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Prospect of Solid Waste Situation and An Approach of Environmental Management Measure (EMM) Model for Sustainable Solid Waste Management: Case Study of Dhaka City

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Abstract
Environmental Management Measure (EMM) model will be a well-designed approach for sustainable and effective solid waste management in Dhaka city. Environmental Management Measure (EMM) model has three instruments such as economic, regulatory and suasive which proposed in this paper. This paper discusses the situation of solid waste in Dhaka city as well as it offers environmental policy recommendations to concerned authorities including effective instruments to minimize the polluting behavior of individuals and industries and to recover the cost of pollution in the city. To improve solid waste management in Dhaka city, a combination of economic, regulatory and suasive instrument are recommended. The findings of the study will be helpful for policy maker, planner, implementer and other stakeholders towards adopting more effective strategy for management of solid waste in Dhaka city.

Key words: Dhaka city, EMM, Solid waste, Solid waste management, Sustainability,

Introduction

Bangladesh is a densely populated country; country's population will be about 17 crore by 2020. In countries like Bangladesh solid wastes make an incredible environmental hazard and social problem in city lives. A massive volume of solid waste is generated every day in the city areas and unfortunately solid waste management is being deteriorated day by day due to the limited resources in handling the increasing rate of generated waste.

Rapid urbanization has made solid waste management a serious problem today. The urban area of Bangladesh generates approximately 16,015 tons of waste per day, which adds up to over 5.84 million tons annually. It is projected that this amount will grow up to 47,000tons/ tons/day and close to 17.16 million tons per year by 2025, due to growth both in population and the increase in per capita waste generation. Based on the present total urban population, per capita waste generation rate is found at 0.41 kg/capita/day in urban area of Bangladesh. Existing infrastructure for waste management showed that waste collection efficiency in different urban areas varies from 37% to 77% with an average of 55%. The overall waste collection situation is not very satisfactory. Huge amount of uncollected waste, a high proportion of which is organic, makes nuisance and pollutes the local environment rapidly.
Solid waste disposal poses a greater problem because it leads to land pollution if openly dumped, water pollution if dumped in low lands and air pollution if burnt. Dhaka, the capital city of Bangladesh is facing serious environmental degradation and public-health risk due to uncollected disposal of waste on streets and other public areas, clogged drainage system by indiscriminately dumped wastes and by contamination of water resources near uncontrolled dumping sites.

In this perspective, Environmental Management Measure (EMM) model will be a useful approach for sustainable and effective solid waste management in Dhaka city and other urban areas of Bangladesh. Many countries implemented this measure and acquired successful outcome by improving environment and its effective management.

Methodology

In this paper, Environmental Management Measures (EMM) model is proposed for sustainable and effective solid waste management in Dhaka city.

1. Framework of Environmental Management Measures (EMM)

Environmental management measures (EMM) are primarily based on the application of theories associated with (i) externalities, (ii) open-access resources, and (iii) public goods. Failure to internalize externalities, ensure property rights, and appropriately manage public goods gives rise to environmental pollution, destruction of natural resources, and free-riding of environmental resources.

- An externality occurs when the consumption or production choices made by an individual or a

firm affects the utility or production function of another entity, without first seeking that entity's permission or offering some form of compensation. A solution to this problem is to internalize externalities.

- An open-access resource or facility is open to uncontrolled access by the people. Some classic examples are ocean fishery, open pastures, forests and public parks. Well-defined property rights provide the solution as they determine the ability of a market to allocate goods efficiently.
- By their very nature, public good and services are made available to a wide group for the benefit of a majority of the people. Environmental quality is essentially a public good. Whenever a public good or service becomes available, certain individuals who enjoy it may actually be free riding on the efforts of others. Free riders underpay or do not pay for a public good or service, although they may enjoy substantial benefits from it. A solution is to introduce some characteristics to public good and services for which the charging of fees is possible.

Environmental management measures (EMM) are prevalent in most developed countries. These measures, which include regulatory instruments (RIs), economic instruments (EIs) and suasive measures (SIs), have helped to prevent further environmental degradation and to improve the quality of life of the people.

2. Basis of Using Environmental Management Measures (EMM) Model

EMM has three instruments such as

1. Regulatory instruments (RIs),
2. Economic instruments (EIs) and
3. Suasive measures (SIs)

These instruments can be used in solid waste management because in human mind there are three foremost elements are:

- ***Fear***

✓ Each and every citizen of a society or country knows that they are subject to laws, rules and regulations and they may be prosecuted if these are disobeyed or ignored.
✓ The Command and Control (CAC) or regulatory measures thus target the fear element of human mind to produce necessary behavioral change.

- ***Economic/financial interest***

Arguably the most powerful element in the human psyche in a capitalist market economy is economic and financial interest. This element in human mind has led economists to denote everyone as an 'economic person' and it has given rise to the assumption of consumers as utility maximizes and producers as profit maximizes and the corresponding economic theories of firms and consumer behavior.
Many criticize economic theories inappropriately on the assumption that economists' focus on the economic element implies it is their 'whole' view of the human mind. Economists are correct as long as they make it clear that the economic theories are based on the 'economic part' of the human mind. Economists are bound to be wrong if they claim that human behavior is only motivated by economic or material interest, whereas, the critics are wrong if they deny that a human mind is devoid of economic interest. In the present context, the point is that the EIs, MBIs or simply economic measures essentially seek to influence human behavior by playing on the economic motive of each and every human being.

- ***Moral and ethical sense***

Yet another powerful element in the human mind or psyche, which oddly gets less attention if not totally ignored, is the fact that each and every human being is blessed with a moral and ethical sense too.
Traditionally religious education and parenting of children serve to imbibe and nurture this element in the human mind. In the present context, moral suasion or suasive measures, i.e., environmental education and awareness-raising campaigns, seek to promote this most valued and environmentally-desirable aspect of the human mind.

These three elements in human mind is the basis of using Regulatory, Economic and Suasive instruments measures.

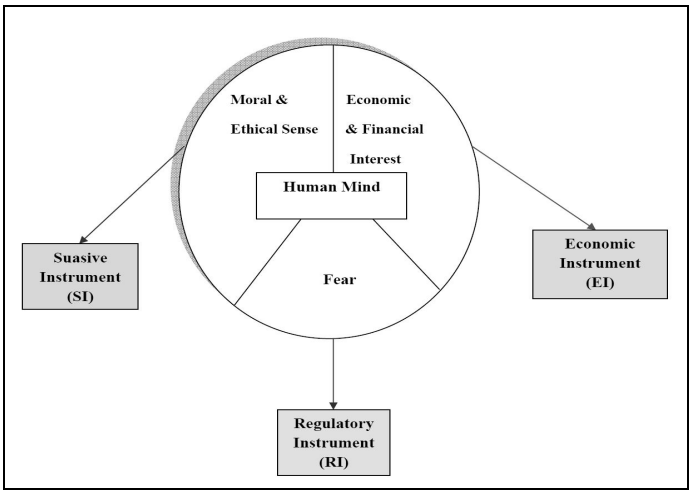

Fig. 1. Coordination of human mind and EMM instruments for effective operation

3. Background of Study Area: Dhaka City

Dhaka city covers an area of about 816 square kilometers. The climate is tropical as in the rest of Bangladesh; for most of the year it is warm with bright sunshine, but during the monsoon season there is heavy rainfall. During the winter months (November to March) it is cool and pleasant. Typical summer temperatures range between 30 to 37 degrees Celsius while in the winter it is a lot milder, ranging between 10 to 20 degrees. Annual rainfall is about 250cm and humidity around 80% of the total population in the city about 64.1 percent are literate. Among the workforce more than 10 percent are unemployed. Another 10 percent are employed below their qualifications. Economic indicators show that the per capita income of the people of Bangladesh is nearly US$450. GDP is US$14.89 million. Around 55 percent of people live below the poverty line in Dhaka. Half of that figure lives in slums and squatter settlements. Within a decade, the slum population has risen to about 3 million. Access to water supply, sanitation, solid waste management, and other civic services is extremely limited.

Land is very scarce in Dhaka City. Only 360 sq. km. of land is available to accommodate residences, offices, services and facilities for more than 5.4 million people. As the capital of Bangladesh, central government offices, large educational institutions, and hospitals are set in Dhaka. Again, major economic activities like business, commerce and industries have been developed in Dhaka over the years. There was no designated place for disposal of wastes at the initial time. The public land was the only place for waste disposal of the city. A good number of areas have been raised from low lying ditches to high places for construction of bus terminals, play grounds and even residential sites. At present Dhaka City Cooperation has acquired one piece of large land at the outer strip of the city for disposal of waste. It would be very difficult to acquire more land for further disposing of wastes unless alternatives are explored.

4. Situation of Solid Waste In Dhaka City

In Dhaka, per capita solid waste generation is quite low; however, due to huge and densely populated city, solid waste problem in Dhaka city is very acute in comparison to many cities of the developing countries. Daily production of solid waste in Dhaka City is more than 4000 Metric Tons. Of those 200 Metric Tons of hospital and clinical waste is a mixture of toxic chemicals, radioactive elements and pathological substances. 15 to 20 percent of medical wastes are highly dangerous for human lives. These waste when dumped with other municipal wastes in the open land poses threat to serious health hazard to the city people.

The nature of solid waste is changing over time and with development. Of the solid wastes plastic and polyethylene goods also cause problems towards human health, environment and drainage system. These goods are cheaply and easily available in the markets. The users do not care to reuse them. They rather throw these things out of the door and window. An Inception Report on Control & Management of Polyethylene bags in Bangladesh showed that people of Dhaka city alone used 600 million bags a day. During floods, floodwater did not drain quickly, as one of the major reasons was due to polyethylene in the draining system. Polyethylene and plastic

materials are not biodegradable. Natural process cannot decompose it. Polyethylene remains intact in the soil, disturbs the flow of nutrients to the soil and hinders entering sunlight. It destroys the beneficial bacteria of soil compaction. In the long run it affected the foundation of physical infrastructures, if there is any on the plastic dumpsite. However, due to effective regulation for banning the polyethylene bags, this problem has been overcome.

Table 1. Waste Generation Rate (WGR) and Total Waste Generation (TWG) in Dhaka city and other cities, 2004

City/Town	WGR(kg/cap/day)	No. of City/Town	Total Population	Population (2005)	TWG (Ton/day)		Average TWG
					Dry season	Wet season	
Dhaka	**0.56**	**1**	**6,116,731**	**6728404**	**3,767.91**	**5,501.14**	**4,634.52**
Chittagong	0.48	1	2,383,725	2,622,098	1,258.61	1,837.57	1,548.09
Rajshahi	0.3	1	425,798	468,378	140.51	205.15	172.83
Khulna	0 27	1	879,422	967,365	261.19	381.34	321 26
Barisal	0.25	1	397,281	437,009	109.25	159.51	134.38
Sylet	0.3	1	351,724	386,896	116.07	169.46	142.76
Pourashavas	0 25	298	13,831,187	15,214,306	3,803.58	5,553.22	4,678.40
Other Urban Centers	0.15	218	8,379,647	9,217,612	1,382.64	2.018.6S	1,700.65

4.1 Generation and distribution by source of solid waste

Reliable estimate of the quantity of solid waste generated in the Dhaka city is very important in the planning for proper solid waste management. Reported estimates (Table 2) of solid waste generation vary widely ranging from 1040 tons/day (1985-86) to 5000 tons/day (in 1997). Most of the reported values have been derived rather empirically with assumptions regarding population, number of trucks available for transportation of wastes and capacities of trucks. Reported solid waste density values used in calculating waste quantity also vary widely ranging from 0.35 ton/m3 to 0.80 ton/m^3.

Table 2. Total waste generation and its distribution by source

Data Source	Solid Waste Generation (Ton/day)	Contribution of Different Source (%)				
		Residential	Commercial	Industrial	Hospital	Street
MMI 1991	1300	46.8	17.3	12.9	0.50	22.6
PAS 1997	3000-5000	46.7	20.0	26.7	6.70	--
RSWC 1998	1200-1600	47.0	17.0	13.5	0.50	22.0
BCAS 1998	2398	81.9	13.9	2.31	1.87	--
DCC 1999	3500	49.0	21.0	24.0	6.00	--

MMI -Mott MacDonald International, PAS - Pan Asia Services, RSWC- Rotted Solid Waste Consultancy, BCAS- Bangladesh Center for Advanced Studies and DCC- Dhaka City Corporation

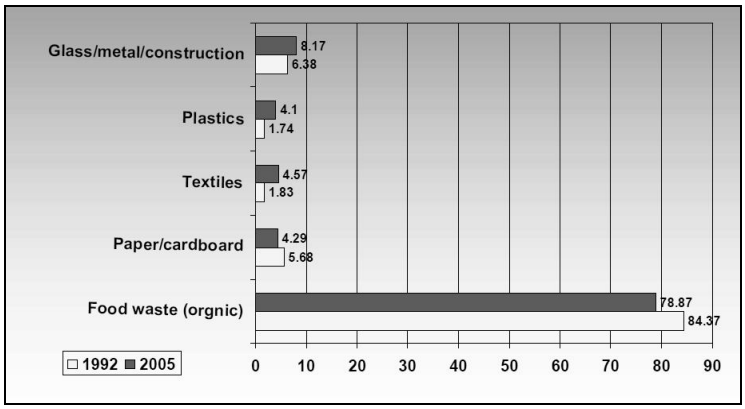

Fig. 2. Composition of solid waste of Dhaka city between 1992 and 2005

The Dhaka City Cooperation estimated that, of the total daily generation of 3500 tons of solid waste, 1800 tons are collected and dumped by them, 900 tons go to backyard and land filling, 400 tons go to road side and open space, 300 tons are recycled by the *Tokais* (mostly the children of slum dwellers), and 100 tons are recycled at the generation point. However, the quantity of solid waste varies depending on month and season by a factor of about 20%, the generation being higher during wet months and fruit seasons. Municipal solid wastes in Dhaka city are mostly generated from residential, industrial and commercial sources. Also a significant portion, initially resulting from widespread littering, comes from street sweeping. Hazardous wastes from industries and hospitals are frequently mixed with municipal wastes, which in turn are poorly collected and disposed, thereby creating public health hazards.

Bangladesh Center for Advanced Studies estimated that the contribution from the residential source is almost twice as much compared to other estimates and that from the industrial source is almost an order of magnitude lower. They gave an apologia for low contribution of industrial source by the argument that wastes from the garment factories are removed from the source and most of the industrial wastes of the Hazaribagh site are dumped in the adjoining low lying sites. The diversity of the nature of available data obviously would restrain the formulation of a management policy and hence a rigorous study is essential to come up with reasonable estimates of solid wastes generated by different sources.

4.2 Per capita waste generation

Per capita waste generation would obviously depend on a number of socio-economic parameters affecting consumption and other behavioral characteristics. Dhaka City Cooperation (1999) conducted a survey and estimated an average waste generation of 2.326 kg/family/day for high-income group, 1.260 kg/family/day for medium income group and 0.461 kg/family/day for the low-income groups.

Dhaka City Cooperation provided the most recent estimates of per capita waste generation. On the basis of the 1981 and 1991 census data, Bangladesh Center for Advanced Studies calculated a compound growth rate of 2.74% for the Dhaka City Cooperation population during this period, and estimated a population of 4.64 million for the year 1998 using the growth rate. With estimated daily generation of 2398 tons, this gives a per capita generation of 0.52 kg/capita/day. Dhaka City Cooperation on the other hand, reported a population of 7 million for the Dhaka City Cooperation area, almost 1.5 times higher than that estimated by Bangladesh Center for Advanced Studies. However, since the waste generation estimate of Dhaka City Cooperation is also much higher (3500 tons/day), per capita generation calculated from Dhaka City Cooperation data (0.50 kg/capita/day) is very close to the value reported by the Bangladesh Center for Advanced Studies.

4.3 Projection of future solid waste generation

To make predictions about future waste generation from estimates of population requires prediction of future per capita waste generation. Bangladesh Center for Advanced Studies used a simple procedure for predicting future waste generation. The intercensal annual compound growth rate of population, on the basis of the 1981 and 1991 census data, was estimated to be 2.74%. Assuming an annual GAP (Gross Annual Product) growth rate of 4%, and

that 70% of the additional income going into consumption, waste generation growth factor based on GAP growth was taken as 2.8%. Based on this growth rate and a 1998 per capita generation of 0.52 kg/capita/day, Bangladesh Center for Advanced Studies (1998) predicted waste generations for the future years up to 2021 (Fig. 2). Using the same procedure as followed by Bangladesh Center For Advanced Studies (1998), another estimate for future waste generation is made based on the population of 1991 (census) and population of 1999 (DCC 1999). The estimated population growth rate is 7.79%. Assuming the same waste generation growth factor of 2.8%, an estimate of waste generation for future years is provided (Fig.2).

Comparing above two estimates it is observed that according to the predictions of Bangladesh Center for Advanced Studies (1998) the generation of solid waste would be around 8,478 tons/day by the year 2020 where as the second estimate predicts that the waste generation will reach over 30,195 tons/day by 2020.

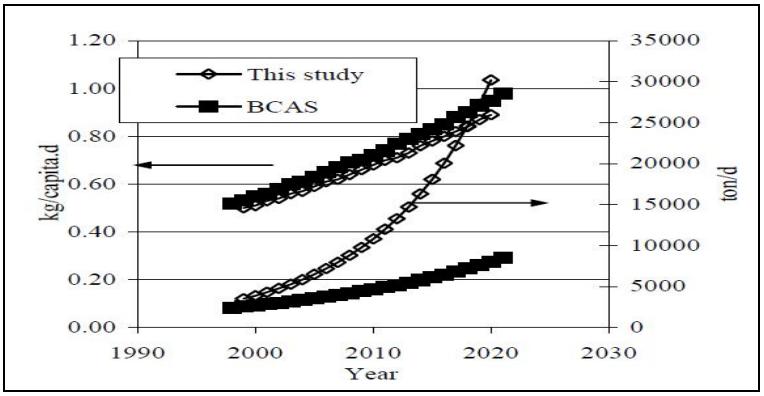

Fig. 3. Projection of future waste generation by Bangladesh Center for Advanced Studies

5. *Local Government AND Solid Waste Management*

Dhaka Municipality was established in 1864. There are two tiers in urban local governmental bodies: City Corporations and Municipalities. Municipalities are comprised of smaller urban towns with less population. Larger municipalities are divided into a number of wards depending on the size and population. Commissioners are elected directly by popular vote. There is one Chairperson of a Municipality. An elected representative represents each ward. On consideration of size, population and law and order situation, the government upgraded four big municipalities in the country into Metropolitan Cities in the 1970s. The advantages of the Metropolitan city are that it has independent policing, judicial system and separate regulations suitable for cities' problems to control law and order situation. Considering the size, population, civic problems and importance, the government again created four Municipal Corporations in 1980. City Corporations are divided into wards. Dhaka City Cooperation is thus divided into 90 wards.

The Institutional Head of the City Corporation is the Mayor. The Mayor of Dhaka City Corporation holds the status of a full Cabinet Minister. The Mayor of City Corporation along with ward Commissioners constitutes Councils of City Corporation. These Councils are responsible for formulation of policies, approving annual budget undertaking development schemes and execution of projects and programs of the respective city corporation.

Own sources of fund of the City corporation are household tax, rents from markets, shops and establishments, fees from licenses, tolls from different temporary public places. The Corporation's own resources are not enough to cater different development activities of the city. The government's financial support has therefore become a regular phenomenon for the Corporation. In the annual budget more than 50 percent fund comes from government treasury in the form of block or total allocation.

In Dhaka City Cooperation, Conservancy department is responsible for solid waste management including cleaning of streets and drains. There is no independent law in Bangladesh to address the problems of solid waste. In Bangladesh, solid waste management is entrusted with the local government bodies. The responsibility of removing solid waste and disposing of it lies with the City Corporation.

The Dhaka City Corporation Ordinance 1983 is the only local law that gives some idea on disposal of municipal waste. Dhaka Municipal Ordinance 1983 has provision for the removal of refuse from all public streets, public latrines, urinal drains, and dustbins and for collection and disposal of such refuse.

Moreover, due to shortage of funding, due to almost no direct user charges as well as insufficient subsidies, and other institutional constraints, the local government has not been able to effectively collect and dispose of the waste properly. Most of the waste is visible on the streets and in the drains and there is almost no sanitary landfill or any other facilities like incineration.

6. Legal Aspect of Solid Waste Management of Dhaka City

6.1 Dhaka City Cooperation Ordinance of 1983

a) Relevant section of the ordinance

Ordinance promulgated by the Chief Martial Law Administrator on 24 August 1983. Section 78 of the Ordinance stipulates as follows:

I. The Corporation shall make adequate arrangements for the removal of refuse11 from all public streets, 12 public latrines, urinals, drains and all buildings and land vested in the Corporation, and for the collection and proper disposal of such refuse.

II. The occupiers of all other buildings and lands within the Corporation shall be responsible for the removal of refuse from such buildings and lands subject to the general control and supervision of the Corporation.

III. The Corporation may cause public dustbins or other suitable receptacles to be provided at suitable places and where such dustbins or receptacles are provided, the Corporation may, by public notice, require that all refuse accumulating in any premises or land shall be deposited by the owner or occupier of such premises or land in such dustbins or receptacles.

IV. All refuse removed and collected by the staff of the Corporation or under their control and supervision and all refuse deposited in the dustbins and other receptacles provided by the Corporation shall be property of the Corporation.

b) Responsibility of Dhaka city cooperation

According to the above, Dhaka City Cooperation is responsible for removal of waste from all public streets, drains and buildings and land of the Corporation and for proper disposal of waste.

c) Responsibility of occupiers

In turn, the occupiers of all other buildings and lands within jurisdiction of Dhaka City Cooperation are responsible for the removal of refuse from their buildings and lands. To discharge their responsibility, they have to carry and dispose of their waste in the receptacle (containers or dustbins), which Dhaka City Cooperation may install, by themselves or to contract an NGO, CBO or private company to carry their refuse to the public dustbins or containers.

d) Offense and penalty

When the occupiers do not follow the Ordinance, i.e., "throwing or placing any refuse on any public street or in any place not provided or appointed for the purpose by the Corporation (item 19 of the Third Schedule of the Ordinance)", it shall constitute an offense and punishment shall be meted out after conviction according to Sections 150 – 153 of the Ordinance.

e) Interpretation of boundary between Dhaka city cooperation and occupiers

Although the ordinance does not explicitly define, the responsibility of disposal of refuse deposited in dustbins or containers is widely regarded as that of Dhaka City Cooperation; then Dhaka City Cooperation transports and disposes of the refuse at dumpsites.

6.2 Environment Conservation Act and Rules

a) Requirement related to solid waste management

Environmental Conservation Act of 1995 and Environmental Conservation Rules of 1997 require the person, who proposes or undertakes every industrial unit or project, to acquire Environmental Clearance Certificate (ECC, Section 12 of the Act). Land filling by industrial, household and commercial wastes is classified as "Red Category", which includes most harmful or dangerous industrial units and projects (Rule 7. and Schedule 1 of the Rules).

b) Little sense of compliance in Dhaka city Cooperation with the Act and Rules

Most of the staff appears not to be aware of these provisions. Uncontrolled or unidentified dumping or disposal prevails. In some cases, this kind of dumping is done by Dhaka City Cooperation upon request of the landowners.

6.3 Preservation Act

a) *Requirement related to solid waste management* Preservation Act of 2000, requires prior consent of the Government for changing the structure of specific lands such as open place, playing field or natural reservoir of water by filling land, building construction and any other construction that alter the original Master Plan of RAJUK.

b) Compliance with the Act by Dhaka city Cooperation
Dhaka City Cooperation currently does not comply with the above Act. Almost its entire staff seems not to know these provisions.

7. Environmental Management Measures (EMM) In Solid Waste Management: Experiences Of Other Countries

A study in the People's Republic of China, Indonesia, Malaysia, Philippines, and Thailand argued for the adoption of economic instrument as complementary tools for environmental protection in the Asian context of rapid industrialization and emerging economic and financial systems (Chen and Bacareza, 1995). The authors also identified four reasons for the adoption of economic instrument in developing countries. First, economic instruments can achieve the desired effect at the least possible cost as implementing those entails lower information, monitoring, and enforcement costs. Second, economic instruments are easier to enforce than command and control (CAC)/ regulations in countries with limited enforcement capability. Third, economic incentives will tend to discourage rent-seeking behavior due to their transparent nature. Fourth, economic instruments generate revenues whereas regulations require bloated bureaucracies. A strong economic instrument decentralizes decision making to a degree that the polluter or resource user has a maximum amount of flexibility to select the production or consumption option that minimizes the social cost of achieving a particular level of environmental quality (Huber *et al.* 1998). Eskeland and Jimenez (1992) state that economic instruments provide equal incentives to all by increasing the marginal cost of polluting. With many heterogeneous polluters and weak public administration, regulatory policies are not effective in implementation. The authors conclude that economic instruments provide greater certainty about abatement costs which are superior when there are concerns that underestimating costs would yield controls that are "too strict" and environmental quality that is "too high." Such concerns trouble policy makers in many developing countries. Empirical studies in the United States (US) show substantial efficiency gains associated with using economic instruments rather than non-economic instruments (United Nations Environment Program 2004). In the same report, Tietenberg suggested that non-economic instrument approaches to regulate pollution were 22 times as expensive in the US as the least costly economic instruments. Gerhard (1994) carried out a study on waste minimization and recycling strategies and their chances of success by using different scenarios combining ecological and economical aspects with facts and trends in human ethnology. He found that the household waste fraction could be reduced 10% by recycling. He also concluded that waste minimization and recycling could be successful given the cooperation of different public educational programs on waste management. Taiwan has implemented several types of recycling systems for polyethylene bottles, glass bottles, aluminum cans, waste paper, used tires, lubricating oils, mercury cell batteries, and pesticide containers. Similarly, Korea has also proposed an ambitious deposit-refund system for a wide range of products. One of the few cases of mandatory deposit-refund systems is found in Mexico (Huber *et al*. 1998). A new car battery can only be sold there with the return of an old one as batteries are considered highly hazardous waste and are very difficult to dispose of.

A study in Olangapo City of the Philippines (Bennagen and Altez 2004) found that shifting from the existing flat-fee structure to unit pricing for solid waste diverted at least 30% of the garbage through various alternative waste management practices such as household recycling and managing food wastes. In the 1990s, the Malaysian government introduced economic instruments for pollution control (with effluent charges and licensing fees) according to the quantity of waste discharge (O'Connor 1996). Beginning the second year of the intervention, the pollution loads to the city decreased by 25%. In Guayaquil, Ecuador and in Colombia, a solid waste collection fee is applied as a 10% surcharge on electricity bills (Huber *et al.* 1998). Although it may not include rationalization of waste generation, the collection costs for such a scheme are low and effective. This definitely saves time and manpower in collecting users' fees from the households in the city.

8. ***Solid Waste Management: Approaches And Problems In Dhaka City***

A combination of government and private companies collects waste from different parts of the city. The municipal administration dictates collection frequency and charges to households and commercial institutions. Up to now, there has been limited proper solid waste management system to solve problems of collection, recycling, reduction, reuse, transformation, and disposal. The city's inhabitants generally perceive the waste problem as a minor one and lack awareness of its importance and seriousness. They therefore make no efforts to reduce waste. Collection services reach only a small proportion, due to the following reasons

- Private and public services are under-financed.
- Households are reluctant to pay the monthly waste collection fees because of the services provided to them are inefficient.
- Collection services are unreliable usually due to insufficient and poor maintenance of equipment.
- Public awareness of the importance of waste disposal is lacking.

The following problems of solid waste management in Dhaka city were observed

- Waste collection is not efficiently planned and does not reach all communities. In most places, the municipality is collecting waste only once a week, a practice that has created illegal dumping.
- Urban dwellers face health risks and environmental damage caused by inappropriate handling of waste. Marginalized and minority groups are the most vulnerable to pollution. These low income communities are exposed to higher environmental risks than other groups in society as they often live in more polluted and industrial areas and may not have ready access to health care services. Coordination between and among the municipality, residents, the private sector, and waste collectors is lacking.
- Open dumping is difficult to monitor and has polluted natural streams and tributaries and created high health risks for human beings.
- The vehicles for waste collection are insufficient for reaching all communities.
- Users' fees are too low to compensate the municipality for the cost of solid waste collection and disposal. As a result, public and commercial institutions are not internalizing the externalities, and the municipality is poorly equipped financially to efficiently manage its solid wastes.

Result and Discussion

Proposed Environmental Management Measures (EMM) Model for Effective Solid Waste Management in Dhaka City

The choice of EMM instruments to internalize the externalities of urban pollution depends on the local context such as geographical region, people's behavior, previous trends, and administrative structures. The instruments of EMM should be used simultaneously for effective and sustainable solid waste management. The EMM instruments can be used in following ways for sustainable solid waste management in Dhaka city

a) Economic instruments (EIs)

Economic Instruments for solid waste management in the form of taxes, user fees, service charges, and fines are very popular in many cities worldwide because they are easy to implement, they strengthen the financial base of solid waste management institutions, and because they attempt to shift the costs of and responsibilities for pollution back to the polluter. Economic Instruments aim at internalizing environmental externalities by setting costs and benefits to influence decisions and behaviors towards more environmentally desirable situations. They offer advantages because they are economically efficient, easily modified, and ultimately lead to better allocation and use of resources. In addition, economic instruments can be effectively introduced even if the administrative structures of solid waste management are not efficient.

In Dhaka city, the local authority charges flat fees for waste collection but does not charge for waste disposal though in reality disposal requires more technical expertise and effort. Waste collection fees for households average about BDT 100-500/household/month in high economic areas and in low economic areas it ranges from BDT 10-50 even free of charge. The rates for commercial institutions are higher but are still very low relative to their contribution to pollution. In line with the principle of the polluter pays, the local authority should increase fees and service charges for waste collection to encourage people to minimize, recycle, or compost their waste. Waste disposal fees should also be introduced.

These two measures will strengthen the financial base of the municipality and ultimately enable efficient and sustainable management of solid waste in Dhaka city.

In Dhaka city, only few waste pickers are currently working and waste pickers contribute a lot to minimizing volume, so they should be given incentives to continue their work. Educational programs for waste pickers should also be organized to include topics such as safety measures for handling dust, smoke, and infectious waste. The living standards of the waste pickers should be improved by providing them with regular incentives and encouragement from the municipality.

Voluntary deposit-refund systems for glass, paper, and plastic and the recycling of ferrous materials, paper, and plastic are well established economic instruments in various parts of the world. Both instruments have considerably decreased the total volume of waste produced. The deposit-refund system is popular for soft drink products in which packaging costs have a higher share of the total product price as the return rates are also high. In the case of other liquor products, however, the packaging cost is a lower share of the total price, therefore the return rate is low and the deposit refund system is not commonly used. Refunds for aluminum cans are now increasingly popular in various parts of the world due to their high value added from recycling and to the expanding use of such containers. Refunds are also appropriate for toxic and hazardous waste management (motor batteries, tires, lubricating oils, etc).

Subsidies for recycling industries will be the most encouraging tools of economic instruments. Land can also be offered at a lower cost to encourage investors to establish solid waste management technology in the city. Along with subsidies, local and national governments should establish a market for recycled products to ensure sustainability. Tax waivers and subsidies to establish recycling industries will attract private sector and NGO investment in solid waste management. Waiving taxes for the establishment of new plants and technologies and offering tax holidays for certain time intervals will also attract investment. Higher duties on imported products will help to establish market for recycled products. The use of compost instead of chemical fertilizer is a good example which implemented in Thailand. The local or national government can create a market for compost by imposing higher duties or fixing quotas on imported or locally produced chemical fertilizers.

The composition of solid waste in Dhaka city reveals a high potential for making compost from organic matter after sorting and appropriate treatment and recycling of paper and plastic products. With composting, it seems feasible to reduce waste volume by 49%. Stakeholders should provide education and subsidies to residents who compost.

b) Regulatory instruments (RIs)

The following regulatory instruments can be used for solid waste management

- Technology standards
- Pollution standards
- Land use restrictions
- Environmental guidelines
- Quota systems
- City zoning
- Waste collection times
- Standards for dump sites
- Frequency of waste collection
- Permits and licenses for infrastructural setup;
- Control of indiscriminate use of land and water bodies for waste disposal
- Different kinds of solid waste plans and regulations.

Setting the standard for waste collection bins should be addressed in Dhaka city. Locally made bins, plastic bags, and plastic bins widely used for waste collection are not safe as they do not control bad odors, and they attract birds and stray dogs. They also occupy a significant amount of space along principal roadsides. Standards for dumpsites are another regulatory instrument that could be adopted. Regulations on solid waste management have been addressed in some measures like the environmental protection law. Although there is provision for permits and licenses for hospitals, commercial establishments, and construction firms, the revenue generated from them is not allocated for solid waste management and for protection of the urban environment as the municipality does not have sufficient resources, expertise, and manpower to do so. Regulatory Instruments require much more detailed information on regulating firms, industries, and other commercial institutions than economic instruments require. Regulatory Instruments generally set fines or penalties that are frequently too low to deter violators. Sophisticated regulatory compliance staff and support are required for them to be effective. Both public and commercial institutions believe that

the management of solid waste is the sole responsibility of government. Involving the private sector and non-profit organizations will change the behavior of the public and will create better alternatives for solid waste management. The private sector can be encouraged to enter into the business of collection, recycling, and disposal by providing incentives and soft loans for purchasing equipment. Government laws and regulations should clearly define the responsibilities of personnel, government organizations, and the private sector. Some residents are reluctant to pay for existing solid waste management services because of their irregularity. This may suggest a need for improvement in management, specifically an increase in the frequency of collection and disposal. The increase should be done in conjunction with setting standards for collection bins and for biological treatment of waste in dumpsites. The municipal administration can also relocate commercial institutions outside of the core city and can limit licenses to new industries that produce solid waste. This will reduce the total volume in the most crowded areas of the city.

Regulatory Instruments require specific expertise to set standards and to formulate solid waste policies and laws. The municipality also needs to increase the experts to monitor solid waste management activities. Training will enhance the capacity of municipal personnel to better implement and monitor activities. Study visits can also be scheduled on a regular basis so that municipal or government personnel can learn from improved solid waste management practices in cities in other countries.

c) Suasive instruments (SIs)

Suasive instruments are also called moral suasion. Training, awareness-raising campaigns, extension activities, school and college educational programs and environmental education are key elements of any policy in this category. The primary purpose of these instruments is to make people aware of the importance of solid waste management as they rely on voluntary compliance by polluters motivated either by the threat of adverse publicity or the prospective favorable publicity.

Environmental education should be mandatory in primary and secondary schools. At the higher level, it should be started some courses on environmental management specialization on waste management. The course may aim to improve the knowledge of students about the production of goods, its impact on the environment, and how to minimize its negative effects. From time to time, the university's student affairs office should organize campus-cleaning campaigns to raise students' awareness of solid waste management. These programs should be continued and extended to schools on a regular basis to ensure better understanding of solid waste management among young people.

The mass media should show environment-related news and issues and awareness building on waste management. This instrument can be useful, but further effort needs to be made to mobilize mass media to raise the awareness of the public (including NGOs and the private sector) about better solid waste management.

Community participation is essential. Waste separation at the source is the main solution to environmentally sustainable solid waste management, and it can significantly reduce both the cost of collection and the overall cost.

Furthermore, the following activities will yield long-term, positive environmental and socioeconomic impacts:

- Regular sharing of information with and raising the awareness of local people;
- Training volunteers to educate households in separating wastes;
- Expanding community and school-operated recycling banks to all communities and schools;
- Continuing and expanding mass media mobilization;
- Establishing community working groups to monitor illegal dumping.

Community participation can significantly reduce the cost of waste collection. Public awareness about proper solid waste management is increasing, but the speed is slow. The changing consumption patterns of the city's inhabitants have altered the composition of the waste stream to mostly plastic materials. Clean campaigns and other educational programs can change public attitudes and create environmental awareness and the proper behavior toward minimizing volume. This may involve messages such as keeping garbage bins in good locations; buying goods without unnecessary packaging; returning packaging materials to production sites; returning products for collective disposal; and recycling items such as used furniture, electrical, and electronic appliances.

Conclusions

The Projection of future solid waste generation rate of Dhaka city indicates that by the year 2020 it may exceed 30 thousand tons/day, which in turn will require over 200 acres/yr of landfill area. In this

perspective simultaneous use of EMM instruments i.e. economic, regulatory and suasive will be more effective way of management of solid waste of Dhaka city.

Economic Instruments for solid waste management will be effective in terms of cost management and ease of implementation as these try to shift the cost of pollution back to the polluters and to internalize the externalities by increasing user fees as a function of the amount of solid waste generated. Regulatory instruments, on the other hand, require strong administrative structures to penalize violators and may be less effective in Dhaka city. Economic Instruments should also be combined with suasive instruments that help change public attitudes towards the handling of solid waste. Effective solid waste management calls for the active participation of communities, local governments, and NGOs. So for sustainable and effective management of solid waste in Dhaka city, all those instruments should be recommended and implemented simultaneously.

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