2021), causing serious health impacts that are largely unknown.

The knowledge, awareness and perceptions of the general public are key elements for policy makers to introduce and implement effective pollution control measures. As MPs are considered as an emerging pollutant, it is reasonable to speculate that their implications and potential dangers are not fully known to the general public. Thus, it is imperative to make the public aware of the consequences of MP pollution before advocating rules and regulations to control over-usage of plastics and their proper disposal. Globally, limited studies have been carried out to evaluate the community awareness of MP pollution and its risks, and none has been conducted in Sri Lanka. The importance of understanding knowledge gaps in MPs as an environmental

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pollutant has been highlighted in a review article by Bayar *et al.* (2022). They also emphasized the importance of raising awareness among the society prior to introducing of management strategies to curtail plastic pollution. The present study aimed at determining the knowledge, awareness, perceptions and practices of the general public on MPs and to explore the relationship between MPs with the level of education, gender, and occupation of the respondents.

MATERIALS AND METHODS

A questionnaire-based survey was conducted to collect data on knowledge, awareness, practices and perceptions on MPs and their impacts, using a population of 166 respondents that was selected based on convenience sampling. As the travel restrictions were in place due to the Covid-19 outbreak, the survey was conducted through various electronic means including electronic mail, Facebook, and WhatsApp during a period of six months in 2021. The questionnaire comprised of six sections with 34 questions; a mixture of Likert scale, multiple-choice, and open-ended questions. The six sections *viz.,* Section 1 - Demographic information (Q1 - Q7), Section 2 - Knowledge on MPs (Q8 - Q16), Section 3 – Usage of plastics (Q17 - Q20), Section 4 – Ways of disposing plastic waste (Q21 - Q24), Section 5 - Perceptions about MPs (Q25 - Q31) and Section 6 - Awareness on regulations related to plastics (Q32 - Q34) (Annexure 1).

Ethical clearance was obtained prior to the research due to the participation of human subjects in the study. Their demographic details and responses to the questions were collected only for the purpose of the study, and the respondents were informed about this at the beginning of the survey. All the respondents participated in the survey as volunteers. The respondents' consent was secured for their voluntary participation in the survey after informing the respondents about the purpose of the study and the potential dissemination of the outcome prior to the survey.

Statistical Analysis

The information collected was analyzed using Minitab software (18.1 version). Chi-square tests were carried out to determine the associations of responses to their demographic characteristics such as level of education, gender and occupation. Responses of the demographic characteristics were tabulated as percentages from the total number of respondents. There were nine questions formulated especially to evaluate the knowledge of respondents on MPs and their impacts on the environment and a chi-square test was conducted to determine the association between the knowledge with demographic characteristics (*i.e.* Level of education, Gender and Occupation). In the analysis, the responses were taken as dependent variables while the demographic characteristics were taken as independent variables.

The questions on the usage of plastics were divided as frequency of plastic usage, plastic materials used for packing food, alternatives for carrying groceries and reasons for plastic usage to determine their behavior on plastic usage. Those were taken as dependent variables while demographic details were taken as independent variables. For Q17, answers were categorized as environmentally friendly, non-environmentally friendly packaging and others. Chi-square tests were conducted to determine the relationship between independent and dependent variables. In questions based on practices of disposing of plastics, each response was taken as a dependent variable and demographic details as independent variables.

Perceptions of the respondents on plastics, MPs and plastic usage were evaluated using five statements and a Likert scale was used to show their level of agreement to those statements. Responses such as 'strongly agree' and 'agree' were pooled together, while 'strongly disagree' and 'disagree' were grouped separately, and 'neither agree nor disagree' were taken as a separate group. In the question 30 (Q30), respondents were allowed to give their own opinions and a word cloud plot was used to determine the frequency of words to highlight their general opinion on MPs and their usage.

For questions related to the awareness on regulations related to plastics, responses of 'no' and 'no idea' were pooled together and responses of 'yes' was taken as a separate group. Responses for the questions based on awareness of regulations were taken as dependent variables while the demographic characteristics were taken as independent variables. For the multiple-choice questions (Q17, Q18, Q19, Q21, Q29**),** choices were coded and presented as percentages accordingly.

RESULTS AND DISCUSSION

Demographic characteristics

The age range of the test population was between 20 to 40 years. The majority of respondents (77.1%) represented the age group of 20 - 26 years. Nearly 15% and 8% of the respondents represented the age groups of 27-33 years and 34 - 40 years, respectively. Among the respondents, a majority were students (58.4%), while 23.5% and 18.1% were unemployed and employed, respectively. Furthermore, 69.9% of respondents were females. Of the total population, 30.1% of respondents have completed their secondary education, while the rest have completed their tertiary education (Table 1). Considering the overall demographic characteristics, the dataset suggested that it is biased in terms of the age, gender and occupation, thus the test population is dominated by relatively young and educated females (Table 1).

Awareness on MPs and their impacts

Majority of respondents (67%) were aware of MPs, and their responses were closely linked to their level of education (Table 2). Furthermore, most of the respondents (80%) were aware that plastics are non-biodegradable, with females proving to be more environmentally conscious than their male counterparts. Moreover, students were more conversant of the biodegradable nature of plastics ($\approx$80%) than that of employed/unemployed respondents (57 and 49%, respectively). The respondents were also aware that MPs persist in soil for a long time (83%), alter soil

properties (67%), and affect plant growth (68%), influence soil microbes (80%) and human health (87%), respectively. Employed respondents (97%) and students (89%) were notably more mindful of health consequences of MPs in comparison to unemployed respondents (77%) (Table 2).

According to results, a majority of the respondents were aware of MPs and their negative consequences on the environment, plant growth and human health, suggesting that the test population is represented by a relatively well-educated and socially-active segment of the general public. Previous studies carried out elsewhere also noted that the young generation is more mindful of environmental issues than the older generation (Song *et al*., 2012; Mainieri *et al*., 1997), though the present study could not fully support or contradict this generalization due to the age-biased test population. However, considering the facts that only one third of the test population (33%) had never heard of MPs and the test population is in the age range of 20 – 40 years, it may be presumed that the young generation is more

aware of environmental issues. Another study carried out in China in 2020 revealed that only 26% of the test population knew about MPs highlighting their unawareness of this emerging issue of MP pollution. Based on the findings, they concluded that any information related to MPs and their potential impacts are generally confined to academic purposes, thus this information has not reached the general public yet (Deng *et al*., 2020). Our study also suggest that the awareness on MPs and their other characteristics are closely linked to the occupation and education level of the test population, in addition to the age. In contrast, a study conducted in Nigeria noted a higher level of public awareness of MPs and their potential health risks despite demonstrating poor perceptions on plastics usage (Omoyajowo *et al*., 2021). Better awareness of the society on environmental issues could eventually favor their willingness to understand the regulations and abiding them to control environmental-related issues (Laroche *et al*., 2001). However, the lack of awareness on MPs and their

Table 1: Demographic characteristics of the test population (as a percentage from the total population of 166).

Demographic characteristics		Number of Individuals	As a % from the total population
Age (Years)	20-26	128	77.1
	27-33	25	15.1
	34-40	13	7.8
Occupation	Unemployed	39	23.5
	Student	97	58.4
	Employed	30	18.1
Education level	Secondary education	50	30.1
	Tertiary education	116	69.9
Gender	Male	50	30.1
	Female	116	69.9
Land ownership	< 10 perches	22	13.3
	11-30 perches	65	39.2
	31-50 perches	39	23.5
	> 50 perches	40	24.0

Table 2: Results following the Chi-square analysis for responses for each question (Q1 to Q9) based on testing respondents' awareness and knowledge on MPs and their impacts based on their gender, occupation and level of education. Significant differences are indicated using asterisk (*); *$p \leq 0.05$, **$p \leq 0.01$, ***$p \leq 0.001$.

Questions (1-9) based on awareness on MPs and its impacts	p-values		
	Gender	Occupation	Educational level
Q1. Have you ever heard of MPs?	0.606	0.094	0.021*
Q2. Do we need to be concerned of MPs?	0.990	0.177	0.293
Q3. Are plastics biodegradable?	0.032*	0.015*	0.012**
Q4. Do plastics degrade easily?	0.927	0.466	0.927
Q5. Do MPs persist in soil for a long time?	0.096	0.129	0.573
Q6. Do MPs alter soil properties?	0.839	0.227	0.839
Q7. Do MPs influence plant growth?	0.707	0.001***	0.143
Q8. Do MPs influence soil microbial activities?	0.920	0.075	0.461
Q9. Do MPs affect human health?	0.731	0.042*	0.869

impacts on plant and human health is probably due to the subtle and emerging nature of this issue in comparison to other environmental pollutants, thus people are paying less attention to MPs and their consequences (Deng *et al.*, 2020).

Usage of plastics

According to the findings, a majority of respondents uses less than two items of plastic bags (82.5%), plastic bottles (91.6%) and cups (84.3%) on daily basis, with no statistically significant relationship with any demographic characteristics (Figure 1).

However, the respondents used plastics for packaging more than they use plastic-based items for other purposes. In favour, previous studies too confirmed that one third of plastic waste that enters the environment is mainly through food packaging (Heidbreder *et al.*, 2019). The results indicated the importance of introducing laws and regulations to cut down disposable (one-time use) plastic-based food packaging material

to help in reducing plastic usage among the general public.

Preference of alternatives

When the respondents were queried about their alternative preferences for packing food, carrying groceries etc., most of the respondents have chosen plastic-based lunch sheets (53.6%) as their preferred way of packing food, while a formidable number of respondents have chosen reusable plastic containers (42.2%) and bio-degradable lunch sheets (24.1%) as ways to reduce plastic waste. In contrast, most respondents (73.5%) preferred cloth bags to carry their groceries highlighting their positive attitudes towards reducing the usage of plastic products. The respondents preferred plastic-based products on a daily basis since they are readily available (61.5%), low-cost (56%) and durable (42.2%). About 18.7% of respondents even claimed that they use plastic-based products as they are not aware of their role as a pollutant, and their negative consequences on health and environment (Table 3).
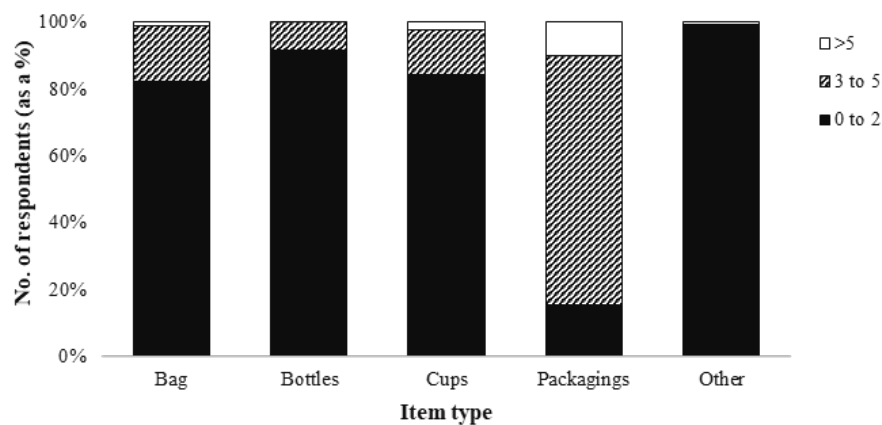

Figure 1: Daily usage of number of plastic items (0-2, 3-5 and > 5) and types (bags, bottles, cups, packaging and other) by the respondents (as a percentage from the total population).

Table 3: Respondents' preferences for plastics items and other alternatives for packing food and carrying groceries, and reasons given for usage of plastic products on a daily basis.

Utility	Responses	Number of respondents	Percentage (%) (From total respondents)
For packing food	Lunch sheets	89	53.6
	Reusable plastic containers	70	42.2
	Bio-degradable lunch sheets	40	24.1
	Other	3	1.81
Carrying groceries	Bio-degradable plastic bags	51	31.3
	Reusable plastic bags	23	13.9
	Cloth bags	122	73.5
	Other means	3	1.8
Reasons for plastics usage	Cheap	93	56
	Durability	70	42.2
	Ready availability	102	61.5
	Lack of awareness on their detrimental impacts	31	18.7
	Any other reasons	3	1.8

The outcomes of the study indicated a high usage of plastic products among the young generation despite showing a reasonable understanding on the negative consequences of plastics. Though "zero waste policy" is suggested as one of the most suited approaches to minimize plastic usage in storing and packing food items (Wagner and Lambert, 2018), it may not be a realistic approach unless a better or even a similar alternative to plastics is introduced. Thus, promoting reusable bags and prohibiting the production of one-time use plastic products can be effective measures in managing this issue. The results also indicated that despite a reasonable knowledge on negative consequences of plastics and MPs, and their potential impacts, people still tend to ignore them due to their own convenience. In a study conducted in South Africa, O'Brien and Thondhlana (2019) also observed that the people use plastic bags due to thier convenience, easy access and reusable ability. Therefore, providing them with a convenient and a less costly substitute is a must towards reducing plastic usage in a more effective manner. Most respondents have shown their willingness to use cloth bags in place of plastic bags, which is an encouraging finding of this study.

Dispose of plastic waste

About 84% of respondents practiced garbage segregation prior to disposal irrespective of their gender, occupation, and the level of education. Almost all respondents (98%) knew that burning plastic waste impacts the climate and human health in a negative manner, with a significant relationship between females and males (p=0.048). However, despite their understanding, 44% of the test population had resorted to burning of plastic waste, while only 22% recycled them (Table 4). A study conducted in China in 2020 too reported that only 18% practiced recycling or reusing plastics (Deng et al., 2020), confirming the lack of good practices among the public when it comes to disposing plastic waste. Furthermore, nearly half of the test population discarded plastic as waste, and with no proper mechanisms to recycle collected plastic-based garbage in all municipal councils/ local authorities in Sri Lanka, there is a high possibility that they will end up in landfills eventually.

In terms of frequency of disposing plastic waste, a majority of the respondents disposed used plastics on a weekly basis (44.6%), while the remainder disposed them daily, monthly, seldom or never (21.7%, 16.9%, 16.3% and 0.60%, respectively) (Figure 2). The results suggest that the respondents use and dispose plastics rather frequently, highlighting the seriousness of this issue. Additionally, the frequency of plastic waste disposal is linked with the level of education of the respondents. Accordingly, most of the respondents (72.4%) who reached the level of tertiary education disposed plastic waste more often compared to those with lower education level (secondary) (p=0.039). No other demographic characters (such as gender, occupation or land tenure) showed any significant relationships with the frequency of disposing of plastic waste (p=0.271, 0.146 and 0.307, respectively).

Table 4: Different ways of disposing of used plastic items. The results were given as a percentage from the total population. Respondents were allowed to choose more than one response.

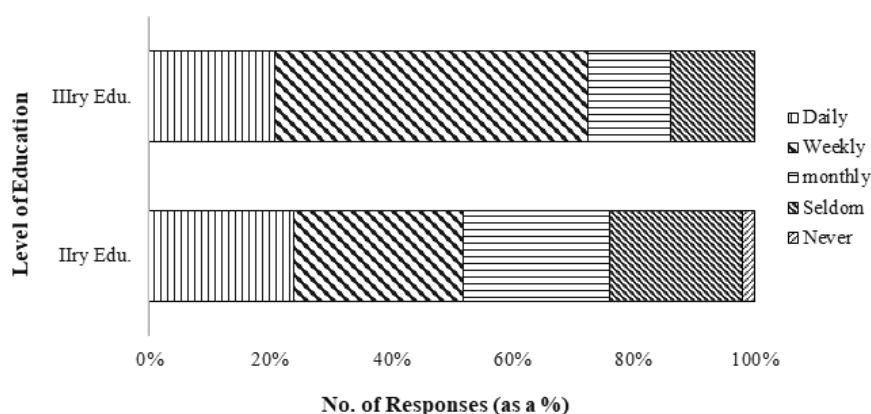| Means of disposing plastic items	Number of responses	As a percentage (%) from total population
Discard as waste	82	49.4
Reuse	45	27.1
Sell	31	18.7
Burn	73	44.0
Recycle	37	22.3
Other	3	1.8

Figure 2: Responses (as a % from the total population) to questions on how frequently the respondents dispose used plastic products based on their level of education, secondary education (II^ry Edu.) and tertiary education (III^ry Edu.)

Perceptions on plastics and MPs

From the test population, 87% of respondents agreed with the Statement 1, followed by 79%, 85%, 78% and 85% for Statements 2 to 5, respectively (Table 5). No gender-based differences were observed between responses of all five statements (S1 – S5) among the respondents. However, responses for perceptions-related statements 2 and 5 were found to be statistically linked with their levels of education. Respondents who had completed the secondary education were more mindful to the fact that plastics are harmful to the environment (S1=94%) and the status of MP as a major soil pollutant (S2=92%) compared to those with a higher level of education (84.5% and 74.1%, respectively)

Table 5: Chi-square test results for responses of the test population to each statement to evaluate their perceptions on MPs based on their level of education. Significant differences are indicated as in asterisk (*); *$p \leq 0.05$, **$p \leq 0.01$, ***$p \leq 0.001$.

Statements based on community perceptions on MPs	p-values
S1: Plastic products are harmful to the environment	0.053
S2: MPs are a major soil pollutant	0.032*
S3: Products made of natural materials (coir, cane etc.) are more ecofriendly than plastic products	0.242
S4: Reducing the usage of disposable (one-time use) plastic items is an eco-friendly practice	0.112
S5: Minimum usage of plastic products in day-to-day life is an environmentally-friendly practice	0.030*

Responses received for Statement 5 (S5) showed associations with both the occupation (p=0.017) and the level of education of the respondents (p=0.03). Interestingly, respondents who completed their education up to secondary level (95%) were more mindful of the importance of reducing plastic products than that of respondents who completed up to tertiary level (80.2%)

(Figure 3). Furthermore, unemployed (95%) respondents agreed more with S5 than that of employed (90%) and students (79%).

Recommendations to reduce plastic pollution

The respondents were given an opportunity to choose recommendations to reduce plastic usage and pollution. Accordingly, approximately 68% of respondents selected that the municipalities or relevant local authorities should take necessary actions to collect segregated plastic waste and recycle them. In addition, respondents recognized the responsibility of the general public to segregate plastic waste before disposal or sending for recycling (60.8%). They even recommended raising awareness about the negative consequences of using plastic products (56.6%) and introducing strict regulations to prohibit the usage of single-use (disposable) plastic products (51.8%) to curtail this issue in Sri Lanka. In a similar study conducted in Australia, 80% of the respondents considered that the prohibition of single-use plastic items as an effective measure to reduce plastic usage (Hoffmann et al., 2019). Xu et al., (2020) proposed some recommendations to improve legislative framework in China and to identify research gaps and the regulatory strategies to mitigate MP pollution. O'Brien and Thondhlana (2019) identified that 'provision of free environment-friendly-bags' would be an effective way to reduce plastic bag usage, and suggested interventions such as 'penalties for plastic usage', 'incentives to reuse plastic bags' and 'behavioral changes through education'. Therefore, it is conceivable to suggest that interventions aimed at promoting eco-friendly items and implementation of rules and regulation to reduce plastic pollution would yield more environmental benefits while mitigating the impacts of plastic pollution.

Overall opinions of the respondents in minimizing plastic usage

The word cloud plot (Figure 4) indicated that the most of the respondents were in the opinion that plastic usage must be reduced by introducing an eco-friendly substitute for plastics.

Awareness of regulations related to plastic usage

Only 34% of respondents were aware of the regulatory measures that the government has imposed to control
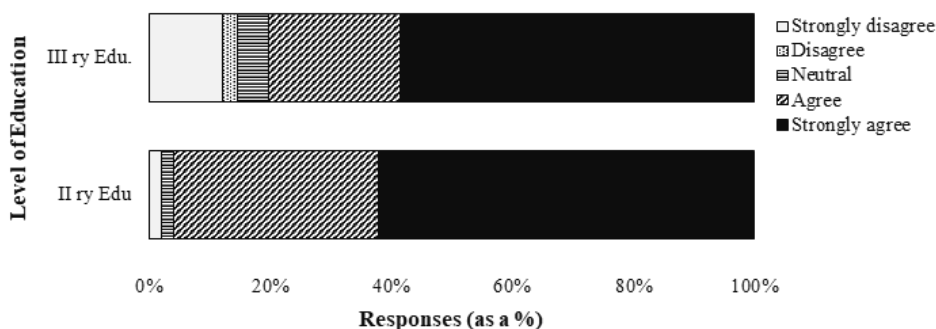

Figure 3: Responses (as a %) to statement, S5: Minimum usage of plastics is an environmentally-friendly act to evaluate respondents' perceptions on practices associated with plastics in relation to their level of education, secondary education (II[ry] Edu.) and tertiary education (III[ry] Edu).

Figure 4: Word cloud of the key words used by the respondents while giving suggestions to reduce the usage of plastic-based products. The size of the words indicates frequency of use of a particular word by the test population.

the usage and manufacture of plastics and plastic-based products. This lack of knowledge on regulatory measures could be a major setback in minimizing the usage of plastics and their proper disposal in the country. Of them, only 26% were aware of the regulation introduced by the authorities to ban the manufacture of plastic products less than 20 μ thickness, while another 23% were aware that open burning of plastics is a prohibited practice. Despite the fact that respondents were relatively known of MPs and their impacts, their awareness of regulatory measures introduced by the authorities to minimize the usage of plastics and their proper disposal was relatively low. Interestingly, despite knowing that burning of plastics could negatively impact environmental health, the respondents were unaware of the fact that open burning of plastics has been a prohibited practice. This lack of awareness of regulatory measures is a major concern as the authorities may not achieve their goals of introducing these measures to minimize the impacts of plastic pollution. This highlights the importance of educating the society on regulations introduced by the authorities to gain maximum returns of these regulations. It is known that adequate environmental knowledge and positive attitudes play a critical role in changing human actions (Ramsay and Rickson, 1978). Awareness of regulatory measures could also contribute to changing human actions. Fernando (2019) too pointed out that the lack of awareness of regulatory measures is one of the major impediments to solid waste management in Sri Lanka. The importance of educating the young generation (especially the primary and secondary level students) on plastic pollution and its consequences has also been highlighted elsewhere (Dalu *et al*., 2020). Thus, the present study recommends that the authorities should take note of these findings and intensify their efforts to educate the public about regulatory measures related to the usage and disposal of plastics to curtail adverse consequences of MP pollution.

CONCLUSIONS

The respondents showed a relatively high awareness of MPs and their effects, although their knowledge on regulatory measures was rather meagre. Therefore, it is imperative for authorities to take immediate actions to raise public awareness of regulations in order to strengthen measures to mitigate impacts of plastic usage in Sri Lanka. The study also suggests that the level of education was not a decisive factor in predicting awareness of environmental issues and their negative impacts. While most respondents demonstrated a poor awareness on regulations, they exhibit good behavior, practices, attitudes, and knowledge of MPs. It is the responsibility of the authorities to introduce other eco-friendly alternatives in place of plastics, which are reachable and affordable to the general public.

REFERENCES

Andrady, A. L. & Neal, M. A. (2009). Applications and societal benefits of plastics. Philosophical Transactions of the Royal Society B: *Biological Sciences* **364**(1526): 1977-1984. DOI: https://doi.org/10.1098%2Frstb.2008.0304

Bayar, J., Hashmi, M. Z., Khan, M. A., Pongpiachan, S., Su, X. & Chakaraborty, P. (2022). Emerging issue

of microplastic in sediments and surface water in South Asia: a review of status, research needs, and data gaps. *Microplastic pollution: Environmental occurrence and treatment technologies* 3-19. DOI: 10.1007/978-3-030-89220

Dalu, M. T., Cuthbert, R. N., Muhali, H., Chari, L. D., Manyani, A. & Dalu, T. (2020). Is awareness on plastic pollution being raised in schools? Understanding perceptions of primary and secondary school educators. *Sustainability* **12**(17): 6775. DOI: https://doi.org/10.3390/su12176775

Deng, L., Cai, L., Sun, F., Li, G. & Che, Y. (2020). Public attitudes towards microplastics: Perceptions, behaviors and policy implications. *Resources, Conservation and Recycling* **163**: 105096. DOI: https://doi.org/10.1016/j.resconrec.2020.105096

Elizalde-Velázquez, G. A. & Gómez-Oliván, L. M. (2021). Microplastics in aquatic environments: A review on occurrence, distribution, toxic effects, and implications for human health. *Science of the Total Environment* **780**: 146551 DOI: https://doi.org/10.1016/j.scitotenv.2021.146551

Fernando, R. L. S. (2019). Solid waste management of local governments in the Western Province of Sri Lanka: An implementation analysis. *Waste Management* **84**: 194-203. DOI: https://doi.org/10.1016/j.wasman.2018.11.030

Geyer, R., Jambeck, J. R. & Law, K. L. (2017). Production, use, and fate of all plastics ever made. *Science advances* **3**(7): e1700782. DOI: https://doi.org/10.1126/sciadv.1700782

Gunarathna, G. P. N., Bandara, N. J. G. J. & Liyanage, S. (2010). Analysis of issues and constraints associated with plastic recycling industry in Sri Lanka. *In Proceedings of International Forestry and Environment Symposium* **15**. DOI: https://doi.org/10.31357/fesympo.v15i0.168

Heidbreder, L. M., Bablok, I., Drews, S. & Menzel, C. (2019). Tackling the plastic problem: A review on perceptions, behaviors, and interventions. *Science of the total environment* **668**: 1077-1093. DOI: https://doi.org/10.1016/j.scitotenv.2019.02.437

Hoffmann, W. A. & Poorter, H. (2002). Avoiding bias in calculations of relative growth rate. *Annals of botany* **90**(1): 37-42. DOI: https://doi.org/10.1093/aob/mcf140

Hopewell, J., Dvorak, R. & Kosior, E. (2009). Plastics recycling: challenges and opportunities. Philosophical Transactions of the Royal Society B: *Biological Sciences* **364**(1526): 2115-2126. DOI: https://doi.org/10.1098/rstb.2008.0311

Horton, A. A., Walton, A., Spurgeon, D. J., Lahive, E. & Svendsen, C. (2017). Microplastics in freshwater and terrestrial environments: evaluating the current understanding to identify the knowledge gaps and future research priorities. *Science of the total environment* **586**: 127-141. https://doi.org/10.1016/j.scitotenv.2017.01.190

Laroche, M., Bergeron, J. & Barbaro-Forleo, G., 2001. Targeting consumers who are willing to pay more for environmentally friendly products. *Journal of Consumer Market*ing **18** (6): 503–520. DOI: https://doi.org/10.1108/EUM0000000006155

Machado, A. A. D. S., Kloas, W., Zarfl, C., Hempel, S. & Rillig, M. C. (2018). Microplastics as an emerging threat to terrestrial ecosystems. *Global change biology* **24**(4): 1405-1416. DOI: https://doi.org/10.1111/gcb.14020

Mainieri, T., Barnett, E. G., Valdero, T. R., Unipan, J. B. & Oskamp, S. (1997). Green buying: The influence of environmental concern on consumer behavior. *The Journal of social psychology* **137**(2): 189-204. DOI: https://doi.org/10.1080/00224549709595430

O'Brien, J. & Thondhlana, G. (2019). Plastic bag use in South Africa: Perceptions, practices and potential intervention strategies. *Waste management* **84**: 320-328. DOI: https://doi.org/10.1016/j.wasman.2018.11.051

Omoyajowo, K., Raimi, M., Waleola, T., Odipe, O. & Ogunyebi, A. (2021). Public awareness, knowledge, attitude and perception on microplastics pollution around Lagos lagoon. *Ecological Safety and Balanced use of Resources* **2**(24): 35-46. DOI: https://doi.org/10.31471/2415-3184-2021-2(24)-35-46

Raab, P. & Bogner, F. X. (2021). Conceptions of university students on microplastics in Germany. *Plos one* **16**(9): e0257. DOI: https://doi.org/10.1371/journal.pone.0257734

Ramsey, C. E., & Rickson, R. E. (1976). Environmental knowledge and attitudes. *The Journal of Environmental Education* **8**(1): 10-18. DOI: https://doi.org/10.1080/00958964.1976.9941552

Song, Q., Wang, Z. & Li, J. (2012). Residents' behaviors, attitudes, and willingness to pay for recycling e-waste in Macau. *Journal of environmental management* **106**: 8-16. DOI: https://doi.org/10.1016/j.jenvman.2012.03.036

Wagner, M. & Lambert, S. (2018). Freshwater microplastics: emerging environmental contaminants?. *Springer Nature* (pp.303) DOI: 10.1007/978-3-319-61615-5

Wang, Q., Zhang, M. & Li, R. (2022). The COVID-19 pandemic reshapes the plastic pollution research - A comparative analysis of plastic pollution research before and during the pandemic. *Environmental research* **208**: 112634. DOI: https://doi.org/10.1016/j.envres.2021.112634

Xu, Y., Chan, F. K. S., He, J., Johnson, M., Gibbins, C., Kay, P., Stanton, T., Xu, Y., Li, G., Feng, M., Paramor, O., Yu, X. & Zhu, Y. G. (2021). A critical review of microplastic pollution in urban freshwater environments and legislative progress in China: recommendations and insights. Critical Reviews in Environmental Science and Technology, 51(22), 2637-2680. https://doi.org/10.1080/10643389.2020.1801308

Yee, M. S. L., Hii, L. W., Looi, C. K., Lim, W. M., Wong, S. F., Kok, Y., Tan, B.K., Wong, C.Y. & Leong, C. O. (2021). Impact of microplastics and nanoplastics on human health. *Nanomaterials*, **11**(2): 496. DOI: https://doi.org/10.3390/nano11020496