

RECYCLING APPROACH OF WASTE PAPER AND PLASTIC IN KHULNA CITY OF BANGLADESH

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ABSTRACT

In order to achieve proper solid waste management, many efforts in Bangladesh have been focused on waste collection and disposal only. However, the informal sector has been practicing recycling as a source of income for a long time. This paper looks at the existing recycling pattern of waste paper and plastic and evaluates the income generation from the recycled products in the Khulna city. This paper presents the findings of a study that was conducted in Khulna city to assess and analyze the existing recycling practice of waste paper and plastic. The study reveals that the profit margin for paper and plastic recycling varies between 40 to 80% and 23 to 100%, respectively. The study finds that about 26% of the total generated waste paper and about 69% of the total generated waste plastic are recycled. Due to this recycling of waste paper and plastic of together 23.85 ton/day, the informal sector is saving the expenditure of solid waste management of about 8,600,000 BDT/year. Finally an approach is proposed to increase the efficiency of existing recycling practice which can earn net profit of 54,676,222 BDT/year.

Keywords: *Informal sector, Income generation, Paper and plastic, Recycling approach, Solid waste management*

1. INTRODUCTION

Management of solid waste has become a major problem and big challenge in most of the urban centers, particularly in the rapidly growing cities of developing countries. Solid waste generation is now increasing due to rapid urbanization, industrialization and population growth. The total municipal solid waste (MSW) generated in Khulna city of Bangladesh is about 520 ton/day and its physical composition is food and vegetables 78.9%, papers 9.5%, plastics 3.1%, textiles 1.3%, metals 1.1%, glasses 0.5%, rubbers 0.5%, dusts 3.7% and others 1.3% (WasteSafe, 2005). From this composition, it is evident that papers (9.5% = 49.4 ton /day) and plastics (3.1% = 16.1 ton/day) are the second and third highest fraction respectively, in Khulna city's waste. The quantity of the recyclable solid waste (RSW) is 70 ton/day in Khulna, which includes paper, plastic, metal, bone and glass (Moniruzzaman, 2007). From this RSW of Khulna city mainly papers and plastics, which are light weight and easily accessible, are recovered by the waste collectors of the informal sector. The informal sector is characterized by small-scale, labor-intensive, largely unregulated and unregistered, low-technology, manufacturing or provisions of services (Wilson et al., 2001). Informal sector entrepreneurs or enterprises do not pay taxes, have no trading license and are not included in social welfare or government insurance schemes (Hann et al., 1998). In the context of solid waste recycling in Bangladesh, the informal sector refers to the waste collectors, dealers and recycling industries (RI).

Waste paper covers a wide variety of different types of used papers such as newspapers, magazines, junk mail, white envelopes without windows, office paper, holiday brochures, catalogues and white directories (e.g. phone books) which can be recycled. However, lack of source segregation results in waste paper getting contaminated and becoming unusable. Recycling of MSW is now recognized as the most environmentally sound strategy by following only a preventive strategy of source reduction and reuse (EPA, 2004). There are mainly three reasons for waste paper recycling. Firstly, waste paper dumped into landfill sites does certainly biodegrade but this produces methane gas that is responsible for global warming. Secondly, recycled paper uses 55% less water than making virgin paper and helps preserve our forests (Gumber, 2006). Thirdly, waste paper recycling actually uses less energy than making virgin paper (According to Gumber, 2006, 60-70% energy savings over virgin paper production).

Plastic is one of the most commonly used materials in the world. However, its popularity is also its curse. Our landfills are filling with waste plastics that do not biodegrade, and we are using nonrenewable resources to produce more plastic. When plastics are buried in a landfill, they occupy about 25 % of the space (Museum of

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Solid Waste, 2006). According to Diamadopoulos et al. (1995), if solid wastes are not recycled, the space in landfills will be exhausted very quickly and necessitate the construction of new ones. Plastics are not the waste and energy culprits that some people think they are. Therefore, recycling and lengthening the lifespan of plastic products are important. Fortunately, plastic recycling has many advantages, and it is one of the easiest ways to be environmentally friendly. The main advantages of plastic recycling are: (1) energy conservation, (2) reduced CO₂ emission, (3) saving landfill space and (4) saving marine life.

Bangladesh is generally faced with the rapid deterioration of environmental and sanitation conditions due to the conventional system of collection, transportation and the crude dumping of MSW. Therefore, urban solid waste management has become a major concern for cities and towns in the country. Many efforts in Bangladesh have only been focused on waste collection and disposal to attain proper solid waste management. However, the recycling activities have been going on traditionally by the informal sector for their livelihoods in Bangladesh from time immemorial. This paper looks in brief at the current waste paper and plastic recycling patterns in Khulna city and evaluates the income generation from this informal sector recycling existing in the country. It is expected that the scenarios in Khulna city can serve as an example in explaining the traditional recycling pattern not only as a way of sustainable solid waste management but also as a source of income generating activity in Bangladesh.

2. SURVEY PROCEDURE

In order to get a clear picture of the waste paper and plastic recycling activities, a field survey was conducted all over the Khulna city. It was observed that many individual waste collectors, recyclable dealers and recycling industries (RI) were practicing recycling activity in Khulna. From the survey, it was found that recycling dealers or industries were available only in some areas, namely Shiromoni, Fulbarigate, Daulatpur, Khalishpur, Shekhpara, Sonadanga, Gollamari and Lobonchora. Therefore, all these areas where recycling activities were going on, were selected. Different sets of questionnaires were designed for waste collectors, dealers and the employees of RI to obtain information about the ongoing waste recycling system. Sixty waste collectors of different ages (12 to 50 years) were selected from all over the study area to take the interview. The amount of waste papers and plastics collected in one day by each of them were weighed. Information about their living place, mode of transportation and working conditions was also obtained from the questionnaire survey.

All the dealers were surveyed in this study and most of them participated in the interview. The quantity of waste collection, the buying and selling prices were collected from the record book of each of the dealers. The information about the source of their collection and selling place were obtained from the questionnaire survey. The study used surveys about the employees working in the recycling industry in order to get information concerning problems, prospects, patterns and the quantity of recycling in real life situations. The number of RI that are producing recycled materials from the processed waste was determined by the field survey. Each of these RI was surveyed in this study. The quantities of recycled product from waste paper or plastic were obtained from the record book of recycling industries. Information about the prices of RSW was also obtained from the questionnaire survey.

3. RECYCLING PATTERN IN KHULNA

The various groups of the informal sector such as waste collectors, dealers and some RI who do not receive any funding from the government are practicing recycling activities in an unorganized and unplanned way as a source of their income. The informal sector recycling is described as follows.

(a) Sources: Households, institutes, market places are the primary source of waste paper and plastic in Khulna. People are using plastic and paper products for different purpose of their daily life. Waste papers and plastics have economic value. Some portion of these wastes are separated by some people at primary source for sale.

(b) Waste collectors: The waste collectors are the first link in a long chain of recycling. They are visible in every community of the city and came from nearby slums. This group comprises of men, women and children. Waste collectors are categorized into two groups: House to house waste collectors (usually men and women; locally known as feriwala) and waste bin collectors (usually children; both sexes, age below 15 years; locally referred to as tokai). Generally tokais collect old paper and plastic products from the mixed waste dumped in the waste bin, disposal site and road side as shown in Figure 1(a). They carry the separated waste in a plastic bag and sell it to the dealers at different prices depending on the type and quality of the waste. They never use gloves and work in unhygienic conditions. This job is identified as the main source of their livelihood. During rainy season, their

collection quantity is very little. Feriwalas, on the other hand, buy the separated waste paper and plastic items stored for selling in homes and institutions as shown in Figure 1(b). They purchase recyclable wastes which are not contaminated by mixing with biodegradable waste in exchange for money or gifts and sell those materials to the dealers at a small profit. The total number of waste collectors in Khulna city is 2000 (1305 tokai and 695 feriwala) (Moniruzzaman *et al.*, 2011).



(a) A tokai collects waste from a waste bin



(b) A feriwala purchase waste from household

Figure 1 Status of waste paper and plastic collection

(c) Dealers: Recycle dealers are the second link in the chain of recycling. They are categorized into three broad groups on the basis of the quantity of waste collection according to Moniruzzaman *et al.*, 2011 as follows. (1) Small Scale Recycling Dealers (SSRD): their collection of RSW is less than 250 kg/day on average, (2) Medium Scale Recycling Dealers (MSRD): RSW collection by each MSRD is within a range between 250 kg/day to 600 kg/day on average and (3) Large Scale Recycling Dealers (LSRD): On an average the amount of RSW collection by each LSRD is greater than 600 kg/day.

The SSRD purchase recyclable waste from waste collectors'. They sort, clean and sell the processed wastes to the MSRD. The MSRD purchase waste paper or plastic from different SSRD, accumulate the processed waste and sell those to LSRD. The LSRD collect waste from all MSRD, accumulate and sell it to recycling industries (RI).

(d) Recycling Industries (RI): Final destination of the materials collected by different actors starting from feriwalas, tokais comes to RI through a chain of dealers like SSRD, MSRD and LSRD. The RI recycle the processed waste and finally sell it to market.

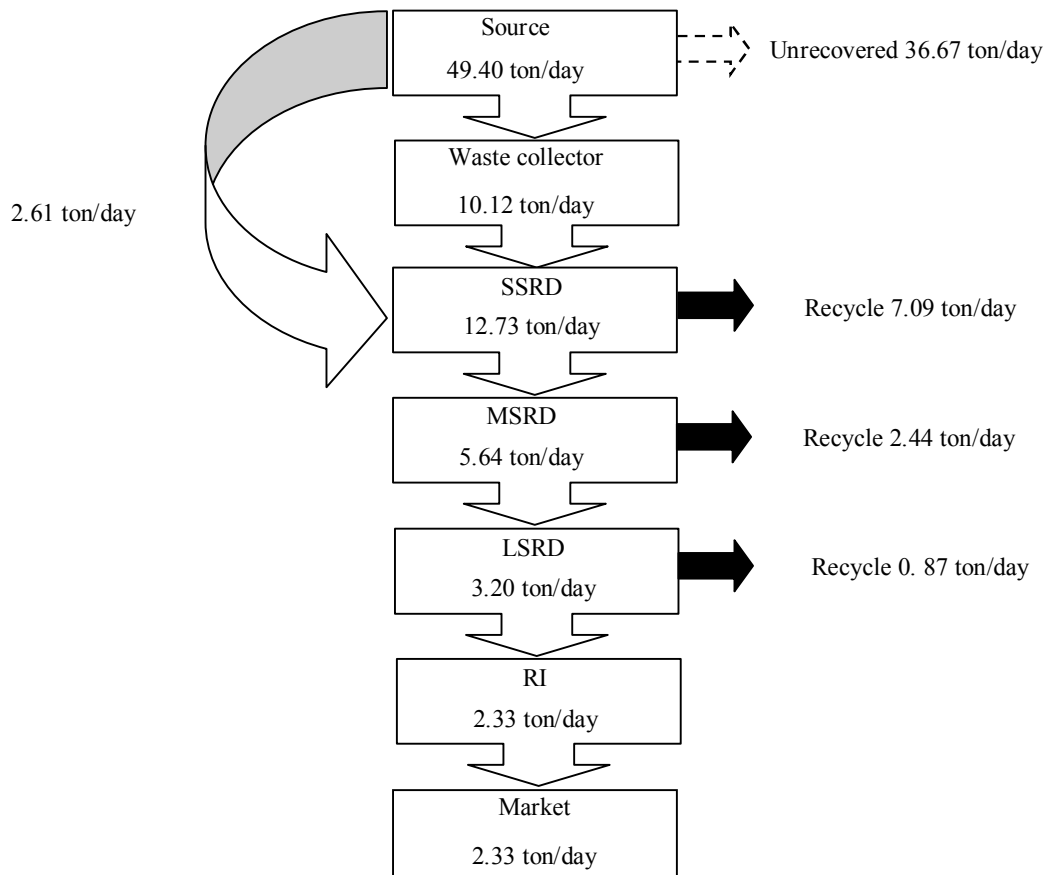
4. RESULTS AND DISCUSSIONS

4.1 Waste Paper Recycling

From the field survey it was found that the average waste paper collected by each collector was 5.06 kg/day. Therefore, total waste paper collected by 2000 collectors was 10.12 ton/day. The amount of waste paper processed/recycled by different dealers (SSRD, MSRD, and LSRD) and RI are summarized in Table 1. The schematic mass balance of waste paper recycling in Khulna city is shown in Figure 2. From this study, it was observed that 12.73 ton/day of waste paper (26% of total generated waste paper) were recovered for recycling of which 10.12 ton/day was collected through the waste collectors (3.38 ton/day by tokai and 6.74 ton /day by feriwala) and 2.61 ton/day was collected by the SSRD directly from sources as shown in Figure 2. In the recycling chain SSRD, MSRD and LSRD were found to recycle paper for writing or covering food or recycle it to paper packets of 7.09 ton/day, 2.44 ton/day and 0.87 ton/day, respectively. The rest amount of 2.33 ton/day was sold to the paper RI for final recycling as shown in Figure 2. Due to lack of source separation and mixing with other biodegradable waste, 36.67 ton/day of waste paper was found to be unrecovered.

Table 1 Average quantity of waste paper processed by informal sector in Khulna city

Location	Amount of Waste Paper Processed (Kg/day)			
	SSRD	MSRD	LSRD	RI
Fulbarigate	324	-	-	-
Shekhpara	8883	3990	1440	-
Dakhbangla	240	74	801	-
Munshipara	180	-	-	-
Dawlotpur	525	276	-	-
Khalishpur	1050	416	234	-
Gollamari	200	243	-	-
Sonadanga	147	-	-	-
Labonchara	140	-	-	2334
Shiromoni	75	-	-	-
Other places	962	644	720	-
Total	12726	5643	3195	2334

**Figure 2** Schematic mass balance for waste paper recycling activity in Khulna city

There is one paper recycling industry in Khulna city. It was found to consume scrap paper to reprocess the paper product. 2.33 ton/day of waste paper such as corrugated cardboard, high-grade paper and mixed paper were found to recycle by the RI. The paper RI was found to purchase additional post consumer waste paper based on fiber strength, fiber yield and brightness according to the type of product produced. RI purchased waste paper from LSRD and recycled it by sorting, cleaning, cutting into small pieces, washing, mixing with water and finally by rolling over a roller. From these recycled papers, new products such as packet of sweets, hardboard, and bookbinder covers, cartons, shopping bags etc were produced. The flow diagram and the pictures of various

steps of waste paper recycling process in the paper RI of Khulna city are shown in Figure 3 and Figure 4, respectively.

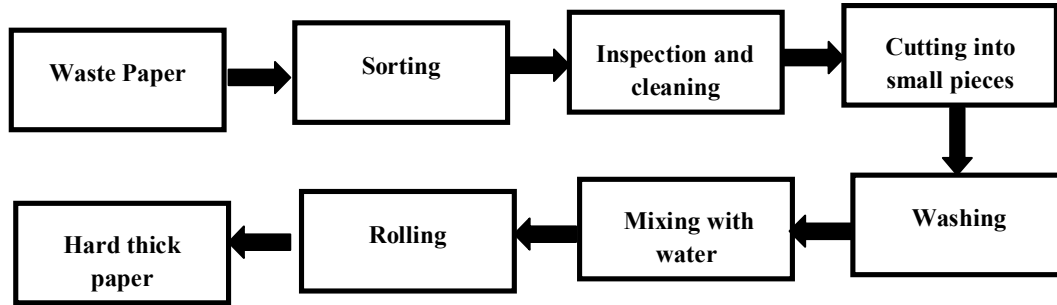


Figure 3 A typical flow diagram for waste paper recycling process in Khulna city



Figure 4 Waste paper recycling process in a paper recycling industry in Khulna city

4.2 Waste Plastic Recycling

It was observed that the average waste plastic collected by each collector was 2.43 kg/day in Khulna city. Therefore, total waste plastic collected by 2000 collectors was 4.85 ton/day. The amount of waste plastic processed or recycled by different dealers (SSRD, MSRD and LSRD) and RI are summarized in Table 2. The schematic mass balance of waste plastic recycling in Khulna city is shown in Figure 5. From this study, it was observed that 11.12 ton/day of waste plastic (69% of total generated waste plastic) were recovered for recycling of which 4.85 ton/day was collected through the waste collectors (1.62 ton/day by tokai and 3.23 ton/day by feriwala) and SSRD and 6.27 ton/day was collected by the MSRD directly from sources as shown in Figure 5. Due to lack of source separation and mixing with other biodegradable waste, 4.98 ton/day of waste plastic was found to be unrecovered. In the recycling chain MSRD were found to reuse plastic bottles for storing water of 3.61 ton/day and sell the remaining processed waste plastic to LSRD and RI as shown in Figure 5.

Table 2 Average quantity of waste plastic processed by informal sector in Khulna

Location	Amount of Plastic Collected (Kg/day)			
	SSRD	MSRD	LSRD	RI
Fulbarigate	144	-	-	-
Shekhpara	2820	9690	4160	2000
Dakhbangla	132	86	493	-
Munshipara	102	-	-	-
Dawlotpur	210	245	-	-
Khalishpur	600	485	342	-
Gollamari	90	135	-	1013
Sonadanga	42	-	-	-
Labonchara	60	-	-	4500
Shiromoni	21	-	-	-
Other places	629	474	856	-
Total	4850	11115	5851	7513

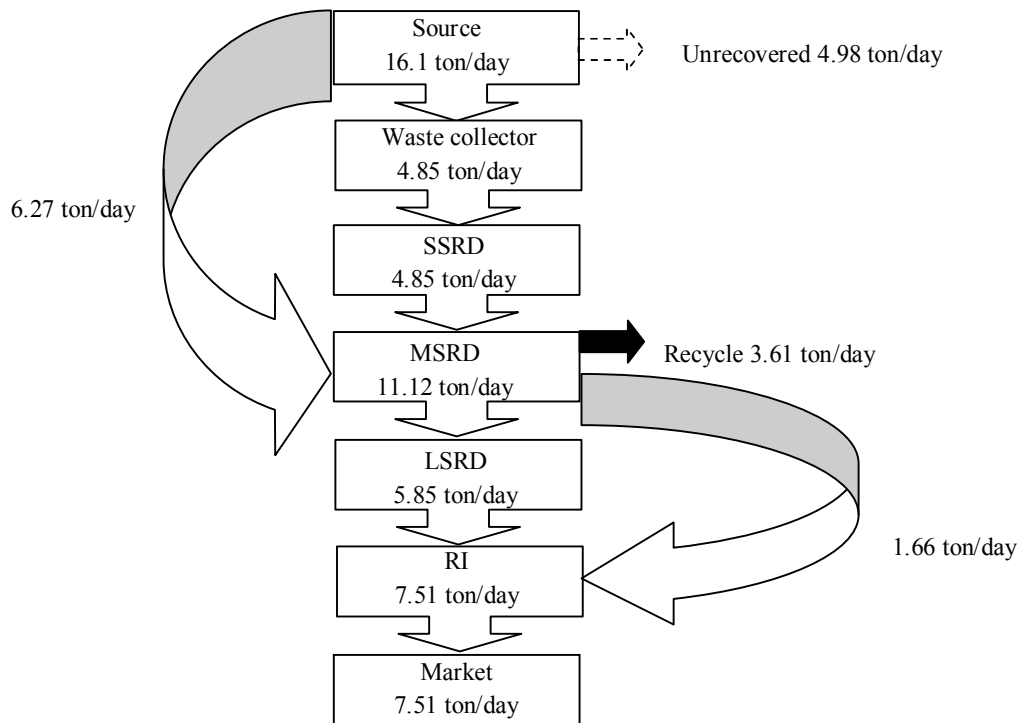


Figure 5 Schematic mass balance for waste plastic recycling activity in Khulna city

The flow diagram of various steps of waste plastic recycling process in RI of Khulna city is shown in Figure 6.

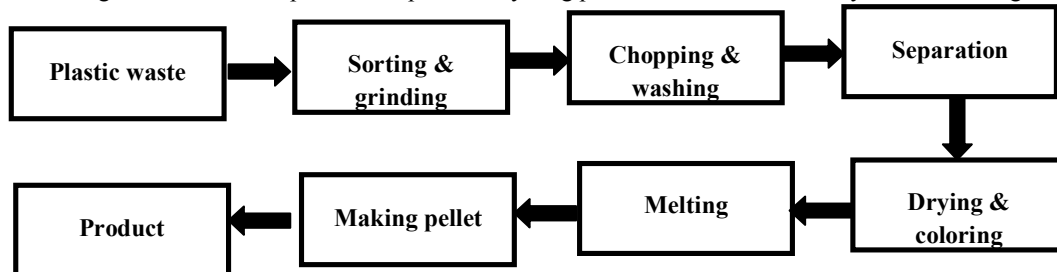


Figure 6 Typical flow diagram of waste plastic recycling process in Khulna city

(b) Washing: Sorted or broken materials are washed. The chips are washed using hot water, detergents to remove labels, adhesives and dirt and a centrifugal separator is used to separate the flakes from the dirty water, paper and debris.

(c) Separation: After they are washed, if the mixture does not separate readily a series of hydro cyclones may be required for both light and heavy streams, with the processes tailored to mix of bottles.

(d) Drying: After separation, a spin dryer is used to remove free water and the flakes are then dried with hot air to reduce moisture content to about 0.5 percent.

The pictures of various steps of waste plastic recycling process in RI of Khulna are shown in Figure 7.



(a) Mixed waste plastic



(b) Chopping



(c) Washing



(d) Drying & coloring



(e) Making pellet



(f) Product (water pot)

Figure 7 Plastic recycling process in a recycling industry in Khulna city

(e) Coloring: After drying, the chips are mixed with colors.

(f) Melting: The flakes are fed into the extruder at large diameter end of the screw and compressed as they are carried toward the extrusion die. The combined heat from flow friction and supplemental heating bands causes the resin to melt and volatile contaminants are vented from the mixture. Immediately before the die the melted plastic passes through a fine screen that removes remaining solid impurities; this step is known as melting.

(g) Making pellet and product: The molten plastic is then formed into strands. The strands are cooled in water, and then chopped into uniform pellets. Pellets are used to form a new product of the designed shape by application of heat in a mould. Various of necessary products are produced such as toy, water pot etc on the basis of local market demand. Sometimes manufacturing companies of Dhaka buy the plastic pellets from RI of Khulna to make new products.

4.3 Profit Margin and Expenses Savings

The recycling activity of waste paper and plastic is going on in Khulna not considering those as waste but as a source of income. The feriwala were found to purchase mixed waste paper at a rate of 4 BDT/Kg and waste plastic at a rate of 17 BDT/Kg on an average from different households or institutions and sell these to SSRD. The prices of separated and processed waste papers and plastics at different dealers and industries were obtained from the field survey as shown in Table 3. The profit margin added to the prices of the wastes in the waste recycling chain from the SSRD level to RI level varies between 40 to 80% for paper recycling and from 23 to 100% for plastic recycling, depending on the recycling potential of the material, its ease of availability and the demand in the market. The highest profit margin occurred in PET bottles, which were found to have a long life span and are readily recyclable and reusable.

The Khulna City Corporation (KCC) is responsible for the waste management in Khulna. KCC spent 288,03,000 taka during the 1998-99 financial year for solid waste management and collected only 80 ton/day. Thus the cost per ton per day for solid waste management in Khulna was 986.40 BDT (Enayetullah and Sinha, 2000). It was found that the informal sector was recycling 23.85 tons of waste paper and plastic per day in Khulna. Therefore, it can be estimated that the informal sector is saving revenue about 8,600,000 BDT/year by removing these solid waste.

Table 3 Prices of processed waste paper and plastic at different recycling levels

Type of waste		Price				Profit Margin (%)
		SSRD (BDT/Kg)	MSRD (BDT/Kg)	LSRD (BDT/Kg)	RI (BDT/Kg)	
Paper	White	10	12	14	-	40
	Mixed shredded paper	6	8	9	10	67
	Cartons and brown packing papers	5	6.5	8	9	80
Plastic	Bottles	1	1.25	1.5	-	50
	Hard plastic(containers etc)	22	23	25	27	23
	PET bottles (mineral water bottles)	5	8	9.5	10	100

4.4 Approach to Increase the Efficiency of Existing Recycling Practice

The proposed approach is based upon regularizing the services of waste collectors from the informal sector as an employment. Some of them could be employed by KCC and could be equipped them with rickshaw vans to enhance their productivity and the rest of the collectors could be employed in different dealers to sort, clean and process the extra waste. The approach is based on the following assumptions:

- Considering collection of all waste paper (49400 kg/day) and plastic (16100 kg/day) producing in Khulna city. The collection ratio of tokai and feriwala would be 1: 2 for both paper and plastic.
- Average collection capacity of each rickshaw van was assumed as 65 kg/day. This implies that 1000 rickshaw van will have to be bought and an equal number of waste collectors be employed to collect total amount of produced waste paper and plastic.
- Price of each rickshaw van would be BDT 11,000 and accounting for a depreciation period 15 years (considering the life time of a rickshaw van is 15 years).

- (d) The salary to be paid to each collector would be 180 BDT/day.
 (e) The waste collector could supply RSW to the SSRD. The calculations have been performed using the prices of the various materials at the level of SSRD (Table 3).
 (f) 30% overhead charge was assumed over the salary component for medical facilities, supervising charges, the storage and transportation of waste and miscellaneous overheads.

Net profit/loss = total value of the recycled waste paper and plastic - expenditure incurred by the KCC.

Net profit/loss = (gross profits earned) - (salaries + one time investment to buy rickshaw van/15 + 30% overheads over salary component) - (buying price of waste paper and plastic).

$$P = \left[\{P_{p1} \times Q_1 + P_{p2} \times Q_2\} \times D \right] - \left[\{N_1 \times S \times D\} + \{N_2 \times C\} / Y + \{F \times N_1 \times S \times D\} \right] - B \quad (1)$$

Where,

P = net profit/loss (BDT/year)

P_{p1} = average selling price of paper (BDT/Kg) = 7 (Table 3)

P_{p2} = selling price of (hard plastic) plastic (BDT/Kg) = 22 (Table 3)

Q_1 = quantity of waste paper produced (Kg/day) = 49400 (Figure 2)

Q_2 = quantity of waste plastic produced (Kg/day) = 16100 (Figure 5)

N_1 = number of waste collectors = 1000

N_2 = number of rickshaw vans = 1000

S = salary of each waste collector (BDT/day) = 180

C = cost of each rickshaw van (BDT/rickshaw van) = 11000

D = number of days in a year = 365

Y = life time of a rickshaw van (year) = 15

F = percent fraction for overhead charge = 0.3

B = total buying price (of feriwala only; because tokai does not pay) for waste paper and plastic (BDT/year)

B can be obtained from the following equation:

$$B = (P_{p11} \times Q_{11} \times D) + (P_{p22} \times Q_{22} \times D) \quad (2)$$

Where,

Q_{11} = quantity of paper to be purchased by feriwala (Kg/day) = 32,933

Q_{22} = quantity of plastic to be purchased by feriwala (Kg/day) = 10,733

P_{p11} = Buying rate of paper by feriwala (BDT/Kg) = 4

P_{p22} = Buying rate of plastic by feriwala (BDT/Kg) = 17

From equation (2) total buying price of waste paper and plastic, $B = 114,680,445$ BDT/year.

From equation (1) net profit, $P = (+) 54,676,222$ BDT/year.

Therefore, the approach seems feasible as KCC earns profit.

5. CONCLUSIONS AND RECOMMENDATIONS

The existence of the recyclable waste, mainly the waste paper and plastic, which are light weight and easily accessible, has opened up a wide possibility for the informal sector in Khulna to utilize it. Although the recycling of waste paper and plastic is not included in the waste management policy of local government, it has become a main source of income for many waste collectors, dealers and industries of the informal sector. This informal sector-recycling pattern creates a market of recyclable solid waste and value addition occurs for the waste paper and plastic in the recycle stream. The profit margin for paper recycling varies between 40 to 80%, whereas for plastic recycling it varies between 23 to 100%. About 26% of the totally generated waste paper and about 69% of the totally generated waste plastic are recycled daily by the informal sector in Khulna city. Due to this recycling of waste paper and plastic of together 23.85 ton/day, the informal sector is saving the expenditure of solid waste management of 8,600,000 BDT/year. Finally, an approach is proposed that results into not only the reduction of quantities of wastes to be disposed of but also increase employment and thus income for the disadvantaged urban poor. Therefore, the proposed approach of increasing the efficiency of existing recycling pattern in Khulna city by organizing the informal sector would be feasible as the KCC earn net profit of 54,676,222 BDT/year.

In order to achieve proper solid waste management and improve recycling rates, one of the major challenges of Bangladesh is how to best effort with the informal sector to improve their working conditions, technologies and efficiency in recycling. Proper storage and source separation system can be adopted for recovering useable and recyclable paper and plastic. Moreover, solid waste management strategies in Bangladesh should be reorganized to include a separate collection and processing system for the recyclable solid waste to avoid mixing with biodegradable waste. That can work parallel with the traditional systems operated by the informal sector for waste separation, processing and final recycling.

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