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*Full Length Research Paper*

# An Emerging City: Solid Waste Generation and Recycling Approach

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**Abstract.** This study was performed to understand solid waste generation rate and its consecutive management approach using qualitative technique in the Rangpur city corporation area of Bangladesh. The city corporation area of Rangpur is 203.19 $km^2$ with population around 1 million. The solid waste generation rate is gradually increased owing to population growth. From this study it was found that solid waste generation rate is around 23.94 ton $d^{-1}$ in the city corporation area. A number of social components like income level, education and age limit showed significant positive correlation with waste segregation and recycling behavior. The informal collectors and recyclers directly endorsed to nation's welfare through waste cleaning along with their waste dependent livelihood strengthen. Unregulated waste generation was negatively impacted on environmental and human health. It was found to be serious problem for public health issues due to lack of poor legislation, improper management and developmental theme. Results also showed a thematic future trend of hazards where it may implies on environmental disaster.

**Keyword:** Solid Waste, Waste Collectors, Informal Recycling, Perceptional attitude, Environmental Health.

## 1. INTRODUCTION

Solid waste (SW) generation and its impact is an emerging issue for public health aspects in the developing countries. A waste management approach and government initiatives are coincided with partial developing factor practice which is a reflection of per capita solid waste generation rate. However, solid waste generation is lower in the developing county than the developed county in relation to per capita income owing to less purchasing and consumption rate (Cairncross and Feachem, 1993). In the growing world, population growth and its fundamental demands attribute to environmental pollution while it is characterized by management system with individual governance power.

The urban pollution growth and solid waste generation is a concerning issues in the developed and developing countries. Their results have negatively impacted on environment, resilience and socioeconomic condition. In the developing countries (e.g. Asia and Africa), solid waste generation and its poor management has become a more challenging issue for the impending days. Now, Solid waste management system (Urban area) has developed to ensure healthier environment and sustainable development in the developing country (Caló and Parise, 2009; Halla and Majani, 2003; Mwangi, 2000; Ogu, 2000; Zia and Devadas, 2008).

In Bangladesh, SW generation scenario in urban area has changed due to population growth, urbanization and ignorance. The unplanned urbanization and massive growing slum is influenced to SW generation in unidentified quantities in the six major cities such as Dhaka, Rajshahi, Khulna, Chittagong, Barisal and Sylhet in Bangladesh (Salequzzaman et al., 2001). Municipal waste management services are unable to cope with over-burden SW generation and its management facility due to lack of manpower, insufficient materials and support (Enayetullah et al., 2005; Hasan and Chowdhury, 2005). Among the different types of solid waste, 30% of all municipal waste covers residential, household and industrial waste while it is generated two or three times higher perspective to Asian rural fellow (World Bank, 1999). The solid waste

production rate has increased where it may reach .49 kg/person/day to .6kg waste by 2025 (Ray 2008: 5).The urban uncollected SW on the street and pile up on the drain which is blocked the drainage channel and water courses (Bhuiyan, 2010). It plays a significant role for the environmental degradation and public health risk.

The Rangpur district is a newly emerging divisional city which is located at the northern part of Bangladesh. The rural and neighboring people are drifting to the Rangpur city from periphery in case of meets the needs of growing demands. At this emerging situation, SW generation rate is gradually increasing in different segment (e.g. institution, education centre, medical, household, office, market and industry). The rapid population growth and its unplanned development are significantly attributed to per capita SW generation and improper management strategy. It is a critical point to make out the overall scenario of solid waste (Plastic, Paper, Metal and Glass) generation in the study area. The aim of the study is to investigate the solid waste generation and management approach. The major aspects of the study were leading to quantification of solid waste generation, composition, managing approach and health risk assessment.

## 2. RESEARCH METHODS

### 2.1. Study Area

The study was conducted at the Rangpur city and its peripheries of Bangladesh. This city is currently rendered as a divisional town out of seven divisions in the country. The newly evolve technological installation along with structural development emphasize on huge materials use and waste generation. The total city corporation area was covered by 203 Sq/km, the total population of the study area was documented around 1 million (Fig. 1). The literacy rate was observed 60 percent. The average rainfall and temperature was found 60-70 cm and 16-32º C respectively.

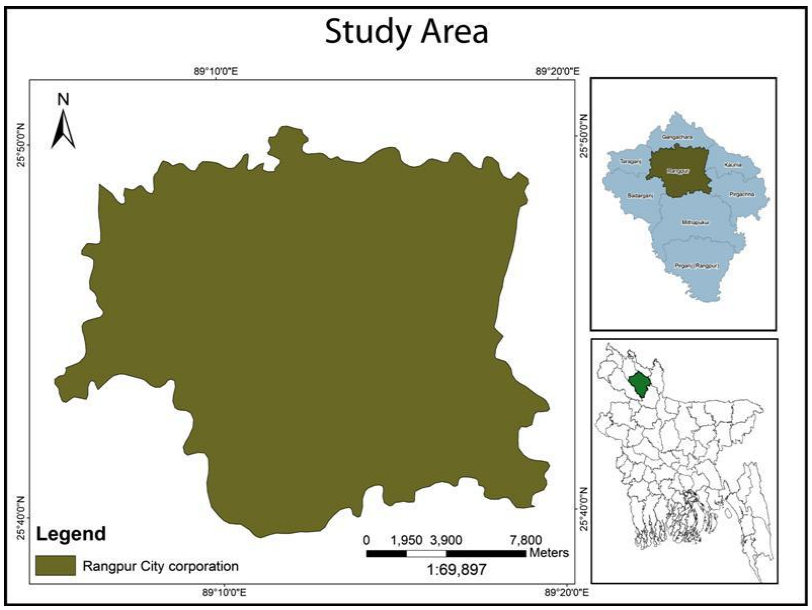


**Fig. 1:** Shows location of the Study area

### 2.2. Research Approach and Design

Waste management research approach and its categorical aspects were considered to find out the real feature of the waste generation site. This study was focused on the present scenario of waste generation and its proper handling technique with third party involvement. The waste management approach of the waste picker and collector through economical exchange (e.g. selling and buying). However, it is identified as a significant technique to evaluate the environmental condition while it would be freed from pollution. For getting real information about waste generation and environmental stress, the study was adopted though primary and secondary information system. The primary method was applied through individual contract which was referred to face to face and/or direct contact with structural form fill up.

The study was conducted from May 2013 to June 2013. Twenty one locations were survived within 33 wards. The qualitative and quantitative data were collected through feedback assessment (e.g. questionnaire) form which was contained basic information to principal cause of waste burden. A complete questionnaire was contained three parts,

whereas first part, second part and third part was enclosed with demographic information, waste generation scenario along with management approach and impact assessment respectively. It was consisted of in-depth information about solid waste collection (picker, worker and owner) and management (recycling factories and disposal system) approach.

### 2.3 Qualitative Research Technique

A qualitative research was performed on solid waste generation and management approach concerning environmental health impact assessment in the study area using different qualitative techniques. This technique was very much effective to get over all scenario of solid waste management approach.

(+) A total number of 180 questionnaires were survived from different waste collecting, recycling shop, waste picker and hawker in the study area. To serve our study purpose, total number of shops was divided into three categories such large, medium and small on the basis of some specific parameter such as size, production rate, selling and buying rate and economical activity. Around 180 shops were found which was involved waste collecting and recycling activities. Around all shops were situated in several point of Rangpur city. These shops were collected almost every item of solid waste, such as plastic, metal (Iron), paper, glass etc. Three types of shops were found such as small, medium and large shop. Among 180 shops mainly 15 shops were larger, 65 shops were medium and 100 shops were small. Among larger 15 shops, mainly 5 large shops collected plastic, 4 large shops collected paper, 3 large shops collected metal and 3 large shop collected glass in the study area. Else among 65 medium shops collected plastic, 65 medium shops collected metal, 50 medium shops collected paper and 20 medium shops collected glass in the study area. On the other hand among 100 small shops mainly 85 shops collected paper, 17 shops collected plastic, 90 shops collected metal and 50 shops collected glass.

(+) The focus group discussion (FGD) was performed among the waste collector, labor and waste picker for getting precise information on waste generation, recycling approach, compositional variation and management approach in the study area. It was executed into several groups which made of 14, 21 and 15 person respectively. Individual group discussions were monitored using structural feedback from fill up. Comparative study among the groups was revealed the situational waste generation and management approach.

(+) Informal dialogue and/or interview were taken owing to get authentic and reliable information which may not be influence or inspirited by others. It was performed at the open place, local tea stall, on the street and house hold area among the local people, waste picker and ferriwalla. This information was more reliable and informative because of accumulating diverse knowledge on solid waste aspect in the study area.

Socioeconomic factors of the respondents were considered. Its consideration helps to get more significant information about development aspects regarding with demand based profession. The educational qualification and family size were considered for getting clear concept on individual income and consumption rate. Based on research aim, interview was taken from stakeholder, waste picker, waste recycling shop owner, manager and labor for getting real information as well primary data collecting on solid waste management. Most of the respondents were congenial to communicate as well as helping attitude towards information giving. In categorical aspects, interview was performed in specific research field to get accurate information and knowledge on daily basis waste generation rate from different source. It was performed in presence of informant and interviewer along with feedback form. The perceptional attitude of the waste picker, collector, shop owner and workers towards waste generation and management scenario was documented for the future trends analysis.

### 2.4. Correlation Coefficient Matrix

For the better understanding on waste generation and management strategy, statistical analysis was performed. The statistical results were coincided with emerging trends, real feature and conceptual prediction measure for the future development.

Person correlation coefficient matrix was performed owing to evaluate interrelationship among socioeconomic components with respect to waste segregation and recycling behavior. It is the best statistical approach to know the actual scenario of waste controlling parameter. The SPSS (version 18) package for windows was used for the statistical analysis and significant interpretation on the basis of existing feature of waste generation and socioeconomic parameters.

## 3. RESULTS AND DISCUSSION

### 3.1. Socioeconomic Status

The study area consists of 33 wards which are densely populated areas. Most of the respondents were marginal people and labor where they are engaged as a daily basis worker in waste management and recycling shops. Both male and female worker were

appointed with temporary where 85% male and 13 female. Among the workers, 2% was children worker. The respondent's age was varied range from 20-45 years for male, 18-35 years for female and 8-14 years for children, respectively. Their income capacity varied with working hour and job availability which range from TK 180-250 (US $2.32-3.21) per/day for male, TK 120-210 (US $1.54-2.70) per/day for female and TK 80-100 (US $1.03-1.28) per/day for children respectively. The socioeconomic status and their income level directly emphasize on their life style. The house owner's socioeconomic condition is a reflection of present solid waste generation rate. Owner's income varied from TK 10000- 30000 (US $128.62-385.85) with respect to investment capacity and waste collection capacity. The education level of labor and owner was found to be class 1-5 and 1-8 respectively. The income level and educational qualification is attributed to family structure and its future development with respect to economical growth.

### 3.2. Waste Quantification

Waste quantification reflects the existent SW generation scenario of a specific area. It is a best approach to quantify the total waste generation through categorical waste shop calculation perspective collected materials per day. The waste picker and ferriwalla act as a primary waste collector (Bari et al., 2012) to aggregate the whole waste from surrounding area. In Rangpur city, waste picker was found highly interested to collect demand based waste from road side dustbins, Shyma Sundary canal, near market garbage, bus and track stands, railway station and others localities such as plastic, iron, polythene, sandle, tin, glass, paper etc. A number of waste collecting and recycling shop was involved with primary waste collector for storing and recycling.

Three categories of waste collecting shops such as large, medium and small were found in Rangpur City. The average amount of plastic waste per shop was found 230 $kgd^{-1}$, 40 $kgd^{-1}$ and 15 $kgd^{-1}$ respectively, among the three types of shops. In categorical aspects, total number of plastic waste collecting shops was found, 5 (5×230=1150 kg/d) for large, 65 (65×40=2600 kg/d) for medium and 17 (17×15=225 kg/d) for small in the study area. The average amount of paper product was found to be comparatively high in different paper collecting shops. A number of paper shops were found to be collecting paper waste, about 310 $kgd^{-1}$ for large, 60 $kgd^{-1}$ for medium and 25 $kgd^{-1}$ for small shops. Total number of waste collector shop was recorded in categorical aspect where 4 (4×310=1240 kg/d) for large, 50 (50×60=3000 kg/d) for medium and 85 (85×25=2125 kg/d) for small shops. Most of the waste pickers were reported that, paper waste collecting is profitable and more convenient than others. In addition, metal waste is a considerable subject in waste management sector. A few specific shops were found to be collecting steel and iron waste product. Its collecting rate was observed per shop around 436 $kgd^{-1}$ (3×436=1308 kg/d) for large, 40 $kgd^{-1}$(65×40=2600 kg/d) for medium and 30 $kgd^{-1}$ (90×30=2700 kg/d) for small shops. The average amount of glass was found in three categories of waste collecting per shop, around 280 $kgd^{-1}$(3×280=840 kg/d) for large, 125 $kgd^{-1}$(20×125=2500 kg/d) for medium and 28 $kgd^{-1}$(50×28=1400 kg/d) for small shops.

### 3.3. Waste Collecting Approach

Solid waste generation rate of the study area has increased owing to population growth along their socioeconomic activities. The solid waste generation was recorded daily basis around 23.94 $tond^{-1}$. It consists of plastics (18.44%), metals (30.42%), paper (29.30%) and glass (21.82%). The income level and consumption rate coincide with one's life style which may be expedited to waste generation rate. Lack of proper management at waste collecting shop, a few wastes such as paper and bone has disintegrated into several parts in presence of biodegradation activities at source. In addition, some of them have lost due to mixing up with soil and organic decomposer (Bari et al., 2012). The categorical aspect of waste generation rate is gradually reached in highest point compared to develop ones. Around 30 waste collecting shops were observed in the heart point and around of the city. A variety of solid waste is collected from waste picker and others at different price based on market demands.

**Table 1:** Waste collection approach of primary waste collectors

| | Plastic | glass | Cartons | Paper and books | iron | Cement bag (Tk/pieces) | Others |
|---|---|---|---|---|---|---|---|
| Waste Collection($kgd^{-1}$) | 15 | 6 | 12 | 15 | 12 | 8 | 5 |
| Buy (Tk/kg) | 10 | 3 | 10 | 13 | 15 | 6 | 15 |
| Sell (Tk/kg) | 15 | 4 | 12 | 16 | 18 | 9 | 18 |

**Plastic=can/pot/bottle/basket/Bowl/pot cover/Jug/flower vase/self; Glass= Small and large bottle/window glass/glassy-plastic; Cartons= fruit cartons/appliances carton/medicine cartons; Paper= News paper/ worn paper/magazine; Books= Worn books/reject books (old); Iron= Tin/steel pipe/tube-well head/reject motor vehicle appliances/rod/ steel wire; Cement Bag= plastic/ paper bag

As a primary waste collector, waste picker and feriwalla act as a key scavenger to remove solid waste from residential and industrial area. A waste picker is able to collect 20-30kg recyclable waste and earn TK 180 per day (Table 1). Feriwalla directly sell his carrying product by taking recyclable solid waste such as food, doll, cookeries etc. Most of those collected materials sell to the recycling factory or storage shop by taking profit. Feriwalla can be earned more comparatively waste picker, about TK 250-300 per day. From the observation, about 200 waste pickers and 200-250 feriwalla are played their noble role and indirectly helps to our environment.

Both waste recycling factory and collecting shops frequently collect solid waste from primary waste collectors at different price level in categorical aspects. A major portion of waste material was sold to large shop owner with more profit in Dhaka city (Table 2). And rest of the waste products was crushed down at local scale for price hiking approach.

**Table 2:** Waste collection approach at recycling and collection shops

| Price | Plastic | Books | Paper | Cement bags (Kg/pieces) | Cartons | Cast | Iron | Silver | Glass bottle | Sandal | Tin | Others |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Buy (Tk/kg) | 20 | 13 | 15 | 10 | 20 | 150 | 28 | 170 | 4 | 20 | 15 | 20 |
| Sell (Tk/kg) | 30 | 16 | 18 | 13 | 25 | 160 | 32 | 185 | 8 | 25 | 18 | 25 |

### 3.4. Waste Management and Recycling Approach

Waste recycling shops are situated at the different point of the study area where waste was processed for further using and/or convert into another shape. Waste recycling and its further usage may lead to regain ambient environmental condition instead of waste disposal. Most of the recycling shops were collected their demand based waste from directly waste picker and waste collecting shops. They are mainly collect recyclable and non-biodegradable waste while it was used to make something new one. In addition, a few recycling shops are observed where they were only waste crushing down. Most of the local recycling factories are involved with waste washing, drying and cutting but main recycling activities is performed in Dhaka city.

#### 3.4.1. Waste Segregation and Livelihood

Waste separation is more profitable and congenial to management approach. It was observed that waste collecting shop and recycling factory attempt to significant efforts on waste separation owing to augmenting income (Fig. 2). The segregation was performed on the basis of economically viable valuation wastage materials. A significant relationship was found between urban poor people and informal waste management (Nguyen et al., 2003; Rouse, 2006b). The recycling and collecting shops took part in creating future job opportunity to meet the needs who are migrating to Rangpur city from rural areas. The informal recyclers and collectors directly attributed to nation's welfare through waste cleaning approach along with waste dependent livelihood strengthen. A certain portion of urban propels' economy and livelihood directly related to waste recycling sectors. It is profoundly found in third worlds, where most of the people were living below the poverty line (Nzeadibe, 2009). Consequently, it could be enhanced economical development through poverty eradication in a society. This desirable attitude towards informal recycling has taken part to poverty eradication and improves lives through job creation instead of large amount of waste disposal (Nzeadibe, 2009). It is positively impacted on social structure, culture and socioeconomic condition.

**Fig. 2:** Shows categorical aspects of recyclable solid waste (from right hand side) in the Rangpur City. (**a.** represents of different size of bottle which is made of glass; **b.** attempt to separate numerous size of bottle owing to reuse in the secondary purpose through washing; **c.** Floating plastic waste mistrials into water body which was keep left at the bank of the water body but lack of proper management it may affect living organism through depleting physic-chemical parameters; **d.** Factory labor try to find out reusable plastic bottle according to economical value and demand; **e.** Aggregate of metal parts of various appliances and electric instruments; **f.** metal waste indicate to tube-well head; **g.** ferriwalla[1] collecting paper waste from several street side shops; **h.** carton [paper] collecting shops which is arranged step by step inside the shops; **i.** Indicated cements bag inside the waste collecting shops).

**Table 3:** Correlation coefficient matrix of solid waste generation variables

| Variable | Waste segregation Behavior | Recycling Behavior | Variable | Waste segregation Behavior | Recycling Behavior |
|---|---|---|---|---|---|
| Income Level | .204** | .183* | Environmental Consequence | .317** | .304** |
| Age | .144* | .091 | Population Growth | .367** | .320** |
| Reuse Attitude | .173* | .201** | Family Members | .204** | .109* |
| Female Education | .038 | .017 | Male education | .029 | .014 |
| Area coverage | .214 | .136 | Recycling attitude | .117* | .174* |
| Waste Collection Manner | .168 | .198 | Waste Management Manner | .149* | .186* |

"*" at the significance level, *p=.05*
"**" at the significance level, *p=.01*

[1] *Ferriwalla*: who collect solid waste by exchanging money or daily useable product from household

### 3.4.2. Waste Recycling

The total amount of waste handled in recycling factory to reform or crushing it. But maximum part of the crushing product was sent to Dhaka due to insufficient capacity to recycle (Fig. 3). A limited amount of the total solid waste was handled for recycling in Rangpur city. Around 6 medium size recycling shops are engaged with only crushing where 11-12 employers appointed to waste processing. Plastics and glasses are crushed down in the study area. After that it sent to Dhaka for recycling which is accounted 3.88 ton/day for plastic and 2.71 ton $d^{-1}$ for glass, respectively. In addition, paper and metal product were directly sent to Dhaka for further processing. The amount is recorded on daily basis 3.45 ton $d^{-1}$ for paper and 3.17 ton $d^{-1}$ for metals in total volume based solid waste. The author reported recycled waste of daily solid waste generation in different cities in Bangladesh as follows: 8.25% in Rajshahi city (Bari et al., 2012), 9.10% in Dhaka city (Memon, 2002 ), and 8.87% in Khulna city (Bari et al., 2009) respectively. Rest of the recyclable waste was sent to another place for recycling. Most of the recyclable wastes are considered to reform process for secondary products. Among the total amount of solid waste (23.94 ton $d^{-1}$), a number of reusable solid wastes were sorted out for using in secondary purpose before crushing regarding with factory owner and labor perception, which is accounted 3.10 ton $d^{-1}$ for paper, 3.76 ton for metals and 2.41 ton $d^{-1}$ for glass respectively.

### 3.5. Correlation Coefficient Matrix

The correlation coefficient matrix is a key approach to understand the interrelationship among the measured variables. Social component and human behavior implies to waste generation rate and management approach. Lee and Paik (2011) reported the correlation between food separation and recycling behavior. Resource utilization and consumption rate is directly attributed to material use and future waste trends. It was observed that a number of social components like as income level, education, age is significantly positively correlated with waste segregation and recycling behavior respectively (Table 3). Population growth is one of the major factors which are directly emphasized on waste production. Human psychological behavior like as reuse, recycling and management attitude is indicated positive correlation with waste segregation and recycling behavior.

### 3.6. Solid Waste Generation and Perception Analysis

Solid waste generation trends is gradually increasing due to population growth and newly emerging divisional city. The rural population is migrating to the Rangpur city for their livelihood. A part of the study was conducted on perceptional attitude towards solid waste generation rate compare to previous status. Most of the factory labor reported that solid waste generation rate is increased compare to past stage of City Corporation. It was found to be increasing rate around 40% for plastic, 30% for paper, 10% for glass and 20% for iron regarding with labor perception. It is not possible to recycle of all materials due to presence of unnecessary parts with main subjects. However, a few materials primarily sorted out for using second time. It was found that the average amount waste is recycled, reused and disposed. The plastic, paper, glass and iron was found to be 55%, 50%, 49.5% and 60% recycled respectively for further processing (Fig. 4). The volume based waste fee is a critical point to reduce waste disposal rate and recycling activities (Hong, 2001). Waste recycling rate has positive trends due to paying more money for waste disposal rate in Korea (Hong, 2001).

On the other hand, paper, iron and glass are reused to serve the secondary purpose rather than plastic waste. It is very difficult to manage the total urban solid waste without any concern and legislation. Consecutively, it was found to be 0.54 ton d-1 for plastics, 0.47 ton d-1 for papers, 0. 35 ton d-1 for metals and 0.10 ton d-1 for glass respectively. This was disposed at open places (Shyama Sundary canal, roadside and household area) in the study area. The small amount of recycled waste is disposing randomly everywhere owing to lack of awareness and environmental education. In addition, mind setup is critical point for solid waste generation and following proper management technique.

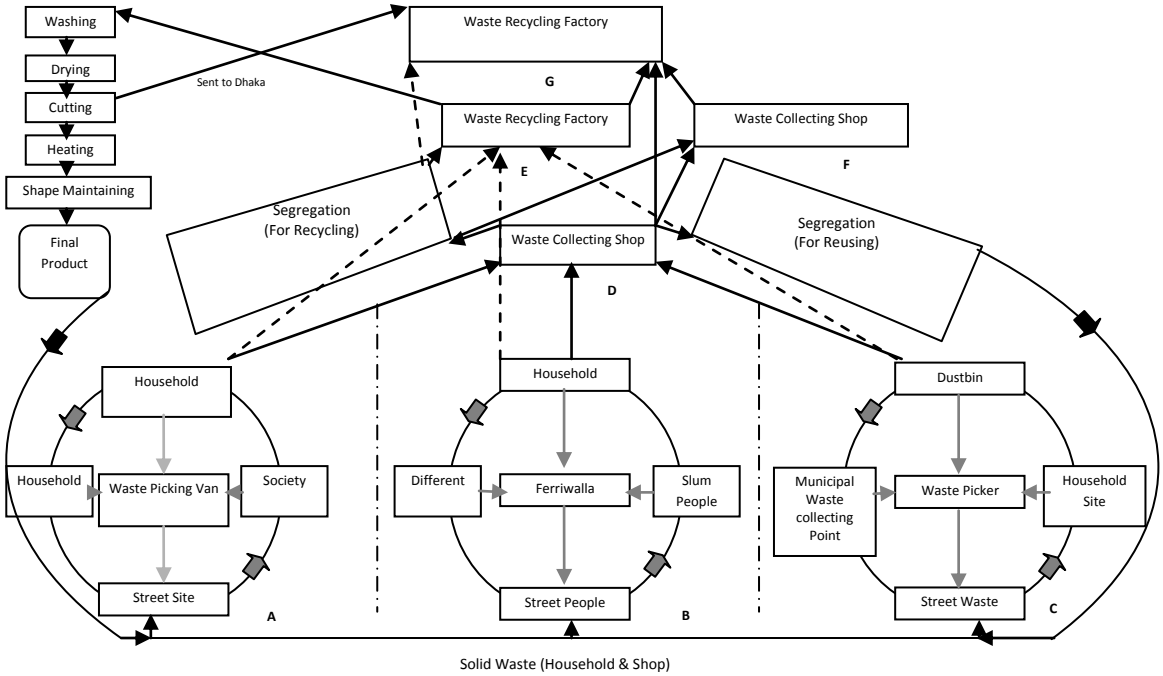


**Fig. 3:** Showing flow diagram of recyclable solid waste management system in Rangpur City (**a**. waste picker collects recyclable solid waste from different sites of the study area while it is distributed in several sectors; **b.** Ferriwalla plays a vital role to collect recyclable waste from hand to hand by exchanging daily usable and/or money; **c.** Waste picking van collects solid waste from door to door two or three days per week; **d.** Waste collecting shop attempt to collect solid waste from waste picker, ferriwalla and waste picking van. It is separated into two parts for using and recycling; **e.** All waste collecting process jointly makes a significant effort on waste recycling end products of the recycling factory while it is sent to Dhaka for further processing and reforming of the raw materials.)

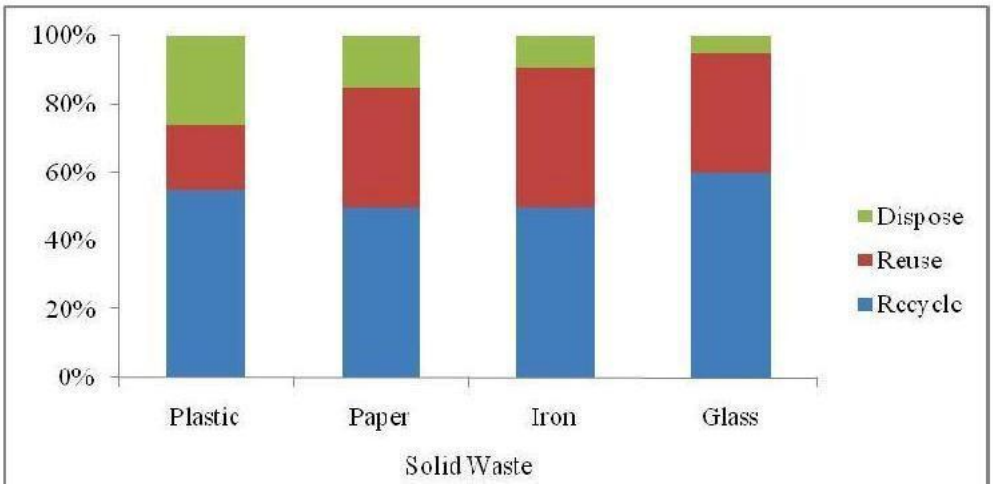


**Fig. 4:** Existing solid waste collection and management scenario regarding with respondents perception in the study area

### 3.7. Health Hazard

In the developing countries, waste burden and its negative impact on environment and human health is a critical issue in this decade. It could affect through biological infection or physical impairment in the consequence of long term exposure in waste handling activities. Most of the labors were engaged for waste collection and recycling work without any precaution measure. At the field level, waste picker was engaged with waste collection job from dustbin, on the street and open place just directly hand using. In the studied area, 87% people were identified as completely unconscious about their health condition. In addition, 13% peoples were concerned about sound health but they are not followed precaution measure for the personal protection. Nevertheless, 5% peoples were suffered from respiratory problem who were involved in waste crushing activities. A number of people were observed physically wounded at the time of heavy

weight materials handling. Labor might be affected owing to carcinogenic ashy materials, microbial pathogenic contamination and so on. However, waste materials were scattered in the several places in the study area. It could be emitted several types of greenhouse gases into the atmosphere. On the other hand, waste disposal in the open place is a great threat for soil and ground water pollution through leaching.

Around 1.105 $tond^{-1}$ waste was found to be disposed through an unplanned way in the growing city. Consecutively, it was converted into continuous process because of upward trends of population density (Per square kilometer) and resource utilization. Meanwhile, it appeared to be unavoidable frequent problem for public health issues due to poor legislation, improper management guidance and development theme. In this study, it was observed lack of formal recycling facility, management strategy, treatment facility, protocol management, dumping strategy, management protocol and safe transportation to avoid environmental pollution. It was found to be a reflection of thematic future trends of hazards where it is implies on environmental and health disaster. Solid waste and its decomposed materials commonly attributed to environmental pollution in all compartments of the environment through odor and leaching into soil profile. It is an emerging issue for air pollution and groundwater pollution by spreading of leaching contaminate and vermin (Matter et al., 2013). Consecutively, it was negatively impacted on environmental and human health.

## 4. CONCLUSION

This study was conducted to evaluate solid waste generation and recycling approach in the Rangpur city corporation area of Bangladesh. As an emerging city corporation, Rangpur is important to make out the mandatory prerequisite conditional factor such as planning and existing environmental condition. The anthropogenic stress is interfering with environment and its components directly and indirectly. The existing management approach of the study area was not so enough to well organized and congenial to environmental health. Results showed that solid waste generation rate has increased owing to population growth and urban development. However, informal solid waste collecting and recycling activities has been made a significant effort to reuse/recovery and reprocessing of urban recyclable waste. Among all types of solid wastes around 40% for plastic, 30% for paper, 10% for glass and 20% for iron. Waste recycling and management behaviors, however, depend on age, income and waste management attitude of the community people. The environmental risk is coincided with environmental attitude towards unplanned waste management system.

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