Change in Global Mean Temperature: Potential Danger for Bangladesh

by Dr M Monirul Qader Mirza

The global climate change is one of the most debated and negotiated environmental issues that has shaken the scientific and political communities of the world over the last three decades of the present century. Many countries in the world are expected to suffer seriously by change in climate and rise in sea level. The magnitude or range of these changes will vary from country to country and region to region. Sitting at a peculiar geographic location in South Asia, flood situation in Bangladesh may be worsened with a slight increase in global mean surface temperature. Possible change in land inundation categories may also bring substantial change in cropping patterns in Bangladesh.

GLOBAL climate change due to the enhanced greenhouse effect has emerged as one of the most pressing environmental issues for the 21st century. Emissions resulting from human activities are substantially increasing the atmospheric concentrations of the greenhouse gases. These increases will enhance the natural greenhouse effect, resulting in an additional warming of the Earth's surface. Over the last 100 years, global mean surface temperature has increased by 0.3 to 0.6°C. The additional data available since 1990 and their re-analyses at the auspices of the Intergovernmental Panel on Climate Change (IPCC) have not significantly changed this range of estimated increase. Based on outputs from the General Circulation Models (GCMs), the IPCC arrived at a conclusion that with no policies to reduce greenhouse gas emissions, the world should, on average be about 2°C warmer by the year 2100 than today and the sea level could rise by about 50 cm.

Changes in climate could produce water resources problems in many parts of the world. Higher temperatures will increase evaporation, change snowfall and snowmelt patterns, and lead to alterations in water demand. Changes in rainfall could affect water availability in soils, rivers and lakes, with implications for domestic and industrial water supplies, hydro-power generation, and agricultural productivity. Rising sea level threatens low-lying coastal areas with flooding, erosion and contamination of coastal freshwater aquifers. However, there are many uncertainties regarding the climate changes and their impacts on water resources. Most of the GCMs point towards increasing global mean annual temperature and precipitation changes but their accuracy in forecasting change in regional precipitation is poor. On the other hand, the hydrologic processes included in the GCMs are far simpler than those in real situations. Despite these limitations, research in the past few years suggests that relatively small climate changes could significantly affect water resources and could intensify flooding and droughts in various parts of the world. On a regional basis, some parts of the world will experience a greater surplus of water and some greater scarcity.

South Asia, particularly the Ganges, Brahmaputra and Meghna (GBM) basins, might be affected by possible changes in the monsoon precipitation patterns. However, the climate model predictions have some uncertainty. For example, when the effects of both greenhouse gases and aerosols are included in model simulations, Asian summer monsoon rainfall decreases as the aerosol cools down atmospheric temperature, whereas in simulations which only take into account the effect of greenhouse gases, increased rainfall increases.

In the downstream delta in Bangladesh which drains vast areas of the GBM river basins the seasonal variation of water availability is very high and largely unpredictable. Large parts of the basins get inundated every year by floods in the monsoon while some areas are exposed to annual drought. Floods have become an annual phenomenon in Bangladesh which is located at the confluence of the three large rivers. In extreme years, floods cause tremendous losses in lives and property in Bangladesh. Increased precipitation in the monsoon under the climatic change scenarios could induce changes in the flooding patterns in terms of the timing, frequency, magnitude, depth and area of inundation in Bangladesh.

However, the processes involved in analysing the effects of climate change on floods are complex. Some of the key factors include changes in temperature, evaporation, precipitation, soil moisture, snowfall/snowmelt, runoff, sea-level rise and extreme events.

Flood Problem

Flooding of catastrophic proportions is often experienced in the Himalayan region. The geographical location of the region has made the flood problem unique in the world. Extreme precipitation (in the form of rainfall) together with the physical setting of the river basins has caused many severe floods in the last few decades. For Bangladesh, located at the extreme end of the Himalayan drainage basins, floods are regular phenomena. Generally, the high monsoon discharge generated by high precipitation in the basin areas of the Ganges, Brahmaputra and Meghna rivers, together with ponding by local precipitation cause floods in Bangladesh. Deforestation in the Himalayas, upstream structural interventions, backwater effects, rise of sea level in the monsoon, synchronisation of flood peaks of the major rivers and the tidal effects also influence, to varying degrees, the severity of flooding in Bangladesh.

For Bangladesh, changes in frequency, magnitude and depth of flooding are very important. On average, annually 21 percent of the area of the country (31,000 sq. km) gets inundated by floods. About 21 percent of the population (considering uniform population distribution) is vulnerable to annual flooding and in exceptional cases, this may exceed 60 per cent. The 1998 flood, which is considered as the most severe flood in recent history in terms of duration and damage, engulfed about 57 per cent of Bangladesh (84,000 sq. km). The 1998 flood has some special characteristics compared to 1987 and 1988 floods. *First*, the monsoon was delayed by almost a month which actually arrived in the mid of July. This is claimed to be related with the El-Nino Southern Oscillation (ENSO). *Second*, prolonged heavy rainfall occurred in the upstream river basins in Nepal, Bhutan and India. In Bangladesh, heavy rainfall (28-59 per cent higher than the normal) recorded in July in the Ganges, Brahmaputra and South-eastern hill basins. Similarly, in August, rainfall was 13, 62 and 16 per cent higher than the normal in the Ganges, Brahmaputra and Meghna basins, respectively. *Third*, duration of flood was 63 days much higher than the 1987 and 1988 floods. For the Ganges, flood levels had crossed the 1988 level. *Fourth*, due to longer duration, the damage of 1998 flood was estimated to be much higher than 1987 and 1988 floods. The crop damage was estimated to be over 2 million tons. Directly 70 million people were affected by the flood.

Global and Regional Climate Change and Bangladesh Floods: The increases in high floods in recent decades also may not be linked with the increase in global mean surface temperature that occurred over the last one hundred years. As mentioned above, since the late 19th century, global mean surface temperature has increased by between about 0.3°C and 0.6°C. Analysis of mean annual temperature over India during the period 1901-1982 indicates about 0.4°C warming. The warming is found to be pronounced in the west coast, the interior peninsula and the north-central (the Ganges basin) and north-east regions (Brahmaputra and Meghna basins). In the Bangladesh region, from the latter part of the last century, there has been, on average, an overall warming of about 0.5°C, comparable in magnitude to the observed global warming. In the last 100 years, broadly there is no discernible increasing or decreasing trend in precipitation in the greater Himalayan region.

Climate models are used to predict possible future changes in climate broadly focused on temperature and precipitation. Prediction of climate change may vary from model to model depending on the underlying assumptions considered during development of a model. The main differences between models within a given hierarchy are: the number of spatial dimensions in the model, the extent to which physical processes are explicitly represented, the level at which empirical parametrizations are involved and computational cost of running the model. Despite these limitations, all the GCMs are in broad agreement about increase in global mean temperature and precipitation in the GBM basin areas.

What are the potential implications of increases in global mean temperature and precipitation in the GBM basins? These changes may have a number of implications. *First*, a possible change in the seasonality of hydrological cycle is expected. This means, monsoon may be delayed and expanded. Presently, monsoon breaks in the middle of June and withdraws by the middle of September. Say, one month delay in monsoon may push it up to the middle of October. *Second*, possible increase in monsoon precipitation indicates about a likelihood of increase in extreme rainfall events. *Third*, increase in monsoon precipitation in the GBM basins may increase the magnitude, depth and duration of floods. *Fourth*, increased magnitude, depth and duration of floods will bring a dramatic change in land-use patterns in Bangladesh. *Fifth*, timing of peaking in the major rivers may also change. Presently, probability of simultaneous occurrence of flood peaks in the Ganges, Brahmaputra and Meghna rivers within 10 days apart is 23 per cent. In 1998, flood peaks of the Ganges and Brahmaputra occurred within only one day time difference. In 1988, time difference of peaking was 3 days. This gap may be shortened, therefore, possibility of increasing the likelihood of synchronisation of flood peaks of the major rivers. Note that a flood situation in Bangladesh takes a severe turn when the flood peaks of the two or three major rivers synchronise.

The Potential Danger: A 2°C Temperature Change

Floods: In order to examine the possible effects on global climate change on Bangladesh, the writer has carried out a research at the International Global Change Institute (IGCI), University of Waikato, Hamilton, New Zealand. The research has two main objectives: *First*, determination of the sensitivity of the annual and mean peak river discharges in Bangladesh to future climate change. *Second*, estimation of the consequent changes in flood magnitude, depth and extent. For these purposes, precipitation changes in the GBM basins projected by 11 GCMs were primarily considered.

The models demonstrate a reasonably high variation in precipitation change in the GBM basins for per degree global warming. Among these models, the UKTR shows uniformly high precipitation changes in the GBM basins. The CSIRO9 indicates high precipitation changes in the Ganges basin and low in the Brahmaputra basin, whereas, the GFDL shows just the opposite for the CSIRO9 GCM. Among the 11 GCMs, the LLNL shows lowest changes in the two river basins. These models show a wide range of uncertainty in precipitation changes under climate change. Therefore, the CSIRO9, UKTR, GFDL and LLNL were selected to maximise the range of predicted changes in precipitation amounts and spatial variability within the Ganges-Brahmaputra-Meghna basins window. Precipitation change scenarios from the four GCMs have been used for sensitivity analysis of Bangladesh floods to future climate change.

Discharge (mean annual and peak) changes at the boundary of Bangladesh for the climate change scenarios were accomplished by applying the 12 precipitation change scenarios in the empirical models and comparing the results to current discharge values. In order to estimate the possible changes in flood extent and depth within Bangladesh, the current and future scenarios of peak discharges of the three major rivers at the boundary of Bangladesh were used to force the MIKE11-GIS model (a hydro-dynamic model coupled to a GIS, run by the Surface Water Modelling Centre, Dhaka). The MIKE11-GIS model simulates river flood stages and depth of flooding within Bangladesh.

With respect to possible future changes in mean discharge, the four GCMs tend (with a few minor exceptions) to show increases in precipitation within the basins and, thus, increases in *mean annual* discharge for all three major rivers. However, the magnitude of the change varies considerably between the GCM-based scenarios. The UKTR scenario gives the highest increases in *mean annual* discharge for the Ganges and Brahmaputra rivers: for a 2°C rise in global mean temperature, the discharges are estimated to increase by 21 per cent and 6 per cent, respectively. The lowest changes (<5 per cent) result from the LLNL (for the Ganges) and CSIRO9 (for the Brahmaputra) scenarios. Overall, the mean discharge of the Brahmaputra River is less sensitive to changes in precipitation than the Ganges River, supporting the contention that runoff or discharge of a wetter basin will be less sensitive to climate change than a relatively drier basin.

The UKTR scenario also produces the largest changes in *mean peak* discharge for the Ganges and Brahmaputra rivers. The mean peak discharges increase by 15 per cent and 6 per cent respectively, for a 2°C rise in global mean temperature. The UKTR and GFDL scenarios both show equally large (19 per cent) increases in discharge for the Meghna River. In general, changes in the peak discharges of the Ganges and Meghna rivers are larger than those of the Brahmaputra River. Only the CSIRO9 scenario produces decreases (albeit slight) in peak discharge, and only for the Brahmaputra River. Increases in peak discharges for the three major rivers will maintain linear trends for higher changes in global mean temperature.

Surprisingly, the model results indicate that most changes in the mean flooded areas occur between 0 and 2°C in relation to the increases in the peak discharges of the Ganges, Brahmaputra and Meghna rivers rather than at higher temperature increases. In the range of 0-2°C, 2-4°C and 4-6°C increases in temperature, increases in flooded area for per degree warming is 0.44 to 0.55 mha, 0.015 to 0.09 mha and 0.015 to 0.075 mha, respectively. In general, increases in peak discharge between 0-2°C will engulf most of the flood vulnerable areas. Therefore, at higher temperature increases, proportionate increases in discharge will not be able to increase the extent of flooding as it will possibly be limited by elevation of lands.

The Brahmaputra and Meghna flood discharges will continue to play a major role in flooding in a warming climate in future. The role of the Ganges River in flooding in Bangladesh is somewhat catalytic. The flood discharge of the Ganges slows down the drainage of the Brahmaputra River through the Goalundo/Baruria transit. This helps to increase the area extent, depth and duration of flood in the Brahmaputra basin because the Brahmaputra water cannot be drained out quickly to the downstream. Further downstream in Chandpur, the combined flow of the Ganges and Brahmaputra rivers obstructs drainage from the Meghna basin. This phenomenon creates problems in the Meghna basin similar to those of the Brahmaputra.

Under the climate change scenarios, four selected GCMs indicate substantial changes in the land inundation categories F_0 (0-30cm), F_1 (31-90 cm), F_2 (91-180 cm) and F_3>180 cm. The analyses of inundation categories for the model simulations indicate that:

- drastic changes in most of the inundation categories may occur between 0 and 2°C global mean temperature rise;
- rates of change are expected to be smaller with higher temperature increases;
- under a 6°C temperature rise, most of the mean flooded areas may be deeply flooded in Bangladesh;
- land area under prolonged inundation (<9 months) may increase;
- changes in the inundation categories may result in reduced cropping intensity in Bangladesh; and
- as a result of changes in the inundation categories, the agricultural sector of Bangladesh may suffer substantially with regard to loss of land productivity.

The first point is that for all four GCMs, changes in the inundation categories are largest in the range of 0 to 2°C. The non-flood category (F_0) may decrease substantially, while the other flood categories especially F_2 and F_3 would increase markedly. The F_0 land category is expected to change in the range of -21 to -17 per cent. This is due to substantial increases in the peak discharge of the three main rivers as well as local rainfall. Individually, the Meghna basin has largely contributed to these changes. Note that most of the area of this basin gets inundated annually. In absolute terms the increase is in the range of 0.46-0.68 million ha. The highest changes (in terms of gain) are expected for the F_3 category which could be in the range of +32 to +47 per cent (between 0.5 to 0.74 million ha) followed by the F_2 category where the changes may be in the range of +30 to +36 per cent (between 0.39 to 0.44 million ha). The lowest change (-7.5 to 0 per cent) may occur for the F_1 category.

Agriculture: Changes in the land inundation categories may substantially affect the agriculture sector in Bangladesh. The effect of changes may be more pronounced for the monsoon rice crops and *rabi* varieties. The high (F_0) and medium high (F_1) lands are suited to HYV Transplanted Aman in monsoon, wheat and HYV boro in *rabi* season. Medium low (F_2) and low (F_3) lands are suited to broadcasted Aman in monsoon and HYV boro in *rabi* season.

Changes in land categories may affect cropping intensity in Bangladesh. Farmers do not plant when the risk of flooding is too high. A flood can damage the aus crop at the end of the growing period and the aman at the beginning of the growing period. Floods may limit the growing of HYVs between June and October, wherever, risk of flooding is too high (above 60 cm more with a 20 per cent probability of exceedence. Under the climate change scenarios, increases in the mean flood volume and depth will increase the volume and depth of floods within higher return periods. Therefore, risk of inundation with higher flood depths may increase. Loss of F_0 and F_1 land categories would reduce area under wheat and winter vegetables. If the gross cultivated area in the monsoon season were reduced, the cropping intensity may reduce unless compensated by the *boro* crop.

Changes in the F_0 and F_1 land categories may affect the high yielding varieties (HYVs) of rice cultivation. Under the climate change scenarios, reduction in the F_0 and F_1 categories is expected to be within the range of -21 to -17 and -25 to -3 per cent, respectively for the four GCMs. This may have a significant effect on the HYV *aman* rice production in Bangladesh.

Productivity of lands may be effected by changes in the inundation categories. Based on land type, per hectare productivity varies from Taka 24,100-35,000 with irrigation and 8,600-20,200 without irrigation. The F_0 land category (irrigated) may be seriously affected if it is transformed into the F_1 category. The non-irrigated F_0 category may gain very little productivity. On the other hand, for transformation of F_2 into F_3, loss in productivity for non-irrigated F_2 may be twice that of the irrigated.

Conclusion

The emission scenarios are highly dependent on population growth, agricultural and economic development, technological choice and climate negotiations. For the lowest to the highest emission scenarios, climate models project an increase in global mean surface temperature relative to 1990 in the range of 1-3.5°C with the mid-value of 2°C by 2100. These projections may be changed with the future course of the factors related to global greenhouse gas emissions. With the highest emission scenario, the world may be warmer by 2°C by as soon as 2050.

The research results show that most of the changes in flood inundation will occur between zero and 2°C increase in global temperature. In this range, the increased volume of flood discharge will occupy most of the flood vulnerable area in Bangladesh. The research is not free from limitations. For example, it has not considered the effects of sea-level rise in the flooding process. Despite limitations, the findings underscore the need of taking into account climate change issue in future planning of water and agriculture sectors in Bangladesh.

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Solid Waste Management for Dhaka City by 2000

by Omar Faruk

DHAKA is one of the world's most crowded cities. It is assumed that by the year 2025 it will become a mega city. How will this city deal with her mega problems during that time?

By the year 2000, the city's population will be approaching 10 million living in an area of 400 square miles approximately. What will be the impact of a population of that size on the socio-economic structure of the city as well as on the whole country, living in such a small area? Due to significant population rise in recent years, one of the major problems that the city has been encountering is its solid waste management. Our age-old technique and management of solid waste handling could not proceed farther to match the rhythm and needs of a changing time.

It is probably one of the most neglected, yet one of the most important parts of public health in our service sector. Its implication is potentially catastrophic on one hand and, another, if properly managed it can be very rewarding. It is therefore high time that we gave a serious look to this growing menace and tried to find out an appropriate management technique that would be environmentally sound and economically feasible in our context.

Current Solid Waste Management Practices and their Impact: Solid waste generated in metropolitan Dhaka is currently managed by the city authority through its own mechanism, that is collection and disposals are managed by regular city staff. Collections are done manually from different bins or disposal areas at different city points and transported to city-operated open landfill area for dumping. The bins are open and often inadequate in size to contain the quantity of waste. Overflow and littering of garbage in the adjacent area are practically a common scene. In addition to the esthetic nuisance, these areas are breeding places for different vectors of deadly diseases. The waste collection system is so overburdened by the population growth that the city authority often fails to handle them in due time.

So we see uncollected waste staying in the bins for days. In the disposal sector, the prevailing situation is equally filthy and unsystematic. Dumping sites are located in the middle of densely populated residential areas. The surrounding area is so heavy with foul odor that one feels like throwing up. The collected wastes are dumped in the low lying areas as landfill materials without knowing the waste composition and its future impact on the ground water. The idea of sanitary landfill, its siting criteria and other technical aspects that a landfill site should posses to contain future contamination or pollution potential is still uncommon.

It is true that until now probably 80 per cent of the municipal solid wastes are household or biologically degradable wastes. Very often they contain hospital, commercial and industrial wastes of all kinds. That makes us concerned about the future environmental degradation and risk to human health by our current practices of waste handling and disposal.

In recent years we have seen a significant rise in industrial development in and around Dhaka city. It is anticipated that a lot more using different types of toxic chemicals will be in operation by the year 2000. The same stands for the rapid growth of the private clinics. Such city areas as Mirpur and Mohammadpur are well known for their auto-repair, recycling and other types of small engineering shops. Wastes from all these sources end up in the same dumping place.

These practices are very dangerous and have to be stopped before they go out of our control. The environmental impact is a slow but inevitable process. When it strikes, it will not spare the rich or bureaucrats or political leaders. They will have the same sufferings as those millions of our ignorant people.

Defining Solid Waste and Regulatory Requirements for Efficient Management: The solid waste stream as a whole consists of 1) Agricultural 2) Municipal (household) 3) Commercial and 4) Industrial wastes. Due to absence of proper data it is difficult to assume waste production capacity of Dhaka city. If we assume a production rate of 0.8 kg/household/day and the number of current households if assumed at 400,000, then probably 320 tons of waste produced daily. This may include contribution from Industrial/Commercial/Institutional (ICI) sector.

However a detailed study is recommended to identify the waste composition, contribution from each sector and ultimate fate of the waste. Particular emphasis should be given to track down the fate of the clinical wastes. Correct information on waste composition and production is pre-requisite to sound waste management practices.

A landfill area in city vicinity. —Star photo

So far I believe that we do not have any concrete legal structure that can be used to regulate dumping of residential and ICI wastes in so called landfill areas. In the US, Environmental Protection Agency (EPA) is the federal administrative body to administer the environmental regulations throughout the United States. In Canada, the Ministry of Environment and Energy is the equivalent of EPA in waste management sector. In the United States a number of incidents led to the formation of different regulations to control current landfill practices. Hazardous and clinical wastes are source separated. Of the remaining solid waste streams, recyclable materials are segregated and taken to the processing facility. Engineering features of a landfill site is much different from that existed in the 1970s. A landfill site now called a sanitary landfill must consist the appropriate engineering technology to contain landfill leachate and its movement. A landfill site must need a permit from an appropriate authority to operate itself.

Landfill sites are also subjected to periodic inspection from the controlling authority. A similar controlling mechanism can be introduced in our context for landfill sites as well as for sources other than residential dwellings that generate wastes — particularly for hospital, clinics, industrial and commercial installations. Benefits for introducing such mechanisms will be 1) revenue earning 2) employment generation 3) preserving quantitative and qualitative information on our waste generators and their environmental pathways.

Waste Management: In our country garbage is still considered to have no material value. Its potential environmental impacts are neglected or ignored. On the contrary, in the developed world, due to various reasons waste management and the 3-R (reduce, reuse and recycle) activities have become integral parts of the overall environmental management programme. Rules and regulations in these areas are being continuously perfected to satisfy the contemporary environmental concerns.

'Energy from wastes' (EFW) and recycling industries are now viable and profitable business opportunities in the developed world. Much of this is due to technological advancement, the global economic situation and environmental awareness of these countries. The idea of recycling of used materials is not uncommon in our country too. In fact recycling of paper, old clothing, bottles etc. had been in practice in our country even decades before those options became a necessity in the western world. Nowadays garbage collection and disposal are a lucrative business where people make money out of nothing.

In North America, residential and ICI wastes in almost all medium and large cities are collected and disposed of by private parties. Population of those cities range somewhere from 50,000 and above. Big cities with a population size 1/10th of that of Dhaka cannot even think of managing these activities by themselves. So contracting out garbage collection and disposal to private parties is one option that the metropolitan city authority may explore in the near future.

A pilot scheme can be tested for areas like Banani, Gulshan and Baridhara. These areas are comparatively newly built with wider roads and systematic dwellings. Therefore modern garbage collection trucks with self compressing unit will have easy access to the collection points. The scheme if proved successful can then be extended to other areas gradually by dividing the city into several sectors and by studying the pros and cons of the pilot project will supervise.

In the disposal sector, the site selection should be regulated strictly than the present practice of using the Corporation's or Government's low laying *khas* lands in the city vicinity as dumping places. A selection committee comprising of environment experts, the environmental pollution control department, city authority and elected representatives of the people should take part in the site selection process. Currently we do not have clear guidelines on solid waste collection and disposal in the Environmental Policy published by the government in 1993.

In Western countries strong citizen reaction is one of the major obstacles that a site selection process can expect. Whereas in our country, an owner of a low lying land will happily accept garbage to fill up the ditch and raise its elevation free of cost. He will practically face no resistance from either his neighbours or any legislative body. This is one of the major social and legal obstacles in the implementation of required environmental policies.

To overcome this problem we need a pragmatic approach to our existing waste management system. Often an incentive is good enough to achieve a goal rather than a number of rules and regulations. If we can make garbage collection and disposal a profitable business, a number of objectives can be achieved such as: 1) Vast number of self-employment generation, 2) Change of our attitude towards garbage handling and disposal, 3) maintaining a clean city and clean environment thereby. The two options in municipal solid waste management e.g. sanitary land filling and incineration (energy from waste) can both be a source of such incentives.

Landfill Option for Solid Waste Management: This is the oldest and widely practiced option in waste management. To make our present practice more effective, economically profitable and environmentally sound, a number of suggestions can be made:

- Ban open dumping of waste in low lying areas in the city vicinity.
- Encourage recycling and create public awareness about recycling. Enforce regulations so that all Government and autonomous bodies must buy a certain quantities of the recycled goods. This will encourage recycling and recycling-based industries.
- Create public awareness about negative health effects of open dumping.
- Select potential landfill sites outside the city vicinity. These places should be sufficiently away from the city vicinity but will possess potential prospect for future development. The sites should also possess necessary hydrogeological criteria. Flood protection dikes may also be needed to contain wastes during high floods. These areas can be leased out to the interested parties who under the supervision of the technical committee will develop these areas into proper sanitary landfill areas. Dumping of wastes should only be allowed in these designated landfill areas.
- Privatized waste collection and disposal operations. Divide city area into several sectors for this purpose.

Energy from Waste Option: This can probably be a more lucrative option in the waste management field for a number of reasons. Due to population density, land scarcity and hydrogeological conditions, sanitary landfill may not be very successful. An EFW facility may be an alternative to sanitary landfill option. An EFW facility burns garbage and can produce steam or electricity as its end product. The incineration of MSW can result in environment pollution particularly with air emissions which may include particulate matter, acid gases, oxides of nitrogen, and products of incomplete combustion including chlorinated organic compounds i.e. dioxin, furans, chlorobenzenes and chlorophenols. Incinerators also emit carbon dioxide, incinerator ash may contain toxic elements.

But nowadays, technology is there to control emission of acid gases, particulate matter and heavy metal. Process and emission monitoring are very important to control performance of incinerator. Incinerator must be designed to fully utilize its anticipated waste flows. In North America, energy from waste incineration developed as an option in waste management in the 1970's and early 1980's. It is now considered as in its matured state having gone through a period of startups and rapid growth. However by the late 1980's EFW began to face opposition from the environmental groups.

In Ontario, a province of Canada, EFW was identified as a number one source of alternate power that would increase the province's energy self-efficiency. The following tables show international status of energy from waste incineration:

Table -1 : Municipal Waste Combustion in the USA

1) 126 WTE plants in the USA process 31 million tpy of waste
2) 26 incinerators (no energy recovery): 1.6 million tpy of waste
3) MWC plants generate 9 million tpy ash
4) WTE plants under construction and in advance planning will process an estimated additional 11 million tpy.

Table - 2 : Municipal Waste Combustion in Canada

1) 5% of solid waste is incinerated
2) 74% landfilled
3) 17 MSW. incineration facilities rated over 15 tonnes per day capacity
4) 95% of waste combusted used for energy recovery, primarily for steam production

• Source : Recycling Council of Ontario, Canada, May 4, 1995
• WTE — Weste to Energy, MCW — Municipal Waste Combustion

Conclusion and Recommendations: The following recommendations are made in connection with the future of Municipal Solid Waste Management before choosing any option :

- Fix a solid waste policy and guideline in the MSW sector.
- Underlake pilot study to determine waste production, characterization and its environmental path
- Underlake detailed study for the suitable options considering factors like topography, climate, social and administrative structure, population and environmental impact of the chosen option, its economic viability and effectiveness.

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