Pattern of The Use and Disposal of Plastic Products in A Typical Village Community in Kerala State, India: A Case Study

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ABSTRACT The 'white pollution' caused by littering plastic waste is becoming severe environmental hazard in India by every passing day. However, not many systematic studies have been reported on the quantification of plastic waste. This gap is addressed in a small way in the current study by investigating the pattern and quantity of use as well as the mode of disposal of plastic waste in a small village community in central Kerala. The quantity of plastic waste thrown around by the entire cross section of the society, irrespective of income or education is alarming. The numbers will be frightening when extrapolated to the entire nation of around 1.30 billion people.

Introduction

Plastic and plastic materials are beneficial to mankind in a variety of ways. Plastic combines the advantages of lightness, strength, toughness, resistance to corrosion, durability, excellent thermal and electrical insulation properties etc. Plastic products are also convenient, water proof, less expensive, odorless and can be made in different exquisite shapes and colors. The versatility of plastic has made it an integral part of many kinds of industries which include packaging, construction, electronics, aeronautics etc. [1-3]. Modern life has become almost unimaginable without the use of plastic in one form or other. However the downside of the extensive use of plastic products in day to day life is the accumulation of non-degradable plastic waste in the environment, partially due to the absence of any economically viable, environment- friendly product of comparable advantages and partially due to laxity in the search for alternative products and processes.

Plastic waste is a severe health hazard as it can contaminate the earth in different ways. Unscientific burying of plastic clogs up the land making it unfit for cultivation or for any other productive utility. They also become water collectors and the breeding grounds for mosquitoes and other harmful insects. Plastic carry-bags find their way into water and can cause severe danger to marine organisms, in particular the fish wealth. Burning of plastic without proper precautions will liberate dioxins and other toxic chemicals which are very harmful to all living organisms. Hence it is very essential to dispose of plastic waste in a safe scientific manner to prevent environmental hazards.

Recycling and reuse of plastics is gaining importance as a sustainable method for plastic waste reduction/disposal. This will reduce the use of virgin materials and save related energy that should have been otherwise used for the production and disposal of plastic. Consequently the carbon dioxide emission also will be reduced. **When plastic products are used or disposed of unscientifically or left in the environment as litter, they can accumulate and cause various direct and indirect hazards and/or slowly break down and release harmful chemicals.** These break-down products include toxic chemicals such as benzene, dioxins and other pollutants which get dispersed in the entire environment of air, water and land [3,4]. Burn-

ing of plastic in the open or in improperly designed incinerators also releases toxic chemicals and heavy metal residues. Eventually they end up in air, water, soil and even in ground water. These toxic gases and residues lead to environmental hazards as well as health effects in humans and other organisms.

Some of the widely used plastic materials, their general properties and applications are listed in Table 1.

The approximate quantity of plastics used over the years in various sectors of application is given in Table 2.

Table 1. Commonly used Plastics

Identification Code	Type of plastic polymer	Properties	Common Packaging Applications
01 PET	Polyethylene terephthalate(PET, PETE)	Clarity, strength, toughness, barrier to gas and moisture.	Soft drink, water and salad dressing bottles; peanut butter and jam jars; small customer electronics.
02 PE-HD	High-density polyethylene(HDPE)	Stiffness, strength, toughness, resistance to moisture, permeability to gas.	Water pipes, hula hoop rings, milk, juice and water bottles; grocery bags, some shampoo/toiletry bottles.
03 PVC	Polyvinyl chloride(PVC)	Versatility, ease of blending, strength, toughness.	Blister packaging for non-food items; cling films for non-food use. May be used for food packaging with the addition of the plasticisers needed to make natively rigid PVC flexible. Non-packaging uses are electrical cable insulation; rigid piping; vinyl records.
04 PE-LD	Low-density polyethylene (LDPE)	Ease of processing, strength, toughness, flexibility, ease of sealing, barrier to moisture.	Frozen food bags; squeezable bottles, e.g. honey, mustard; cling films; flexible container lids.
05 PP	Polypropylene (PP)	Strength, toughness, resistance to heat, chemicals, grease and oil, versatile, barrier to moisture.	Reusable microwaveable ware; kitchenware; yogurt containers; margarine tubs; microwaveable disposable take-away containers; disposable cups; soft drink bottle caps; plates.
06 PS	Polystyrene (PS)	Versatility, clarity, easily formed	Egg cartons; packing peanuts; disposable cups, plates, trays and cutlery; disposable take-away containers.
07 O	Other (often polycarbonate)	Dependent on polymers or combination of polymers	Beverage bottles; baby milk bottles. Non-packaging uses for polycarbonate: compact discs; "unbreakable" glazing; electronic apparatus housings; lenses including sunglasses, prescription glasses, automotive headlamps, riot shields, instrument panels.

Table 2. Approximate quantity of different types of plastics used over the years (in '000 tons)

Year	Adv. composites	Speciality	Engineering	Commodity
1979	1	60	950	8,000
1989	30	100	3,000	80,000
2000	90	300	6,500	90,000
2010	300	600	20,000	200,000
2020*	700	1000	40,000	700,000

*Estimated figures

The consumption pattern of plastics in various sectors of the economy in India is shown in the chart in Fig. 1.
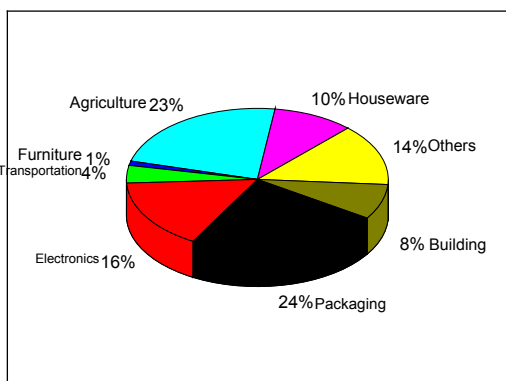

Fig.1. Plastic consumption pattern (India)

Being one of the fastest growing economies in the world, the production and consumption of plastic is growing very fast in India. Hence it is imperative that integrated measures are adopted to minimize the environmental hazards of plastics. These include, but are not limited to, minimization in the use of plastics and plastic products, recycling, reuse and safe disposal, education of the public on the hazards of plastics and the need for protecting the environment from plastics etc. In this context, investigations are in progress in many laboratories on the application of advanced oxidation processes (AOP) such as photolysis and photocatalysis for the safe disposal of plastics [5-8]. Semiconductor mediated photocatalysis has been identified as a potential technology for the safe irreversible disposal polyethylene and polystyrene plastics using water as the reaction medium [6,7]. Further studies on the application of other AOPs and combination processes are in progress in our laboratory. As a precursor to these investigations, a survey has been conducted on the quantity and pattern of plastic use in a typical residential village in the southern state of Kerala, India. The results indicate unambiguously that the quantity of plastic waste generated from even an ordinary household is much more than what was generally believed and if corrective measures are not taken expeditiously, the consequences will be disastrous.

The sample size is kept small but sufficiently representative for precise personal collection and analysis of data. The data together with the analytical deductions is expected to be an eye-opener and useful in identifying appropriate disposal methods for domestic plastic wastes in regions with comparable households across the region.

2. Methodology
The survey and data collection were conducted for a continuous period of four months from 1 October 2014 to 31

January 2015. All sample households were located in and around of Kadukutty, a village in Mukundapuram Taluk of Thrissur district, Kerala state. The sample households were so chosen as to bring diversity in terms of the number of family members, education level, economic affluence, age of members, etc. Only exclusive residential homes were considered here. Commercial establishments, shops, offices, educational institutions etc. which also generate substantial quantity of plastic waste were excluded. The sample size was eleven (11) households. The actual quantity of plastic waste generated in each of the households is computed individually by physical inspection. The researchers were personally monitoring the collection of plastics and precisely calculating the quantities.

Before the actual study began, the family members were made aware of the objectives and were encouraged to ask any questions on it. They had the option to remain anonymous if they so desired and to opt out of the survey at any time. Before actually starting the collection of data, minimum of three visits were made to each household to build confidence and rapport among the members and reassure them. Every household was provided with large plastic containers with lids (Fig. 2) and large thick black plastic bags (Fig. 3) for collection of the waste.

Fig. 2. 'Plastic waste' collection containers with lids given to the sample households

Fig.3. Monthly collection of waste plastics wrapped in thick plastic bags.

The plastic bags can be fully opened and conveniently inserted in the containers with lids. The households were asked to deposit each and every item of their plastic waste irrespective of the size, thickness, weight, shape or any other parameters in the bags. It was always a responsible female member of the family who was assigned the task. On the first day of every month, the accumulated plastic wastes from the previous month were picked up personally for detailed characterization. Initially the total weight was noted. The contents of each container were then sorted into different category as casual carry bags, grocery bags, milk covers, diaper shield, chocolate wrapper, hard plastic, bottles, pipe strips etc. The weight of each category is also noted separately.

3. Results and Discussion
3.1. Quantity of plastic wastes generated
The total quantity of plastic wastes generated from the eleven households together in four months during the study period (October 2014-January 2015) is given in Fig. 4.

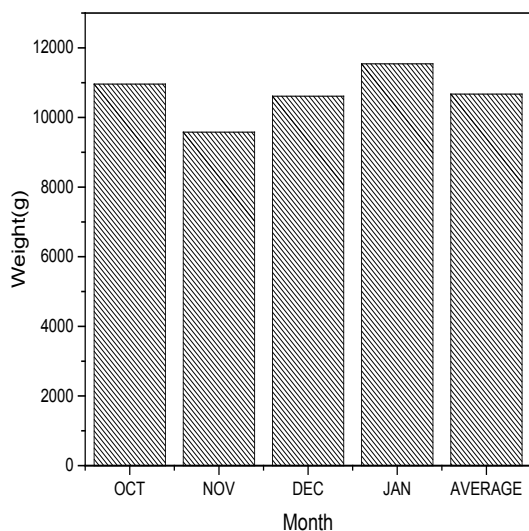Fig.5A. Typical assorted 'carry bags' in the plastic waste

Fig.4. Total quantity of plastic waste generated from all sample households during the study period (2014-15)

As the figure shows, the total monthly generation of all types of plastic waste from the eleven households together is ~ 10kg. The average quantity is ~ 900-1000g/household/month. This implies that unless properly treated, an average of 11 kg/year of plastic waste will be dumped into the environment from every household. One can imagine the gravity of the problem in a densely populated state like Kerala. Even simple extrapolation of the data to the national level will give an indication of the potential for environmental disaster in a country with ~ 1.3 billion people.

3.2. Types of common plastic wastes
Among the various types of plastic wastes accumulated in households, maximum contribution comes from the 'carry- bags' used for carrying grocery, vegetables, stationery etc. purchased for daily consumption from different shops. Typical collection is shown in Fig. 5A. The quantity of monthly accumulation of this type of plastic waste from the sample households combined is shown in Fig.5B.
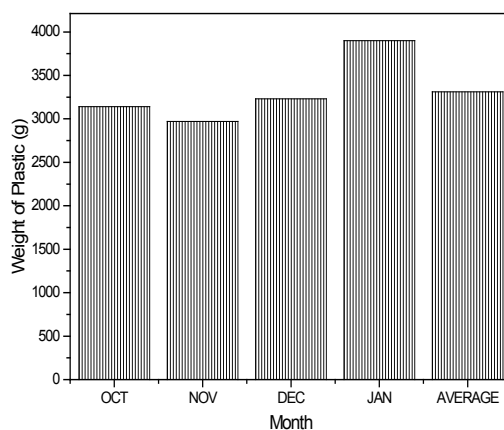

Fig.5B. Combined monthly accumulation of 'carry bags' from all sample households

An average of 3.3kg/month of plastic 'carry-bag' waste is generated from the eleven households. Average individual household contribution is ~ 300g/month. These bags are generally made from high density polyethylene (HDPE). The main advantages of these bags are: cost effectiveness, light-weight and convenience. Even though this plastic variety is recyclable / reusable, no serious or concerted effort is taking place in that direction. Careless and casual littering of used carry-bags leads to major environmental pollution. The new 'imported' supermarket culture in the country has made a major contribution to this menace. Of late there has been a slight decline in the number of 'carry-bags' accumulated in households in Kerala as a result of campaigns and education on the plastic-related hazards. A small percentage of consumers are reusing old plastic bags. Charging a moderate price by shops for this kind of carry-bags is also making a positive impact on the reduction of this type of wastes. It is worth undertaking a detailed study on the impact of charging a price for plastic bags in reducing the accumulation of this waste and arrive at an optimum price that will not be an undue burden to the customer and will be beneficial to the environment. During the survey many respondents informally suggested that the maximum reasonable price may be Rs. 1/bag

Another type of plastic bags, which has become a major menace of disastrous consequences to the environment, is light weight thinner plastic bags and wraps used for packing and selling light weight products. The monthly ac-

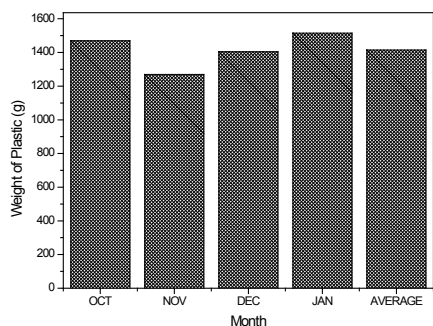cumulation of this type of plastic waste in the combined households is shown in Fig.6A.

Fig.6 A. Month-wise accumulation of used lighter, thinner plastic bags/paper

As seen from the data, this type of wastes is accumulated at the average rate of ~1.4 kg/month from all the sample households, i.e. ~130g/month/household. They constitute ~15 % of the domestic plastic waste by weight. However in terms of volume, the quantity is much more due to the physical light-weight nature of the material. Low density polyethylene (LDPE) is used for making this type of bags and wraps. Most of these are carelessly thrown around and eventually end up in landfills, dumpsites and water bodies. The problem is further aggravated because these materials can fly around, reach and contaminate anywhere and everywhere. Some such typical lightweight plastic waste accumulated in an average household is shown in Fig. 6B.

Fig.6 B. Typical light weight waste plastic carry bags from an average household

Another major contribution to plastic waste comes from modern packed 'ready to eat' food sectors such as bakeries and 'take away' kiosks. The total quantity of plastic waste generation associated with such products in the households combined is shown in fig.7A.
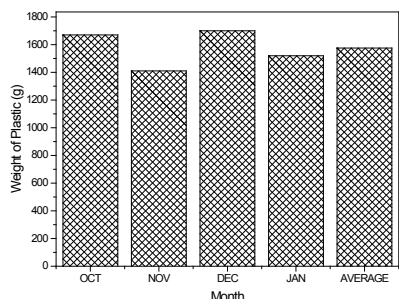

Fig.7A. Month-wise accumulation of 'ready to eat' food-

**related plastic waste from all the sample households combined**

The average quantity of bakery/food related plastic accumulated in the sample households combined is ~1.5 kg/month. The average contribution is ~140g/month/household. Some of the typical plastic wastes of this type from an average household is shown in Fig.7B.

Fig.7B.Typical bakery/food related plastic waste

The ever-increasing accumulation of this type of waste, even from low-income households is a reflection of the consequence of globalization and 'closing the kitchen' culture imported from the western world.

Yet another kind of plastic waste , though small in terms of number or volume, but significant in terms of weight is hard plastics such as containers for mineral water, soft drinks, 'ready to eat' food, cosmetics (shampoo, talcum powder, body creams etc.), disposable cups & plates, baby milk bottles, toys etc . These are made of different types of heavy and stronger plastics like polyethylene terephthalate (PET), high density polyethylene (HDPE), polyvinylchloride (PVC), polypropylene (PP), polystyrene (PS) etc. They are not uniformly distributed month-wise or household-wise. Figure 8A shows the month-wise cumulative contribution of such hard items to the total plastic waste from the households during the study period.
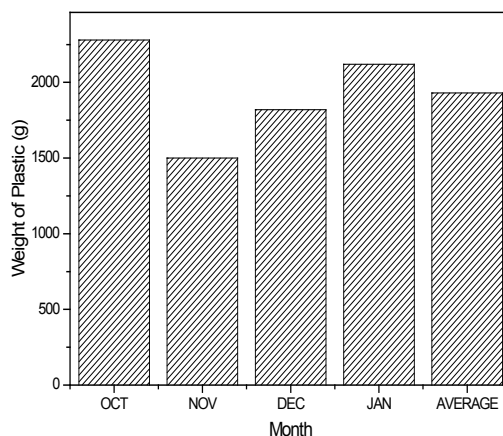
The average accumulation of this type of plastic wastes for all sample households together is 1.8 kg/month, i.e. average contribution of 170g/month/household. Some of the typical hard plastics that accumulate in an average household are shown in Fig.8B.

Fig.8B. Typical hard plastic wastes from sample households

Another important observation is the presence of significant quantity of diaper shields in the plastic wastes from even middle class and lower middle class households with small babies and bed-ridden patients. Such diapers are replacing the traditional reusable clothes used earlier. This is not a common day-to-day plastic waste from all households. In the present context, of the eleven households subjected to the study, four have members either below 3 years of age or bed-ridden patients (due to age related illness) requiring bed pads/diapers. This was the cause for the unusually large proportion of this type of waste from those households.

3.3. Category-wise quantification of different types of waste

The quantity of different types of plastic waste from the sample households for the entire study period is shown in Fig. 9.
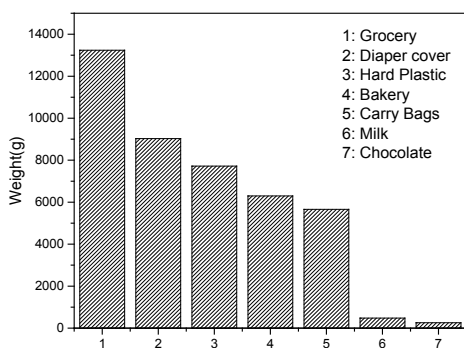

Fig.9. Cumulative category-wise distribution of different types of plastic wastes from all households during study period

Various types of waste plastics in terms of weight is in the order; heavy carry-bags > diaper shields > hard plastic > fast food-related > lighter carry-bags > milk cover > chocolate wrapper. Surprisingly even chocolate and candy wrappers constituted small but significant quantity. This clearly shows how the change in lifestyle and economic affluence of the society contributes, among other things, to the plastic menace as well as deterioration of ecology and environment.

3.4. Quantity of plastic waste vs family size

Another finding of the study is that the quantity of plastic waste generated is more or less directly proportional to the number of family members among all income groups. With increase in the family income the quantity of waste generated per person also goes up. When the family income is > Rs.100,000/pm, the average waste per person is ~400g/person/month. When the income is in the range of Rs.50,000-100,000, the average waste generated is less by 40%, i.e. ~250g/person/month. The waste generation falls drastically when the income is in the range Rs.20,000 – 50,000 and < 20,000 pm with the quantity being ~70g and ~60g/person/ month respectively. The findings are summarized in Fig 10 and Table 3.
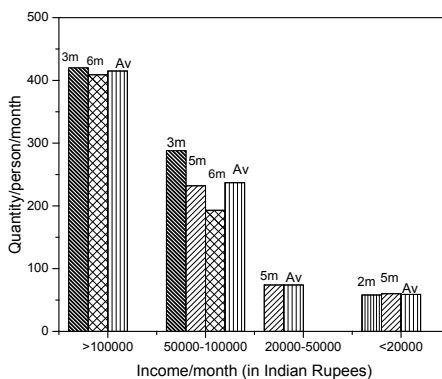

Fig.10. Family size vs income vs plastic waste generation m: number of members in the family, Av: Average

Table 3. Relative quantity of plastic waste generated vs economic affluence

Family income/ month	Average plastic waste per month/person (g)
>100,000	415
70,000-100,000	253
40,000-70,000	195
20,000-40,000	74
<20,000	60

[The income range as given by the households is taken as such with no verification of any kind]. The number of members in the families was different in different income segments and hence the average waste generated/person/ month is chosen for comparison.

The study thus clearly indicates that affluence and life style of the family contributes significantly towards the generation of plastic waste. Almost anything and everything comes wrapped in plastic accompanied by high voltage advertisement in the name of hygiene and aesthetics. This is the root cause of plastic menace, especially the low quality thin plastics. It is frightening to note that even the traditional banana leaf which was believed to be essential for auspicious occasions in India is being replaced by plastics and related products.

4. Questionnaire survey of plastic pollution-related facts

As part of the study, an opinion survey on the use and

disposal profile of plastic products in the community in a middle class village in central Kerala (including the households that participated in the study reported above) was conducted by direct interaction with respective families. A questionnaire for the purpose was designed in consultation with a cross-section of the society and   was given to the participants. The objectives of the survey and the specific meaning of each question were explained to the participants and necessary clarifications were provided. Follow-up calls were made to see whether any assistance was needed with the questions or probable answers.

4.1. Findings from the questionnaire survey
The educational qualification of the respondents ranged from high school graduation to post graduation and professional degrees. The general awareness on various plastic –related matters is more or less the same, even though the in-depth knowledge on science and technology related aspects varied widely. All the respondents use plastic products extensively, in particular carry bags and bottles. More than half of the respondents were aware of different types of plastics, most common being polyvinylchloride (PVC) followed by polyethylene (PE). Almost all of them have heard about the ecological, environmental and health problems associated with plastics. Many are of the view that plastics also cause cancer. In spite of the known adverse effects, they still find plastic products convenient and hence are not willing to abandon fully. Nearly 30% of the respondents burn the plastic periodically in their backyard or common open areas. Another ~30% hand over the plastic waste to 'waste collectors' from the local self-government. But this waste collection system is not functioning efficiently or regularly. The remaining respondents either accumulate waste plastics at home for possible future use or better sale price later. Only very few responded that they throw the waste plastic away and do not worry about them later. It is possible that there are more households that litter plastic and plastic products, but do not want to admit the same. More than half of the respondents reuse plastic containers, especially the thicker and stronger durable type.

Nearly 70% of the respondents collect plastic wastes separately from organic/food wastes for disposal. Nearly 25% responded that the plastic content of the product packaging influenced their decision to buy or not to buy the product, the more the plastic content, the less the probability of buying that product. [This need not necessarily be an honest comment as seen from the quantum of generation of plastic waste even from educated/high income households.] More than 50% said that they care about the safety of the materials used for making toys which they buy for the children. Majority of the respondents said that they have been packing their purchases optimally in recent times to ensure the use of minimum number of plastic bags. Nearly 25% of the respondents recycle the carry bags for repeated purchases. According to 35% of the respondents, the most common plastic item that get accumulated in their households is carry bags followed by thin light bags and bakery covers. Nearly 15% believe that there is nothing wrong or unsafe in open pit burning of plastics. Only a small % (<10%) of the respondents believe that burying is acceptable for the disposal of plastics.

Many respondents confirmed that occasionally family members do engage in discussions on the long term hazards of plastics. Nearly 50% believe that the fumes from open burning of plastic are toxic, generate suffocating odor and can cause dermatological problems and irrita-

tion to eyes. Many experienced cough, chest congestion and breathing difficulty from such fumes. Nearly 25% have seen domestic animals eating plastic at least once but did not do anything to dissuade them. More than 50% have seen plastics dumped in water bodies such as ponds, rivers and lakes. Many of them believe that the plastics may eventually decay and turn the water into toxic. They are also aware that the plastic products are harmful to aquatic organisms including fish wealth. Nearly 50% do not mind a complete ban on plastic products and can manage without. But less than 30% only believe that a world without plastic of any kind is possible in today's context.

More than 75% of the respondents feel that government sponsored initiatives on reducing plastic waste are not adequate and there must be more efforts to create awareness among the public. Only less than a quarter of the respondents have attended at least one awareness programme conducted by government/local bodies/Non-Governmental Organizations on plastic related hazards. Many have not heard about such programmes. This reveals the need for more concerted efforts on educating the people on the hazards of plastic waste and safer methods of disposal.

Only less than 20% favor stricter rules and stringent punishment for plastic littering and prefer voluntary reduction through education and awareness programmes. About 30% will accept a government ban on plastic use without resentment or protest. Nearly all respondents are willing to reduce the use of plastic products progressively and are already doing it. There is near unanimity that the new lifestyle and supermarket culture are mainly responsible for the exponential growth in plastic waste generation. But only less than 50% think that it may be possible to go back to traditional customs including wrapping purchases in paper/cloth bags.

5. Conclusions
The study shows that an average of ~1 kg of plastic waste/month/household is generated even in a typical middle class/lower middle class community. Biggest contribution to plastic pollution in terms of volume and spread comes from thinner lighter 'carry bags'. This can be attributed to the new 'supermarket' culture and the packing used for 'ready to eat' bakery items and fast-food. The quantity of plastic waste in any household, irrespective of the income, is directly proportional to the number of family members. An encouraging observation is that the culture of reuse of plastic bags is slowly picking up. The survey shows that concerted efforts are needed by government agencies/NGOs to create more awareness among the public on the need for reduction in plastic waste and its safe disposal.

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