Muhammed Alamgir, S.M. Tariqul Islam and J. A. Saju (Eds.)
ISBN: 978-984-35-4034-8

Full Paper of the WasteSafe 2023 –8th International Conference on
Integrated Solid Waste & Faecal Sludge Management
25-26 February 2023, Khulna, Bangladesh

COMPOSITION ANALYSIS OF PLASTIC WASTE IN RECYCLING SHOPS OF KHULNA CITY IN BANGLADESH

Md. Kawsar Ahmed[1], Jobaer Ahmed Saju[2], Quazi Hamidul Bari[3], Md. Rafizul Islam[4], Muhammed Alamgir[5], Eckhard Kraft[6] and Philipp Lorber[7]

[1,2]SCIP Plastics Project, Department of Civil Engineering, Khulna University of Engineering & Technology, Khulna-9203, Bangladesh
[3,4,5]Department of Civil Engineering, Khulna University of Engineering & Technology, Khulna-9203, Bangladesh
[6,7]Bauhaus-Universität Weimar, Bauhaus-Institute for Infrastructure Solutions (b.is) Weimar, Germany

ABSTRACT

Plastic waste being a part of solid waste is now a great concern for health and the environment all over the world as it is being generated massively due to its very cheap price and uncontrolled use. It is quite impossible to stop the plastic waste generation in the anthroposphere system as it is being generated or deposited almost in every place. According to the report of The Business Standard, Bangladesh drowns in 8 lakh tons of plastic waste every year. Hence the proper management of plastic waste is a crying need. In Bangladesh, dynamic, systematic, smooth, sustainable plastic recycling shops have been established under private initiatives without official or formal funds over the years. These recycling shops have kept our life comfortable from being drowned in plastic waste as well as put the environment clean and safe from negative waste flows. In Khulna City Area, 26 well-recognized plastics recycling shops were found especially engaged with flakes-making operations from plastic waste. This study assessed the recyclable plastics fraction in selected recycling shops. The waste composition analysis of recycling shops was conducted by following local sorting instructions and converting the individual plastic waste fractions into PETE, HDPE, PVC, LDPE, PP, PS, and others. This study quantified the plastic waste fraction being utilized in recycling shops and accordingly establish a baseline scenario of plastic recycling in Khulna city.

INTRODUCTION

Due to urbanization and human activities, solid waste produces more biodegradable and non-biodegradable components. Biodegradable wastes are easily decomposable while non-biodegradable wastes are persistent and cause various problems to the environment and human health hazards. Plastics, glass, ceramics, e-wastes, medical wastes, etc. are non-biodegradable wastes that cannot be decomposed and remain as such in the environment. Recycling, an important part of solid waste management, recovers value or resources from these non-biodegradable wastes and is enriched by physical and biological reprocessing as well as by the recovery of energy (Demirbas, 2011). Post-consumer plastic waste is getting effort to recycle which can circulate in the on-demand market economy by converting plastic waste into new products. Recycling plastic waste saves the environment from being polluted as well as practices a circular economy rather than the 'take-make-use-dispose' economy (Hahladakis & Iacovidou, 2019). Recycling shops being a part of the economy holds an important role in mitigating solid waste and turning solid waste into reusable products. These shops have been built in Bangladesh totally by entrepreneurs of the informal sectors. However, plastic recycling shops are increasing day by day in Khulna City, Bangladesh as plastic may be a substitution in many sectors of metal (Roy & Bari, 2019).

Recycling waste can reduce greenhouse gas, and new infrastructure and innovative approaches to recycling activities can turn waste into reusable rather than final disposal (USEPA 2011). Recycling of solid wastes extends the lifetime of landfill sites, as well as economic benefits, are achieved by selling the recycled materials (Diamadopoulos et al, 1995). In Europe, almost the whole plastic waste is either recycled or incinerated although the processes of incineration and recycling are not a piece of cake (Irena & Carina, 2017). However, in Bangladesh, recycling plastic waste is practiced not any single use of incineration at all. There was established a silent, systematic, smooth, sustainable, and dynamic chain of recycling plastic waste in the Khulna city area under private initiatives (Bari et al, 2012). The

total amount of solid waste generation in the Khulna city area is 520 tons/day from which only 70 tons of solid waste is recycled daily. Household solid waste generation rate ranges from 0.421 to 5.81kg/day including plastic (film and dense) waste generation rate is 3.28% (Jodder et al, 2022) Post-consumed PETE bottles and other compositions of plastic are sorted from the solid wastes generated in the household and sell them to Informal waste collectors(Jodder et al, 2022). Informal waste collectors sell them to the nearest recycling waste traders and recycling shops buy this waste plastic from the recycling waste traders. Sometimes, waste collectors "Tokai" are seen collecting waste from the streets, drains, and garbage containers and selling them to recycling waste traders. Plastic wastes are simultaneously shredded, dried, and packed in recycling shops. Some recycling shops make products from the grains produced from flakes. From the collection of plastic waste to the final production, a number of individuals are associated with each activity (Moniruzamzan et al, 2022).

In Bangladesh, the recycling system started its journey in the late fifties (1955-1960) with only paper recycling activities in Dhaka city area by 30 to 40 manually operated paper repulping plants. At the evaluation of time and demand of products, different types of recycling shops – plastic, metal, and others have been developed for ensuring environmental safety as well as diversifying the economy involving waste pickers/scavengers, recycling shopkeepers, and wholesalers (Ahsan et al, 1991). At present, plastic recycling shops are being built enormously by the private initiative in Bangladesh. These shops collect plastic waste, recycle it into new products, save the environment, and run the economy (Kabir et al, 2021). Since the branches of plastic recycling shops in Bangladesh are growing geometrically, it is quite difficult to identify and quantify the grades of these plastics (Haque et al, 2000). This paper aims to analyze the composition of plastic waste in the recycling shops in the Khulna city area, Bangladesh.

METHODOLOGY

Based on the processing activity, plastic recycling shops are identified into several categories that are very complicated to define due to the variety of recovery activities and recycling (Alabi, et al. 2019). Bangladesh, a developing country in south Asia, is practicing the recycling process of solid wastes through private initiatives. Each recycling shop is directly dependent on the recycling waste traders. Scavengers and Informal waste collectors collect waste from various sources in the surroundings and finally sell them to the recycling waste traders. Valuable wastes extracted from the generation sources are finally turned into reusable products in recycling shops. However, each plastic recycling shop in the Khulna city area in Bangladesh has signed an agreement with at least 15 recycling waste traders, and the partnership is obviously increased with the economic flexibility of the recycling shops. A postpaid security system has been followed by the recycling shop owners. Due to the agreement, the assigned recycling waste traders are confined to selling the sorted valuable wastes in the associated recycling shops and a target amount of sales is to be fulfilled by the recycling waste traders. Plastic wastes are graded into different categories in the recycling shops by the designated workers, especially female workers due to the cheap labor cost.

Selection of study area

Khulna City Corporation belongs to an area of 40.79 square km bounded by 31 wards starting with ward no. 1 in the northern part and the last ward no. 31 covering the southern part located in between 24°45' and 24°54' north latitudes and in between 89°28' and 89°35' east longitudes. A list of some recycling shops is collected from Khulna Plastic Recycling Association – 2186 and conducted a structured questionnaire survey from 1 November to 30 November. A total of 26 recycling shops were identified within the KCC admin boundary line (Figure 1).

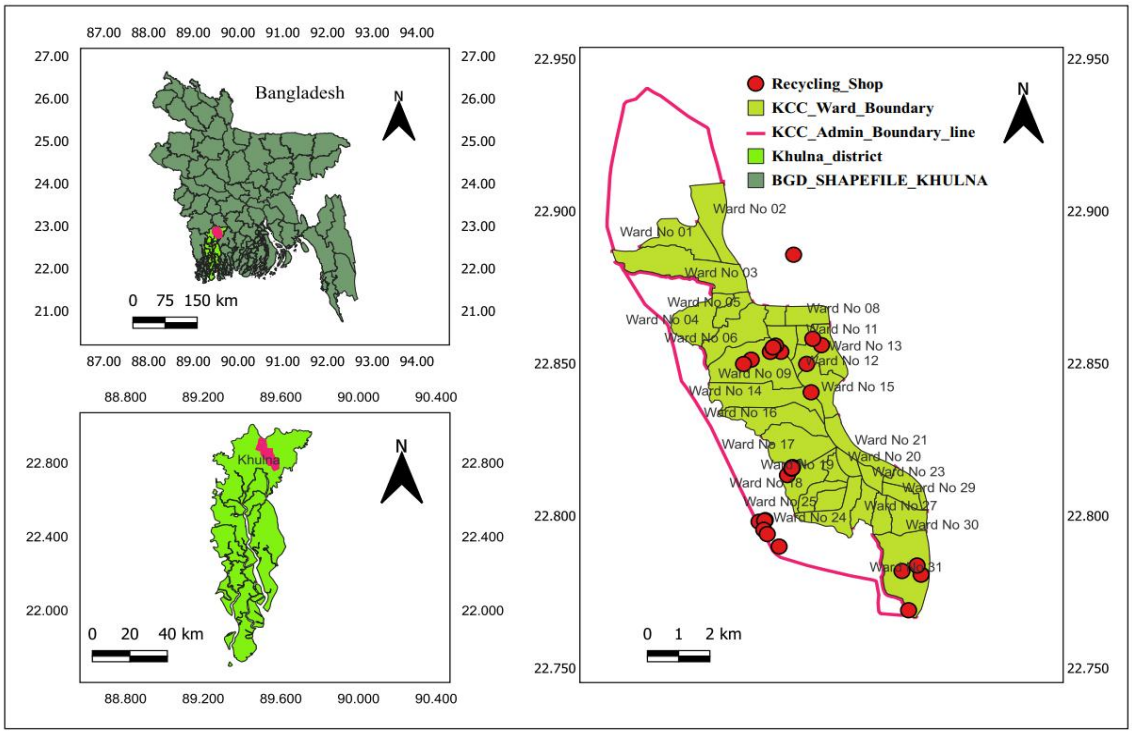

Figure 1 Location map for the existing recycling shops in the Khulna city corporation showing the admin boundary line

Questionnaire survey

A structured detailed survey information was conveyed regarding the collection rate of wastes, conducted works, workmanship, and monthly turnover. The survey was conducted to determine the existing number of recycling shops, categorize the shops, and move forward to each category for detailed analysis. Shop owners, managers, waste collectors, and personnel associated with the activities willingly supported getting all necessary data and information. Some recycling shops were found dealing with PET only, and a maximum of them dealt with mixed plastic wastes (Figure 2).

(a) PET found in Khulna Plastic (b) Mixed plastics found in Jahid Enterprise

Figure 2 (a) Khulna Plastic dealt only with PET plastic composition; (b) Mixed plastic wastes were separated based on local grades in Jahid Enterprise (Photographer: Md. Kawsar Ahmed, 2022)

Quantification of the different grades of plastics in the recycling shops

There were locally found 15 to 22 grades from soft plastic wastes (locally called mulam). It was planned to put each local grade by mass in kilogram to HDPE, LDPE, PP, PVC, and others (Lahtela et al, 2018). PETE and LDPE were collected separately, that is why it could not contribute any fraction by mass

while mixed plastic was analyzed. Milk cartons, detergent bottles, etc were locally called “hybrudge”, and they were weighed in kilograms putting them in the HDPE category. Other local grades were weighed and categorized in a similar way (Table 1).

Table 1 Composition of plastic wastes with examples

Types	Example
PETE/ PETEE	Soft drinks, mineral water, fruit juice & cooking oil bottles; Food bottles/jars polyester clothing or rope
HDPE	Milk cartons, detergent bottles, cereal box liners, shampoo bottles, washing and shower soap cases, toys, buckets, park benches, and rigid pipes
PVC	Plumbing pipes, credit cards, human and PETE toys, rain gutters, teething rings, fluid bags and medical tubing, and oxygen masks
LDPE	Plastic/cling wrap, sandwich and bread bags, bubble wrap, garbage bags, grocery bags, and beverage cups
PP	Straws, bottle caps, prescription bottles, hot food containers, packaging tape, disposable diapers, and DVD/CD
PS	Cups, takeout food containers, shipping and product packaging, egg cartons, cutlery, and building insulation
Others	Acrylic, polycarbonate, polylactic fiber, nylon, fiberglass, Eyeglasses, baby and sports bottles, electronics, CD/DVDs, lighting fixtures, and clear plastic cutlery

RESULT AND DISCUSSION

Recycling shops here in the KCC area started their journey very earlier in 90 decades although few recycling shops dealing with PETE only were established very recently. A good bonding chain has been built among informal waste collectors, recycling waste traders, recycling shops, and industries. A massive number of these shops have been established in Khalishpur and Shonadanga areas, whereas few recycling shops are found in Lobonchora and Zero Point areas. People who are scattered from the growing economy of educated individuals are basically engaged in working at these particular sections. Some of them are uneducated, and handicraft; some of them did not manage jobs in their favor. However, the owners of such recycling shops lead a standard life even if they are included as rich ones while their monthly turnover is more than fifty lacs taka. 26 recycling shops were found among which the maximum of them dealt with mixed plastics, some of them traded with PETE only and a very few were hard plastic recycling shops (Table 2).

Table 2 Plastic recycling shops, their establishment, dealing events, and monthly turnover

Name of recycling shops	Location	Establishment	Dealing Events	Monthly Turnover (BDT)
Khulna Plastic	Lobonchora	2022[1]	PETE	50,000
Sarwar Recycling	Lobonchora	2015	Mixed Plastics	1,65,000
M/S Jabbar Enterprise	Lobonchora	2018	Mixed Plastics	1,20,000
Islam Plastic	Lobonchora	1990	Mixed Plastics	5,00,000
Ma Babar Dowa	Khalishpur	2011	Mixed Plastics	4,00,000
Jahid Enterprise	Khalishpur	2018	Mixed Plastics	7,00,000
`Babu Plastic	Khalishpur	2022[2]	Mixed Plastics	4,00,000
Jihad Plastic Cutting	Khalishpur	2015	Mixed Plastics	20,00,000
Anika Plastic	Khalishpur	2005	Mixed Plastics	45,00,000
Sharif & Brothers	Khalishpur	2019	Mixed Plastics	70,00,000
Sumaiya Plastic	Khalishpur	2020	PETE	22,00,000
Al Madina Traders	Khalishpur	2012	Mixed Plastics	15,00,000
Asma Akhtar Lipi Enterprise	Khalishpur	2009	Mixed Plastics	2,00,000
Tithi Sneha PETE Flakes	Khalishpur	2022[3]	Mixed Plastics	15,00,000
Mayer Doa Metal & Hasib Traders	Khalishpur	1999	Mixed Plastics	9,00,000
Aladin Plastic Center	Zero Point		Mixed Plastics	
SR Poultry Plastic	Zero Point	2017	Mixed Plastics	15,00,000
J.K. Green Bangla Polymer	Zero Point	2022[3]	PETE	50,00,000
Mayer Doa Plastic Recycling Center	Zero Point	2014	Mixed Plastics	1,50,000

Wasifa Plastic Cutting Center	Zero Point	2019	Hard Plastic	5,00,000
Bismillah Plastics	Shonadanga	2019	Mixed Plastics	70,00,000
Madina Plastics	Shonadanga	2014	Mixed Plastics	6,00,000
Dia Enterprise	Shonadanga	2021	Mixed Plastics	8,00,000
Mayer Doa Enterprise	Shonadanga	2000	Mixed Plastics	15,00,000
M/S Rahman Enterprise	Shonadanga	2016	Mixed Plastics	10,00,000
M/S J. N. PETE FLAKES	Shonadanga	2002	Mixed Plastics	15,00,000

Plastic waste collection

Designated waste collectors are employed to collect plastic wastes from the recycling waste traders and motorized trucks, as well as vans, are utilized for loading and unloading purposes. Recycling shops that collect the wastes comparatively from long-distance recycling waste traders generally use high-capacity motorized trucks. And the vans either motorized or non-motorized are used to collect waste from the nearest recycling waste traders. From collection to manufacturing products, each activity was performed in a synchronized way (Bari et al., 2012)

Plastic waste processing

Employed workers, especially female workers, segregate plastic waste into 15 to 22 grades. Each grade came to light in flakes while flakes are turned into grains and then the final product was opened. Flakes were formed in the cutter machine and packed into bags after drying. These bags were sold to factories via wholesalers and finally, products are available in the market. Manufactured products were available for utilization in households and all other consumers, and turned into waste after consumption. Plastic materials were circulated until they were non-recyclable or stacked in the marine environment (Figure 3).

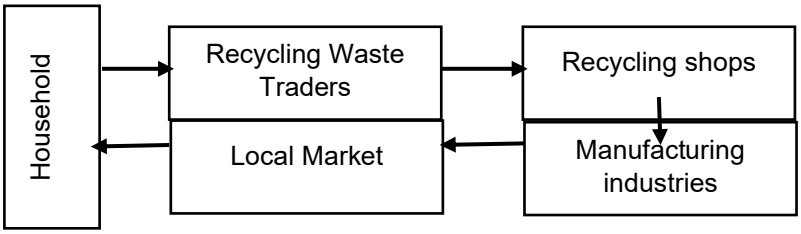

Figure 3 Plastic materials circulated from the generation source to different media with the help of recycling activities

Male-Female worker status in the recycling shops

A recycling shop is not a different place in society where it is unbelievable without the participation of females. However, the wages of female workers are either half or less than that of male workers. Based on the survey, the monthly salary of a male worker ranges from 12000 to 18000 BDT, whereas a female worker gets a maximum of 9000 BDT per month (Table 3). Sometimes, a female worker is paid daily and has to remain unpaid when there is no contribution from her in those shops. Even there is no job security and pension system for female workers in the recycling shops.

In the Khulna city area, 26 recycling shops were found that collected plastic waste in order to recycle them and finally produced products. From collection to the manufacturing process, around 400 people were directly incorporated. Recycling shops that manufactured plastic products would not appoint female workers. No female laborers were found in the recycling shops dealing with hard plastic waste materials with small revenue. Except for these, female workers were seen to work in all other recycling shops. They were usually employed for sorting plastic wastes based on the local grades. In these recycling shops, the number of female workers was much more than that of male ones in the recycling shops (Figure 4).

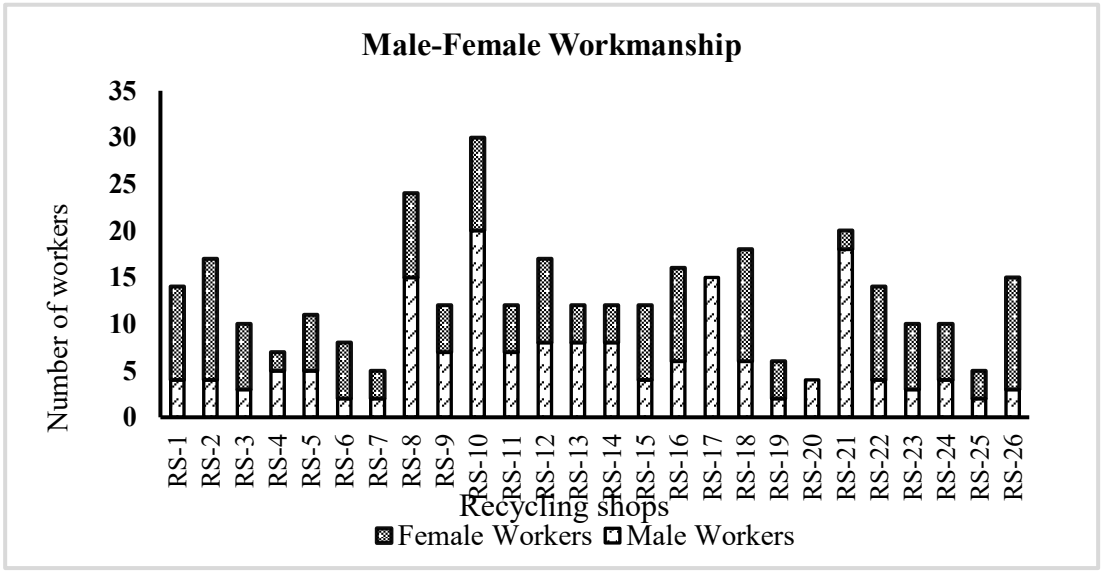

Figure 4 Male-Female Workmanship scenario in the recycling shops having female workers almost in all recycling shops was greater in number

Table 3 Male-Female Workmanship exhibiting monthly remuneration

SL No	Male Workers	Monthly Salary	Female Workers	Monthly Salary	SL No	Male Workers	Monthly Salary	Female Workers	Monthly Salary
RS-1	4	12000	10	6900	RS-14	8	10000 to 15000	4	7000
RS-2	4	12000	13	6500	RS-15	4	12000 to 18000	8	7000
RS-3	3	15000	7	7500	RS-16	6	12000 to 18000	10	7000
RS-4	5	10000 to 15000	2	6000	RS-17	15	7000 to 20000	0	0
RS-5	5	7500	6	6000	RS-18	6	12000 to 18000	12	7000 to 9000
RS-6	2	12000 to 18000	6	5000 to 7000	RS-19	2	12000 to 15000	4	6000
RS-7	2	12000 to 15000	3	5000 to 6000	RS-20	4	10000 to 12000	0	0
RS-8	15	12000 to 18000	9	5000 to 6000	RS-21	18	12000 to 18000	2	6000 to 7000
RS-9	7	10000 to 12000	5	6500	RS-22	4	12000	10	6000
RS-10	20	12000 to 18000	10	9000	RS-23	3	12000	7	6000
RS-11	7	12000 to 18000	5	6000 to 7000	RS-24	4	12000 to 18000	6	6000 to 7000
RS-12	8	12000 to 18000	9	6000 to 7500	RS-25	2	12000	3	6000
RS-13	8	12000 to 18000	4	8000	RS-26	3	12000 to 18000	12	7000 to 9000

Plastic waste recycling activities scenario in the recycling shops

Recycling shops were defined as which shops actually performed recycling activities, no recycling waste traders were included in the term “Recycling Shop”. There were found each recycling shop performed the activities – sorting, shredding, drying, and so on (Figure 5).

ISBN: 978-984-35-4034-8

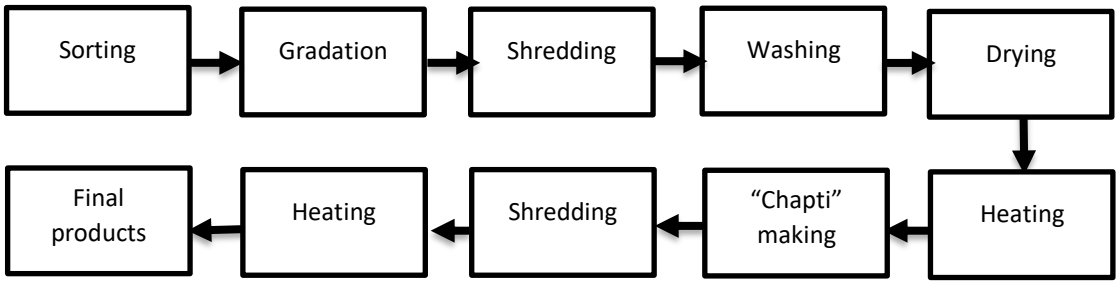

Figure 5 Process flow diagram of a plastic recycling shop in the Khulna City area

Composition analysis of plastic wastes in the recycling shops

Recycling shops practiced separating plastic wastes into different grades based on color, physical characteristics, and experiences so that each grade of plastic could produce unique flakes. PETE plastic waste was categorized into white, green, and color, while HDPE was found in the grades of hybrudge (red, green, and blue), PP was in the form of 1 No PP, RFL PP, water PP, and milk PP. No 1 PP and RFL PP were broken by hand pressure while the other PP did not break by hand pressure (Figure 6).

Figure 6 Grades of plastic waste in the recycling shops: (a) Green PP, b) Blue PP, c) 1 No PP, d) Red RFL, e) Hard Pipe, f) Green Hybrudge, g) Water PP, h) Blue Hybrudge, i) Pran Product, j) Milk PP, k) saline Lota, l) Hard Water Pipe (Photographer: Md. Kawsar Ahmed, 2022)

Two recycling shops of different categories (mixed plastics recycling shop and product manufacturing recycling shop) were chosen for the composition analysis to find each percentage. Zahid Enterprise and M/S J.N. PETE FLAKS were selected correspondingly as the representative of the mixed plastics recycling shops and the product manufacturing recycling shops. 20 local grades of plastic waste were found in Zahid Enterprise where M/S J.N. PETE FLAKS kept 18 local grades while sorting them based on color and physical characteristics. Local grades were then comprised into the recognized composition of plastics - PETE, HDPE, LDPE, PVC, PP, PS, and others (Table 4).

Table 4 Composition and its local grades found in (A) Zahid Enterprise (B) M/S J.N. PETE FLAKES

Composition	Grades	Weight, A (kg)	Weight, B (kg)
HDPE	Red Hybrudge	5.726	8.111
	Blue Hybrudge	2.316	3.438
	Green Hybrudge	3.495	7.532
	RFL (Red)	4.295	5.098
	RFL (Blue)	6.653	4.751
	Pepsodent	5.389	9.656
	Pran Product	0.884	0.695
LDPE	-	-	-
PP	Hard Pipe	14.611	11.317
	1 No PP	7.958	5.021
	Red PP	8.337	9.772
	Green PP	6.989	3.940
	Blue PP	8.758	5.987
	Milk PP	3.958	7.918
	Water PP	8.084	0.000
PET	-	-	-
PVC	Lota Saline	0.968	0.618
	Medical Syringe	0.632	0.464
PS	Egg Cartoons	2.358	3.785
	Pen & Brush	2.821	2.240
	Plastic Cup	1.642	0.000
Others	Wastes/Hard Item	4.126	9.656

The amount of PP in each recycling shop was in greater form than all other compositions, PVC was less and LDPE was not found there, as LDPE even if PVC items were collected separately. At the same time, they bought PETE items (locally called “Kotka”) and categorized them into white, green, and colored. Both of the recycling shops separated hard plastic items ranging from 4% to 9% that they would sell into brick manufacturing factories where it could make burning (Figure 7).

ISBN: 978-984-35-4034-8

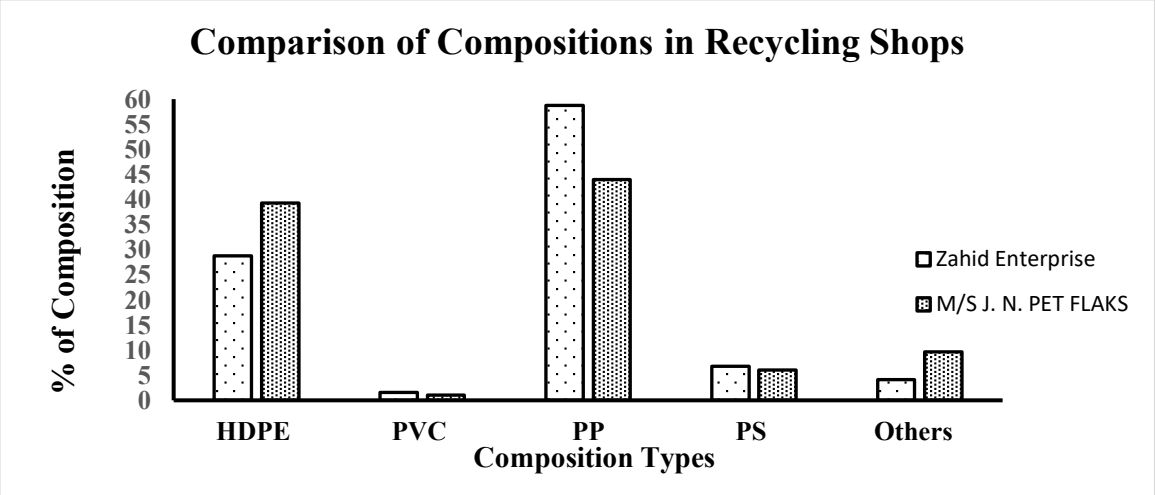

Figure 7 Composition of plastic wastes generated from the locally found grades in the recycling shops

Environmental Aspects of Plastic Waste Recycling

Plastic pollution by irreversible plastic wastes is now recognized widely to be a major environmental burden, especially in the marine environment where there is a prolonged biophysical breakdown of plastics, detrimental negative effects on wildlife, and limited plastic removal options. However, recycling shops collect these wastes, turn them into valuable materials, save lives, and clean the environment. Though the main concern of the recycling shops is economically benefited, they indirectly play an important role in the environment by keeping drainage free from water logging, the stack of plastic waste in secondary disposal points, landfill sites, and here and there in the environment. Some recycling shops were noticed to sell non-recyclable plastic fractions of 5% to 9% of the total plastic wastes they buy to the brick manufacturing industries that utilized them with burning (Figure 8. a). A maximum of the shops kept their non-recyclable PETE labels in the KCC waste trucks that were dumped in final disposal sites. Very few recycling shops situated in the residential area produced noise pollution as the cutting/shredding machine created an unbearable sound (Figure 8. b)

(a) (b)

Figure 8 (a) The non-recyclable fractions in a recycling shop stored for transporting in brick kilns; (b) a shredding machine used to make flakes of different unique plastic waste (photographer: Md. Kawsar Ahmed, 2022)

CONCLUSION

The more we use plastic materials and the less we recycle them, the more we generate plastic waste that should lead to a stack of waste in either landfill or marine environments. Therefore, a recycling shop is a must in order to reduce plastic waste from the environment. At the same time, recycling shops run a useful ongoing economy as well as create employment facilities for people who are not eligible to

work in another section of society, especially for the needy and uneducated city dwellers. However, recycling shops were engaged in separating grades of plastic waste materials in the Khulna city area in such a way that could produce unique flakes and grains that manufactured valuable products according to consumer demands. According to the composition analysis of utilized plastic waste in recycling shops, PP and HDPE were found as most abundant fractions of waste. PP materials are comparatively inexpensive which leads up to the 60 % appearance of it among the other seven categories of plastics. This study followed the local categorizing method for plastic waste composition analysis which can be improved using near-infrared spectroscopy. However, proper management of plastic recycling activities in Khulna should be maintained to emphasize plastic waste recycling practices.

ACKNOWLEDGEMENTS

The SCIP Plastics project on which this publication is based is funded by the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection under grant no. 67MM0004. Responsibility for the content of this publication lies with the author(s).

REFERENCES

Demirbas, A. (2011). Waste management, waste resource facilities and waste conversion processes. Energy Conversion and Management, 52, 1280 -1287.

Kabir, M. F., Alam, M. A., & Hridoy, R. M. (2021). Plastic Recycling from Municipal Solid Waste in Jashore City of Bangladesh. Proceedings of the 11th Annual International Conference on Industrial Engineering and Operations Management 2021 Conference (pp. 5466-5473). Singapore

Hahladakis, J. N. & Iacovidou, E. (2019). An overview of the challenges and trade-offs in closing the loop of post-consumer plastic waste (PCPW): Focus on recycling. Journal of Hazardous Materials (2019), doi.org/10.1016/j.jhazmat.2019.120887

Moniruzzaman, S. M., Bari, Q. H., & Fukuhara, T. (2011). Recycling practices of solid waste in Khulna city, Bangladesh. The Journal of Solid Waste Technology and Management, 37(1), 1-15.

Bari, Q. H., Hasan, K. M., & Haque, R. (2012). Scenario of solid waste reuse in Khulna city of Bangladesh. Waste Management, 32(12), 2526–2534

Silva, A. L. P., Prata, J. C., Walker, T. R., Campos, D., Duarte, A. C., Soares, A. M., ... & Rocha-Santos, T. (2020). Rethinking and optimising plastic waste management under COVID-19 pandemic: policy solutions based on redesign and reduction of single-use plastics and personal protective equipment. Science of the Total Environment, 742, 140565.

Roy, K. & Bari, Q. H., 2020. Study On Paper And Metal Waste Recycling In Khulna City, Proceedings of the International Conference of WasteSafe 2019 Conference (pp. 1-13). Bangladesh

Bari, Q. H., Hassan, K. M., & Haque, M. E. (2012). Solid waste recycling in Rajshahi city of Bangladesh. Waste management, 32(11), 2029-2036.

Žmak, I., & Hartmann, C. (2017). Current state of the plastic waste recycling system in the European Union and in Germany. Tehnički glasnik, 11(3), 138-142.

Jodder, P. K., Leya, R. S., Rana, M. S., & Sarkar, B. (2022). Generation and Characteristics of Household Solid Waste In Khulna City, Bangladesh. Khulna University Studies, 105-115.

Haque, A. (1998). Limits to plastics recycling in the developing and developed economy.

Diamadopoulos, E., Koutsantonakis, Y., & Zaglara, V. (1995). Optimal design of municipal solid waste recycling systems. Resources, Conservation and Recycling, 14(1), 21-34.

Lahtela, V., Hyvärinen, M., & Kärki, T. (2019). Composition of plastic fractions in waste streams: Toward more efficient recycling and utilization. Polymers, 11(1), 69.

Alabi, O. A., Ologbonjaye, K. I., Awosolu, O., & Alalade, O. E. (2019). Public and environmental health effects of plastic wastes disposal: a review. J Toxicol Risk Assess, 5(021), 1-13.