Scenario of paper waste recycling and reuse practices in Khulna city of Bangladesh

Riyad A.S.M.

Abstract— Everywhere you look you see one thing: paper. From posters and notebooks to cardboard boxes and magazines, paper is part of our everyday lives. Used paper and paper products are important raw material for paper and board industry. Recycling paper conserves natural resources, saves energy, reduces greenhouse gas emissions, and keeps landfill space free for other types of trash that can't be recycled. This study helps to scrutiny the existing management process and introduces a new proposal of sustainable management scheme to increase the capacity of the existing recycling and reuse practices. A structured questionnaire survey has been conducted in Khulna city located in the southern part of Bangladesh and ranked third largest city in the country and wastes collected from different paper industries were segregated and weighed. The total waste generation rate in Khulna city area was estimated to be 0.35 kg/cap/day and hence the total yield of waste in the city area was found to be 520 tons/day where only paper wastes contribute to almost 9.5% of this total amount. This large quantity of paper contents present in the Khulna's waste composition indicates the necessity for frequent collection and removal. This also indicates the potentials of recycling of paper wastes for resource recovery. Paper mills purchase additional post-consumer waste paper based on fiber strength, fiber yield and brightness according to the type of product produced. Khulna Newsprint Mills (KNM) a prime newsprint paper producing industrial unit of Bangladesh in the public sector. For the reuses of paper waste materials and products, a chain system was found to collect reusable wastes under a total number of 49 identified PRM with about 136 persons directly or indirectly involved in the scheme. This study revealed that apparently a silent, systematic, smooth, and clean recycling chain has been established in Khulna city area under private initiatives, whose sustainability was confirmed over the years in the country without any official or formal funds. However, proper adjustment between the higher and lower chain in the materials flow path, as well as personal hygiene training for the workers, would further improve the achievements of the established recycling scheme.

Index Terms— Solid waste, recycling, carton, paper, old used books, Khulna, reuse.

———————————————————— ◆ ————————————————————

1 INTRODUCTION

Solid waste management (SWM) is one of the critical concerns facing the developing countries because of the social, economic and environmental implementations once not properly managed. Studies shows that only 30-50% of the waste generated in developing countries is collected and managed properly (Dawit and Alebel, 2003). Higher recycling rates for valuable materials from waste streams could play a significant role substituting for virgin material production and saving fossil resources (Tonini and Astrup, 2012). Recycling is clearly a waste-management strategy, but it can also be seen as one current example of implementing the concept of industrial ecology, whereas in a natural ecosystem there are no wastes but only products (Frosch & Gallopoulos 1989; McDonough & Braungart 2002). The urban areas of Asia now spend about US$25 billion on solid waste management per year, with this figure increasing to at least US$50 billion in 2025 (World Bank, 1999). Generally, solid waste planners place too much emphasis on residential waste; this waste represents only about 30% of the overall municipal waste stream, but often receives the lion's share of attention (World Bank, 1999). The waste components requiring priority attention in Asia are organics and paper (World Bank, 1999).

———————————————

• *Riyad, A.S.M., Undergraduate Student; Dept. of Civil Enineering, Khulna University of Engineering & Technology, Khulna-9203, Bangladesh, PH-+8801825281736. E-mail: riyadtowhid@yahoo.com*

Thus, an appropriate solid waste management scheme is necessary to face global environmental challenges in the 21st century. More specifically, solid waste problems in developing countries are aggravated by the malfunctioning of traditional waste management systems due to the rapid development and the concentration of the population (Deshmukh et al., 2002). The total population of developing countries accounts for more than 70% of the world's population (JICA, 2005). Waste management in these countries is of grave concern from two points of view. Firstly, the process of urbanization and population concentration that is inextricably linked to waste management issues is progressing at a pace that is much faster than was ever experienced by today's industrialized countries (DESA, 2011). The issue of waste management in developing countries, therefore, has emerged as a critical and impending disaster. Secondly, these countries often have difficulty in streamlining the institutional systems, administrative bodies, management capabilities and human resources that are needed to take the lead in solving solid waste problems (UNEP, 2009).

Khulna, the third largest city of Bangladesh with a large population has been a place of commercial importance for more than 150 years. Management of solid waste in the municipal area is the responsibility of KCC. Average total per capita waste generation rate of KCC area is estimated at 0.35 kg/cap/day. Total waste generation is calculated at 520 tons/day where paper waste forms almost 9.5% of this total waste (Waste safe 2005). The main motive of this study is to introduce a sustainable management process for paper waste recycling which is beneficial in economic consideration and defend the working environment from its harmful effect.

2 METHODOLOGY

2.1 Selection of study area

Khulna, the third largest city of Bangladesh, is located in the southern part of the country and is situated below the tropic of cancer, around the intersection of latitude 22.490N and longitude 89.340E. The area of Khulna city is 47 square km with a population 1.5 million (BBS, 2009). With regards to investigating the activities of paper waste recycling, a field survey was conducted in the Khulna city area. The shops for recycling materials (PRMs) were developed in the vicinity of three types of transportation modes such as the city railway station, city river port and a local truck stand. The selected study sites for PRM in Khulna city were: Khalishpur (KP), Daulatpur (DP), Railway Market (RM), Power House (PH), and other places (OPs) which cover Moilapota (MP), Gollamari and the Lobonchora area (Fig. 1).
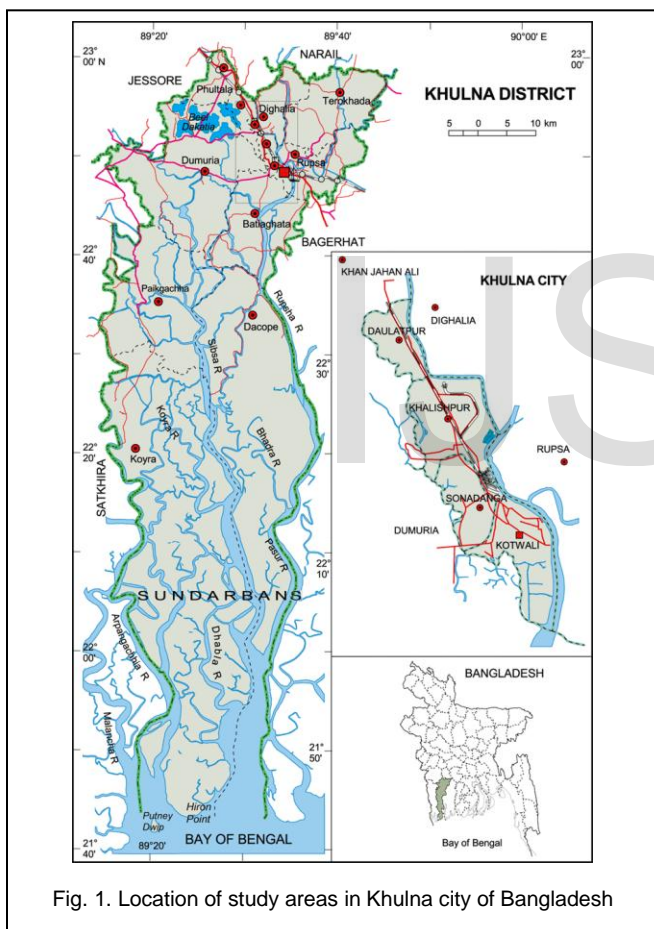

Fig. 1. Location of study areas in Khulna city of Bangladesh

2.2 Data Collection & Analysis

Both primary and secondary data were collected in doing this research. Primary data, such as the opinion from waste collectors, recyclable dealers, industry workers and KCC officials through in depth interview. Secondary data, such as statistics and reports on the quantity of solid waste generated and its composition and management practices of Khulna has been collected by searching previous study, books and journals etc.

The data has been interpreted in a quite simple and straightforward way. The important points were noted, sorted and classified from the information obtained from observations and interviews.

3 RESULTS AND DISCUSSION

3.1 Recycling trade chain

From survey, it is clear that private sectors are responsible for recycling of solid waste in Khulna city. The waste collectors from private sectors are playing a prominent role in collection of recyclables as a main source of income. At the lowest stratum of the recycling industry is the wastebin tokais. They are visible in every community of the city and come from nearby slums and squatter settlements. It is estimated that at present 1312 tokais are working in KCC area. Feriwallas are the buyers of separated recyclable items stored for selling at the primary source. This study reveals that there are around 695 feriwallas involved in the chain of recycling network of Khulna. The small recyclable dealers (SRDs) purchase waste materials from tokais and feriwallas in exchange of money. More than 277 SRDs in Khulna accept all types of waste from tokais and feriwallas and sell the recovered materials to medium recyclable dealers (MRDs). The MRDs usually deals with more than two kinds of specific wastes and passes these recyclable to the large recyclable dealers (LRDs) that essentially specialize in specific wastes. There are about 140 medium recyclable dealers in Khulna. They employ 5 to 7 people to segregate the waste. In KCC area there are about 33 LRDs. They receive their supply from all over Khulna and also from Chittagong. Most of the LRDs employ 12 to 15 people to sort, clean and sell the recovered materials to industries both in the formal and the private sectors. They do not buy directly from the waste collectors. One of the important reasons for this is the variable quantity and small quantity. Trade between LRDs and RIs is more formal than the existing relationships among the SRDs and tokais. Sometimes LRDs use their own transport may be a tricycle (rickshaw van) or open truck. The price of these materials varies with the supply and demand of the market. Table 1 show that a feriwalla fetches highest amount of paper (37.56%) every day. Most of the papers comprise of newspapers, magazines, books and other source separated clean papers.

3.2 Recycling shops and reuse scheme in Khulna city

There are few numbers of papers recycling shop in Khulna. Scrap papers were recycled in a factory to reprocess paper products. The paper materials were found to be the second highest, 9.5% by weight, of all the total waste components generated in the city area (Moniruzzaman, 2007). Including corrugated cardboard, high grade paper and mixed paper typically accounted for 39% of the total recyclable wastes collected by different collectors and dealers. A paper-recycling factory usually recycled damaged articles and scrap papers and finally produced card board and thin papers. The secondary products from card boards were packets for sweets, shoes, electrical fittings, cartons, etc. Another use of this card board was for book binding. The thin recycled papers were used to produce shopping bags especially for clothes stores. The world has a huge appetite for paper, even in these days of the so-called 'paper-

TABLE 1
DAILY QUANTITY OF RECYCLABLES PAPER COLLECTED PER DAY
IN KHULNA

Collectors	Quantity Collected per day (kg)	Percentage of Recyclable Materials
Wastebin Tokais	300	18.18
Feriwallas	2400	37.56
Vangari Dokans	2000	16.26
Wholesale shops	2400	20

(Source: Waste Concern, 2005)

less' office. Global paper consumption is currently running at more than 350 million tons per year and rapidly approaching an unsustainable one million tons per day (EPN, 2007). In Fig. 2, Informal waste recovery and recycling network in Khulna city has been shown.
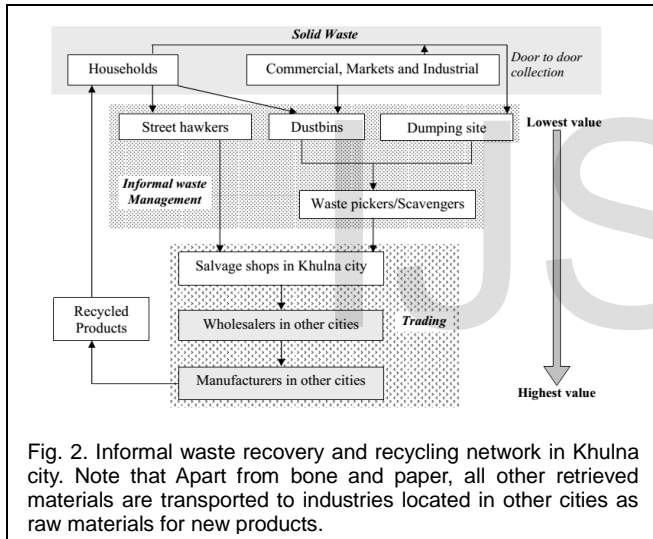

Fig. 2. Informal waste recovery and recycling network in Khulna city. Note that Apart from bone and paper, all other retrieved materials are transported to industries located in other cities as raw materials for new products.

Grocer reuses one portion of discarded paper by making packets. Paper mills have always recycled damaged product and scrap from converters such as Sattar Paper Mill. Paper mills purchase additional post-consumer waste paper based on fiber strength, fiber yield and brightness according to the type of product produced. Khulna Newsprint Mills (KNM) a prime newsprint paper producing industrial unit of Bangladesh in the public sector. The initial production capacity of KNM was 50,000 tons, distributed as newsprint (23,000 tons), mechanical print papers (17,000 tons) and lightweight papers like blue match, tissue and wraps (10,000 tons). KNM has about 3,000 workers and other employees. The mill consumes 20 million gallons of water, 350,000 kilowatt of electricity and 33,600 gallons of furnace oil daily to produce papers of different qualities and weight. The types of paper produced include newsprint of 52 and 48.8 gram per square metre (gsm), bluish white print of 50-60 gsm, coloured paper of 55-60 gsm, wrapping paper of 42-125 gsm, blue match papers of 42 gsm, dupli-

cating paper of 68 gsm and tissue paper of 28-29 gsm. The processes of paper recycling in steps are shown in Fig.3 & 4. Much of the virgin paper is not recycled and ends up buried in landfill. Recyclable paper can be ruined by mixing it with other materials such as food scraps. This means the paper cannot be recycled and has to be sent to landfill. The fact that paper degrades quite slowly in a landfill situation counts against it. It has been estimated that the recovery rate of paper in India is only 26%, compared to Thailand's 45%, China's 38%, and Germany's 80% (Cybermedia, 2009). The reason for this is mainly due to low levels of awareness among the public, as well as the unorganized nature of the business.
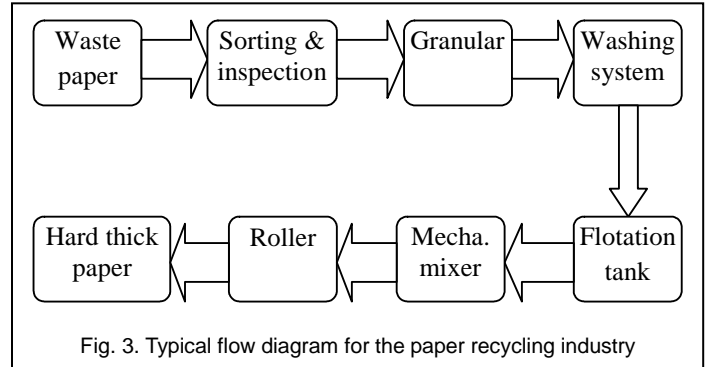

Fig. 3. Typical flow diagram for the paper recycling industry

Fig. 4. Mixing and rolling in a paper mill

The shops for reusable material (PRM) use to sell and buy the valuable parts of paper waste materials for their further use. These shops were classified into four groups according to the materials dealt with: paper carton, book, paper, and mixed items (Table 2). Most of the shops were small in size with few workers, 1–3 (average 1.75 per PRM), and located near Khulna Railway Market and Powerhouse Truck Station areas. From the field survey it was found that the major reusable materials were different types of papers, paper products (packets), books, etc.

Specific outcomes of this study for major reusable materials were delineated in the following sections

3.2.1 Cartons

A total number of 12 SRM were found to dealing with different types of cartons or packaging boxes. Mostly, they handled

around 80–500 kg cartons every day for each shop as shown in Table 3. They used to buy cartons about @Tk 10 per kg and sale @ Tk 12 per kg. The activities had been continuing smoothly under a systematic chain which gradually increased the reuse of the materials and hence reduced the total waste generation (Fig. 5).

TABLE 2
NUMBER, CLASSIFICATION AND WORKER OF PRMs IN DIFFERENT LOCATIONS

Place (paper)	Carton	Book	Paper	Mixed of all	Total	Worker
KP	-	-	5 (5)	9 (9)	14	21+[a]4
DP	-	-	1 (1)	3 (3)	4	10+35
RM	6 (12)	-	(1)	-	6	10+6
PH	-	5 (13)	-	1 (1)	6	11
OP	-	-	-	4 (4)	4	11+15
Total	6 (12)	5 (13)	6 (7)	17 (17)	34 (49)	63+60
Average worker (internal including owner+ external)		1.75 + 1.02				
Total worker (internal including owner+ external)		86+50				
Total worker		136				

() Number including all identified PRM from preliminary survey

[a] Number of external workers.

TABLE 3
WASTE MATERIALS AND PRODUCTS FOR REUSE: CARTON AND PAPER

Shop no.	Waste			Product		
	Types	Amount (kg d^{-1})	Price (Tk/kg)	Types	Price (Tk/kg)	
01	Cartons	400-500	10	Cartons	12	
02	Paper	75-200	12-23	Paper	15-25	
03	Cartons	340-420	10.50	Cartons	12	
04	Paper	85-160	11-22	Paper	13-23	
05	Cartons	370-500	10-20	Cartons	11-21	
06	Paper	600-800	-	Small paper	-	
07	Cartons	80-120	12.50	Cartons	13.50	
08	Cartons	500	10	Cartons	12	
	Average of carton	373[b]				
	Average of paper	320[b]				

[b] kg d-1 per PRM; (1 Euro=105 Taka, September 30, 2013)..

3.2.2 Old books

Most of the PRM for old books were found in close proximity to Power House and Railway market area. A total number of 13 PRM for old books were identified in Khulna city area. Among those, five PRM were surveyed in detail and the information was documented in Table 4. Usually, those PRM had been dealing with all kinds of books. Their buying capacity varied in the range of TK 750–1500 per day, while sales ranged from around Tk 900 to 2200 per day. Most of the good looking books were bought by students and other books by different shopkeepers for packaging purposes (Fig. 6).

Fig. 5. Activities observed on production of cartons in Khulna

Fig. 6. Shops for buying and selling of books in Khulna city area.

3.2.3 Paper reuses

Paper packets have been used traditionally by all the shopkeepers to sell consumer goods. These packets were made of new papers or used papers (including newspaper, books and used office paper) by informal cottage industries. Used papers were collected from different SRM or directly from the community in residential areas. Subsequently, different sizes and types of paper packets were made using glue and papers (Fig. 7). The number of different sizes of paper packets per kg was given in Table 5. The number of packets varied widely accord-

TABLE 4
WASTE MATERIALS AND PRODUCTS FOR REUSE: OLD USED BOOKS

Shop no.	Amount* (kg d-1)	Buy (Tk d-1)	Sale (Tk d-1)
01	65-75	975-1125	1050-1500
02	100	1500	2167
03	50	750	900-1000
04	70-80	1050-1200	1500
05	50-60	750-900	900-1500
Average	70		

*Calculated value (considering a price calculated from Table 3 for paper as 15Tk kg-1)

ing to their size. The price of the packet was not assigned according to the sizes but to the weights. The price of different sized paper packets were approximately Tk 50 per kg. The quantity of books, papers and mixed papers that were reused every day were 0.85, 2.07 and 3.32 tons, respectively in Khulna city.
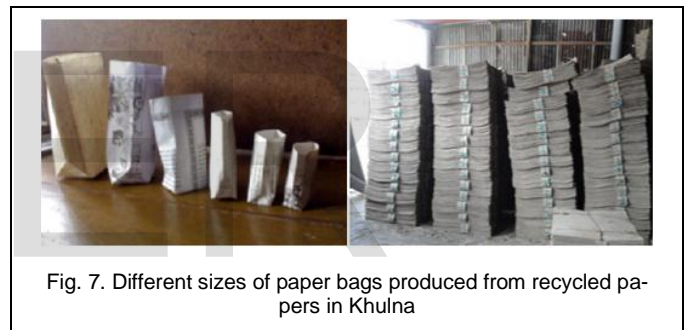

Fig. 7. Different sizes of paper bags produced from recycled papers in Khulna

TABLE 5
DIFFERENT SIZES OF PACKETS MADE OF WASTE PAPERS (PRICE: 50TK KG-1 OF ANY SIZE PACKET)

Different sizes of packets	Number of packets per kg
Tiny	800
Small 1	500
Small 2	300
Medium 1	250
Medium 2	200

A total number of 17 PRM in mixed of different solid waste were identified in Khulna city area. Among those, eight PRM were surveyed in detail and the information was documented in Table 6.

TABLE 6
ESTIMATION OF PAPERS IN MIXED PRM

Shop no.	Location	Total amount of paper, plastic and metal (kg d⁻¹)	Estimated amount of paper* (kg d⁻¹)
01	DP	400-600	228
02	DP	1200	548
03	DP	150-600	171
04	DP	150-300	103
05	MP	500-700	274
06	MP	80-100	41
07	MP	700-1200	434
08	MP	35-130	38
		Average	230

*Calculation based on the ratio paper:plastic:metal = 2.65:1:2.15, which was derived from another study by Moniruzzaman (2007).

3.2.4 Quantities of paper reused in Khulna city

The estimated total quantity of waste per category was shown in Table 7. The total quantity of waste materials and products subjected to reuse under all PRMs was estimated at an average 10.94 ton d⁻¹. In fact, this part of reused waste materials had not been entered into the waste stream for disposal. Both the recycled and reused materials (mostly paper and plastics) had a level of moisture content less than 8.5%, while the municipal solid waste (MSW) generated in Bangladesh had an average moisture content of around 65% (Bari, 1999).

TABLE 7
ESTIMATION OF TOTAL REUSABLE WASTE PER DAY BY ALL PRM IN KHULNA CITY AREA

Parameters (paper)	Carton	Book	Paper	Mixed (paper)	Total
No. of SRM in each category	12	13	7	17	49 No.
Average kg d⁻¹ per SRM	373	70	320	195	-
Total kg d⁻¹ in each category	4476	910	2240	3315	10,941
Total ton d⁻¹ in each category	4.48	0.91	2.24	3.32	10.94

4 PROPOSED MODEL

New proposed management process progressed by the following diagram (Fig. 8). In this process, In this process, firstly generated solid waste are recognized and these are stored separately in different bins according to their types such as plastic bins, glass bins etc. Different colors bins are used for storage. It is helpful to differentiate the storage materials. Recycling factory should have one divisional factory in every district. NGO/ Recycling Factory agent of Pouroshova/City Corporation in urban area collect paper waste from household/office. In rural area, thana collectors collect the waste and transfer these to pouroshova/city corporation. District branch collectors collect the waste and separate it according to types such as parts of books, newspapers, cartons etc. In divisional recycling factory, workers of different units separate the recyclable and non-recyclable wastes and then recycle the recyclable waste separately. New products go to the consumer hand and reuse it. Non-recyclable wastes are properly transported to landfill site for converting into compost/fertilizer and after processing deliver to the consumer.

5 CONCLUSIONS

In summary, recycling is one strategy for end-of-life waste management of paper products. Paper waste management has assumed great significance in view of the urbanization activities in Khulna. KNM has about 3,000 workers and other employees. A silent, systematic, smooth-running and clean reuse chain has been established in Khulna city area managed entirely by the private sector. A total number of 49 shops for reusable materials (PRMs) were identified in the city area in which 136 people were employed in different activities of the established reuse scheme. According to mass balance, about 10.94 tons d⁻¹ paper wastes were recycled and reused in the Khulna city area which accounted for 2.10% of the total generated wastes. This study revealed that the solid waste reuse pattern in the Khulna city area has become quiet established; however, further extensive public motivation would increase the number of other reusable items as well as the amount of total reusable materials. The formulated general physical model suggests that the large number of waste wholesale shops in the city area should be properly adjusted with their upper and lower chains in order to improve the overall reuse and recycling scheme. Furthermore, a comprehensive training program on personal hygiene was deemed imperative for the workers in all reuse schemes. Particularly, the outcome of this study would provide data for any future endeavor concerning the reuse and recycling of solid wastes in cities and towns in-developing countries.

Fig. 8. Proposed management process of paper waste
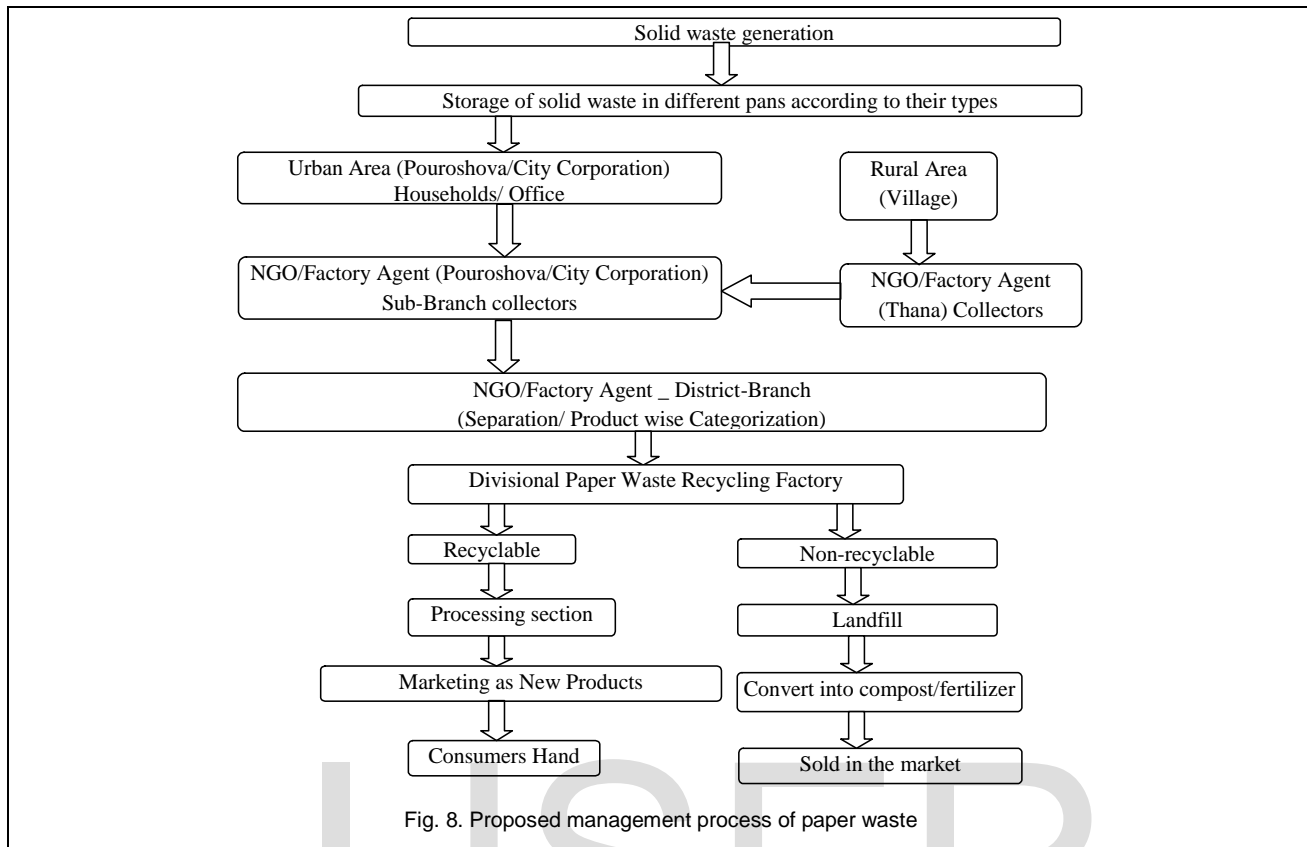
REFERENCES

[1] Bari, Q.H., 1999. Effect of different modes of aeration on composting of solid waste in a closed system. Ph.D. Thesis, Department of Civil Engineering, The University of Hong Kong, Hong Kong.K F Hansen, Bending and shear test with masonry, SBI bulletin 123, Danish Building research Institute , Hørsholm, Denmark, 1999.

[2] BBS, 2009. Statistical Pocket Book of Bangladesh. Bangladesh Bureau of Statistics. p.8.

[3] Cybermedia, 2009. Waste Paper Business: Opportunities – Energy & Environment. http://www.dare.co.in/opportunities/energy-environment/waste-paper-business. htm (accessed 14.04.12)

[4] Dawit W. and Alebel B, 2003. Improvement of solid waste management in Addis Ababa, A participatory Approach (Draft). Addis Ababa, Ethiopia.

[5] Deshmukh, S., Gupta, R., Agrawal, V.S., 2002. Improving the solid waste management by developing the people's perception – a case study. International Waste Management Biennial Congress & Exhibition, Durban.

[6] DESA, 2011. World Urbanization Prospects. Department of Economic and Social Affairs/Population Division, United Nations, New York.

[7] Environmental Paper Network (EPN), 2007. Social Impact of the Paper Industry. http://www.greenpressinitiative.org/documents/socialimpactsfactsheet.pdf (accessed 14.04.13).

[8] Frosch, R. & Gallopoulos, N. 1989. Strategies for manufacturing. Sci. Am.261, 144–152.

[9] JICA 2005. Supporting Capacity Development in Solid Waste Management in Developing Countries – Towards Improving Solid Waste Management Capacity of Entire Societies, Japan International Cooperation Agency.

[10] McDonough, W. & Braungart, M. 2002. Cradle to cradle: remaking the way we make things New York, NY: North Point Press.

[11] Moniruzzaman, S.M., 2007. Recycling of solid waste in Khulna City. M. Eng. Thesis. Department of Civil Engineering, Khulna University of Engineering & Technology, KUET, Bangladesh.

[12] Tonini, D., Astrup, T., 2012. Life-cycle assessment of a waste refinery process for enzymatic treatment of municipal solid waste. Waste Management 32, 165–176.

[13] UNEP, 2009. Developing Integrated Solid Waste Management Plan, Training Manual, vol. 4. ISWM Plan, United Nations Environmental Programme, Osaka/ Shiga, Japan.

[14] Waste Concern 2000, Aborjona O Poribesh. A Newsletter on solid waste management and recycling in Bangladesh, Issue- 5, Edited by Enayetullah, I. And Sinha, M. M.

[15] Waste Safe, 2005. Integrated Management and Safe Disposal of Municipal Solid Waste in Least Developed Asian Countries – A Feasibility Study. Department of Civil Engineering, KUET, Bangladesh & Asia Pro Eco Program of the European Commission.

[16] World Bank, 1999. What a waste: solid waste management in Asia, urban development sector unit. East Asia and Pacific Region. The International Bank for Reconstruction and Development, Washington DC, USA.