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SUSTAINABLE MODEL DEVELOPMENT FOR PET (POLYETHYLENE TEREPHTHALATE) BOTTLE RECYCLING AT SELECTED DISTRICTS IN BANGLADESH

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ABSTRACT
The huge amount of plastic waste accumulates in the environment worldwide and threat to the environment. Plastic waste includes a consider amount of PET (polyethylene terephthalate) bottle. Due to socio-economic structures developing countries have no proper system for recycling PET bottles. Therefore, the aim of this research was to develop a sustainable model for PET bottle recycling without additional investment. Studied model in brief, when customers buy drinks in PET from the shop they will pay some extra money and when they return the empty PET bottles to the grocers, the extra amount will be refundable and retailers return PET to the related companies to recycle. The related companies may be benefited with recycling and may share their profits with retailers. A questionnaire was prepared for survey on the basis of this model. Around 800 multidisciplinary people were participating in that study from 8 different districts in Bangladesh. About 97% people were in positive response to adopt this model for PET bottle recycle. This research model may be useful for reducing plastic pollution without extra investment. This model also may be applicable in developing countries as well as developed countries for PET bottles recycle.

Key words: Plastic pollution, PET (polyethylene terephthalate) bottle, recycle model.

INTRODUCTION
Plastic products become essential elements globally and about 20 types of plastics are used worldwide, including PET (polyethylene terephthalate). In modern life more than 300 million metric tons of plastic are produced yearly, including 72 million tons of PET (polyethylene terephthalate) bottles (Hossion et al. 2021) and its increasing day by day. Plastic products are cheap, lightweight, durable, stable and easily useable leading to a wide range of applications (Hopewell et al. 2009; Shen et al. 2020) and moreover, the PET is lightweight, hard, tough and resistant to grease, oil, heat and it makes the fasting growing food or beverage packaging applications (Hossion et al. 2021). However, poor management of plastic wastes becomes a massive threat to human, animal, plant and the environment (Schmaltz et al. 2020; Nadiruzzaman et al. 2022). Additionally, PET packaging is not only a threat to environmental health, but also blocks drains leading to drain overflow and flooding (Foolmaun et al. 2011).
In 2015, global plastic waste was produced 141 million tons (Benyathiar et al. 2022). So far, the municipal waste stream in plastics by weight is about 10 percent (Hossion et al. 2021) and PET accounted for 12 percent of total solid waste globally (Benyathiar et al. 2022). Post-consume PET bottles are highly potential and 100% recyclable (Hopewell et al. 2009; Creixell and Mayenberger, 2017). PET bottle waste recycling is leading to combine economical and environmental perspectives (Choudhary et al. 2019).

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Post-consume PET bottles are recycled to produce fabrics, monofilaments, bottles, sleeping bags, pillow and carpet, etc (Choudhary et al. 2019; Hossaion et al. 2021). Therefore, it has a huge market value and reduces pollution by recycle process. However, only 20 percent plastics are recycled, including PET 90% in India, 72.1% in Japan, 48.3% in Europe, 31% in United States and 55 percent is directly released into the environment (Choudhary et al. 2019; Hossion et al. 2021). But, PET bottles are mainly collected by the scavenging system (unorganized system) and segregated from landfills in developing countries (Creixell and Mayenberger, 2017: Foolmaun and Ramjecawon, 2012) like Bangladesh. So far, there is no suitable model for PET bottle recycle process, including collection system in a developing country as Bangladesh. Therefore, the aim of this study was to develop a sustainable model for PET (polyethylene terephthalate) bottle recycling of developing countries including Bangladesh.

MATERIALS AND METHODS

The research was conducted during the period from April 2021 to November 2022 in eight districts as Khulna (22°49'N 89°33'E), Dhaka (23° 45′ 50″ N, 90° 23′ 20″ E), Jhenaidah (23°15'N–23°45'N and 88°45'E–89°15'E), Faridpur (23°17' - 23°40' N, 89°29' - 90°11' E), Rajbari (23°35'N–23°55'N and 89°09'E–89°55'E), Dinajpur (25°10'N–26°04'N and 88°05'E–88°28'E, Joypurhat (25° 6′ 0″ N, 89° 1′ 48″ E) and Bagerhat (22° 40′ 0″ N, 89° 48′ 0″ E) in Bangladesh, and around 800 multidisciplinary people (randomly) included also consumers, retailers, traditional pet bottle collectors, officials of PET bottled drinks or food manufacturing companies. The model for PET bottle recycles or management was prepared in the basic of Bangladesh socio-economic condition. The model in details: when customers buy drinks/food in PET from the shop, they will pay some extra money and when they return the empty PET bottles to the grocers (anywhere in the country where PET bottled drinks or food is sold), the extra amount may be refundable. For the developed countries, it may be either cash or shopping voucher or points. Thus shopkeepers collect the PET bottles and return these to the manufacturing companies to recycle. The manufacturing companies may be benefited with recycling and may share their profits with retailers. Brief model is shown in figure 1. Structured written questionnaires were used to evaluate the current PET (post-consume) bottle recycles. Written consent of the participants for structured written questionnaires are unnecessary in Bangladesh. All the participants read and approved the ethic statement which was included the questionnaires. Questionnaires are shown in figure 2. The data obtained from the questionnaires and analyzed it by using R (Team, 2020.)

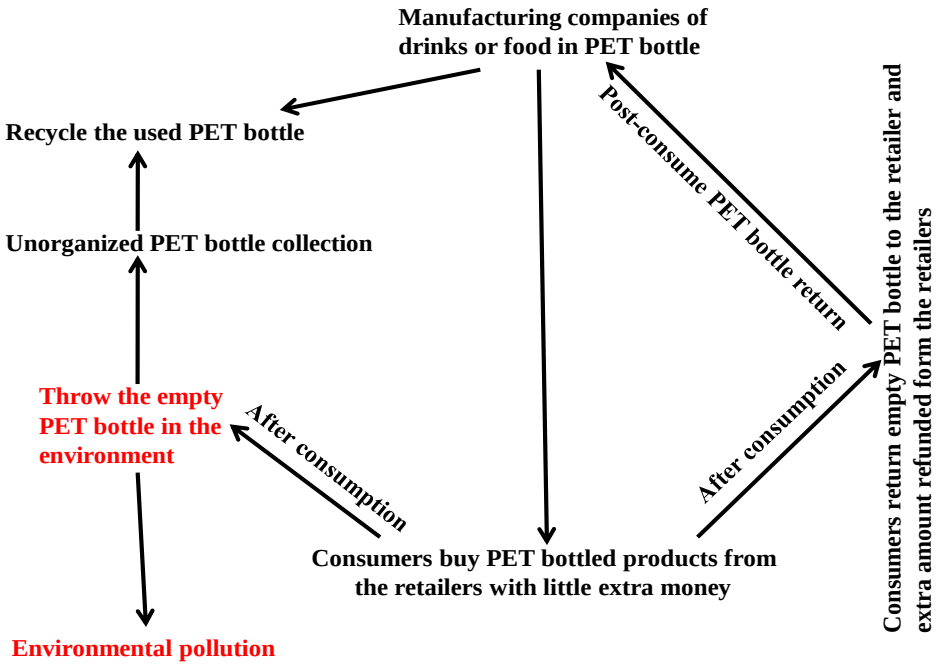

Figure 1 Conceptual framework outlining of the sustainable model for PET bottle recycles or management

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Questionnaires for PET bottle recycles

Name: District: Sex: Male/Female/Transgender Age:

If you agree we will use your provided information.

❖ **Questionnaires for PET bottle recycle or management. (please ✔ mark on your answer)**

SL	Questions	Yes	No
1	Do you know the PET bottles?		
2	Do you buy bottled (plastic) drinks/foods?		
3	Do you know the recycle sign?		
4	Do you know the PET bottle has recycle sign?		
5	Do you know the PET bottles are recyclable?		
6	Do you think that recycle signs are needed much publicity for people?		
7	Do you think that plastic (PET) bottles are responsible for pollutions?		
8	Do you want to properly recycle PET bottles?		
9	At the time of purchasing the PET bottled drinks or food, the customers will pay little extra money than the actual price and post-consume PET bottle return to retailers (anywhere in the country where PET bottled drinks or food is sold) and they will re-back that extra money. Do you think that this system can reduce pollutions?		
10	Do you want to apply the above system mentioned in Q. 9 to reduce pollutions?		
11	Do you think that the above system mentioned in Q. 9 will apply only the government?		
12	Do you think that the above system mentioned in Q. 9 will apply only the manufacturing company?		
13	Do you think that the above system mentioned in Q. 9 will apply jointly the government and the manufacturing company?		
14	Interviewer educational levels: Only signature/Primary/High /Graduate/post-graduate		
15	Interviewer visit abroad: No/Least developing/developing/developed country		

Figure 2 Questionnaires

RESULTS

In table 1 is shown the demographic characteristics of the survey population, which shows 40.75% were female, more than 80% were 25 – 50 years old and the 2.38% of 19 respondents visited the developed country visiting history and they were minimum graduate. We found that only 2.75% participants know the PET bottle in meaning and identify the recycle symbol, 95.88% of them seems that PET bottle are responsible for environmental pollution, 96.75% of the participants agreed to use the current model for PET bottle recycle and guess the model will decrease environmental pollution. Detailed survey data is shown in table 2.

Table1: Demographic characteristics of survey populations

Parameters	Response options	Frequency (n= 800)	Percentage (%)
Gender	Male	472	59.00
	Female	326	40.75
	Transgender	2	0.25
Age	Less than 25 years	86	10.75
	25 - 50 years	623	77.88
	More than 50 years	91	11.38
Educational attainments	None/signature only	74	9.25
	Primary	123	15.38
	Secondary	494	61.75
	Graduate	93	11.63
	Post-graduate	16	2.00
Abroad visit history	None	679	84.88
	Least developing country	09	1.13

Developing country	93	11.63
Developed country	19	2.38

Table 2 survey data

SL	Questions	Percentage (%) (n=800)		
		Compliance	Noncompliance	p-value
1	Do you know the PET bottles?	2.75	97.25	0.00
2	Do you buy/drink bottled (plastic) drinks/foods?	98.63	1.38	0.00
3	Do you know the recycle sign?	2.88	97.13	0.00
4	Do you know the PET bottle has recycle sign?	2.88	97.13	0.00
5	Do you know the PET bottles are recyclable?	92.88	7.13	0.00
6	Recycle signs are needed much publicity for people?	96.38	3.63	0.00
7	Do you think plastic (PET) bottles are responsible for pollutions?	95.88	4.13	0.00
8	Do you want to properly recycle/dispose PET bottles?	96.63	3.38	0.00
9	When customers buy drinks/foods in PET from the shop they would pay some extra money and when they return the empty PET bottles to the grocers (anywhere in the country who sells PET bottled drinks or foods), the extra amount would be refundable. These ways shopkeepers collect the PET bottle and return to the manufacturing company to recycle. This system can reduce pollutions.	96.75	3.25	0.00
10	Do you want to apply the above system to reduce pollutions?	96.75	3.25	0.00
11	The above system will apply only the government.	1.63	98.38	0.00
12	The above system will apply only the manufacturing company.	8.38	91.63	0.00
13	The above system will apply jointly the government and the manufacturing company	98.88	1.13	0.00

n= Number of participants, p= significance value

DISCUSSION

Plastic is one of the most applied materials and massively used worldwide, but the poor management creates so many problems (Woldemar d'Ambrieres, 2019). Plastic waste management as well as post-consume PET bottles management or recycle and the impact of the global environment are one of the burning issues at present (Nadiruzzaman et al. 2022). Fortunately, post-consume PET bottles are easily recyclable, but it needs a proper management system. The current model achieves positive opinion of the participants engaged in the survey to post-consume PET bottle recycle or management and to reduce environmental pollution. At the time of purchasing the PET bottled drinks or food, the customers will pay little extra money than the actual price and post-consume PET bottle return to retailers (anywhere in the country where PET bottled drinks or food is sold) and they will re-back that extra money. Previously, virtuous circle was recommended in Mexico to post-consume PET bottle recycle or management (Creixell and Mayenberger, 2017). Not only the customers do not expend any excess money, but also the related companies need not much money, but the current model can play a vital role to reduce plastic pollution, and maximum citizens will be involved to prevent the plastic pollution. For post-consume PET bottle collection more than 25,000 of the population (including scavenger collector) is directly or indirectly engaged in Mexico (Creixell and Mayenberger, 2017) and large amounts of money are needed. In Europe, the conditional kerbside collection scheme has been successfully recorded 30-40% of post-consume plastic bottle recovered (Hopewell et al. 2009). Without direct economic benefit and absence of highly committed public behavior are responsible to poor plastic bottle collection leads to recycle (Hopewell et al. 2009). Moreover, from the present model, customers get instant financial benefit (pseudo benefit) and post-consume PET bottle recycling can be influenced. Due to inadequate awareness of environmental pollution in developing countries, PET waste end point is mainly landfills, though the PET bottles are collected for recycling, but lose their original value (Creixell and Mayenberger, 2017). The present model has no chance to decline the proper value of empty PET bottle, because it may be

collected directly from customers. In Bangladesh socio-economic condition, the studied model can be useful to post-consume PET bottle recycle or management and to reduce pollution. The current model was not applied in the field level, therefore the model needs practical implementation for validation and justification.

CONCLUSIONS

Plastic pollution can be reduced by applying the studied model not only in Bangladesh but also in other developing countries as well as in developed countries. Moreover the related manufacturing companies and the retailers can be also financially and environmentally benefited. The current results suggest that the respective Government and the related companies jointly may implement the studied model.

DECLARATION OF COMPETING INTEREST

None

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