Solid Waste Management of Rajshahi City in Bangladesh and Its Impacts on Human Health and Environment

Dr. Md. Moshiur Rahman[1], Tahmid Jakia[2]
[1] Program Coordinator, Environmental and Population Research Centre (EPRC)
Mohakhali, Dhaka-1206, Bangladesh, E-mail: moshiur007@yahoo.com
[2] Department of International Relations, University of Dhaka, Dhaka-1000, Bangladesh Email: tahmida.jakia@gmail.com
Keywords: solid waste, waste management, sustainable, diseases, health, environment, pollution.
Corresponding author E-mail: moshiur007@yahoo.com

Abstract: Bangladesh faces a huge waste management problem. Much of the country and specially the metropolitan cities are facing the impact of urbanization, as a growing population houses itself in congestion, leading to a severe pressure on infrastructure facilities at all levels. This has resulted in a decline in sanitation, which in turn causes adverse health impacts. Rajshahi City, the divisional head quarter of Bangladesh has more concern to the fact of solid waste management. The present study reveals that in spite of huge allocation in drainage and sanitation purpose the city fail to ensure a sound environment due to lack of proper waste management. Consequently, waste is indiscriminate by dumped on roads and into open space thus leading to serious health risk and degradation of living environment for about a million of city dwellers. The study conducted through personal in depth interview; data collection from primary and secondary sources; MSW sample collection with performing laboratory test; data processing and analysis; and drawing recommendation and conclusion. This paper attempts to find out the flaws lays behind solid waste management through traditional methods as well as adapting technologies for improving the sustainable waste management system. It is found that lack of knowledge of common people regarding waste management is one of the main reasons to pollute the environment. Simultaneously, unplanned waste dumping system practiced by the city authority worsens the situation which causes threat on health.

1 Introduction

Urban waste management is considered as one of the most immediate and serious environmental problems confronting municipal authorities in Bangladesh. Municipal authorities are the only government institution to tackle this situation. Rajshahi city has distinguished name and fame in culture and education. It is an old city with a host of several remarkable places. With the increase of population, the city area is expanding. In 1876, its area was only 12.96 square km and population was only 10 thousand, whereas, in 2012, its area reached into 96.72 square km and population exceed to nine lac. However, citizen amenities are not increased keep pace with population that lead suffering to its inhabitants. The legal framework is not supported by timely enforcement actions and there is a general lack of funding to develop common facilities for efficient waste management. This report is a commentary on all these aspects.

Rajshahi is an under privileged City Corporation comparing to other and one of the issues concerned of this city is the management of municipal waste. Inadequate waste management is mainly responsible for

environmental pollution in the city. Industries, factories, markets, health centers and households produces huge amount of wastes every day in the city. Rajshahi City Corporation is unable to perform its operation in dumping the wastes or keeping it in proper place in proper way due to lack of work force and technology. People are habituated to throw the wastes here and there to save their cost, time and labor. About 350 tons wastes are produced each day while the amount increases to 400 tonnes during summer in Rajshahi City, among them 12 tons are treated as hazardous wastes. Among the total collected wastes, only 210 tonnes are dumped into the dumping ground and the remaining 140 tonnes are dumped straight into drains, water bodies and open spaces (Atik, 2013). Most of these are thrown beside the institutions without proper management. Vast amount of waste gathering is found at the periphery area of the city in unplanned way. A large portion of waste is used in land filling and a few portions are found to incineration. When waste is not properly collected, it will be illegally disposed of, and this will pose serious environmental and health hazards to the areas. As a result, it creates an unhygienic environment in the city. Odor spreading and water logging is common phenomena that arises due to unplanned waste management. Spreading of disease through wastes impose a severe effect on the health and environment in the city. The most important environmental impact reported in scientific research is the effect on global warming of emissions of greenhouse gases (mainly methane) from landfill of municipal solid waste. Methane is generated at all landfill sites accepting municipal solid waste, and the contribution of methane emitted from landfills to global warming is important. Study undertaken at residential areas in close proximity to a commercial composting plant looked at the incidence of some common infectious disease and minor ailments in people living in this area.

Therefore, it is immense need to do research more about the matter and this study reveals the level of health risk and provides proper suggestions to mitigate the risk. It will help to increase consciousness about the above said matter and able to keep contribution to make sure of a sound environment which will ensure healthy living in the city.

2. Review of Literature

Even though much research has been conducted based on waste management in context of Asian countries including Bangladesh, it is still scanty for the study area Rajshahi City. Moreover, researcher has analytically reviewed documents related to the topic of the study. Therefore, extensively reviewed documents, papers, articles and reports on waste management have been cited in this study. In addition, writer has mentioned some of the findings of researchers related to the topic which have taken from a detail of the review of literature.

Rahman and Ahmeduzzaman (2013) suggest that the solid waste of Rajshahi generally has a high organic content (60% to 70%) and a low proportion of combustible matter. The wastes, which remain uncollected, are dumped in open spaces, street and drains, clogging the drainage system, which create

serious environmental degradation and health risks. The collected waste is presently being disposed off mainly in a low-lying area about 3 kilometers from the corporation area. In Rajshahi, wastes, which have market value, are being reclaimed or salvaged for recycling. The unmanaged solid waste should be collected and managed properly and the authority should be more concerned about that feature for making the city healthiest and livable.

Saha (2013) reports that the disposal and handling of waste leads to environmental degradation, damage of the ecosystem and poses great risks to public health in Pabna city. The study shows that there is a significant link between the improper management of urban solid wastes and the environmental pollution. In findings of the research it cited that currently Pabna is facing serious environmental degradation such as land, water and air pollution and public-health risk such as skin disease, asthma, diarrhea and even skin diseases etc due to uncollected disposal of waste on streets and other public areas, drainage congestion by haphazardly dumped wastes and contamination of water resources near uncontrolled dumping site. Leachate, gas, odor, noise and dust etc are the common environmental problems in the existing sites that cause threat to human health and environment.

Rouf (2011) argues that Municipal solid waste is a serious environmental hazard and social problem in Bangladesh. Currently a massive volume of solid waste is generated every day in the Municipal areas and unfortunately solid waste management is being deteriorated day by day. Consequently the country has had serious crisis of electricity, load shedding is now impractical as living standards and become a great barrier in socio- economical growth.

Bari, Hassan and Haque (2012) mentioned traditional recycling pattern of solid waste was investigated in Rajshahi municipality. Carrying out a questionnaire survey they show as findings that various recycle shops during April 2010 to January 2011. There were 140 recycle shops and most of them were located in the vicinity of Stadium market in Rajshahi. About 1906 people were found to be involved in recycling activities of the city. Every day, an estimated 28.13 tons of recycled solid wastes were handled in Rajshahi city area. This recycled portion accounted for 8.25% of the daily total generated wastes, 54.6% of total recyclable wastes and 68.29% of readily recyclable wastes.

Major recycled materials were found to be iron, glass, plastic, and papers. Only five factories were involved in preliminary processing of recyclable wastes. Collecting and processing secondary materials, manufacturing recycled-content products, and then buying recycled products created a circle or loop that ensured the overall success of recycling and generated a host of financial, environmental, and social returns.

Bhuiya (2007) states that one of the most obvious impacts of rapidly increasing urbanization and economic development can be witnessed in the form of heaps of municipal solid waste. Based on estimates, waste generation in Asia has reached 1 million tons per day. Solid-waste management has become an important issue in the Asia-Pacific region, and it is essential to be resolved through an integrated community, private- sector, and policy-based approach. Bangladesh being a member country of Asian Productivity Organization (APO) conducted a survey on solid-waste management to assess current solid-waste management practices and to highlight issues, problems, and the initiatives undertaken to tackle them. Supporting the findings of Bari and Hassan (2012) Zahur (2007) states that Although municipal authorities acknowledge the importance of adequate solid waste collection and disposal as well as resource recovery and recycling, it is mostly beyond their resource to deal effectively with the growing amount of solid waste generated by the expanding cities. Consequently solid waste is indiscriminate by dumped on roads and into open drains thus leading to serious health risk and degradation of living environment for millions of urban people.

The authors' statement, however, is not supported by their empirical research, opposite estimates of gain from research of Islam and Saifullah (2001) where they emphasizes on produce renewable energy through waste. Carrying out a study on solid waste and sugarcane bagasse-a renewable source of energy in Rajshahi city, they showed Municipal wastes and sugarcane bagasse are also a renewable energy source and energy can be harnessed easily to meet the increasing global energy crisis considering 3 "E" S. The wastes in the city are mainly non hazardous type and these are food wastes, weeds, ashes, papers, packages, plastic bags, polythene, broken glass, tins, worn cloths, casings, cover of pharmaceuticals and many other things.

3. Objectives

The objectives of the study are:

- To visualize the present status of solid waste collection and transportation system of the Rajshahi City;
- To identify the problems of solid waste collection, transportation and disposal system in study area;

- To assess the impact of solid waste on health and environment;
- To recommend the possible way to get rid of these problems through exploring means to manage solid waste for reduction, recycling, recovery and reuse.

4. Materials and Methods

Both primary and secondary data have been used in conducting the study. Primary data have been collected by personal Municipal Solid Waste (MSW) sample collection and in depth interview of respondents group like city corporation employees and garbage collectors. Their opinion is collected to get an insight into existing waste management system. Secondary data have been collected through pursuing different reports of City Corporation, web materials, various articles, journals, published and unpublished thesis and books. In collecting the MSW sample to conduct a study at local conditions, a variety of waste characterization methods can be used (USEPA, 1996). A simple method is the sampling for the characterization of MSW is sampling directly from waste generation sources, which is applied for this study. The first level is stratification by waste generation sources such as residential, commercial, institutional and open areas (as street sweeping). The Second is seasonal stratification as Bangladesh has three main seasons: summer, monsoon and winter thus sampling was designed to collect during these seasons. A total of sixty samples were collected from the thirty wards of the City Corporation area of Rajshahi. The overall work to be done is described schematically by the flow chart showing in the Figure 1

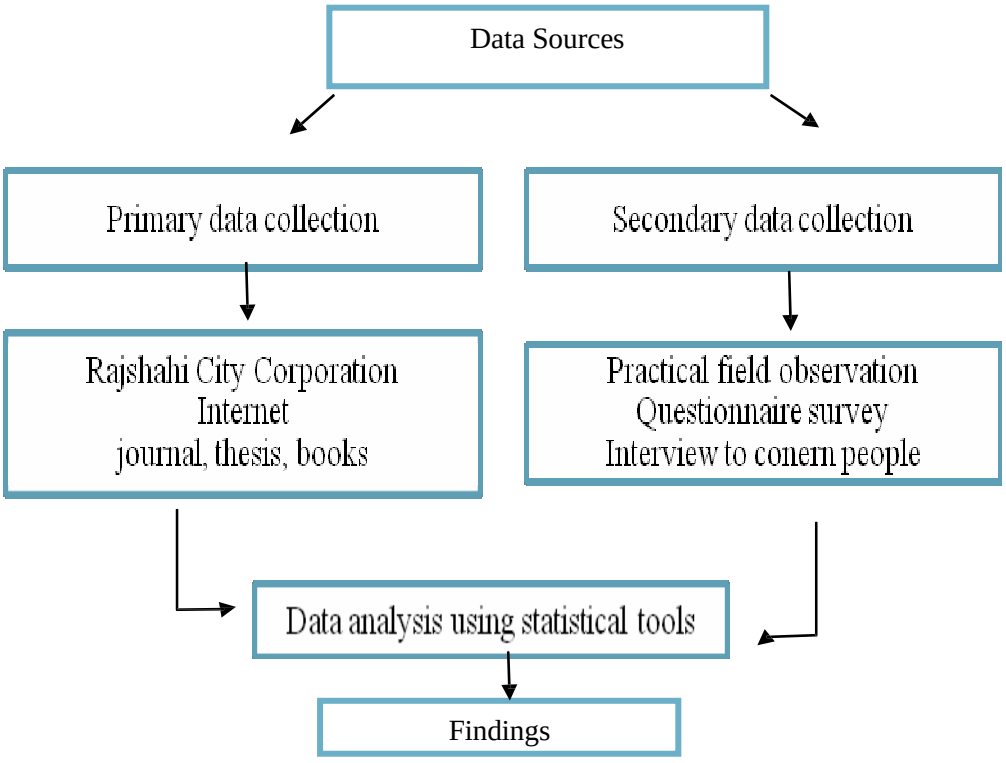


Figure 1: Flow chart of research methodology

5 . Solid Waste Generations in Rajshahi City

In 1995, total production of solid waste was estimated at 10742 tons/day in Bangladesh whereas, in 2001 it was 17000 -tons/ day. It is projected that within 2025, the total production of solid waste will be 4.064 tons/day (Zahur 2007). In Rajshahi city, it generates approximately 350 tonnes of solid waste every day while the amount increases to 400 tonnes during summer. Of the total, only 210 tonnes are collected and dumped into the open dumping ground at Nawdapara. Over 40 percent solid wastes of Rajshahi city are dumped into drains, open spaces and water bodies, causing environmental pollution and health hazards (Ali 2010).

Even the officially designated dumping ground remains open to pollute the air and water while liquid wastes collected from drains are often kept on streets to dry up as Rajshahi City Corporation (RCC) lacks proper waste management logistics, said experts and sources in the RCC.

Waste generation per day in a specific area and percent composition of various waste components are the two most important types of data for decision makers (Cheng & Hu 2010). This information is necessary in order to identify waste components to target for finding resource of energy and recycling programs (Staley & Barlaz, 2009). To meet this demand waste generation per day is estimated (Table 1).

Table 1: Waste generation in RCC

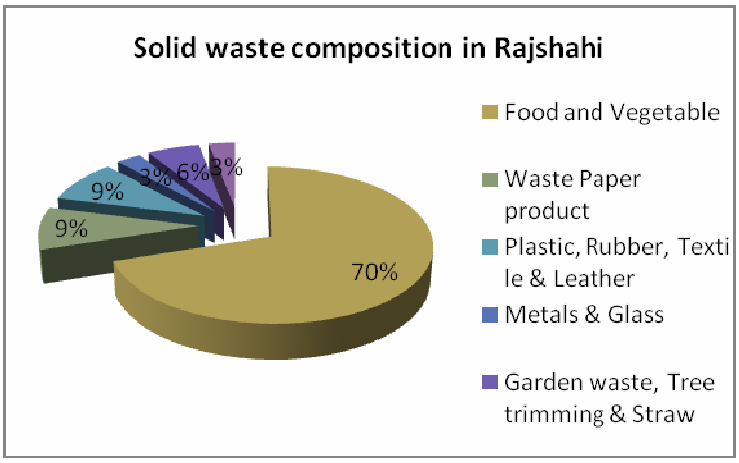
Sources	**MSW generation (kg/day/capita)**	**MSW from different sources/day (%)**
Domestic waste	0.409	40.9
Street sweeping	0.10	10
Commercial including market waste	0.44	44.0
Industrial waste	0.004	0.40
Clinical waste	0.003	0.30
Others	0.05	5.0
Total	**Waste generated 1.00 6 kg per day**	**100%**

Source: Field survey 2014

5.1. Composition of the Waste

The nature and quantity of solid waste is changing over time and with development (EEA, 2002). In urban Bangladesh, solid wastes are originated from residential houses, street sweeping, commercial, 45industrial and other sources includes dust, ash, vegetable and animal bones, paper and packing of all kinds, rags and other torn fabrics, garment materials and many other trash (Alam & Sohel, 2008). From the field survey it is found that there are a number of organic compounds in the solid waste of RCC. The average percent fraction of total generated solid waste of Rajshahi City collected from different sources at different location

of the city is given in figure 2.



Source: RCC (2014) and Field Survey (2014).

From the above figure it is found that the composition of solid waste generated in Rajshahi city is multi sectored. One of the major compositions of generating solid waste is food and vegetable waste which is almost 70% of total waste generation. The generated solid waste also contains paper products and plastics, rubber, textile and leather are same rate that is 9% each. Garden wastes and tree trimming materials are 6%. Among all of this composition rock, dirt and metal glasses are found in a slighter amount (3%).

5.2 Major sectors of waste production

Waste is produced from different sources. The major sources of waste production are residential, commercial, institutional and street sweeping. The generation of residential and commercial- industrial solid waste takes place in every home, every apartment building, and every commercial and industrial facility as well as on the streets, parks, event vacant areas. In study area, the proportion of waste generation are given in figure 3

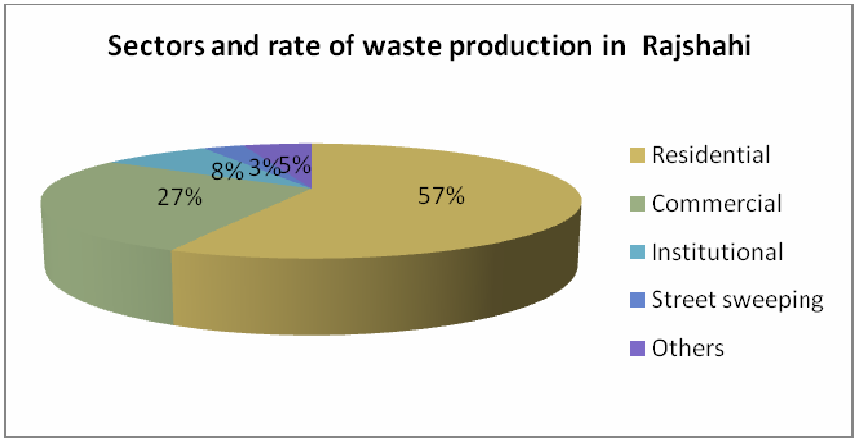


Figure 3: Different sectors to contribute the generation of solid waste

In Rajshahi city, residential sectors contribute 78.6% waste in total generation of solid waste. From the above figure it can be seen that commercial sectors and institutional sectors contribute 17.7% and 1.3% waste in total generation of solid waste in the Rajshahi city respectively.

5.3 Solid waste collection

Collection of solid waste in an urban area is difficult and complex because the generation of residential and commercial-industrial solid waste takes place in every home, every apartment building, and every commercial and industrial facility as well as on the streets, parks, event vacant areas. There are 30 wards in the Rajshahi City Corporation. Two third of the total wards are covered by 'door to door waste collection' facilities. The conservancy department of RCC is responsible for the secondary waste collection to remove waste from its dustbins and transport it to the final disposal sites. There are one dumping site (3.5 feet deep in 15.98 acre area located at the periphery area of the city known as "City By pass" and 37 secondary collection points. Still the waste collection and management process in not well planned. Waste collection and carrying in open truck and therefore, it leads to pollute the environment. In spite of having guidance to collect and carry waste in the drawn nevertheless it is very often seen at day time of waste collection and transportation. Besides, wastes are carried away by open van, rickshaw and truck. As a result, dry and light wastes often fly on and pollute environment. Thus, it hampers the main purpose of waste management. Number of vehicles used to waste collection and waste transportation system is shown in figure 4.

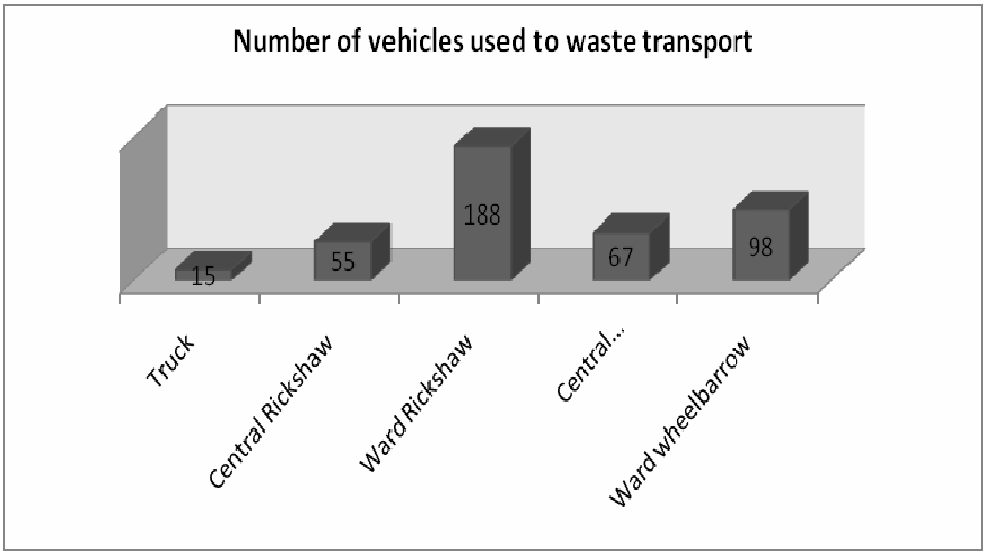


Figure 4 Total number of vehicles used to transport solid waste in Rajshahi (Source RCC 2013)

6. Waste Transportation and Disposal

Wastes are being disposed of in an open land in an insufficient manner in many cities of Bangladesh. Many

residents have to dump solid wastes into drains and other spaces as the RCC has poor logistic support. The collected solid waste is presently being disposed off mainly in a low-lying area named "Nawdapara" about 3 kilometers from the corporation area. It is the second dumping zone. This disposal site does not follow the principle of sanitary landfills. In this disposal site, waste spreads all over the site. There is no proper system to maintain the landfill area. With the blowing of wind there is an unpleasant odour spread all over the disposal area. Compaction, leveling of waste and final covering by the earth is rarely observed at a Nawdapara disposal site in Rajshahi city. Thus, open dumping ground at Nawdapara is unscientific and contributing to pollution.

The hospital waste that is generally generated from various hospitals located in city corporation area are incinerate on the Rajshahi Medical Hospital immediately. The wastes which are not burnable those are dumped under the ground. The solid waste disposal site of the Rajshahi City Corporation is shown in Figure 5.

Figure 5: Unplanned dumping of waste at the city area and waste transportation in open truck

7. Impacts on Environment

A healthy life, cleaner city and a better environment are the logical demands for the city dwellers. However, poor waste management leads suffering to the city dwellers. Due to lack of proper waste management, pollution occurs in many part of the city. Therefore, it is crucial to take to ensure sound waste management to trim down the impacts of waste on environment. A major source of waste removal is drainage system. The drainage system of Rajshahi city is not developed uniformly. Consequently, a heterogeneous feature arises in case of pollution in the city. Pollution is not spread all over the city. It is mostly occurring where the drainage facilities are absent and where waste management is not sound. The

polluted area of Rajshahi City can be grouped based on the intensity of pollution by drainage waste. Ward wise polluted area of the city are mentioned in table 2.

Table **2** Ward wise polluted area based on drainage waste

Ward No.	**Drain type**	**Waste flow type**	**Density**	**Level of pollution**
1, 2, 3, 4, 5, 7, 8, 26, 27, 30	Mostly Primary drains	Good	Low	Least polluted
10, 13, 14, 16, 17, 19	Primary and secondary	Moderate	Moderate	Moderate polluted
16, 18, 21, 22, 25, 28, 29	Mixed	Poor	High	High polluted
5, 6, 9, 11, 12, 20, 23, 24	Mostly tertiary drains	Very poor	Very High	Excessive polluted

(Source: Rahman 2013)

From the above table it is found that, the excessive polluted area are ward No. 5, 6, 9, 11, 12, 20, 23 and 24. This is due to the priority of tertiary drains in this area and the waste flow type of this drains are very poor. On the other hand, population density is very high in these wards. These areas are:

Court area, Shaheb Bazar, Laxmipur, Sagorpara, Ramchandrapur. Least polluted areas are found at the ward No. 1, 2, 3, 4, 5, 7, 8, 26, 27 and 30.

8. Impacts of Solid Waste Disposal on Environment

- Open air dumping creates unhygienic and poses enormous threat to the people.
- Causes aesthetic problem and nuisance due to nauseating pungent odour.
- Promotes spreading of diseases
- The situation further aggravated by the indiscriminate disposal of Hospital and Clinical Waste.
- Presence of extremely high level of Total and Facial coliform.
- Pollute water bodies.
- Carbon dioxide and Methane produced from solid waste are extremely harmful to the environment.
- Gases are produced in the landfills through aerobic and anaerobic decomposition of organic compounds, which are threat to the environment.

9. Impacts on Health

One of the most adverse impacts of poor waste management, especially municipal waste, is the incidence and prevalence of diseases such as malaria and respiratory problems, as well as other illnesses through the contamination of ground water. Biomedical wastes pose great danger in Bangladesh too as a

report estimated that 20% of the biomedical waste is “highly infectious” and is a hazard since it is often disposed of into the sewage system or drains. Such poor sanitation has serious consequences for the health of the residents and a report suggests that “most of the child mortality could be related with this problem. With regards to the living standards, solid waste leads to blockage in the drainage system which leads to flooding in the streets. Consequently, mosquitoes and bad odour are among the negative impacts resulted (Waste Concern 2004).

It is found that waste disposal system of Rajshahi City is not perfect. Therefore, there is a high risk to spread diseases in the surrounding areas. As waste management of the study area is not sufficient, disease contamination spreading tremendously. The level of disease contamination risks are increasing due to poor waste management. It is for that imposes bad impacts on environment of the city. The observation is a small increase in the risk of a birth defect happening in babies born to families living near waste dumping sites, if waste is not handled properly. The increase is much smaller than other factors which influence the likelihood of birth defects, and the numerical results cannot at present be reliably used.

However, a few aspects of waste management have been linked to health effects in local people of Rajshahi city. A portion of waste are incinerate in the study area without maintaining proper guidelines. Municipal solid waste incinerators were found to contribute 20% of the overall background mercury concentration at locations surrounding the incinerator. Emissions of dioxins from municipal solid waste incinerators can increase levels of dioxins in soil.

Based on questionnaire survey, a map of disease risky area of Rajshahi city caused by waste are shown below in figure 6

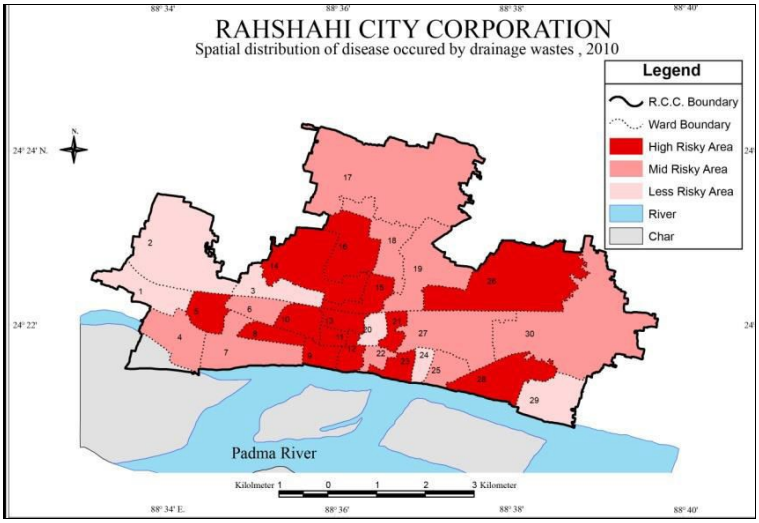


Figure 6: Disease risky area of Rajshahi city caused by drainage waste (Source: Rahman 2013)

10. Recommendations

The objective of solid waste management is to reduce the adverse environmental effects caused by the indecent solid waste management. In order to achieve this objective, waste management is to be approached in an efficient and orderly fashion through a clear understanding of the fundamental aspects and relationships of the functional elements of waste management. Following can be maintained for waste management:

a. An emergence initiative is required to develop a properly engineered landfill at Nawdapara dumping ground. Once the landfill is developed, many waste related problems will be solved.
b. Solid wastes produced in Municipalities may be used as a renewable clean energy source.
c. An immediate decision is needed to be taken by the RCC authority as well as the Government of Bangladesh to implement waste recycling project in Rajshahi city.
d. Waste should stored first and then it transfer to the dumping site as early as possible so that it cannot get chance to spread germs and pathogens.
e. Mass awareness program should arranged by the city corporation with environmentalist, healthcare service providers, waste handlers, and common people.
f. It is essential to follow proper guidelines or methodology while transferring, and transporting wastes
g. Proper dustbins, drainage facilities should ensure to the city area.
h. Effective training program for cleaners, sweepers and waste collectors should be arranged by the city authority.
i. City Corporation should develop separate system to collect liquid waste weeks after those are kept on open roads for drying.
j. Proper method should follow in waste collection, carrying, recycling and dumping.

11. Conclusion

Waste to energy solves the problem of solid waste disposal while recovering the energy from the waste materials with the significant benefits of environmental quality, increasingly accepted as a clean source of energy. The challenge of MSW disposal and the demand for alternative energy resources are common in many developing countries. Experimentally a 5-10 MW power plant may be installed based on the quality and current generation of solid wastes in RCC. Authority of Rajshahi City Corporation should to look on proper management of generated waste. Need implementation laws and regulations in the proper way. Need to upgrade the concept of solid waste management and improve the system of entire management.

Waste management is a major challenge in urban areas throughout the world. Without an effective and

efficient waste management program, the waste generated from various human activities, both industrial and domestic, can result in health hazards and have a negative impact on the environment. Understanding the waste generated, the availability of resources, and the environmental conditions of a particular society are important to developing an appropriate waste-management system.

It has looked at the available information on the health and environmental effects of waste management. While the information is incomplete and not ideal, the weight of evidence from the studies so far is that present-day practice for managing municipal solid waste has at most a minor effect on human health and the environment. This should be viewed in the light of the benefits of collection and disposal of the waste that we all generate. If waste were not collected, treated and disposed, it would become a source of disease, odours, litters and pests.

It is recommended that efforts continue to be made to reduce the amount of municipal solid waste generated by and for us all. The government, regulators and the waste management industry should continue to be vigilant and improve their own understanding of the effects of municipal solid waste management, so that we can better regulate and control this essential industry. This will need to be communicated to the public so that we can all develop a proper perspective on the health and environmental effects of MSW. Specifically, it is recommended that a number of further studies would be helpful in improving an understanding of the health and environmental effects of solid waste management.

Acknowledgement

Rajshahi City Corporation has provided many information and data to conduct this research. Bangladesh Council for Science, Industrial and Research (BCSIR) laboratory is used to test water and waste quality. It is hereby acknowledged their cooperation.

References

Ali, A. (2010) Faulty solid waste management in Rajshahi city, The Daily Star, A national daily of Bangladesh, Dhaka, Bangladesh, 11 February 2010 www. thedailystar.com

Atik, S.M. (2013) Rajshahi waste management in disarray, online edition, The Daily New Age, 7 March 2013, Dhaka, Bangladesh.

Bhuiyan, S. H. (2010) A crisis in governance: Urban solid waste management in Bangladesh. *Habitat International, 34* (1), 125-133.

Clemett, A. Amin, M. M., Ara, S. & Akan, M. M. R. (2006). *Background information for Rajshahi City, Bangladesh.* Stockholm: Stockholm Environment Institute.

Chowdhury, A. I. (2008) *Instruments of local financial reform and their impact on service delivery, institutional and development concerns: Bangladesh Case Study.* Dhaka: Centre for Urban Studies.

Cheng, H. and Hu, Y. (2010) Municipal solid waste (MSW) as a renewable source of energy: Current and future practices in China. *Bioresource Technology*, 101, 3816–3824.

Rouf, Md. Abdur (2011) Prospect of Electric Energy from Solid Wastes of Rajshahi City Corporation: A Metropolitan City in Bangladesh. 2011 2nd International Conference on Environmental Engineering and Applications, IPCBEE vol.17 (2011) IACSIT Press, Singapore.

Bhuiya. G. M. J. A (2007) Bangladesh Solid Waste Management: Issues and Challenges in Asia, Published by the Asian Productivity Organization. Mumbai, India, p 29

Rahman, N. Ahmeduzzaman, M. (2013) Case study on the recent solid waste management scenario in Rajshahi city, Bangladesh, science publishing group, *American Journal of Environmental Protection*, Vol. 2, No. 2, 2013, pp. 58-63.

Bari, Q.H., Hassan, M. and Haque, E,M. (2012) Solid waste recycling in Rajshahi city of Bangladesh

ELSIEVER Journal, Special Thematic Issue: Waste Management in Developing Countries

Volume 32, Issue 11, Pp 2029–2036 violence extortion tender

Rahman, M. (2013) The Drainage System of Rajshahi City and its Impact on Human Health, PhD thesis, Institute of Environmental Science, University of Rajshahi, Rajshahi, pp 188-192.

Saha, A. K. (2013) Environmental aspects of solid waste management: a case study of Pabna city in Bangladesh, *International journal of Advanced Scientific Engineering and Technology*, 2(2), p. 1-8.

Staley, B. F. & Barlaz, M. A. (2009). Composition of municipal solid waste in the United States and implication for carbon sequestration and methane yield. *Journal of Environmental Engineering, DOI: 10.1061*/_ASCE_EE.1943-7870.0000032.

Waste Concern, Department of Environment. (2004). Country Paper Bangladesh. Agargaon, Dhaka.

Zahur, M.(2007) Solid Waste Management of Dhaka City: Public Private Community Partnership, *BRAC University Journal, Vol. IV, No. 2, 2007, pp. 93-97*

Islam, D, M and Saifullah, A.Z.A (2001) Solid Waste and Sugarcane Bagasse-A Renewable Source of Energy In Rajshahi City, Bangladesh, *4th International Conference on Mechanical Engineering,* December 26-28, 2001, Dhaka, Bangladesh/1: 33, pp. I 33-36

Appendix

Questionnaire

Dear respondent,

I am doing research for an article entitled **Solid Waste Management of Rajshahi City in Bangladesh and Its Impact on Human Health and Environment**

This questionnaire is for research purposes only. Your information will be kept secret. I seek your earnest cooperation.

Thank you

Researcher

Name of the respondent: Age :

Sex : Contact No.:

Note: Please give tick (√) mark where appropriate.

1. Is there any waste dumping area near your locality?
   a)Yes b) No
   If yes, then how far?
   a) Within 100 meters b) Within 100 to 200 meters
   c) Within 500 meters d) Others (specify)….

2. What types of waste usually dumped there?
   a) Solid b) Liquid c) Semi solid d) Others
   If no dumping area then
3. What is the waste disposal system practices in your city?
   a) Dustbin b) Dumping c) Drains
   d) Thrown open space e) Incineration, f) Other

4. What is the waste disposal time?
   a) Day b) Night c) No fixed time
5. What is the level of odour emitted by waste

a) Intense odor b) Odorless c) Medium odour d) No comment

6. What do you think about present waste management condition?

a) Proper management b) Improper c) No management at all d) other

7. Who monitor the waste management

a) Councilor of concerned Ward b) Authority of health centre

c) Common people d) No monitoring system

8. What types of disease spread usually?

a) Infectious b) Contagious c) Water born d) Air born e) others

9. What do you think about diseases spread range?

a) High b) Medium c) Least d) No idea

10. Do you think RCC authority is concern about waste management

a) Yes b) No c) Sometimes

11. Who engaged in waste disposal work?

a) Concern person of authority b) Scavenger

c) Common people d) City Corporation

12. Is there any waste recycling system in Rajshahi City?

a) Yes b) No

13. If yes, who are the concern authorities?

a) Govt. b) Private sector c) NGO/INGO d) Others

14. What are the main sources of waste?

a) Residential b) Commercial

c) Street d) Health centers

15. Do you think waste pollute the environment?

a) Yes b) No

16. If yes, then how?

a) Waste's odour b) Waste fluids

c) Disease infection d) Others

16. Who monitor the waste management system of Rajshahi City?

a) Monitoring committee of RCC b) Government

c) Private authority d) none

17. Do you need to pay for waste management?

a) Yes b) No

18. How often is monitored?

a) Regular b) sometimes c) very few d) not at all

19. Is the authority of RCC spray medicine to dispose waste?

a) Yes b) No c) Not in knowledge d) No comments

20. What do you think about the problems of waste disposal?

a) Lack of knowledge b) Inadequate budget for disposal

c) Lack of skilled manpower d) Lack of sound techniques

e) Lack of proper plan