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Generation patterns and consumer behavior of single-use plastic towards plastic-free university campuses

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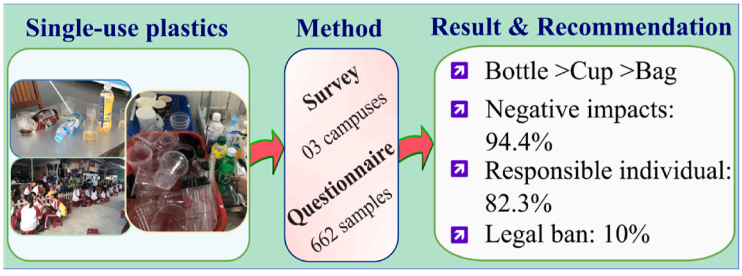
HIGHLIGHTS

- The highest consumption rate was plastic bottles, followed by plastic cups and plastic bags.
- The individual was primarily responsible for plastic (82%), then governments and businesses.
- The majority felt uneasy (66.57%) and guilty (15.13%) for plastic consumption.
- Suggestions are a ban, awareness-raising, and alternative products.

GRAPHICAL ABSTRACT



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ABSTRACT

This study was conducted to estimate the generation of single-use plastics (SUPs) and elucidate consumer behavior towards a plastic-free university. The results show that the consumption rate of plastic bottles was the highest at 1.39 g per student per day ($g.s^{-1}.d^{-1}$), followed by plastic cups (0.20 g $s^{-1}.d^{-1}$), and plastic bags (0.14 g $s^{-1}.d^{-1}$). Approximately 94.41% of students were highly aware of the negative impacts of SUPs. More than four-fifths of the students (82.32%) assumed that they were responsible for the SUP pollution issue, whereas 59.52% considered SUP reduction (or lack thereof) by individuals, governments, and producers/businesses be important factors. Approximately 19.03% of the students supported implementing a high fine, one-tenth agreed for a total ban on SUPs, while nearly one-fifth believed reducing SUP consumption was unnecessary. Strategies

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for plastic-free universities was initiated by establishing the goal of “plastic-free university” and implementing integrated actions including a ban (plastic cups and bags) awareness-raising, and suitable alternatives.

1. Introduction

Plastic is a commonly used material in the present times, but it is also a significant source of pollution, resulting in one of the most critical environmental challenges for our planet (UNEP, 2018; Khan et al., 2019; Bishop et al., 2020; Wanner, 2021). Plastic production has increased exponentially since the 1950s (Ostle et al., 2019; Schmaltz et al., 2020; Zhang et al., 2021); however, since then, approximately 77–79% of the plastic waste was disposed of landfills, dumps, or directly in the environment, and only 9% was recycled (Geyer et al., 2017; Di et al., 2021). Contaminants from the landfills (e.g., heavy metals) dumping plastic waste can be leaked and pollute the groundwater and surface water, while incineration causes toxic emissions (e.g., dioxins) (North and Halden, 2013; Verma et al., 2016). In Vietnam, approximately 0.35–0.78 million tons of plastics are released annually into the environment (WWF, 2019), and plastics constitute 16.0–23.0% of the total waste in landfills (MONRE, 2019; WWF, 2019).

The issue of plastic pollution in oceans and coastal areas is highly severe; the current rate of plastic consumption and disposal will result in catastrophic consequences on marine life and the health of the oceans (Jang et al., 2020; Van Rensburg et al., 2020; Kumar and Sheela A, 2021). Due to increased disposal but slow degradation rates, plastics have become ubiquitous and have affected marine organisms by entanglement, ingestion, suffocation, toxicity, and contamination through biomagnification (Hermabessiere et al., 2017; Law, 2017; Wagner and Schlummer, 2020; Ali et al., 2021; Pham et al., 2021). Furthermore, studies have shown that plastic waste accounted for 82% of the total waste on the beaches in South Korea (Jang et al., 2020).

Single-use plastics (SUPs) are often referred to as disposable plastics and include items intended to be used only once before being discarded or recycled. Nearly 50% of the global plastic waste generated in 2015, including SUP packaging materials, such as plastic bottles, bags, and containers (UNEP, 2018), and 50% of this global SUP waste were from Asia (Geyer et al., 2017). Out of the annual number of coffee cups ranging between 2.5 and 10 billion disposed of in the UK, none are recycled (Poortinga and Whitaker, 2018), while only 23% of the discarded plastic bottles are recycled in the U.S. (Parker, 2019). The consumption rate of plastic bags per person was 1.26 unit.d^{-1} in South Korea (Jang et al., 2020), 0.82–0.99 unit.d^{-1} in developed countries (Wagner, 2017), and 1.0–1.25 unit.d^{-1} in Vietnam (WWF, 2019). Besides the generation rate of SUPs, various users’ consumer behavior is also discussed in the research. From the online survey, Van Rensburg et al. (2020) reported that Durban beachgoers had more negative thoughts and a high willingness to reduce their consumption of SUPs. Another study on the consumption behavior of plastic bags of households found that female householders were more likely to use non-plastic bags when shopping and more educated were more likely to consume cloth bags or reusable containers (Zambrano-Monserrate and Alejandra Ruano, 2020). Furthermore, challenges and opportunities for SUP reduction in healthcare were investigated by Leissner and Ryan-Fogarty (2019). In Vietnam, SUP bags and lightweight plastic packaging materials accounted for 6% and 8% of the total waste in landfills, respectively (MONRE, 2019). In addition to the emergence of the largest market for plastic packaging materials, the rapid global shift from reusable to SUP products is highly alarming (Geyer et al., 2017; Horodytska et al., 2020; Nguyen et al., 2021).

SUPs in the form of bottles, caps, food wrappers, grocery bags, lids, straws, and stirrers account for most of the plastic waste existing in the environment (coastal, inland, *etc*.). Irresponsible behavior of individuals and poor waste management systems result in SUP waste in the environment (UNEP, 2018). To address the root cause of SUP pollution, change in the consumption and disposal habits of consumers, retailers, and manufacturers is highly important, along with comprehensive waste management practices and financial incentives for management. Furthermore, to reduce the consumption and impact of SUP on the environment, understanding the perceptions and behavior of consumers toward SUP consumption is necessary, along with estimating the generation of SUPs. However, to the best of our knowledge, no attempt has been made previously to investigate the generation patterns and consumer behavior associated with SUP wastes in universities. Various "plastic-free schools" or “plastic reduction” movements have been implemented globally, but their records in scientific literature do not exist.

This study aimed to understand the generation patterns of SUPs and the corresponding consumer behavior of university students. In addition, our attempt included recommending opinions and suitable alternatives to reduce SUP consumption towards green consumption and plastic-free universities. Qualitative and quantitative methods were adopted to analyze the SUP consumption patterns of students of three university campuses in Vietnam.

2. Conceptual background and methods

2.1. Public health impact and degradation of plastics

2.1.1. Public health impact of plastics

The specific impact of plastic wastes on human health is controversial or lacks direct evidence (Lim, 2021). In addition, studies on the health effects of plastics were mainly performed in the laboratory (Rodrigues et al., 2019). However, researchers found that several polymers and polymer additives are associated with carcinogenic potential and endocrine disruptors and may cause neurological cardiovascular, liver, and kidney problems with acute, chronic exposure (Cook and Halden, 2020). Two types of plastic particles, including microplastics and nanoplastics, can transform into human bodies through inhalation and ingestion. Not only the microplastics from plastic products but also human health risks are also numerous additives contained therein. Humans can be exposed the toxicity from the polymer matrix, degraded particles, additives, and adsorbed contaminants (Wright and Kelly, 2017; Rodrigues et al., 2019). The risks from plastic litter to human health could be the monomeric building block of polycarbonate plastics (*e.g.*, bisphenol A), additives (*e.g.*, plasticizers), or combination (*e.g.*, antimicrobial polycarbonate) (Halden, 2010). Lithner et al. (2011) categorized plastic polymer into carcinogenic, mutagenic, and toxic for reproduction.

Chronic exposure is a matter of substantial concern due to the accumulative effect of microplastics (Wright and Kelly, 2017). Almost plastics threaten human health are related to plastic products used in daily life, such as packaging, building, and construction. Packaging and bottle plastics are mainly constituted by polyethylene, polypropylene, and polyethylene terephthalate. In addition, microplastics are available in the marine environment, providing seafood for almost 3 billion people worldwide; thus, humanity can get the disease by eating this food. Moreover, the prevalence of synthetic microfibers and fragments was documented in honey and sugar, which was thought of by microplastics’ deposition on flowers and foliage (Wright and Kelly, 2017).

Two popular methods for addressing plastic waste are landfill and incineration. However, these ways own some positive aspects, such as sequestration of pollution, preventing disease transmission, low space requirement, and energy recovery. Plastic containing toxic heavy metals or other contaminants disposed of the landfills can be leaked in leachate, polluting the groundwater, soil, and surface water (North and Halden,

2013; Verma et al., 2016). While treating plastic waste by incineration causes unwanted emissions such as greenhouse gases, carcinogenic polycyclic aromatic hydrocarbons, mercury, polychlorinated biphenyls, and dioxins. Improper incineration or open field for burning plastic waste poses crucial human health risks by carcinogenic air toxins like dioxins (Halden, 2010). Besides directly inhaling poison, dioxins released from the burning of plastic waste settle down on the crops and in waterways that potentially invade food and the body. There is evidence that dioxins (e.g., 2,3,7,8 tetrachlorodibenzo-p-dioxin) enhance the risk of heart disease and aggravate respiratory ailments (Verma et al., 2016). Furthermore, ashes from plastic incineration containing heavy metals or unburnt material - categorized as hazardous waste pose potential risks to public health.

2.1.2. Plastic degradation

The degradation potential of plastic litter in the environment is a vital key for environmental management and control. Several commercial polymers used commonly - polyethylene, polyethylene terephthalate polypropylene, and polyurethane were highly resistant to biodegradation by microorganisms (Gricajeva et al., 2021; Mohanan et al., 2020). In contrast, some polymers with hydrolyzable backbones (i.e., polyethers, polyurethanes, polyesters, and polyamides) can be degraded by microorganisms in natural conditions (Harper and Petrie, 2003; Dinesh et al., 2020). In the marine environment, plastic degradation is relatively low due to solar radiation and slow thermal oxidation. In general, it takes several hundred years to completely degrade plastic litter (Lithner et al., 2011). Plastic products containing more antioxidants and stabilize - prolonging the working life can slow the natural degradation of plastic waste in the environment (Chamas et al., 2020).

Abiotic and biotic processes generally work in parallel, initiated by abiotic degradation resulting in smaller molecules and subsequently mineralized by the microorganism (Gautam et al., 2007). For the biotic process, microbial activity utilizes polymers as a carbon source. The biodegradation process of polymers is very slow in the environment. The hydrolytic cleavage and mineralization of polymers to CO_2 and H_2O occur through hydrolysis of the enzyme. In addition, the ability of fungi, bacteria, and algae was documented that can develop quickly on degradable plastics, such as lignin and cellulose (Ali et al., 2021). Two popular abiotic degradation mechanisms of plastics in the environment include physical (*i.e.,* changes in the bulk structure) and chemical (*e.g.*, cleavage or oxidation) (Chamas et al., 2020; Ali et al., 2021). Physicochemical degradation of plastics involves some processes such as photodegradation, thermal degradation, and oxidation or hydrolysis. These processes can be boosted by microbial activity, light, heat, or conjunctions (Andrady, 2011).

2.2. University campuses

Subjects for the survey were selected based on the diversity of students, disciplines, and types of universities to achieve comprehensive and holistic results. Therefore, we decided on three universities, including Duy Tan University (DTU), University of Education (UD), and University of Foreign Languages (USLF). These are sizeable schools and located in Danang city, Vietnam.

2.3. Methodology

The method applied in this work involves semi-quantitative, quantitative, and qualitative analysis, which was reported in previous studies (Creswell and Creswell, 2017; Van Rensburg et al., 2020). The survey was conducted in two phases in the school year (2020), namely: a field survey and a questionnaire. The questionnaire only focused on university students at three campuses.

The contents of the questionnaire included semi-quantitative components (questions about SUP consumption) and qualitative components (questions about knowledge, behavior, and consensus of SUP). We used pre-prepared questionnaire survey tables to fill in the information on SUP consumption patterns. The number of SUPs consumed by male and female students for all daily activities was calculated based on data from the questionnaire and weighted analysis of SUP samples. Given that, each student's mean for SUP units consumed per week was reported and called self–report results. The table consisted of five SUPs categories: hard plastic cups, soft plastic cups, plastic-paper cups, lightweight plastic bags, and plastic bottles. Plastic-paper cups were poly-coated paper cups with plastic lids, while lightweight containers/bags and packaging materials were grouped as plastic bags. Based on the pre-prepared questionnaire, we collected 712 questionnaire survey samples to create the data for analysis. After an initial inspection, survey samples with missing, conflicting, or unusual responses were eliminated; finally, 662 samples were selected for further analysis. Due to unorganized data of schooling years, two survey samples of fifth-year students were combined with survey samples of fourth-year students. The 662 samples included 32 categories of medicine, technology, finance, tourism, language, environment, oriental studies, basic sciences, psychology, social work, and education subjects. Table 1 summarizes the demographic characteristics of the students, and Fig. 1 presents the SUP items generated at the university campuses.

Field surveys were conducted at the campuses of the three university campuses. We collected data associated with SUP consumption of students by measuring SUP generation at the source - a quantitative analysis. To achieve this, we assumed that the quantity of SUP generation equals the number of SUPs purchased in canteens, coffee shops, or water vending machines on the campus, and the SUP purchased from other sources outside the campus. We counted SUP usage by units (i.e., hard plastic cups, soft plastic cups, plastic-paper cups, lightweight plastic bags, and plastic bottles) at the canteens; collected the vending machines; and counted the amount of SUP brought into the campuses. Also, used SUP items on campuses were collected to weigh for calculating consumption rate per student. 14, 3, 2, 4, 1, 5, and 4 brands of SUP bottles, hard cups, soft cups, plastic-paper cups, spoons, straws, and lightweight bags, respectively, were gathered to determine weight. Each brand type of SUPs had three different samples, which were weighed, and mean ± standard deviation was reported. Moreover, through field surveys, we collected data on qualitative observations, such as characteristics of canteens and garbage bins, waste disposal regulations, SUP consumption rates, and disposal habits of students.

2.4. Data analysis

The survey results were recorded and analyzed using MS Excel and R (Open source statistical software: https://www.r-project.org/). Descriptive statistics, including calculations of mean values, standard deviations, and percentages, were conducted. In addition, the survey results were visualized by plots and bar graphs. Moreover, the "qualitative" variable data (subgroup variable) were analyzed by the statistical software R (with the "psych" package).

Table 1
Demographic characteristics of the study participants.

Demographic factors	Categories	Sample size (n)	Percentage (%)
Gender	Male	235	35.50
	Female	427	64.50
Schooling year	1	167	25.22
	2	158	23.82
	3	233	35.16
	4	104	15.79
Campus	DTU	241	36.41
	UD	213	32.18
	UFLS	208	31.42

Fig. 1. Single-use plastic items were generated at three university campuses: hard cups (a), plastic-paper cups (b), soft cups (c), bottles (d), lightweight bags (e), and straws – spoons (f).

3. Results and discussion

3.1. Plastic generation and consumption rates

3.1.1. Survey results

The average number of SUP units used per day by each student is summarized in Table 2. The mean consumption rate of plastic bottles was the highest with 0.061 unit per student per day (unit.s^{-1}.d^{-1}), whereas the lowest consumption rate was observed for plastic-paper cups (0.006 unit.s^{-1}.d^{-1}). The consumption rate of plastic bags or lightweight plastics, including food packaging materials and plastic containers, was 0.046 unit.s^{-1}.d^{-1}. The rate of plastic bags consumption per person was in the range of 1.0–1.25 unit.d^{-1} in Vietnam (WWF, 2019), 1.26 unit.d^{-1} in South Korea (Jang et al., 2020), and 0.82–0.99 unit.d^{-1} in developed countries (USA, Japan, Australia, Ireland, and Israel) (Wagner, 2017). Significant differences in the number of consumed SUP units among the campuses were observed. Furthermore, the rate of consumption of plastic bottles in DTU (0.106 unit.s^{-1}.d^{-1}) was 10 times greater than that of USLF (0.015 unit.s^{-1}.d^{-1}) while USLF students did not use paper cups. This variation can be attributed to the canteen policy and habits of students. Similarly, the consumption rate of plastic cups in DTU accounted for the highest with 0.041, followed by UFLS of 0.014, and UD of 0.005 unit.s^{-1}.d^{-1}. On average, the consumption rate of plastic cups per student of three schools of 0.02 unit.s^{-1}.d^{-1} was lower than that of the residents in South Korea, with a mean of 0.18 unit.s^{-1}.d^{-1} (Jang et al., 2020).

Owing to the recycling value and the difference in collection price, we split the plastic cups into soft and hard plastic cups. The hard plastic cups are usually low-priced at local collection centers; thus, they are less frequently collected and directly released into the environment. The mean rate of soft/hard plastic cup consumption based on SUP units was 16.52%, 65.79%, and 66.67% for DTU, UFLS, and UD, respectively. The collection rates of plastic bottles, soft plastic cups, and other SUP items (hard plastic cups, plastic-paper cups, plastic bags, straws, spoons, and plates) were 98%, 90%, and 0%, respectively. A low collection rate was observed for other SUP items because plastic waste buying centers were not purchased at a low price.

The percentage of students of each campus using SUPs is shown in Table 3. The campus of UD had the highest rate of students consuming SUPs (28.59%), which was followed by the DTU (17.89%) and the UFLS (9.63%). The high consumption rate of UD students may be due to some students staying in the campus dormitory who use SUPs from the campus canteen. Comparison of the SUPs consumed inside and outside the campuses indicated that many SUPs were brought from outside the campuses (Table 3). Approximately 64.40% of students brought SUPs outside the UFLS campus, whereas the percentage of students who brought SUPs from outside the DTU and UD campuses was 24.18% and 40.66%, respectively. On average, 56.92% of students used SUPs and generated plastic waste on the campuses, while the remaining used SUPs outside. Thus, solutions for reducing SUP generation need to be focused on the campus canteens and outside the campuses.

To quantify the number of SUPs consumed, we calculated the weight of each unit and the mean SUP generation by each student (Table 4). The

Table 2
Mean consumption rate of different SUP units consumed per student.

University	Plastic cups (unit)	Plastic-paper cups (unit)	Plastic bottle (unit)	Plastic bags (unit)
DTU	0.041	0.009	0.106	0.042
UFLS	0.014	0.000	0.015	0.030
UD	0.005	0.009	0.061	0.065
Mean[a]	0.020 ± 0.019	0.006 ± 0.005	0.061 ± 0.045	0.046 ± 0.018

[a] Average ± standard deviation.

Table 3
Comparison of percentage of students using SUPs inside and outside the campus.

University	Students using SUPs (%)	Students consuming SUPs inside the campus (%)	Students bringing and consuming SUPs outside the campus (%)
DTU	17.89	75.82	24.18
UFLS	9.63	35.61	64.39
UD	28.59	59.34	40.66

Table 4
Mean weight of each SUP unit and mean SUP generation per student per day.

Type	Plastic cups (n[a] = 15)	Plastic-paper cups[b] (=12)	Plastic bottles (n = 42)	Plastic bags (n = 12)	Plastic spoons (n = 3)	Plastic straws (n = 15)	Total (n = 99)
Mean weight of SUP (g.unit^{-1})	10.00 ± 6.66	2.05 ± 2.99	22.96 ± 3.02	3.15 ± 1.03	1.93 ± 0.06	0.99 ± 0.78	
Mean SUP consumption rate (g. s^{-1}.d^{-1})	0.200	0.013	1.391	0.144	0.002	0.026	1.775

[a] n = number of SUP samples.
[b] Plastic-paper cups: weight of plastic lids was 19.7% of total weight of cups with lids.

results indicated that plastic bottles were the heaviest, with an average weight of 22.96 g.unit^{-1}, which was twice the weight of infant formula bottles as reported by Leissner and Ryan-Fogarty (2019). The weight of plastic-paper cups, plastic bags, and plastic spoons ranged from 1.93 to 3.15 g.unit^{-1}, whereas plastic straws weighed the least (0.99 g.unit^{-1}). For paper cups with plastic lids, only the lids constituted 19.7% of the total weight of the cups. The number of straws was equal to the number of total cups (plastic and paper cups). Plastic bottles were the most consumed SUP item by students (1.391 g per student per day: g.s^{-1}.d^{-1}), which was followed by plastic cups (0.2 g s^{-1}.d^{-1}) and plastic bags (0.144 g s^{-1}.d^{-1}). Other SUPs, including plastic straws, spoons, and plastic-paper cups contributed to low consumption rates.

Overall, the average SUPs consumed by each student in all the universities was 1.775 g s^{-1}.d^{-1}. A survey in Can Tho City of Vietnam, Thanh et al. (2011) found that the average generation rate of household plastic waste per capita per day was 17.24 g, which was equivalent to 6.15% of the total domestic waste, and approximately 95.64% of the plastic waste included plastic packaging materials and containers. China's residential area accounted for 7.02 g of plastic waste per capita per day (Qu et al., 2009), and plastic generation in the Vietnamese household was 112.33 g per capita per day (2015) (MONRE, 2019). In South Korea, the SUPs per capita per day was 32.33 g, calculated based on four items, including PET (polyethylene terephthalate) drinking bottles, cups, bags, and containers of cutlery from packaged food delivery (Jang et al., 2020).

Fig. 2 represents the percentage of SUP consumed by students in terms of unit (a) and weight (b). The mass percentage of plastic bottles used was the highest and ranged between 61.06 and 81.11% (Fig. 2-b); meanwhile, that calculated by the number of SUP units varied with the highest consumption at the DTU (52.52%), followed by the UD (42.6%) and the UFLS (26.83%) (Fig. 2-a). The percentage consumption by units of plastic bags ranged between 21.21% and 53.66%, while that calculated by weight was low and ranged between 4.3% and 11.88%. Consumption of plastic spoons and plastic-paper cups was infrequent in the studied universities, with an overall highest percentage of 6.5%. Thus, plastic bottles, cups, and bags accounted for the highest consumption, and solutions need to be majorly oriented toward management and reduction of these SUP items.

3.1.2. *Self-report results*

In addition to the SUP consumption rates of students in the universities, we investigated the differences in the quantity of SUP used for all daily activities of male and female students, and corresponding results have been presented in Table 5 and Fig. 3. The consumption of plastic bottles and plates differed significantly between males and females ($P < 0.05$) (Table 5). Plastic plates consumed by females of 0.47 unit per student per week (unit.s^{-1}.w^{-1}) were greater than that consumed by males (0.22 unit.s^{-1}.w^{-1}), while consumption of plastic bottles by males (4.51 unit.s^{-1}.w^{-1}) was greater than that of females (3.57 unit.s^{-1}.w^{-1}).

The mean number of plastic bottles consumed by students was 3.91 unit.s^{-1}.w^{-1} and 0.56 unit.s^{-1}.d^{-1} (Fig. 3). This consumption pattern was lower than Vietnamese urban residents, who used approximately 0.75 bottles per day (WWF, 2019). Plastic plates were the least utilized (0.38 unit.s^{-1}.w^{-1}), while the consumption of cups (plastic and plastic-paper) ranged between 2.63 and 2.79 unit.s^{-1}.w^{-1}. The self-report results for SUP consumption were 9.16, 18.79, and 66.43 times higher than that of survey results at the campuses for plastic bottles, cups, and plates, respectively. The differences between survey and self-report results may be related to the temporal variations of the presence of students in the universities. In general, the mean SUP consumption of students was 17.76 g s^{-1}.d^{-1}, which was approximately ten times higher than that in university campuses (1.78 g s^{-1}.d^{-1}).

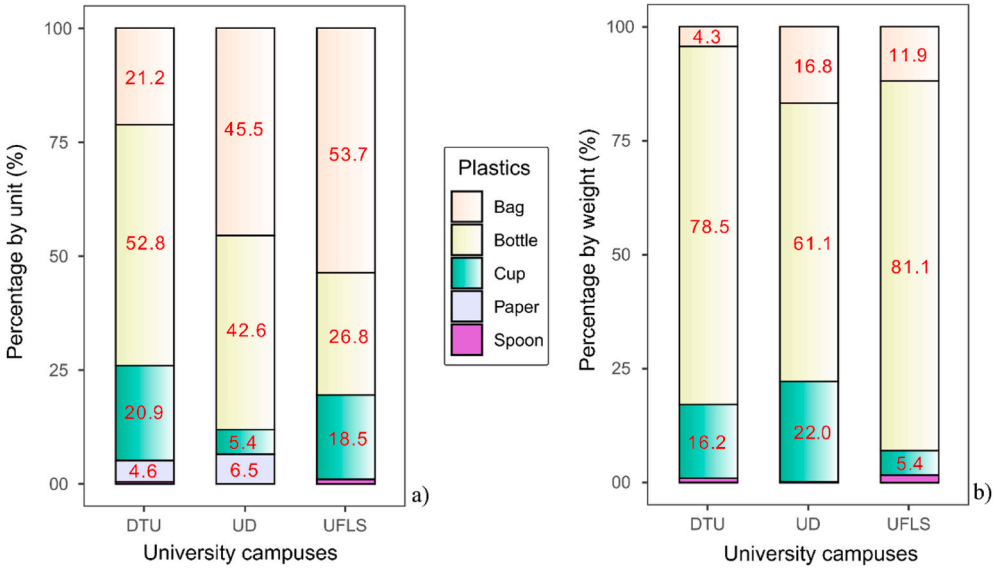

Fig. 2. Percentage of the single-use plastics consumed by students calculated by unit (a) and weight (b).

Table 5
The average number of SUP units consumed per week by male and female students.

	Plastic cups	P[a]	Plastic plates	P	Plastic bottles	P	Plastic-paper cups	P
Female (n = 505)	2.65 ± 3.20	*0.83*	0.47 ± 0.97	*2.90-e4*	3.57 ± 3.89	*2.5-e3*	3.03 ± 4.11	*0.04*
Male (n = 280)	2.60 ± 3.06		0.22 ± 0.73		4.51 ± 3.78		2.36 ± 3.87	

[a] P is the value of statistical tests that accepts or rejects assumptions (null hypothesis): $P < 0.05$, indicating that there is a significant difference between groups (i.e., male and female) and vice versa.

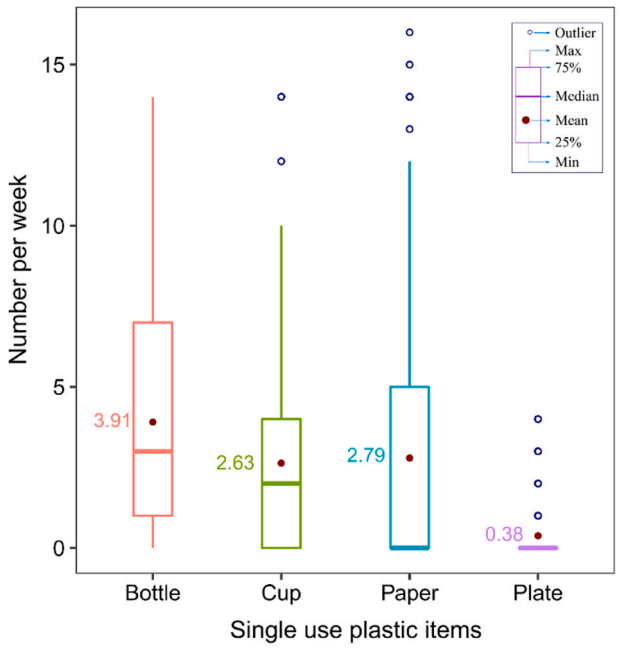

Fig. 3. Mean of single-use plastic units consumed per week by each student.

3.2. Consumption behavior of students

3.2.1. Awareness on impacts of SUPs and responsibility

To understand the level of knowledge or awareness regarding SUPs and impacts, whether considered plastic as an environmental menace, students were asked, "What are the impacts of single-use plastics on the environment and ocean?". The responses to that question are presented in Fig. 4. They were required to answer from four options, including "Pollution" (causing pollution to the environment and ocean), "Normal" (affecting the environment and ocean typically), "Not at all" (Not affecting the environment and ocean), and "Other" (specifying any other opinions). The majority of the students had a good understanding of the impact of SUP on the environment and oceans as the answers for "Pollution" accounted for 94.41% (Fig. 4). Previous investigations reported similar results. Dilkes-Hoffman et al. (2019) concluded that more than 70% of the respondents agreed that plastic caused severe environmental issues, such as marine pollution, biodiversity loss, waste disposal problems, and air and water pollution. Van Rensburg et al. (2020) and Charlebois et al. (2019) reported that 90% of the Durban beachgoers (in South Africa) and 87.20% of Canadian consumers considered that SUPs harmed the environment. A study on the awareness of German consumers about plastic packaging materials also confirmed that the majority of the consumers were aware that plastic packaging materials contribute to serious environmental issues (Rhein and Schmid, 2020). Multiple studies summarized that people who lack environmental knowledge are more likely not to adopt sustainable practices (Haron et al., 2005; Van Rensburg et al., 2020). Thus, awareness about plastic and its negative implications on the environment is essential to practice the green consumption of SUPs in universities. The negative response of "Not at all" accounted for only 0.76%, which was given by five respondents. The option of "Normal," which conveyed a neutral impact of SUP on the environment and ocean, accounted for 4.53% (30 respondents, 19 males, and 11 females). Students who selected the option "Other" gave multiple opinions, such as "terrible effect if SUP items are thrown indiscriminately and wasted," "Depending on how to use," and "Both beneficial and harmful."

In addition, differences in opinions were observed among males and females, whereas the views were similar among the different schooling years. Females more likely chose "Pollution" (97.19%) than males (94.22%); furthermore, four males opined as "Not at all" as opposed to

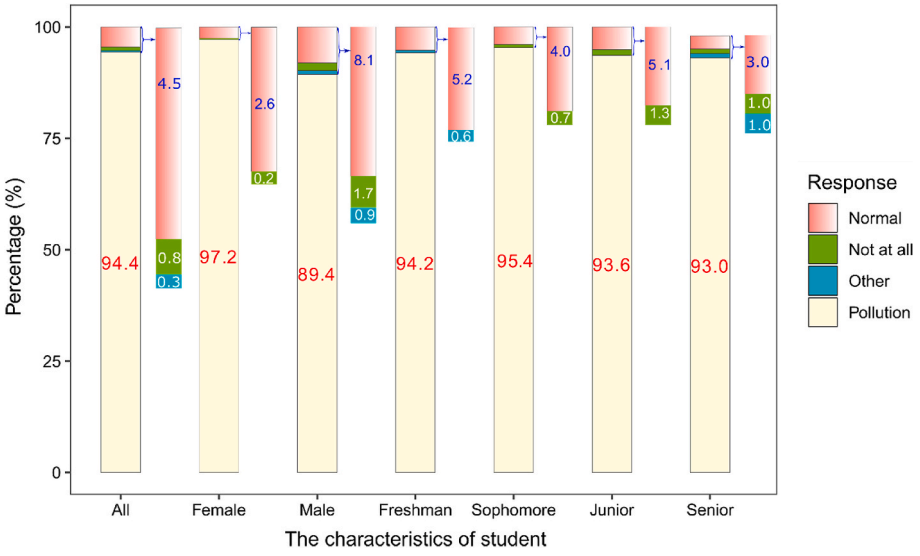

Fig. 4. Results of the answers to the question, "What are the impacts of single-use plastics on the environment and ocean?". Smaller bars are exaggerations of hidden places of main bar plots.

only one female having that opinion. The proportion of females (53.40%), who considered plastic a severe environmental issue, was higher than the proportion of males (45.40%). Similar observations were presented by Dilkes-Hoffman et al. (2019). Thus, the high rating of "Pollution" indicates that most of the students were well aware that SUPs are serious pollutants for the environment and oceans.

To understand students' opinions on the responsibility for addressing the SUP environmental issue, we designed the question, "Who is responsible to fix the problem of SUP"; the results are summarized in Table 6. The respondents could select multiple answers to this question; thus, results were adjusted by combining relevant answers into particular groups; for example, "*Individual*"-"*Producer*" and "*Individual*" became "*Individual-related all*" (it was shortened as "*Individual*"). The proportion of students selecting "*Individual"* to "*individual-related all"* was 52.66%, "*Government"* to "*Government-related all"* was 18.32%, "*Manager"* to "*Manager-related all"* was 40.31%, and "*Industry"* to "*Industry-related all"* was 11.99%. Among the students, 61.07% opted for multiple options, and the average number of choices per respondent was 1.26.

Therefore, most of the students (82.32%) held "*Individual*" responsible for the SUP issue, indicating a good level of awareness among students. These findings differed from Dilkes-Hoffman et al. (2019), which stated that 64% of the respondents opined that industry/producers had the highest level of responsibility, which was followed by *individuals* and *government*. The second-highest choice was that "*Government*" is amenable to address the SUP issue. Australians also believed that the government is responsible for managing SUPs through legislation (Dilkes-Hoffman et al., 2019). Females may be more actively aware than males based on their opinions of responsibility. The proportion of females (82.44%), selecting "*Individual*" was higher than males (79.57%), whereas a lower proportion of females (32.32%) established "*Government*", while 45.53% males responded "*Government.*"

The ratings for university managers and SUP producers as responsible for the SUP issues were 19.50% and 26.43%, respectively. A survey in England revealed that two-thirds of the respondents thought producers should be legally mandated to produce eco-friendly plastic packaging materials (YouGov, 2019). In addition, a small percentage of students (0.91%) chose all the answer options while 7.55% of the students had other comments, such as "*Everyone has a share of responsibility*, " "*Business of food and drink*," "*All agencies - departments – branches*," "*Environmental company*", etc.

3.2.2. Opinions on the consumption and solutions to fix the SUP issue

Students' perceptions on the use of SUPs were examined through the question, "How do you feel about consuming SUP?" The results of individual perceptions regarding SUP consumption are shown in Fig. 5. The majority of the students (average 66.57%) felt uneasy about consuming SUPs, with marginal differences in opinions among genders and schooling years. A small proportion of students (average 15.13%) were guilty of using SUPs, while 13.3% felt normal or did not feel guilty or uneasy. These rates are lower than the survey results by YouGov, which stated that 46% of Britons felt guilty about their plastic consumption rates (YouGov, 2019). Females and sophomore students felt more guilty than others (Fig. 5). Females (83.24%) felt more guilty and uneasy as compared with males (79.16%), suggesting that women were more likely to actively seek non-plastic packaging materials than men (Charlebois et al., 2019).

In addition to the knowledge and awareness that explains the SUP generation patterns and shows the willingness to reduce SUP actively, the opinion and consensus of individuals on solutions to fix the SUP issues are critical for implementing green consumption. To understand the views of students regarding SUP reduction, we asked the question, "What solutions do you think can be implemented to fix the issue of single-use plastics?"; the subsequent results are presented in Table 7. The students could choose multiple answers to this question; thus, the results were adjusted by combining the relevant answers into particular groups. For example, "*Ban*"-"*Reduction"* and *"Ban*" became "*Ban-related all"* (it was abbreviated as "*Ban*"), "High fee"-"*Right place*", "*High* fee" became overall (it was shortened as "High fee"), *etc*. Among the total students, 36.73% selected multiple choices, and 3.26% selected "*Other*"; furthermore, the average number of options per student was 1.25. The correlation between the ratings of "*Ban*" and "*Ban-related all*" was 86.69%, "*High* fee" and "*High* fee-*related all*" was 38.86%, "*Reduction"* and "*Reduction-related all*" was 67.79%, "*No action*" and "*No action-related all*" was 92.34%, "*Right place*" and "*Right place-related all*" was 57.99%, and "*Other*" and "*Other-related all*" was 48.16%. Other comments on solutions for addressing the SUP issue were "*Creating non-plastic alternative products*," "*Propaganda*," "*Bring it back to reuse*," "*Bring the utensils yourself - glass iron and then wash*," "*Recycling*," "*Replace plastic cups by paper cups*," *etc*.

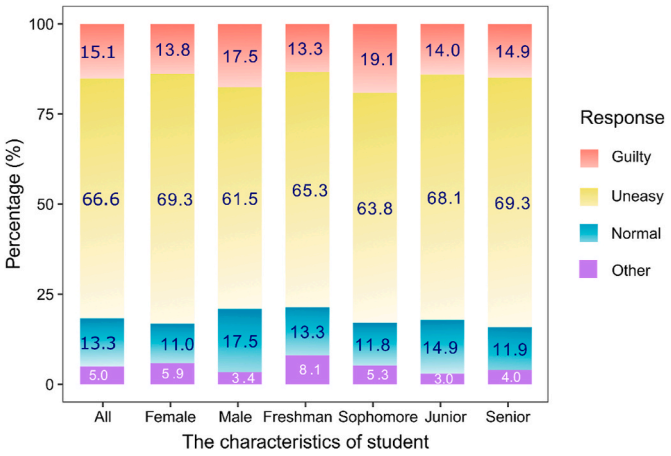

Fig. 5. Results of the answers to the question, "How do you feel about consuming single-use plastics?"

A high proportion of students (59.52%) agreed that they should practice SUP reduction individually. Differences in this opinion were observed among males (46.82%) and females (66.55%), but no differences were observed among schooling years (Table 7). A survey in Great Britain reported that 82% of Britons were actively trying to reduce the quantity of SUP waste they discarded (YouGov, 2019). Females may have a higher awareness of SUP reduction than males, which was verified through the above findings for individual perceptions and the previous survey (Charlebois et al., 2019). The response rate for implementing a high fee for SUP products as a solution to reduce SUP was 19.03%. This rating was slightly lower than 23.2% in a study reported by Charlebois et al. (2019), which stated that respondents would agree to pay a fee for SUP food packaging materials. However, the result was higher than the ratings in favour of fees for plastic bottles (15%) in the study by Bartolotta and Hardy (2018). A considerable proportion of the students (30.22%) thought that discarding the waste in the right

Table 6
Combined results of responsibility to fix the single-use plastic issue.

(%)	Correction	All	Individual	Government	Manager	Producer	Other
All		0.91	82.32	37.93	19.50	26.43	7.55
Gender	Female	1.17	82.44	32.32	19.67	24.59	8.90
	Male	0.43	79.57	45.53	19.15	29.79	5.11

Table 7
Results of proposed solutions to fix the single-use plastic issue.

(%)		Ban	High fee	Individual reduction	Right place	No action	Other
All		10.22	19.03	59.52	30.22	1.96	4.07
Gender	Female	8.93	14.5	66.55	22.00	2.34	4.24
	Male	12.35	27.21	46.82	45.12	1.28	3.83

place is the optimal way to fix the SUP problem, while 10.22% selected a legal ban as a solution to reduce SUPs. The number of students who selected the option of "R*ight place"* accounted for 30.22%. The proportion of males who decided "*Right place*" and "*Ban*" was higher than females. Only 1.96% of the students believed that it was not necessary to reduce SUP. The findings of this work also indicate that the differences among schooling years for choices were not significant.

Banning SUPs was the most preferred solution with high consensus from the public to reduce SUP consumption in many areas (Amenábar Cristi et al., 2020). The current rating of this opinion (10.22%) was lower than that in previous reports. Approximately 71.20% of the students supported a ban on all SUPs used for food packaging (Charlebois et al., 2019), while 61% of residents agreed on a ban on plastic bags with thickness exceeding 50 μm (Luís et al., 2020). In addition, 43% of Durban beachgoers considered that a ban was the most effective way to reduce plastic bag consumption and waste (Amenábar Cristi et al., 2020).

4. Summary and recommendations for plastic reduction

The findings of this study - to support the recommendations toward green consumption and plastic reduction, can be summarized as follows:

(1) Consumption rate of plastic bottles by students was the highest (0.061 unit.s^{-1}.d^{-1} and 1.391 g s^{-1}.d^{-1}), which was followed by that of plastic cups (0.2 g s^{-1}.d^{-1}) and plastic bags (0.144 g s^{-1}.d^{-1}). The collection rate for recycling hard plastic cups (accounting for half of the total plastic cups), plastic-paper cups, plastic bags, straws, spoons, and plates was zero. In contrast, the majority of the soft plastic cups and bottles (~98%) were collected for recycling. A large proportion of students (40.08%) brought SUPs outside into the university campuses, and different SUP consumption rates among university campuses were observed.

(2) The survey results revealed that most of the students (94.41%) had relatively high awareness about the negative impacts of SUPs on the environment and oceans. Attention toward the responsibility to fix the SUP issue was also positive; the majority of the students (82.32%) considered it their duty to address the SUP issue, while 59.52% believed that individuals and governments must make efforts and producers/businesses to reduce SUPs. A small proportion of students (19.50%) thought that university managers were also responsible for the SUP issue on university campuses. Females may be more actively aware than males toward SUP consumption, reduction, and responsibility.

(3) For individual perceptions toward SUP consumption, the majority of students felt uneasy (66.57%) and guilty (15.13%) concerning SUP consumption, indicating considerable potential for reducing SUP consumption if moral consciousness is rekindled among users. In addition, a large number of students supported the implementation of high fees for SUP products as a solution to reduce SUPs (19.03%), and one-tenth of the students agreed on a legal ban. However, nearly one-fifth of the students felt that reducing SUPs was unnecessary and that only discarding SUP wastes in the correct location was essential.

The following recommendations have been suggested based on the findings of this survey and results from previous studies. Based on the high awareness of students, two potential ways to minimise SUP consumption are the implementation of solutions that encourage each individual to reduce SUPs and the implementation of legal regulations as they have a high probability of success.

Based on the actual perceptions of students, increasing awareness to encourage consumers to reduce SUPs at the individual level may be feasible, as mentioned in the previous literature (Van Rensburg et al., 2020; Zambrano-Monserrate and Alejandra Ruano, 2020). However, we estimated that a small structured organization, as a university, can quickly launch a robust solution. Therefore, we support a complete ban on plastic cups and plastic bags. Although students suggested a combined solution of a ban and a high fee, previous studies (Bartolotta and Hardy, 2018; Schnurr et al., 2018; Amenábar Cristi et al., 2020) concluded that practical application of this solution at the university level is not possible to lack of enforcement and affordable alternatives. Thus, a complete plastic ban in universities needs to be supported by finance so that stakeholders can arrange affordable options, such as reusable cups (glass or plastic) or reusable containers. Since 2011, an international framework to reduce marine plastic pollution (the Honolulu Strategy) imposed outright bans on various SUPs (Schnurr et al., 2018); subsequently, more than 60 countries have legally issued SUP bans. Approximately 30% of the nations reported remarkable drops in consumption of SUP bags within the first year of the implementation of their ban (UNEP, 2018). In Vietnam, a movement of plastic-free schools launched recently. A few primary schools in Hoi An city, Quang Nam province, performed successfully with a robust reduction of 90% plastic waste. These cases of implementation of a SUP ban are promising for launching a ban on plastic cups and lightweight plastic bags in the universities.

A ban on SUP cups and bags needs to be linked with a strategy to incentivize the use of reusable cups. These may be implemented simultaneously during or before the ban is launched; providing an alternative is also essential. Promoting reusable cups as alternatives to plastic cups is a sustainable reduction strategy, which has been announced as the "green" choice of consumers (UNEP, 2018). Another study indicated that incentivizing consumers to change their behavioural needs is important before or during the ban's implementation, ensuring that the consumers readily adopt the ban (Schnurr et al., 2018). Furthermore, a lack of awareness regarding suitable alternatives that can replace disposable SUPs may increase the consumption rate of disposable SUPs. In addition, a combination of environmental awareness and the provision of suitable alternatives promoted behavioural changes, and the consumption of reusable cups increased by 33.7% (Poortinga and Whitaker, 2018).

Universities need to encourage students to use reusable cups, such as multiple-use stainless steel cups, hard plastic cups, and glass cups. In addition, glass and hard plastic cups serve as alternatives in canteens and cafeterias for consumers, while other reusable containers or cups as an individual choice. A recent study demonstrated that multiple-use stainless steel cups are the best environment-friendly alternatives among all the options available (Changwichan and Gheewala, 2020). Students who consumed beverages in glass cups served at the site would be incentivized to prepare multiple-use beverage containers individually.

Among all the SUP reduction strategies reported, raising awareness or providing education is a primary approach (Wagner, 2017). UNEP (2018) declared that adequate social attention is necessary for plastic reduction strategies to succeed. This is an effective way to change

consumer behaviour and can be implemented by an awareness campaign or similar integrated actions. Awareness campaigns are more likely to fail if they are implemented alone. Eagle et al. (2016) remarked that strategies should incorporate other broader strategic programs, integrating de-marketing and social marketing approaches. Awareness should be created through written messages, social awareness, and visible prompts to remind consumers and focus on the negative aspects of SUP bags. The implementation and success of an awareness-raising strategy will serve as a foundation for launching a promising premise toward green consumption initiatives, such as a plastic-free university.

Plastic-free universities should be considered an irrevocable goal for universities in light of global environmental and ocean pollution due to plastic waste. These are because highly educated subjects are primarily accountable to the throwaway culture; thus, we need to recognize the importance of ethical and ecological policies. This issue was evident in our survey results, which indicated that the majority of the students were highly aware of SUP consumption and the negative implications of SUPs on marine ecosystems. In addition, multiple previous studies concluded that highly educated citizens tend to have increased environmental knowledge and are positively aware of plastic waste or have a higher probability of using reusable products (Schnurr et al., 2018; Zambrano-Monserrate and Alejandra Ruano, 2020). Ambitious movements ("Plastic free schools", "Plastic-free Campuses" or "Say no plastics in school") have been launched globally in different schools, such as Hoi An's primary schools (BoredTeachers, 2020) and universities (BUFDG, 2019).

In summary, a strategy for plastic-free universities can be initiated by establishing a "plastic-free university" goal with complete commitment. It can follow by integrating actions, including banning plastic cups and bags, creating awareness about SUPs and their negative impacts on the environment, and incentivizing reusable products while providing alternatives. The final step in achieving the goal of plastic-free universities is to significantly reduce the amount or eliminate the use of plastic bottles, depending on specific university conditions.

5. Conclusion

This study clarified the situation of SUP generation patterns and consumer behaviour of university students - being the basis for suggesting solutions to reduce green consumption and towards plastic-free universities. The results show that plastic bottle consumed by students was largest with 1.39 g $s^{-1}.d^{-1}$ followed by cup with 0.20 g $s^{-1}.d^{-1}$, and bag with 0.144 g $s^{-1}.d^{-1}$. Almost students had a high awareness of the impact caused by SUP (94.41%). More than four-fifths of students (82.32%) thought they were responsible for SUP issues and reduced individually SUP (59.52%), followed by government and producer/business. Students believed that school managers were also responsible for the SUP problem (19.50%), and the majority felt uneasy to guilty by consuming SUP (66.57% uneasy and 15.13% guilty). About 19.03% of students supported a high fee, and one-tenth agreed on a legal ban, while nearly one-fifth thought there was no need to reduce SUP - just put SUP waste in the right place.

Credit roles

X. C. Nguyen: Conceptualization, Writing - original draft. D. C. Dao: Data curation, Formal analysis, Writing - review & editing. Nguyen T. Tinh: Investigation, Formal analysis. Q. Ba Tran: Methodology, Writing - review & editing. T. T. H. Nguyen: Data curation, Formal analysis. Tran A. Tuan: Methodology, Writing - review & editing. K. L. Phuong Nguyen: Writing - review & editing. V. T. Nguyen: Writing - review & editing. A. Kumar N.: Writing - review & editing. T. N. Nguyen: Writing - review & editing. W.J. Chung: Writing - review & editing. S.W. Chang: Funding acquisition. D. D. Nguyen: Conceptualization, Supervision Methodology, Writing - review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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