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Study on Bio-Fertilizer Extraction and Management of Municipal Solid Waste of Khulna City

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ABSTRACT

The increasing population of Bangladesh leads to the growth of urban areas and slums which in turn, generating a huge volume of wastes. In this study, Main focus is given on bio-fertilizer extraction from municipal solid waste as well as analyzing present waste generation and management procedure. Although major portion of solid waste is organic but unsatisfactory solid waste management system creates some common problems. At the same time, those wastes have a potential value of producing organic bio-fertilizer. The total daily household wastes generated in Khulna City areas is about 500 tons and from this total waste it is possible to produce 200 tons of compost daily. But only 1.5 tons of compost is producing per day in Rajbandh by RUSTIC and generating about 10,000 taka profits. In this context, to meet up the growing demand of bio-fertilizer, it is the best way to use renewable resources like municipal solid waste.

Keywords: Municipal solid waste, Solid waste management, Bio-fertilizer, Khulna city.

1. Introduction

Municipal solid waste comprises of all the wastes arising from human and animal activities those are normally solid and are discarded as useless or unwanted things. It may be heterogeneous mass of throw-away from the urban community as well as the more homogenous accumulation of agricultural, industrial and mineral wastes. It includes durable goods, non-durable goods, containers and packaging, food wastes, yard wastes and miscellaneous inorganic wastes from residential, commercial, institutional, and industrial sources. Least Developed Asian Countries like Bangladesh is not too much concerned and anxious about her environmental problems on Municipal Waste Management. In the major cities of Bangladesh, per capita production of waste is 0.5 kg/day but only 0.2 kg of waste per capita is carried to the final disposal site. The rest is disposed locally [1]. The total daily household solid wastes generated in Khulna City areas is about 490 to 510 tons. Around 40% of total household wastes are managed by different organizations [2]. Because of unsatisfying solid waste management system in Khulna city, some common problems are occurring such as diseases, fire hazards, odor for nuisance atmosphere, water pollution and consequently economic losses [3]. To prevent those problems, it becomes necessary to manage properly the municipal solid waste rather than dumping outside the main city. These municipal solid wastes can be used to produce bio-gas by anaerobic digestion process and generate electricity and it can also be used to produce bio-fertilizer [4].

Objectives of the Study are followed:

- (1) To study the recent potential of municipal solid waste in KCC area.
- (2) To study existing bio-fertilizer extraction process from Municipal Solid Waste (MSW).
- (3) To disclose the existing Municipal solid waste management practice.
- (4) To find out the efficient way to extract bio-fertilizer from municipal waste among a few alternatives.

2. Methodology

2.1 Research Design

This research is mainly descriptive in nature. Both primary and secondary data is used to prepare this research. The primary data is collected from various sources such as interview, talking with experts and people directly or indirectly related to waste management. Secondary information such as statistical data, reports, MSWM (Municipal Solid Waste Management), transportation related data etc. is collected from various Government offices and Non-Government Organizations (NGOs), CBOs such as:

- (1) Khulna Development Authority (KDA).
- (2) Khulna City Corporation (KCC).
- (3) Demographic information from Bangladesh Bureau of Statistics (BBS).
- (4) Journals and papers relevant to the study from NGOs and various web sites.

Information is also collected from informal talking with the personalities who are directly or indirectly related with this matter.

2.2 Survey

A survey was conducted in Rajbandh Landfill located in Botiaghata Thana in Khulna city. Questionnaires were prepared and interview of the persons related with the administration and management of the wastes was taken. Around 20 questions were asked to Md. Anisur Rahman (Conservancy Officer of KCC), Md. Abdur Sattar (Conservancy Officer RTD of KCC), Anowar (Supervisor of Conservancy Transport Support Authority), Md. Liton (Driver), Md. Amjad Hossain (Driver), Md. Abul Basahar (Driver), Moral Noor Mohammad (Executive Director, RUSTIC), Md. Sohel (Store and Delivery manager), Hozrat Ali (Senior Compost field maker), Md. Rashed (Senior Compost field maker), Nasima and Asma (Compost field worker), Sagor and Raja (Farmer), Nurul Islam (Field Supervisor in Rajbandh), Ilias (Field Co-supervisor in Rajbandh) and they answered gently.

3. Literature Review

(According to the Khulna City Corporation Ordinance, 1984) Khulna City Corporation (KCC) is responsible for collection, transportation, and treatment of solid waste in Khulna City but KCC does not collect any waste in 7 wards out of 31 wards because these wards are situated remote area and waste are locally managed there. Sometimes causes few regional affect for constructive factors but in the rest of 24 wards only 20% wastes where collect by KCC and 80% wastes are not managed properly (Conservancy Department of Khulna and RUSTIC).

Hoque [5] reported that the location of disposal (secondary) sites of KCC represent the unconsciousness about the environmental and public health hazards arising from disposing of waste in improper location.

Richard et al. [6] reported that in the rapidly growing cities of developing countries, urban solid waste management is currently been regarded as one of the most immediate and serious issues for city authorities. Due to inadequate and often inefficient solid waste management and visible environmental degradation, solid waste generated at an increasing rate has also become an important environmental issue for the residents of the major cities of Least Developed Asian Countries (LDACs) like Bangladesh.

Alamgir and Ahsan [7] said that management of this steeply increasing vast quantity of solid wastes is a very complex process indeed. Due to severe financial constraints, absence of appropriate technology, lack of people's awareness, motivation and participation, ineffective legislation and law enforcement to protect the environment and to handle the waste, the whole system is becoming a threat to city dwellers, planners and other stakeholders including these factors, resource and other constraints and limitations, KCC has not been able to manage well entirely the whole task of solid waste disposal.

Sultana T. [1] stated the existing Municipal Waste Utilization of Khulna City Corporation and determined the ecological footprint of waste generation of KCC area. She also recommended the way by which the ecological footprint of waste generation can be very effective tool for sustainable waste utilization in KCC area.

Alamgir and Ahsan [3] stated most of the wastes of landfill are waghered to our soil nutrition and to ensure our food security, intensive cultivation and applied commercial fertilizer are also degrading air soil health.

Kashem [8] stated in his research that, if the municipal waste which is generated in Khulna city is managed properly, it can be a potential resource. By using waste, biogas can be produced and the residue of biogas can be used as compost fertilizer.

4. Eco-Friendly Waste Management Approaches and Disposal Alternatives

Waste management and disposal treatment is an appropriate management technique based on prevailing socio-economic settings, technological capabilities and

waste separation into the organic, inorganic, depositional, thermal, recycling, reduce and reuse treatment [9]. In Bangladesh, the Solution for MSW management handled separately as the situation varies city by city, within different regions of the city and within different parts of the region [10]. There are lots of alternatives for managing Municipal Waste like Recycle of Wastes, Waste Reduction and Reuse, Incineration, Pyrolysis and Gasification, Open Burning, Controlled Dumps, Biological Waste Treatment as Composting, Anaerobic Digestion and Integrated Solid Waste Management. Among those Biological Waste Treatment as Composting is most suitable process for waste management in Khulna City.

4.1 Potentials of Composting in Khulna City

The factors which favor for composting are: waste generated in Khulna is suitable for composting as around 78% of it is compostable. Moisture content of 50 to 60 percent is optimum for aerobic composting. The typical moisture content of Khulna city is 55 percent, which is within the acceptable range for composting. Source separated organic waste, free from toxic and clinical wastes, which are essential for good quality compost, can easily be obtained in Khulna. House to house collection of waste and separate collection of clinical and hospital waste are being introduced in Khulna with community participation by NGOs/ CBOs and active support of KCC [11].

4.2 Possibilities of Using Composts in Agriculture in Khulna City

An enormous amount of commercial fertilizer has been spilled over to improve our agricultural production and now a day our agriculture is going to depend as an artificial fertilizer day by day. But it is a threat to our soil health, crop yield and natural habitat because use of commercial fertilizer and pesticides to land again and again causes many affect to soil nutrition's, soil water and plant resistant to pathogen. Although this report shown the solid waste management of KCC by compost production but also our farmers can produce it easily by their agricultural waste, domestic waste and other villagers' sources. So in future, the compost manure of waste management can played an important role to our agriculture in Bangladesh.

5. Existing Municipal Solid Waste Management in Khulna City

5.1 KCC Initiatives for Solid Waste Management

Khulna City Corporation (KCC), the only public sector organization responsible for collection, transportation and disposal of solid waste in Khulna City, is not providing satisfactorily level of conservancy services [12]. It collects 40 to 50 percent of the total waste and the rest is used for land reclamation. Very insignificant portion is also collected by the scavengers. This results in odor and obnoxious conditions in Khulna City according to Sabikunnahar [13]. With 50 garbage trucks, 462 cleaners, and an annual budget of Taka 175.00

lakes, according to vehicles support facilities of KCC. KCC is not well equipped to cater satisfactorily the need of conservancy services of the city dwellers of Khulna. Over the years, KCC has increased its staff size and equipment, but these are insufficient in terms of quality and quantity according to the need [14].

Table 1 Facilities of manpower, infrastructure and transport in KCC.

Facilities of manpower, infrastructure and transport in KCC.		
Manpower	Supervisory	40
	Sweepers etc	104
	Drain cleaners	358
	Drivers	37
	Spray men	31
	Fogger Operators	5
	Truck Helpers/Labors	79/54
Physical Infrastructure	Secondary collection Points	60
	Dustbins	1200
	Metal waste containers	45
Transport and Vehicles	Covered Trucks	5
	Normal Trucks	10
	Container Carries Truck	11
	Rickshaw Vans	200
	Tractors	4
	Damp Truck	8
	Paur-tetar	2
	Vacutac	4
	Night soil carrier	6

5.2 Current Situation of Wastes Generated from KCC

Khulna City Corporation consists of 31 wards and the wastes of 24 wards out of 31 were collected by Conservancy Department Activity of City Corporation. Seven wards (No 1 to 7) are situated in the remote area and manage their wastes locally. Sometime the wastes of above seven wards cause few regional effect for constructive factors.

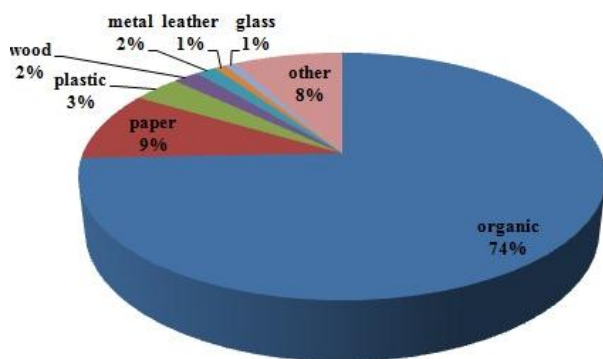


Fig.1 Distribution of different wastes in percentage generated from KCC [1], [7].

Only 40-50% wastes are collected by KCC and 60-50% wastes are not collected and managed (Conservancy Department of KCC). It has been observed that 70% to 80% of the generated waste is organic in nature and these are easily bio-degradable and the rest 30% to 20%

of the total waste generated are inorganic and non-biodegradable.

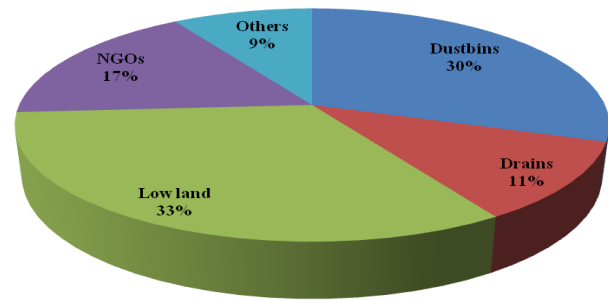


Fig.2 Current Distribution of KCC Wastes [2].

It has been estimated that at present Khulna city generates 490 to 510 metric tons of solid wastes per day with a per capita of about 0.3 to 0.5 Kg/day [15]. Conservancy Department of KCC is responsible for the collection, transportation and disposal of solid waste in Khulna city. Apart from this, a number of government and semi-government organizations are giving emphasis to manage solid wastes that is being generated in their own premises and compounds [16].

5.3 Solid waste collection system

The KCC is considered as the most important organization involved in waste collection. The collection services in urban centers concentrate only in the removal of wastes from communal bins. Wastes removal services involve manual collection from the bins and manual loading of the collection vehicles. However, recently, some NGOs, CBOs and private organization work with city authorities. But the situation remains unchanged. The strengths and drawbacks at all levels of the existing wastes management system are identified by Waste-safe [17].

Table 2 Involvement and area coverage by different NGOs.

Name of NGO/CBO	Area Coverage(Ward)
Prodipan	6,12,17,18 and 24
Prasanti	119 Health Care Center
Amadar Paribartan	30
ASODE	24(part)
Shabolambi	25 and 26(part)
Muktir Alo	11
Niharika	23
RUSTIC	30(part)
Centre of Human Development	18(part)
Unnayan	15 and 16(part)
	25(part)

The wastes generated in the home is stored and collected everyday by a primary collector who transports the waste to the nearby transfer point, normally in a rickshaw van and transport points are

placed where waste is unloaded from primary collection vehicles to be taken away by secondary transport. KCC has a collection area of 47 sq. km. with total number of conservancy staff about 462 and 1200 dustbins. There are minimum 10 to 20 dustbins in each ward. Some of the dustbins are open at the top and some are covered. KCC estimates about 510 ton of wastes are generated daily in the city area and only 300 to 320 ton are collected by its workers and the remaining are dumped irregularly. KCC has 60 secondary disposal sites and some disposal sites are placed with demountable container, from where workers collect wastes with recommended KCC vehicles to the final disposal site in a regulated timetable. It has regular 22 to 25 trips to the final disposal site daily. Rajbandh is the main dumping station of the KCC. It is at the western side of Khulna City and of about 25 acres. The waste truck of the KCC is reported to dump their wastes in many illegal places. This is due to lack of skilled manpower and knowledge and also the lack of sufficient places.

5.4 Existing recycling process in KCC

The KCC does not perform any kind of resource recovery activities. Wastes of some market value are being reclaimed or salvaged informally. The housewives separate the refuse of higher market value such as papers, bottles, fresh containers, old cloths, and shoes and sell them to street hawkers (locally called feriwallas). Then salvaging is carried out by waste pickers (mostly the children of slum dwellers). The items include broken glass, can, card board, waste paper, rag, plastics, metals and miscellaneous wastes discarded by households. The estimated number of scavenger of Khulna city is nearly 600, who are annually earning BDT 4,500,000 by removing solid waste [18].

6. Bio-Fertilizer Extraction from Municipal Solid Waste

Composting is the process of decomposing organic matter, whether manure, crop residue or municipal wastes, by a mixed microbial population in a warm, moist aerobic environment. On the other hand, Composting is certainly one of the most natural types of recycling processes there are. It happens in the open air (in a ditch or a heap) or an enclosure (silo, etc) and consists simply of organic waste transforming in the presence of oxygen in the air. Over a total of six months (generally spring and summer), it happens in two stages: Decomposition during which any still-intact organic material is attacked by high temperature bacteria (50-70°C). Maturation during which the fresh compost transforms little by little into compost rich humus thanks to the action of low-temperature yeast (35-45°C). Materials and chemicals required for composting are Bamboo, Leader, Boding a windrow, Thermometer, Turning the pile and Mineral addition. Few things are avoided for composting like Meat and meat byproducts, Oil, Dairy products, Diseased plants, Invasive plants gone to seed, Yard waste treated with pesticides and conventional fertilizers.

6.1 Steps of Making Compost

Making good compost depends on having the proper sources of nutrients with a balance of carbon and nitrogen, keeping the pile of compost moist and making sure that there is adequate aeration. Different levels of processing are required for achieving the decomposition. The compost pile can heat up to 60-70°C due to the microbial activity. However, high temperatures will result in substantial losses of nitrogen in the form of ammonia gas. Farmers with many years experience at compost-making recommend that temperatures are kept below 55°C to avoid overheating and nutrient losses. The most commonly used materials for the compost pile are manure mixed with livestock bedding. When the bedding (which is predominantly carbon) is mixed with the raw manure (which is an excellent source of nitrogen), the balance of carbon to nitrogen (25-35:1) will be achieved which is needed to begin the composting process.

Steps of Making Compost are breaking of wastes pile, Bedding for composting, Turning/mixing, Additional materials used for composting, Rebidding and Manufacturing process. During composting of first bedding, at the initial stage the temperature rises at 50°C to 55°C within 12 to 15 days. Then new materials should be added to the composting system during turning or mixing. For favorable composting, the physical, chemical, biological and degradable changes occurred under the extra component are used to influence the composting activity like watering, soil, cow-dung, fire-ashes, light sources etc. After that the temperature regain at 50°C to 55°C and this treatment are runs under 15 to 20 days and in the last bedded treatment and within 15 to 17 days to complete all microbial activity, the temperature is come down from 15 to 18°C. Then the pile is breakdown and this raw compost is spreader-up to everywhere around the bed and it rests for 1 to 3 days for normal temperature.

6.2 Sign of the completion of composting

Sumon [19] found, the material should have a pleasant "woody" odor and a friable texture similar to a good potting soil. The material will likely feel moist and cool and have a dark brown color.

Table 3 Composition of finished compost [20].

Parameter	Result
Present Composition	
Color	Grey
Physical conditions	Non-granular
Odor	Absence of foul odor
Moisture	17.0%
pH	7.0
Organic Carbon	10.65%
Total Nitrogen(N)	0.95%
C:N	11.2:1
Phosphorus (P)	0.70%
Potassium (K)	1.25%
Sulfur (S)	0.29%

Zinc(Zn)	0.04%
Copper (Cu)	0.016%
Chromium (Cr)	18.28ppm
Cadmium(Cd)	0.18ppm
Lead (Pb)	22.57 ppm
Nickel(Ni)	24.44 ppm
Inert material	<1%

6.3 Cost and Profit Analysis of composting in Rajbandh According to KCC, daily waste generation in Khulna city is 490-510 tons. RUSTIC says that after an initial screening they collect 3.75 to 4.00 tons of waste and from that they collect 2.50 tons of compostable waste. Finally they produce 1.5 tons of bio-fertilizer.

The materials required for composting are cow dung, saw dust, water, fire ash etc. Cow dung is the most useable part which is collected from different domestic sources and its cost is 2.00Tk per kg. Every bed needs 40 kg everyday 10 beds are placed so; 400 kg cow-dung is used. Its total cost is 800.00 Tk. Useable sawdust and shred wood per bed 10 kg and for 10 bed needs 100 kg which cost is 166.70Tk, oil cost 170Tk and Others cost (tools) for every day 310.00Tk.

All management activities of composting are carried out manually by RUSTIC where waste collectors are generally women and child.

Table 4 Expenditure for workers and employees.

Employees	Man power (per day)	Per day bill (Tk)
Female workers	10	2000
Male workers	5	1250
Coordinator	1	666.67
Total	16	3916.67

6.4 Net Income (per day)

Selling price per kg= 11Tk

Material Cost per day=800Tk+166.70Tk+170Tk+310Tk
= 1446.70Tk

Labors cost per day = 3916.67Tk

Total cost per day =1446.70Tk+ 3916.67Tk
= 6640.07Tk

Cost per kg for finished product = $\frac{\text{Total cost per day}}{\text{Finished product per day}}$
= $\frac{6640.07 \text{ Tk}}{1500 \text{ kg}} = 4.42\text{Tk}$

Net income per bag= Market value of finished product per kg - Cost per kg = 11Tk – 4.42k = 6.58Tk

Net profit per day= Net profit per kg * finished product per day= 4.58Tk * 1500 kg = 9870Tk

From the results of RUSTIC, it is clear that the compost production by Solid waste management in Khulna city is profitable. Now, present profit is around 9870.00Tk

per day. But if it is possible to use half of the total waste that is 250 tons then usable and degradable waste is two third which approximately 168 tons and the finished products will be approximately 100 tons/day. In that case, per day income could be 658000.00Tk. From previous calculation to produce 100 tons of bio-fertilizer/day 27 tons of cow dung and 7 tons of sawdust will be needed which is easily gettable from nearest cow farm and village.

Finally if it is possible to use of all waste from Rajbandh landfill which is around 500 tons then the compostable waste will be two third that is approximately 334 tons and the finished products will be approximately 200 tons/day. In this case, per day income could be 1316000.00Tk.

7. Discussion

The Main goal of the project is to find out the recent potential of municipal solid waste in KCC area and disclose the existing Municipal solid waste management practice. Firstly, existing waste generation is a burden for its dumping due to lack of dumping sites of Khulna city. In addition, most of the residents of KCC throw their waste outside of the dustbin, on the road into the drainage system. Decentralizing ultimate dumping site could be a better option for transportation of waste and composting. In this situation, Municipal Solid Waste has a great significance to produce ecologically sustainable organic bio-fertilizer from the biodegradable waste by using the composting. There are also some problems like waste collection problem, transportation problem, lack of financial support, lack of public awareness, lack of worker and infrastructure and insufficient tax collection which need to be solved as well. It is almost impossible to find any viable comparative information in this field of study. Because no other organization rather than RUSTIC working on bio fertilizer production from Municipal Solid Waste in Khulna.

At the same time, composition of Municipal Solid Waste changes in every seven kilometers [12] and for this reason data from this project cannot be compared with other projects from different state or country. On the other hand, Khulna University of Engineering & Technology (KUET) has a project up and running to produce bio fertilizer from their daily waste collection of their university campus. But their average bio fertilizer production per day is only 1.67 kg [21] and it will be an informational bias to compare the whole Khulna city waste disposal and management project with the small project of KUET.

8. Conclusions

The main constraints are weak organization and limited budget allocation for wastes management. From the discussion of this report the following conclusions can be drawn.

Municipal waste contains various compositions with specific merit of each. So waste needed to be separated with its merit to compost, reuse or recycle. More than

200 tons of organic compost can be produced in Khulna city if the total generated organic waste is recycled every day. The decentralized community based composting plants can generate employment for the poor, especially the women, and offers new prospects for small entrepreneurs to take part in recycling business. Improvement in overall environment of the neighborhood is possible by checking illegal disposal of waste on roads, drains. At the same time waste is directly collected from household recently which is very much appreciated. Public awareness about waste disposal is very important and they need to be responsible enough to dump their daily waste in selective places. Awareness about using compost as a replacement of chemical fertilizer should be increased to sell more compost to farmers.

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