International Journal of Environmental Sciences
ISSN: 2229-7359
Vol. 11 No. 15s, 2025
https://www.theaspd.com/ijes.php

Application Of Public Awareness, Innovation, And Technology To Improve The Solid Waste Management Of Dhaka City: The Role Of Administration

[1]**Bitan Kumar Mandal,** [2]**Abonti Rani,** [3]**Muhammad Al-Amin,** [4]**Bishnu Kumar Adhikary**
[1]Additional Deputy Commissioner (General), Office of the Deputy Commissioner, Khulna, Bangladesh bitankm@gmail.com
[2]BSc (Honours), MSc**,** Department of Economics, Jahangirnagar University, Bangladesh**,** abonti43ju@gmail.com
[3]Chief Executive Officer (Senior Assistant Secretary)**,** Ministry of Public Administration**,** Government of the People's Republic of Bangladesh**,** amin.notredame@gmail.com
[4]Professor, School of Economics and Management, University of Hyogo, Japan.**,** adhikarykobejp@gmail.com;, adhikary@em.u-hyogo.ac.jp

Abstract
This study examines the role of administration in enhancing solid waste management (SWM) in Dhaka, Bangladesh, through public awareness, innovation, and the application of technology. Dhaka, one of the world's most densely populated megacities, faces significant challenges in solid waste management (SWM) due to inadequate infrastructure, rapid urbanization, and limited public participation. The research identifies key issues, including inefficient waste collection, a lack of segregation, and insufficient recycling facilities. By analyzing successful SWM practices from developed and developing countries, the study proposes solutions that include the use of Geographic Information Systems (GIS) for route optimization, biogas production from organic waste, sanitary landfills, and black soldier fly technology for waste treatment, among others. Additionally, the study emphasizes the importance of public awareness campaigns and administrative leadership in implementing these strategies. The findings suggest that a combination of technological innovation, community engagement, and robust policy frameworks can significantly enhance solid waste management (SWM) in Dhaka, thereby contributing to a cleaner and healthier urban environment.
Keywords: *Solid waste management, Dhaka, public awareness, innovation, technology, administration*

1. INTRODUCTION

Effective solid waste management (SWM) remains a significant challenge for urban governance, particularly in rapidly growing megacities within developing countries. Dhaka, the capital city of Bangladesh, is a striking example. Despite being the administrative and economic heart of the nation, Dhaka suffers from a fragmented, underfunded, and largely inefficient waste management system. The problems are multifaceted—ranging from environmental pollution and health hazards to institutional incapacity and public disengagement (Hoornweg & Bhada-Tata, 2012; Guerrero et al., 2013). This warrants a practical study to investigate the current level of SWM in Dhaka City, with the aim of formulating actionable solutions.

Solid waste management in Dhaka faces severe constraints due to its rapid population growth, estimated to increase at an annual rate of 4%, resulting in over 6,000 tons of waste generated daily (Rahman, Sultana, & Hoque, 2020). Yet, only about 40% of this waste reaches designated disposal sites, with the remainder accumulating in open spaces, drains, and waterways, severely impacting public health and environmental quality (Afroz et al., 2010; Yasmin & Rahman, 2017). Additionally, the waste is hardly separated into groups, such as biodegradable, non-biodegradable, recyclable, and non-recyclable, while collecting. As a result, all these types of waste are dumped or disposed of in the same open spaces and low-lying lands near the city, causing serious health hazards. Figure 1 shows how the low-lying lands near the Dhaka city corporation area, such as Aminbazar and Matuail, are used to dispose of all waste materials randomly.

Figure 1: Open dumping in Aminbazar and Matuail area

Another major concern lies in the mismanagement of hazardous and medical waste. Hospitals and clinics across Dhaka generate a significant amount of infectious and toxic waste. Yet, most of it is disposed of in the same bins as household waste, without segregation or treatment—posing serious health risks to waste workers and the general public (Akter, 2000; Ministry of Health and Family Welfare, 2001). Similarly, the tanning industries in Hazaribag discharge large quantities of untreated solid and liquid waste into the Buriganga River, contributing to extensive water and soil pollution (Azom et al., 2012; Ozturk, 2015).

Infrastructure inadequacies further impede efficient waste collection and transportation. The city's roads are often narrow, poorly maintained, and congested, while the number of waste collection vehicles is insufficient, and their operational condition is suboptimal (Henry et al., 2006). Moreover, the placement of waste bins across the city lacks strategic planning based on population density or waste generation patterns, leading to low usage and frequent overflow (Senthil, 2012). This situation is further compounded by the insufficient budgetary and human resources within the city corporations, namely the Dhaka North City Corporation (DNCC) and the Dhaka South City Corporation (DSCC) (Ahsan et al., 2014).

Furthermore, the prevailing socio-economic context exacerbates this crisis. A significant portion of Dhaka's residents live below the poverty line, rendering them largely indifferent to environmental issues, such as waste disposal (Zuberi, 1998; Salequzzaman & Stocker, 2001). Studies have shown that public apathy toward waste segregation and disposal is widespread, often due to limited awareness, lack of incentives, and the absence of viable recycling infrastructure (Sujauddin et al., 2008; Matter et al., 2015).

In contrast, cities in both developed and emerging economies have demonstrated notable success in managing solid waste through a combination of public awareness campaigns, technological innovation, and effective administrative oversight (Troschinetz & Mihelcic, 2009; Timlett & Williams, 2008). Technological interventions such as Geographic Information Systems (GIS) for route optimization, biogas production from organic waste, and the application of black soldier fly larvae for organic waste treatment have emerged as viable solutions (Vaishampayan, 2014; Omer, 2017; Diener et al., 2009). So, Dhaka has significant potential to improve its solid waste management practices through administrative reform, technological innovation, and community engagement. However, the key question remains: how can the administration improve SWM in Dhaka through public awareness, innovation, and technology?

Given the above, this study aims to explore how the Dhaka city administration can harness innovation, technology, and public engagement to address the city's persistent waste management challenges. In doing so, the study applies primary data containing 400 samples and reviews best practices from global case studies to recommend actionable strategies tailored to the local context.

The study offers significant value to the administrative governance and waste management literature in the following ways. Firstly, the study provides empirical evidence on current solid waste management (SWM) practices in Dhaka by incorporating both primary and secondary data. It evaluates the perceptions, behaviors, and attitudes of residents toward waste management and examines the role of administrative bodies such as DSCC and DNCC. This localized insight is essential, as many existing studies are either based on global best practices or focused on different socio-economic contexts, often lacking applicability to South Asian

megacities. Secondly, the study bridges a gap in the academic literature by integrating technological solutions—such as Geographic Information Systems (GIS), biogas production, and Black Soldier Fly (BSF) technology—with behavioral interventions, including public awareness campaigns and incentive-based participation. While these approaches have been independently studied, this research uniquely explores their synergistic potential under coordinated administrative oversight. Thirdly, it highlights the critical role of governance in ensuring sustainable solid waste management (SWM). The study emphasizes that technological tools and public participation are unlikely to succeed without robust institutional frameworks, adequate policy support, and precise accountability mechanisms. In this regard, it offers policy-relevant recommendations, including the development of innovation units within city corporations, partnerships with private and non-governmental actors, and water-based waste transport strategies—an area that remains largely absent in prior solid waste management (SWM) literature. Lastly, this study serves as a practical model for other developing cities facing similar waste management crises. By contextualizing global innovations within the infrastructural and cultural realities of Dhaka, the study not only adds to academic discourse but also offers actionable guidance for urban planners, policymakers, environmental NGOs, and public administrators.

In summary, this research advances the discourse on urban waste governance by demonstrating that sustainable solid waste management (SWM) requires an integrated approach that combines technical innovation, public engagement, and strong administrative leadership. Its findings have the potential to inform both future research and on-the-ground policy interventions, making it a valuable contribution to the fields of environmental management, urban planning, and public policy.

The rest of the paper is organized as follows. Section 2 reviews previous literature. Section 3 discusses research design. Section 4 analyses data and reports findings. Section 4 presents recommendations that synthesize previous case studies, and Section 5 concludes the study with policy implications.

2. Underpinning Previous Literature

Solid waste management (SWM) encompasses the systematic collection, transportation, treatment, and disposal of waste materials, including the supervision and monitoring of these processes (Hoornweg & Bhada-Tata, 2012). Solid waste primarily consists of unwanted, partially used, and expired materials generated from residential, industrial, and commercial sources (Tammemagi, 1999). These wastes often include plastics, food remnants, and glass, with some types posing significant threats to public health due to their toxic, flammable, or radioactive nature. Ineffective SWM contributes to environmental degradation, including air and water pollution and public health hazards (Jilan, 2002). Standard methods of waste disposal globally include open dumping, incineration, and recycling. However, open dumping remains prevalent in many developing nations, where waste is frequently deposited in low-lying areas for future land reclamation. Composting organic waste is also practiced to produce fertilizers for agriculture.

In developing countries, SWM faces numerous challenges stemming from environmental, financial, socio-cultural, and institutional constraints. A key issue is the lack of technical expertise and technology for waste processing (Hazra & Goel, 2009). Moreover, inadequate infrastructure significantly hampers effective waste collection and transportation (Moghadam et al., 2009; Henry et al., 2006). Technological inadequacies further constrain sustainable waste management efforts (Mreyyan & Hamdi, 2006). In many developing cities, environmental controls are limited or nonexistent, and the broader implications of mismanaged waste are often underestimated (Matete & Trois, 2008; Guerrero et al., 2013).

Financial limitations remain a fundamental barrier, impeding investments in waste infrastructure (Massoud et al., 2009). Additionally, solid waste is rarely a priority in policy agendas, and available data are often incomplete or disorganized (Sharholy et al., 2007; Sawalem et al., 2009). Socio-cultural dynamics also contribute to the problem. For instance, residents frequently rely solely on municipal authorities for waste management, neglecting their own responsibilities, which exacerbates the issue (Tawhid, 2004; Vidanaarachchi et al., 2006). At the same time, political leaders involved in waste-related decision-making often lack adequate technical expertise (Moghadam et al., 2009), resulting in weak governance and inadequate enforcement of waste management regulations.

2.1 Geographic Information System (GIS)

The Geographic Information System (GIS) is a computer-based technology that plays a pivotal role in enhancing urban solid waste management. GIS enables authorities to capture, store, analyze, and visualize spatial data concerning waste generation, bin placement, and collection routes. This data-driven system aids urban planners in forecasting waste volumes, optimizing transportation routes, and identifying optimal locations for waste bins and disposal facilities (Shoba & Rasappan, 2013). Katpal and Rao (2012) demonstrated the effectiveness of GIS in decision-making by integrating satellite imagery and geographic data to assess the physical and chemical characteristics of waste. Similarly, in Kumbakonam, Tamil Nadu, GIS facilitated the reassessment of waste bin locations to enhance accessibility and efficiency (Senthil, 2012). GIS has also been utilized to optimize waste collection routes, thereby reducing operational costs and improving service delivery (Karadimas et al., 2008). In Pallavapuram municipality, India, Kanchanabhan et al. (2011) developed a GIS-based model considering factors such as population density, waste generation rates, and vehicular capacity. Furthermore, Natesan and Suresh (2002) introduced a GIS-supported Decision Support System to identify suitable landfill sites based on criteria such as soil type, drainage, and land use. The use of GIS not only facilitates operational efficiency but also enhances long-term planning and monitoring of SWM systems (Vaishampayan, 2014).

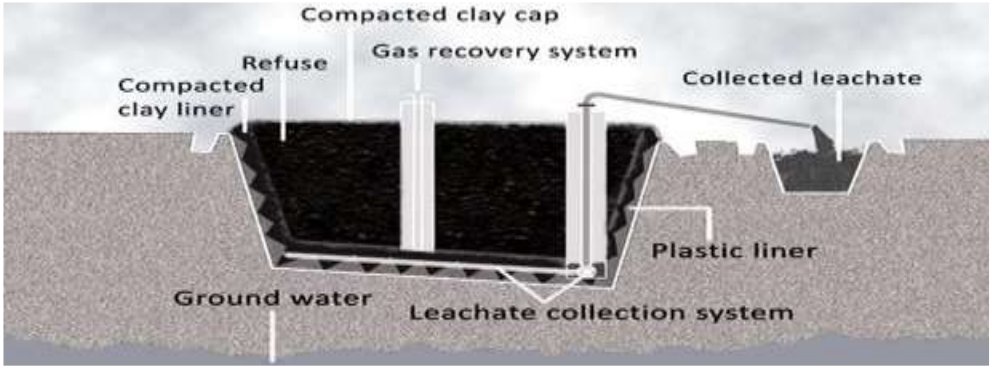
2.2 Biogas Production from Waste

Biogas generation from organic waste represents an innovative and sustainable approach to solid waste management (SWM). Organic waste, being biodegradable, serves as an effective raw material for biogas production, simultaneously addressing waste reduction and energy shortages. Methane, the primary component of biogas, can be harnessed for electricity generation, thereby reducing reliance on non-renewable energy sources (Omer, 2017). Chaerul et al. (2008) highlighted that utilizing methane from waste mitigates greenhouse gas emissions and supports the development of renewable energy. Biogas plants convert organic waste into energy while also producing nutrient-rich slurry for agricultural use. This dual benefit positions biogas technology as a crucial component of integrated solid waste management (SWM) and sustainable energy strategies.

2.3 Sanitary Landfill

The sanitary landfill is a scientifically designed method for waste disposal that minimizes environmental and public health risks. Unlike open dumping, sanitary landfills involve the systematic layering and compaction of waste, followed by a layer of soil cover. The United States Environmental Protection Agency (EPA) promotes this approach, stipulating the use of clay and plastic liners to prevent leachate infiltration into groundwater and to capture methane gas for energy use (Qasim, 2017). Although this method is well-established in developed nations, its application in developing countries remains limited. Sanitary landfills offer long-term environmental benefits and efficient land use, with leachate collection systems and gas recovery mechanisms that enhance sustainability.

Figure 2: Sanitary Landfill



Source: Adapted from Help Save Nature, 2019.

2.4 The 3Rs Approach: Reduce, Reuse, Recycle

The 3Rs—Reduce, Reuse, and Recycle—are foundational principles in sustainable waste management (Momen, 2010). "Reduce" advocates for the minimization of waste generation through conscious consumption and reduced reliance on disposable goods. "Reuse" emphasizes the repeated use of materials to extend their life cycle and reduce the need for new products. Finally, "Recycle" involves processing used materials into new products, thus conserving resources and minimizing landfill dependency. Globally, recycling plays a critical role in waste diversion strategies. Materials such as aluminum, plastic, glass, and paper can be efficiently recycled into value-added products. According to Troschinetz and Mihelcic (2009), nearly half of the solid waste produced in urban centers can be recycled, thereby significantly reducing environmental burdens.

2.5 Reward and Incentive Mechanisms

Incentive-based schemes have emerged as effective tools to promote proper waste disposal and recycling practices. For example, in Portsmouth, UK, a community-based rewards program was implemented to improve recycling rates (Timlett & William, 2008). Residents were evaluated based on the composition and cleanliness of their recycling bins and were assigned scores such as "Green," "Amber," or "Red." Households maintaining high standards over time received vouchers and public recognition. The program demonstrated that strategic incentives could enhance civic engagement and foster a culture of responsible waste management.

2.6 Black Soldier Fly Technology

Black Soldier Fly (BSF) technology is an emerging innovation in the treatment of organic waste. The larvae of the BSF (Hermetia illucens) are capable of consuming large volumes of organic waste, reducing its mass by over 90% (Abdel-Shafy & Mansour, 2018). These larvae transform organic waste into nutrient-rich biomass, which can be repurposed as animal feed, particularly in aquaculture and poultry farming (Diener et al., 2009). In their "prepupal" stage, the larvae contain approximately 40% protein and 30% fat, making them highly valuable in agricultural applications. Moreover, they efficiently absorb nutrients such as nitrogen and phosphorus from waste substrates, including pig and cow manure (Williams et al., 2006), thereby supporting nutrient recycling and reducing reliance on synthetic feed and fertilizers.

2.7 Public Awareness

Public awareness and participation are crucial for the success of any solid waste management (SWM) initiative. According to Banga (2013), inclusive stakeholder engagement has a significant impact on improving waste management outcomes. However, awareness alone does not guarantee participation. Ayodeji (2012) found that although schoolteachers in Nigeria understood proper waste disposal practices, many were unwilling to engage in them actively. A strong correlation exists between public knowledge, socio-economic factors (such as education and income), and waste management behavior. Gentil et al. (2009) emphasized that cities with higher levels of awareness tend to exhibit more effective waste management systems. Therefore, public education and awareness campaigns are indispensable components of sustainable waste management strategies.

3. RESEARCH DESIGN

3.1 Study Area

The study was conducted within the administrative boundaries of Dhaka North City Corporation (DNCC) and Dhaka South City Corporation (DSCC), which jointly form the governance framework for metropolitan Dhaka. These areas were selected due to their critical role in solid waste management and their dense population, which exacerbates the challenges of managing urban waste.

3.2 Research Method

This research employed a descriptive survey method to understand the perceptions, attitudes, and behaviors of city residents regarding solid waste management (SWM). The survey method was chosen due to its efficacy

in gathering data from a large population and its suitability for assessing opinions and practices related to public service delivery.

3.3 Sources of Data

Both primary and secondary data sources were utilized to ensure the reliability and validity of the study. Primary data were obtained through structured questionnaires, oral interviews, and direct observation of SWM practices in selected areas of DNCC and DSCC. Secondary data were collected from relevant academic journals, government reports, international organization publications, and various credible online sources related to waste management.

3.4 Methods of Data Collection

Data collection employed a combination of the following methods:

a) Questionnaire Survey: Structured questionnaires were administered to a representative sample of residents to collect quantitative and qualitative data on SWM practices and perceptions.

b) Oral Interviews: Semi-structured interviews were conducted with key stakeholders, including city officials, environmental experts, and community members.

c) Personal Observation: Field visits were undertaken to observe waste collection, transportation, disposal, and public participation practices.

3.5 Study Population and Samples

The target population of the study consisted of the residents of Dhaka city within the jurisdiction of the DSCC and DNCC. According to the World Population Review (2020), the combined population of these two corporations is approximately 21,005,860. The study sample includes diverse demographic segments, ensuring representation across gender, occupation, and education levels. For sampling a multi-stage sampling technique was employed for the study. First, we adopted stratified sampling, where the population was initially stratified into distinct groups based on socio-demographic characteristics. Then, we applied simple random sampling. Within each stratum, individuals were selected randomly to ensure fairness and eliminate bias. The sample size was determined using the Taro Yamane formula:

$n = N/ 1+ N(e)2$

Where:

n = sample size, N = total population (21,005,860), and e = margin of error (0.05)

Applying the formula yielded an approximate sample size of 400 respondents, which was deemed statistically sufficient for the study's objectives.

3.7 Validity and Reliability of Research Instruments

To ensure the validity and reliability of the research instruments, the following measures were implemented:

a) Pilot Testing: A preliminary test was conducted on a subset of the sample to identify and correct ambiguities in the questionnaire, ensuring that all respondents understood the items uniformly.

b) Expert Review (Face Validity): The questionnaire and interview guides were reviewed by academic experts and research supervisors who provided feedback for refinement.

c) Content Validity: The questions were aligned with the study objectives and covered key thematic areas relevant to SWM, ensuring comprehensiveness.

d) Criterion-Related Validity: Instrument validity was further ensured by comparing responses with external indicators and benchmarks known to measure similar attributes.

These procedures collectively enhanced the reliability and rigor of the research instruments, ensuring the collection of accurate and consistent data.

4: RESULTS AND DISCUSSION

This section presents the findings of the study based on both primary and secondary data. The results are discussed concerning the research questions and objectives and are interpreted using appropriate statistical and analytical tools.

4.1 Primary Data Analysis

4.1.1 Method of Data Analysis

The data collected from respondents were analyzed using simple percentage calculations and chi-square statistics. These methods facilitated the evaluation of frequencies and the relationship between variables such as demographic characteristics and perceptions of solid waste management (SWM).

4.1.2 Demographic Profile of Respondents

Table 1 shows that out of 390 respondents, 270 (69.2%) were male and 120 (30.8%) were female. This distribution suggests higher male participation in the survey, which may influence perspectives on sustainable waste management (SWM) practices.

Table 1: Gender Distribution

S/N	Sex	Frequency	Percentage
01	Male	270	69.2
02	Female	120	30.8
	Total	390	100

Source: Authors' construction, Field Survey, 2020

Table 2 portrays that respondents demonstrated varied educational backgrounds. Out of the 390 respondents, 5.64% had completed primary education, 20.51% had passed JSC, 23.07% had SSC, 32.82% had HSC, 9.23% held undergraduate degrees (BA/BSc/BSS), 8.71% held postgraduate or doctoral degrees (MA/MSc/MSS/PhD). Therefore, it was found from the table that all respondents possessed basic literacy, which was essential for understanding and answering the questionnaire.

Table 2: Educational Qualification

S/N	Educational Qualification	Frequency	Percentage
01	Primary education	22	5.64
02	JSC	80	20.51
03	SSC	90	23.07
04	HSC	128	32.82
05	BA/ BSc/BSS	36	9.23
06	MA/MSc/MSS/PhD	34	8.71
	Total	390	100

Source: Authors' construction, Field Survey, 2020

Table 3 shows the occupational breakdown of the respondents. As is observed from Table 3 above, out of the 390 respondents, 22.56% were self-employed, 38.71% were government employees, 34.61% worked in the private sector, and 4.1% included students, experts, or other categories. These findings indicate a diverse and informed sample suitable for concluding SWM attitudes and behaviors.

Table 3: Occupational Status

S/N	Occupation	Frequency	Percentage
01	Self-employed	88	22.56
02	Govt. Service holder	151	38.71
03	Private Service holder	135	34.61
04	Others (Students, experts, resource persons)	16	4.1
	Total	390	100

Source: Authors' construction, Field Survey, 2020

4.2 Key Findings from Questionnaire Responses

Table 4 demonstrates respondents' opinions on the collection of waste. The responses were recorded on five dimensions: Strongly Agree (SA), Agree (A), Neutral (N), Strongly Disagree (SD), and Disagree (D). It was found that the majority of respondents (41.53% strongly disagreed and 38.2% disagreed) expressed dissatisfaction with the current household waste collection practices. Only 13.07% agreed or strongly agreed that waste collection was satisfactory, highlighting significant gaps in service delivery.

Table 4: Satisfaction with Waste Collection from Primary Sources

Option	SA	A	N	SD	D	Total
Male	12	28	22	99	109	270
Female	4	7	6	63	40	120
Total	16	35	28	162	149	390

Source: Authors' construction, Field Survey, 2020

Likewise, Table 5 presents respondents' opinions on the separation of waste at the collection level. It was found that an overwhelming majority (44.35% strongly agreed, 36.15% agreed) believed that separating waste at the source is essential for effective solid waste management (SWM). This indicates a high level of awareness regarding best practices, though such practices are not yet widely implemented.

Table 5: Importance of Waste Separation at Source

Option	SA	A	N	SD	D	Total
Male	110	101	15	15	29	270
Female	63	40	7	4	6	120
Total	173	141	22	19	35	390

Source: Authors' construction, Field Survey, 2020

Similarly, Table 6 illustrates public awareness of SWM. As evidenced in Table 6, approximately 83% of respondents (strongly agree and agree) believed that city residents lack sufficient awareness regarding proper solid waste management (SWM). This consensus underscores the urgent need for educational campaigns and community engagement.

Table 6: Public Awareness of SWM

Option	SA	A	N	SD	D	Total
Male	101	110	29	14	16	270
Female	61	42	7	6	4	120
Total	172	152	36	20	20	390

Source: Authors' construction, Field Survey, 2020

Similarly, Table 7 illustrates the role of public awareness in enhancing solid waste management (SWM). Table 7 reveals that, out of 390 respondents, a substantial majority (86.14%) agreed that public awareness is crucial to enhancing waste management outcomes. This supports the hypothesis that behavioral change is necessary in conjunction with administrative reform.

Table 7: Role of Public Awareness in Improving SWM

Option	SA	A	N	SD	D	Total
Male	120	107	23	4	16	270
Female	56	53	9	1	2	120
Total	176	160	32	5	18	390

Source: Authors' construction, Field Survey, 2020

Similarly, Table 8 highlights the significance of innovation in SWM. As shown in Table 8, out of 390 responses, over 85% of respondents (41.5% strongly agreed, 43.84% agreed) viewed innovation—through new ideas and technologies—as essential for improving Dhaka's solid waste management (SWM) system.

Table 8: Perceived Importance of Innovation in SWM

Option	SA	A	N	SD	D	Total
Male	108	121	20	3	18	270
Female	54	50	6	2	8	120
Total	162	171	26	5	26	390

Source: Authors' construction, Field Survey, 2020

Likewise, Table 9 reveals the role of administration in promoting effective, sustainable waste management (SWM). The survey revealed that most participants (85.88%) recognized the administration—including city corporations and ward councils—as playing a pivotal role in promoting innovation, raising awareness, and ensuring effective waste management.

Table 9: Role of Administration in Promoting Effective SWM

Option	SA	A	N	SD	D	Total
Male	120	107	22	2	17	270
Female	56	52	5	1	6	120
Total	176	159	27	3	23	390

Source: Authors' construction, Field Survey, 2020

4.2: Synthesis from Secondary Data

Secondary data provided broader insights into the structural and policy-related challenges of solid waste management in Dhaka. Solid waste management is one of the most pressing issues in megacities worldwide. There is an increased rate of attention and awareness among the authorities responsible for solid waste management due to the larger volume of waste produced by a growing population. Additionally, the nature of waste has been changing due to the ever-changing lifestyles and daily necessities, as well as the emergence of new products and technologies. The authorities, therefore, need to consider newer and innovative ways to deal with changed scenarios. Furthermore, public awareness plays a crucial role in addressing these types of problems. The challenges DSCC, DNCC, and other stakeholders are facing in managing solid waste materials are listed below:

- Absence of a smooth transportation system for the solid waste materials;
- Negative public perception of waste management;
- Absence of SWM-friendly infrastructures;
- Ever-growing growth of population density;
- Lack of waste treatment plan;
- Absence of incentives for encouraging the city dwellers in SWM;
- Absence of sorting the waste in their primary sources;
- Insufficiency of recycling facilities; and
- Lack of study about the innovative ways of solid waste management.

One of the most critical issues regarding solid waste management is sorting waste at its source. To achieve this, the number of waste bins must be increased. It is not feasible for city corporations to provide all the waste bins; therefore, some private organizations should be encouraged to come forward. Private organizations and NGOs can be involved in door-to-door collection. The entire task of sorting waste materials should not be free of charge; a minimum fee must be set to help fund the program. The private sector can thus be directly involved in collecting and sorting waste by nature, while the public sector will supervise and monitor these activities. Sorting waste materials by source can ease the overall waste management plan. Some Non-Governmental Organizations (NGOs) and private organizations are getting involved in solid waste management in Dhaka city (JICA, 2005). These organizations primarily help in the collection and disposal of solid waste materials. More NGOs and private organizations should be encouraged by the government and the city corporation to take action now so that these organizations can not only collect and accumulate waste but also sort it into categories according to its nature. The reason behind this type of sorting is that different types of waste require different methods of disposal. Some wastes can be easily reused; some are suitable for recycling, while others can be composted and used as fertilizers for agricultural production.

Additionally, some wastes can be used for biogas and electricity generation. The current state of solid waste management in Dhaka City is measurable, one of the main reasons for which is the absence of this type of sorting during the collection of solid waste from primary sources. For sorting effectively, special waste bins with separate boxes for waste of different natures, such as plastic, paper, and cans, are used. In the different boxes of the waste bins, items should be disposed of, which the NGOs and private organizations will ensure, along with the staff of the city corporation. The representatives of both the public and private sectors will inspect the sorting of waste from time to time.

The sanitary landfill has been successfully used by many countries, which can also be considered for solid waste management in Dhaka city. In the case of Dhaka, most solid waste is disposed of in dumpsites, resulting in significant pollution. Sanitary landfilling should replace open dumping. This step can have multiple benefits. It will require less land than open dumping, and it will produce less or almost zero pollution. Within a few years, the land will be suitable for various purposes. Furthermore, a gas collection system is installed in sanitary landfills, which collects methane gas that can be used in power production. Therefore, the authorities

of Dhaka City, as well as the government, must take necessary steps to ensure the replacement of open dumping with sanitary landfills.

Biogas production from the solid waste of Dhaka city seems to be a feasible option. Since there is a crisis of electricity due to the increasing demand of a growing population, biogas production from the vast volume of organic waste materials can not only minimize the solid waste management problem but also contribute to the national power grid. The technology of biogas production is not new to the people of Bangladesh. However, almost all biogas production initiatives are at the individual level. Now, this technology for producing biogas from the organic portion of solid waste needs to be adopted by the authorities. There should be an annual five-year plan for producing biogas. An annual target can be set for every ward of the city. This work breakdown structure (WBS) for meeting the targeted volume of biogas can ultimately lead to a significant increase in power production in the national grid. As a result, apart from minimizing the waste management problem, it will also bring a positive impact on the power sector.

Waste treatment technology using the larvae of the black spider fly can be considered. This technology has been proven to be beneficial on multiple levels. The larvae have a short period of life while they eat up the organic part of waste very quickly (Appendix 1). These omnivorous larvae of black spider flies will be very much suitable for the waste management of Dhaka city as well as for other cities of Bangladesh. Because Bangladesh has an economy based mainly on agriculture, the remains of the larvae can be helpful. There can be a significant amount of beneficial natural manure produced by these larvae, which can further enhance agricultural production. Besides, the adult larvae of black spider fly can successfully be used for fish meal and animal food. As the larvae absorb nutrients from the organic waste in fish cultivation, animal farming, and agricultural production, it is essential to maximize the benefits of this technology.

GIS (Geographic Information System) has been proven to be a pragmatic step for smart solid waste management in several cities worldwide (Chang et al., 2008). This computer-based system can help city corporations trace the locations of waste materials. Through tracing the locations of waste materials, this computer-based system can help city corporations estimate the generation of waste materials by location over time. Through the data and information provided by GIS, they will be able to determine how many waste bins should be placed in specific areas. The volume of different types of waste can also be traced, in consequence of which it will be much easier to make further decisions about the disposal and the ways of treatment of the waste materials.

Additionally, this computer-based system can help optimize the route for waste transportation. Since the road conditions and infrastructure are not suitable for the smooth transportation of waste-carrying vehicles, it becomes very difficult for the city corporation to collect and transport waste from different locations to the final disposal sites. The route optimization facility of the Geographic Information System will be of the most help in this regard, making the transportation of solid waste easier than before.

As this technology facilitates the measurement of waste generation volume, city corporations can make more informed decisions about the necessary quantity of equipment, machines, and vehicles. Thus, the city corporation can also determine the required budget for total solid waste management. GIS, therefore, can work as an intelligent decision support system for the authority. This decision support system will not only benefit the present day but also the future. Apart from aiding in decision-making, it can also enhance the monitoring of Dhaka city's total solid waste management.

An organized recycling system will be highly effective for Dhaka city, as it generates a substantial volume of recyclable waste materials. As mentioned earlier, there are some examples of recycling in the city of Dhaka that are not organized by the city corporations or government offices but instead are being done through individual efforts with little concern for the total recyclable waste. In this type of informal recycling, some impoverished individuals collect recyclable waste from dumpsites and other open spaces and then sell it to individually established recycling points. The city corporations now have to rethink giving a formal shape to these recycling activities. After sorting the waste materials in the primary sources, the recyclable wastes should

be separated. After that, the waste can be recycled according to its potential future uses. The recycling points must be set up with wise consideration for the accessibility and convenience of all stakeholders.

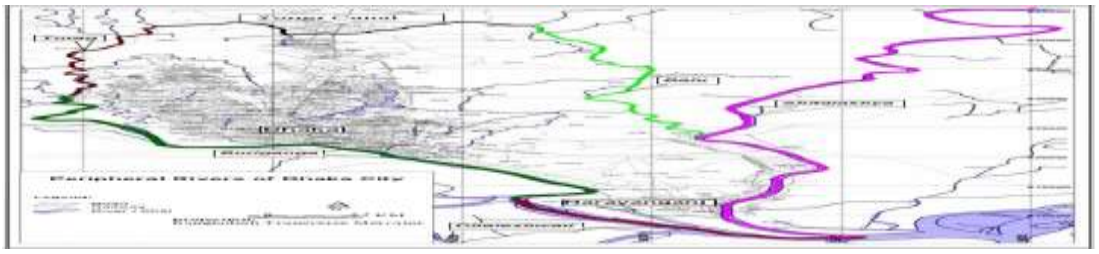
Setting targets for solid waste management in specific areas can be a practical approach, particularly when accompanied by a performance award. In many countries, the best performance award in solid waste management has been established, resulting in improved waste disposal and management practices. An example of this has been discussed above, where the council of Portsmouth, UK, developed a scheme of giving reward vouchers to the best practitioners of waste management. In DSCC and DNCC, a Performance Award System can also be developed. The ward councils can engage in a positive competition to practice best waste management practices. One inspection committee should be established to determine which wards are implementing best practices. The criteria for this assessment will include the range of waste types, the number of contaminants, the volume of recyclable waste materials, and other relevant factors. The award should include a certificate of recognition and a handsome amount of money as an incentive.

Public awareness plays a vital role in any public issue. Solid waste management involves numerous stakeholders, including city corporations, ward councils, and city dwellers across all spheres of life. Therefore, any scheme or plan will see the light of success only with the active involvement of all stakeholders. Stakeholders, such as city corporations and ward councils, are involved in waste management, while city dwellers exhibit a measured indifference to contributing to the overall waste management system. City dwellers in Dhaka believe that only the city corporation and ward councils are solely responsible for ensuring proper solid waste management. Most city dwellers only want to get rid of their waste materials and dispose of them irrespective of the nature of the place, whether it is a dumpsite, waste bin, or any open space. One of the causes of their indifference to solid waste management is that more than half of the population here struggles to meet their basic needs, leaving them with little opportunity to be conscious about waste management.

Moreover, they are not exposed to an environmentally friendly culture, and almost no information or campaigns are available to make them aware of proper waste disposal methods. Besides, people involved in cleaning and other waste management activities often do not receive respect from society, and they are usually looked down upon. Therefore, solid waste disposal faces a huge negative attitude from the public. It is high time that Dhaka City Corporation took solid and pragmatic steps to turn a negative attitude into a positive one. The government and private television channels, prominent newspapers, and magazines can play a vital role in increasing positive public awareness of waste management. The public as well as private sectors should come forward together to build a smart, solid waste management culture. Some dedicated committees and groups should be formed to prepare a roadmap for increasing public awareness to the desired level. The specialized committees can organize campaigns for public engagement regarding the harms caused by improper waste disposal practices, as well as promote effective waste management strategies.

Transportation is a key factor in solid waste management. As mentioned earlier, the road conditions and infrastructure of Dhaka City are not suitable for the smooth movement of solid waste-carrying vehicles. It is high time for Dhaka City Corporation to consider an alternative method of transporting solid waste materials to the final disposal site. If we examine the map of Dhaka city, it can be easily seen that the city is surrounded by the rivers Buriganga, Sitalakhya, Turag, Dhaleshwari, Balu, and Tongi canal (Figure 3).

Figure 3: Rivers and canals surrounding Dhaka city (Anon, 2019).



Source: Adapted from Anon, 2019.

These rivers and canals can be successfully used for the transportation of solid waste materials. Transporting waste materials through rivers and canals will ease the overall transportation of solid waste in many ways. The waste can be carried farther from the city to suitable places. Additionally, water transport generally costs less than any other form of transportation. Moreover, the waterways will consequently get attention to be improved.

Dedicated innovation unit for solid waste management is the demand of the present situation of the solid waste management of Dhaka city. The nature of solid waste materials is changing daily due to the frequent advancements and rapid growth of scientific inventions as well as technological developments. It is now very important to develop a dedicated innovation unit within city corporations that can study and formulate suitable plans to cope with potential future solid waste problems. There is a Governance Innovation Unit (GIU) in Bangladesh that works under the direct supervision of the Office of the Honorable Prime Minister. The innovation unit is composed of skilled young employees who possess a solid knowledge of science, information technology, and communication technology. This innovation unit has the potential to help city corporations utilize GIS technology more effectively.

Furthermore, they can help the authority to make better decisions. This innovation unit is facilitating most government offices across the country. City corporations can make the best use of it. Initially, they can outsource skilled employees from GIU and gather their expertise, eventually forming their innovation units. The innovation units will be able to conduct constant studies of the present situation in order to formulate plans for future actions. They will conduct the research work and assist in the feasibility testing of future projects related to solid waste management.

As a whole, the present condition of Dhaka city's solid waste management can be improved by creating public awareness, as well as by utilizing innovative ideas and technology. Therefore, all stakeholders of the city, including the City Corporation, the Government of Bangladesh, Ward councils, and general city dwellers, should collaborate to address the existing problems of solid waste management and develop a cleaner and healthier Dhaka city. At the same time, the concerned administration will play a vital role in ensuring, coordinating, and monitoring the entire enterprise.

5. CONCLUSION AND POLICY RECOMMENDATIONS

This paper examines the role of administration in enhancing solid waste management (SWM) in Dhaka City, Bangladesh, through public awareness, innovation, and the application of technology. In doing so, the study relies on primary data and synthesis from secondary literature. The study as a whole unearths that the challenges associated with solid waste management (SWM) in Dhaka reflect the broader difficulties experienced by rapidly urbanizing cities in developing countries. As the capital of Bangladesh and one of the world's most densely populated megacities, Dhaka generates vast volumes of waste daily—yet lacks the infrastructure, financial resources, and institutional coordination necessary to manage this effectively. The analysis presented in this study reveals that the existing waste management system is not only fragmented and under-resourced but also largely unsustainable.

One of the primary shortcomings identified is the lack of integration across critical stages of waste management, including waste collection, segregation, transportation, treatment, and final disposal. The reliance on open dumping, minimal separation at source, and informal recycling systems has resulted in severe environmental degradation, adverse health outcomes, and the inefficient use of both materials and human resources. Moreover, public participation remains alarmingly low due to inadequate awareness campaigns, socio-economic constraints, and the absence of community-based incentives.

The study also highlights the underutilization of existing and emerging technologies that could significantly improve waste management outcomes. For instance, Geographic Information Systems (GIS) have demonstrated the potential to optimize waste collection routes and monitor disposal sites. Biogas production from organic waste presents an opportunity for energy recovery, while black soldier fly larvae technology offers an innovative approach to organic waste treatment, providing co-benefits for agriculture and aquaculture.

These technologies, however, require institutional support, investment, and skilled personnel for successful implementation.

Furthermore, this research highlights the pivotal role of city administration and governance in shaping the future of solid waste management (SWM) in Dhaka. Sustainable waste management cannot be achieved without the proactive engagement of local authorities in planning, regulating, and facilitating innovative solutions. Administrative leadership must prioritize inter-agency coordination, public-private partnerships, and the formal inclusion of informal sector workers in the waste economy.

Overall, addressing Dhaka's waste management crisis demands a multifaceted approach—one that combines technological innovation, institutional reform, and community engagement. The findings of this study suggest that, through strategic administrative action and the adoption of proven international best practices, Dhaka can transition from its current unsustainable waste management model to a more resilient and inclusive solid waste management system. This transformation is essential not only for environmental sustainability but also for public health, urban livability, and the broader goal of achieving sustainable development in Bangladesh.

Policy recommendations

Based on our study, several recommendations are proposed:

a) Waste Sorting at Source: Special bins should be installed for segregating waste at the household level. NGOs and private enterprises can be contracted to assist in collection and categorization.

b) Public-Private Partnerships (PPP): Incentivizing the private sector to engage in waste collection and recycling can enhance service efficiency and resource mobilization.

c) Sanitary Landfills: The replacement of open dumping with sanitary landfills can reduce environmental pollution and support future land development.

d) Biogas Generation: Organic waste can be repurposed into biogas to support power production, offering a dual benefit for waste reduction and energy supply.

e) Black Soldier Fly Technology: This environmentally friendly method allows for rapid decomposition of organic waste and produces valuable biomass for agriculture and aquaculture.

f) Use of GIS Technology: Geographic Information Systems can aid in waste bin placement, route optimization, and overall system monitoring, leading to data-driven decision-making.

g) Formalized Recycling Programs: Organizing recycling activities through officially designated collection points and community-based systems can boost efficiency and reduce informal labor exploitation.

h) Performance-Based Incentives: A rewards program for communities or wards demonstrating effective waste practices (e.g., Portsmouth model) could promote positive competition and civic participation.

i) Water-Based Waste Transport: Utilizing Dhaka's rivers and canals for transporting waste to disposal sites could alleviate pressure on overburdened road networks and reduce transport costs.

j) Innovation Units: A dedicated waste management innovation cell—potentially supported by the Governance Innovation Unit (GIU)—should be tasked with continuous research, planning, and monitoring of SWM strategies.

REFERENCES

1. Abdel-Shafy, H.I. and Mansour, M.S., 2018. Solid waste issue: Sources, composition, disposal, recycling, and valorization. Egyptian journal of petroleum.
2. Afroz, R., Hanaki, K., Tuddin, R. and Ayup, K., 2010. A survey of recycling behaviour in households in Dhaka, Bangladesh. Waste Management & Research, 28(6), pp.552-560.
3. Ahsan, A., Alamgir, M., El-Sergany, M.M., Shams, S., Rowshon, M.K. and Daud, N.N., 2014. Assessment of municipal solid waste management system in a developing country. Chinese Journal of Engineering, 2014.
4. Akter, N., 2000. Medical waste management: a review. Environmental Engineering Program, School of Environment, Resources and Development Asian Institute of Technology, Thailand, pp.1-25.
5. Anon, (2019). [online] Available at: https://www.researchgate.net/figure/Map-of-peripheral- rivers-around-Dhaka-City_fig1_237126568 [Accessed 16 Aug. 2019].
6. Ayodeji, I., 2012. Waste Management Awareness, Knowledge and Practices of Secondary Schoolteachers in Ogun State, Nigeria. The Journal of Solid Waste Technology and Management, 37, pp.221-234.

7. Ayotamuno, J.M. and Gobo, A.E., 2004. Municipal solid waste management in Port Harcourt, Nigeria: Obstacles and prospects. Management of environmental quality: an international journal, 15(4), pp.389-398.
8. Azom, M.R., Mahmud, K., Yahya, S.M., Sontu, A. and Himon, S.B., 2012. Environmental impact assessment of tanneries: a case study of Hazaribag in Bangladesh. International Journal of Environmental Science and Development, 3(2), p.152.
9. Bahauddin, K.M. and Uddin, M.H., 2012. Prospect of solid waste situation and an approach of Environmental Management Measure (EMM) model for sustainable solid waste management: case study of Dhaka city. Journal of Environmental Science and Natural Resources, 5(1), pp.99- 111.
10. Banga, M., 2011. Household knowledge, attitudes and practices in solid waste segregation and recycling: the case of urban Kampala. Zambia Social Science Journal, 2(1), p.4.
11. Begum, A.A., 2009. Enhancing urban governance through public private partnership: a study of solid waste management in Dhaka City (Doctoral dissertation, BRAC University).
12. Chaerul, M., Tanaka, M. and Shekdar, A.V., 2008. A system dynamics approach for hospital waste management. Wastemanagement, 28(2), pp.442-449.
13. Chang, N.B., Parvathinathan, G. and Breeden, J.B., 2008. Combining GIS with fuzzy multicriteria decision-making for landfill siting in a fast-growing urban region. Journal of environmental management, 87(1), pp.139-153.
14. DCC (Dhaka City Corporation) (2005). Clean Dhaka master plan: The study on the solid waste management in Dhaka City. Final Report.
15. Diener, S., Zurbrügg, C. and Tockner, K., 2009. Conversion of organic material by black soldier fly larvae: establishing optimal feeding rates. Waste Management & Research, 27(6), pp.603- 610.
16. Gentil, E., Clavreul, J. and Christensen, T.H., 2009. Global warming factor of municipal solid waste management in Europe. Waste Management & Research, 27(9), pp.850-860.
17. Guerrero, L.A., Maas, G. and Hogland, W., 2013. Solid waste management challenges for cities in developing countries. Waste management, 33(1), pp.220-232.
18. Hai, F.I. and Ali, M.A., 2005. A study on solid waste management system of Dhaka City Corporation: effect of composting and landfill location.
19. Hasan, S. and Mulamoottil, G., 1994. Environmental problems of Dhaka City: a study of mismanagement. Cities, 11(3), pp.195-200.
20. Hazra, T. and Goel, S., 2009. Solid waste management in Kolkata, India: Practices and challenges. Waste management, 29(1), pp.470-478.
21. HelpSaveNature. (2019). Difference Between Sanitary Landfills and Open Dumps You Must Know. [online] Available at: https://helpsavenature.com/difference-between-sanitary-landfills- open-dumps [Accessed 6 Aug. 2019].
22. Henry, R.K., Yongsheng, Z. and Jun, D., 2006. Municipal solid waste management challenges in developing countries–Kenyan case study. Waste management, 26(1), pp.92-100.
23. Hoornweg, D. and Bhada-Tata, P., 2012. What a waste: a global review of solid waste management (Vol. 15, p. 116). World Bank, Washington, DC.
24. Jilani T ;(2002) State of solid waste management in Khulna City. Environment science Discipline, Khulna University Khulna, Bangladesh 25-85
25. Kanchanabhan, T.E., Abbas Mohaideen, J., Srinivasan, S. and KalyanaSundaram, V.L., 2011. Optimum municipal solid waste collection using geographical information system (GIS) and vehicle tracking for Pallavapuram municipality. Waste Management & Research, 29(3), pp.323- 339.
26. Karadimas, N.V. and Loumos, V.G., 2008. GIS-based modelling for the estimation of municipal solid waste generation and collection. Waste Management & Research, 26(4), pp.337-346.
27. Labib, S.M., 2017. Volunteer GIS (VGIS) based waste management: A conceptual design and use of web 2.0 for smart waste management in Dhaka City. 2017 Third International Conference on Research in Computational Intelligence and Communication Networks (ICRCICN), 2017, pp.137–141.
28. Mail Online. (2019). Heart-breaking photos of Bangladeshis forced to scavenge for a living. [online] Available at: https://www.dailymail.co.uk/news/article-2999005/Rummaging-rubbish- just-survive-Heart-breaking-photographs-Bangladeshis-forced-scavenge-make-living.html [Accessed 10 Aug. 2019].
29. Massoud, M.A., Tarhini, A. and Nasr, J.A., 2009. Decentralized approaches to wastewater treatment and management: applicability in developing countries. Journal of environmental management, 90(1), pp.652-659
30. Matete, N. and Trois, C., 2008. Towards zero waste in emerging countries–a South African experience. Waste Management, 28(8), pp.1480-1492.
31. Matter, A., Ahsan, M., Marbach, M. and Zurbrügg, C., 2015. Impacts of policy and market incentives for solid waste recycling in Dhaka, Bangladesh. Waste management, 39, pp.321-328.
32. Memon, M.A., 2010. Integrated solid waste management based on the 3R approach. Journal of Material Cycles and Waste Management, 12(1), pp.30-40.
33. Moghadam, M.A., Mokhtarani, N. and Mokhtarani, B., 2009. Municipal solid waste management in Rasht City, Iran. Waste Management, 29(1), pp.485-489.

34. Mrayyan, B. and Hamdi, M.R., 2006. Management approaches to integrated solid waste in industrialized zones in Jordan: A case of Zarqa City. Waste Management, 26(2), pp.195-205.
35. Natesan, U. and Suresh, E.S., 2002. Site suitability evaluation for locating sanitary landfills using GIS. Journal of the Indian Society of Remote Sensing, 30(4), pp.261-264.
36. Omer, A.M., 2017. Identifying, developing, and moving sustainable communities through application of bioenergy for energy or materials: future perspective through energy efficiency. International journal of life sciences, 1(1), pp.9-39.
37. Ozturk, T., Turp, M.T., Türkes, M., Kurnaz, M.L. and An, N., 2015. Simulations of Future Drought Conditions in Central Asia CORDEX Region 8 by Using RegCM4. 3.5. Organizers, p.87.
38. Pargal, S., Gilligan, D.O. and Huq, M., 2002. Does social capital increase participation in voluntary solid waste management? Evidence from Dhaka, Bangladesh. The role of social capital in development, pp.188-212.
39. Qasim, S.R., 2017. Wastewater treatment plants: planning, design, and operation. Routledge.
40. Salequzzaman, M. and Stocker, L., 2001. The context and prospects for environmental education and environmental careers in Bangladesh. International Journal of Sustainability in Higher Education, 2(2), pp.104-127.
41. Sharholy, M., Ahmad, K., Mahmood, G. and Trivedi, R.C., 2008.Municipal solid waste management in Indian cities–A review. Waste management, 28(2), pp.459-467.
42. Sawalem, M., Selic, E. and Herbell, J.D., 2009. Hospital waste management in Libya: A case study. Waste management, 29(4), pp.1370-1375.
43. Sujauddin, M., Huda, S.M.S. and Hoque, A.R., 2008.Household solid waste characteristics and management in Chittagong, Bangladesh. Waste management, 28(9), pp.1688-1695.
44. Senthil, J., Vadivel, S. and Murugesan, J., 2012. Optimum location of dust bins using geo-spatial technology: a case study of Kumbakonam town, Tamil Nadu, India. Advances in Applied Science Research, 3(5), pp.2997-3003.
45. Taiwo, M.A., Ayodeji, A.M. and Yusuf, B.A., 2012. Impact of small and medium enterprises on economic growth and development. American journal of business and management, 1(1), pp.18- 22.
46. Tammemagi, H.Y., 1999. The waste crisis: landfills, incinerators, and the search for a sustainable future. Oxford university press.
47. Tawhid, K.G., 2004. Causes and effects of water logging in Dhaka City, Bangladesh. TRITA- LWR master thesis, Department of Land and Water Resource Engineering, Royal Institute of Technology, Stockholm.
48. Tchobanoglous, G., Theisen, H., Vigil, S.A. and Alaniz, V.M., 1993.Integrated solid waste management: engineering principles and management issues (Vol. 4). New York: McGraw-Hill.
49. Timlett, R.E. and Williams, I.D., 2008. Public participation and recycling performance in England: A comparison of tools for behaviour change. Resources, Conservation and Recycling, 52(4), pp.622-634.

Appendix

Figure 1: The Lifecycle of Black Spider Fly