# Concept Paper on Waste Management

**1. A 'waste' is 'a resource *remaining unutilized*' or 'a resource *out of place*'.**

For example, out of the food that we consume, only a part is 'utilized' by the body system and the balance is thrown out as 'waste'. The part 'utilized' is converted into useful components such as blood, bones, flesh, nerves, and so on, or looked at in another way, into cells and microorganisms constituting the body, and these too, in turn are thrown out as 'waste'. Finally, the body itself, on death, becomes a 'waste'.

Another example: to run a 1 million tonne steel mill, nearly 5 million tonnes of raw materials---mostly iron ore, limestone and coal/coke---are needed, the extraction of which leaves behind huge mineral and allied wastes. Most of these raw materials themselves are released as wastes from the mill. Steel ingots are sent to rolling mills, which release their own wastes. The rolled sections are utilized in manufacturing and construction industries which release the concomitant wastes. After the manufactured equipment and structures have lived their life, these too are junked mostly as wastes.

The 'wastes' may be solid, liquid, gaseous, or radioactive; hazardous and non-hazardous, or, toxic and non-toxic.

## 2. 'Wastes' and 'Waste Management'

How a society manages its 'wastes' has critical socio-economic-health-environmental implications, because;

- A 'waste', like any other product, represents inputs of valuable and scarce material and energy resources, and, hence, appears as a loss of these resources.
- A 'waste' generally causes environmental pollution and damage---of land, water, air and living environment---being beyond the capacity of the environment to absorb and recycle it through natural processes, and, in most

cases, is also a human health hazard. For example, polluted drinking water alone is likely to kill around 1.6 million people in the world this year.

- A 'waste' requires to be collected, transported, and disposed off, often after being suitably treated, and the collection-cum-disposal systems are themselves becoming increasingly costly and cumbersome. In the process, these may themselves require large inputs of energy, material, land and labour resources, and cause widespread environmental distress.

The term '*Waste Management'* includes all issues and processes associated with the generation, processing, and disposal of all categories of wastes produced by human activities or related to human existence; it includes, therefore, the stages of production and minimization, collection, handling and transportation, reuse and recycling, and treatment and disposal of all such wastes. It is undertaken mainly to minimize the effect of wastes on resource loss and conservation, health, environment, costs, and aesthetics. It incurs financial and social and other costs including 'external' costs. The term includes the issue of 'regulation' of the various aspects of management of wastes.

*The responsibility for the management* of specific wastes may lie with governments, local bodies, and/or waste generators. For example, a) The *Extended Producer Responsibility* (EPR) concept promotes the integration of all costs associated with a product throughout its life-cycle (including the packaging and the end of life waste disposal costs) into the market price of the product; and b) the *Polluter Pays Principle* (PPP) is another concept to make the polluter bear all the incidental costs of environmental pollution.

## 3. Hierarchy of Options and Stages in Waste Management

Important options and stages in 'Waste Management' are listed below in a broad hierarchical order:

- *Prevention and Reduction:* The first option should be to prevent the generation itself of a waste, and since that may not be mostly possibly, to minimize its generation.
- *Reuse:* Once produced, the best option would be to 'reuse' ('salvage' or 'repair') it to the maximum extent possible.
- *Recycling:* Whatever waste remains after 'reuse', should be 'recycled' through suitable treatment processes for recovery of usable products (resources including energy).
- *Treatment and Disposal:* Whatever waste remains after 'reuse' and 'recycling', should be treated for being disposed off in a suitable and, to the extent possible, socially useful manner. Many wastes, such as human waste, garbage, and e-waste, due to their highly polluting, health-hazardous or toxic nature require extensive physical, and/or chemical---biological 'treatment' before being safely disposed of into land, water or air.

Thus, a Waste Management System (WMS) may involve four primary stages or processes: Minimization of Waste Generation, Efficient Waste Collection, Optimal Waste Reuse and Recycling, and Effective Waste Treatment and Disposal. (see Paras 4 to 6 below)

## 4. Minimization of Waste Generation

Both material and energy resources go into the formation of all products which in stages end up as 'wastes'. Even the processes of reuse, recycling, treatment and disposal of wastes, along with the processes of waste collection, handling, transportation, and storage, involve significant material, energy, environmental, and financial inputs. All un-recovered energy inputs finally end up degraded as low grade heat and are lost. Conventional energy resources, being mostly non-renewable, are getting scarce, particularly in India, where 75% of its hydrocarbon energy resources are imported at exorbitant costs, and other fossil fuels too are not plentiful. Material resources, particularly mineral resources, too are becoming increasingly scarce in the scenario of growing population and fast economic growth. Therefore, the growing use of energy and material resources is becoming more and more unsustainable.

Hence, the greatest challenge in Waste Management is how to minimize the loss of these resources through 'prevention' and 'reduction' of waste generation. There is a large-scale scope for 'prevention' of waste generation by avoidance of production and consumption of obviously superfluous, non-essential, non-utilitarian products and services. Easily preventable waste generation occurs when such goods and services are patronized. Lifestyles and social attitudes that encourage tendencies such as consumerism, shop-alcoholism, and display of enticing advertisements, encourage generation of easily avoidable wastes in a society. It particularly happens in societies where large disparities exist in purchasing power, consumption of socially unaffordable goods and services becomes increasingly respectable, and economic growth itself is partly measured in terms of such a consumption pattern. All this happens because of the growing dichotomy between individual and social perspectives. This also costs heavily in terms of scarce energy and material resources while a large part of society still awaits satisfaction of basic needs.

Promotion of waste 'prevention' in society will require extensive and on-going studies and research, documentation, and propagation and advocacy of ill-effects of avoidable production and consumption of goods and services.

Obviously, there are limits to such a 'preventive' approach for minimization of waste generation and an equal emphasis is needed on 'reduction' of waste generation without materially affecting the consumption and life styles. It may be done, say, by increasing the efficiency of processes of production and the durability of products, improving their maintainability, instituting performance standards, minimizing packaging, storage and transportation requirements, improving 'repair' and upgradation services, and discouraging the 'throwaway' tendencies. Adoption of the principle of *Swadeshi*, as was done during the freedom struggle of India, to encourage use of local resources and products and self-reliance as important bases of economic growth, can also help in minimizing transport, packaging and energy costs and curbing socially undesirable consumerist tendencies, apart from providing an ideological support towards resource conservation and social concern.

Specially organized approaches are necessary in the cases of building construction, transportation and numerous industrial sectors. For example, use of 'passive' architectural practices and designing buildings in conformity with the climate can reduce the energy and material needs considerably. Preference for public over personal transport and non-motorized over motorized means of transport, wherever feasible, and use of smaller use-oriented vehicles can result in considerable all round waste reduction. The scope for waste reduction in each major industry is nearly unlimited.

In general, generation of wastes can be discouraged also by levying the real 'marginal' costs or 'luxury' taxes as well as by including the 'external' (social and environmental) costs, such as the costs of pollution of air and health effects on fuel exhausts, on the use of material and energy resources in production of non-essential goods and services. Also, graded charges may be levied on consumption of scarce commodities and on generation of avoidable wastes.

## 5. Optimal Waste Reuse and Recycling

India is a large semi-tropical country with an extensive agricultural economy and large human and animal (particularly cattle) populations. Therefore, all over the country enormous quantities of organic wastes (human, animal, and plant wastes) are produced. These have been traditionally handled through their reuse/ recycling to a large extent by their being utilized in multiple ways such as manure, fuel, feed, fermentable substrates and soil conditioner, directly or after some simple treatment procedures. In a way, these 'wastes' have been utilized as valuable resources for the rural economy. These traditional methods have been also largely environment friendly. We need to study these traditional approaches and see how these can be improved and adapted to the management of increasing density and extent of such organic wastes under modern circumstances.

The subject of reuse/ recycling of different categories of wastes, to the extent it may be practically, technologically and financially feasible, needs much greater study and research and technical and management inputs than are being devoted at present. The process of reuse/ recycling of wastes starts right from the point of waste generation and till its final disposal. As a waste is collected, transported, stored, and treated, sorting out and handling and extraction of useful components (such as paper, metals, plastics, plant components and energy) from it usually becomes increasingly more difficult and expensive at each successive step. Hence, reuse/ recycling of wastes requires meticulous planning and execution of different steps, and building into waste collection and treatment and disposal systems adequate financial incentives so that different agents are encouraged to take up the recommended sorting and separation tasks. For example, waste paper is best sorted out at the point of generation and collection itself. Writing paper which has been used only on one side, can be simply retained for reuse on the unused side, while used up and printed paper waste, if sorted out, can be recycled into varieties of useful paper and packaging materials in a small factory. (1 tonne of recycled paper amounts to a saving of about 15 trees, 2500 kwh of energy, 20,000 litres of water, and 25 kg of air pollutants!)

Water is becoming more and more a scarce resource in India. Hence, reuse/ recycling of any wastewater is a major field for study and research under 'Waste Management'. Similarly reuse/ recycling of municipal wastes, building wastes, clothing wastes, industrial wastes, electronic wastes (e-waste) and all other such categories of wastes presents immense and increasingly cost-effective possibilities and meets socially-essential requirement of resource conservation. For example, recent innovation of reusing plastic wastes in a plastic-tar mix for provision and repair of road surfaces offers immense possibilities.

Sugar Industry is a classic example where utmost recycling is being practised in some of the progressive sugar factories. Typically, sugarcane contains about 12% (by weight) of sugar and the rest was earlier being released mostly as factory wastes. Now water which constitutes 50-60% of the weight of sugar-cane, and which becomes vapour, may be condensed and recycled resulting in substantial savings in cost of sugar production. The molasses (say, 4%) may be used to manufacture spirit, alcohol, ethanol, animal feed, lactic acid and other chemicals while the distillery effluents may be processed to yield fertilizer and biogas. Bagasse (nearly 30%) may be used to make paper, briquettes, manure and fuel (for the cogeneration plant). Even the 'pressmud', the residue removed during purification of sugar juice, may be used as fertilizer. On similar lines, reuse/ recycling of wastes offers enormous opportunities in all industrial and agricultural sectors and it not only reduces the incidence of waste generation but also yields valuable material and energy resources.

Many of the 'modern' wastes are not easily biodegradable and hence remain unprocessed by natural processes. Typically, wood may take 10 years to be full biodegraded, but a tin can may take 100 years and a glass bottle 500 years! But most of such materials can be recycled.

**6. <u>Efficient Waste Collection & Effective Waste Treatment and Disposal</u>**

Since most of the wastes are generated in residential, commercial, industrial, or agricultural establishments which are scattered, to a greater or lesser extent, in areas all over the country, waste 'collection' systems, including the processes of handling, transfer, storage, and transportation of collected wastes, assume a critical importance. Different categories of wastes, e.g., organic v. inorganic wastes, biodegradable v. non-biodegradable wastes, solid v. liquid v. gaseous wastes, hazardous/toxic v. non-hazardous/non-toxic wastes, isolated v. concentrated wastes, urban v. rural wastes, municipal v. industrial v. agricultural wastes, will require different strategies for their collection, treatment and disposal.

If waste collection systems are not efficient, some of the wastes may escape collection and/ or may be exposed, thus causing environmental and health hazards and ungainly sights. Waste collection and associated processes are still being managed largely through 'scavenging' resulting in human degradation and drudgery (the primary basis of the practice of 'untouchability' in India was such practices of waste collection and disposal). Insanitary methods of waste collection and disposal can be injurious to the associated workers who handle these wastes. Therefore, extensive studies and research and action are needed to ensure that the waste collection systems do not pose any hazards to the health of the workers involved in it. In a recent example, Indian Railways in Mumbai have organized employment of 'rag-pickers' who are well-equipped against any health hazard, to keep railway tracks clean by collection of all categories of throw-aways.

Collection of widely scattered wastes such as garbage particularly in large cities, presents major problems in logistics and management and is an area requiring much greater research and regulation. For example, the USA alone generates 220 million tonnes garbage annually. Even in Delhi, collection, separation, storage, transportation and disposal of the daily generated 6,500 tonnes garbage continues to defy a satisfactory solution.

There is a large corpus of rules and regulations in different parts of India on treatment and disposal of various wastes, particularly for municipal wastes and industrial effluents. These are also being formulated now for the upcoming more specialized kinds of wastes. For example, Biomedical Waste (Management and Handling) Rules came into force in Delhi in 1998 for regulation of treatment and disposal of Hospital-generated wastes.

In most cases, a waste is required to be suitably 'treated' before it may be disposed off into land, water or air, lest it may pollute and damage the environment, may accumulate without being processed by natural processes, may become a serious health hazard, or may result in avoidable depletion of scarce resources. For example, human waste collected through sewerage system in cities has to go through a multi-stage treatment in sewage treatment plants before it may be disposed off, while the same waste collected in a less diluted form in rural areas may be treated by composting for conversion into organic manure.

The treatment processes for different categories of wastes may be physical (mechanical processes such as separation, sedimentation, and filtration, or compression or drying), or chemical (such as oxidation or reduction processes, or other chemical reactions), or biological (such as aerobic or anaerobic), or a combination of these. Radioactive wastes require special treatment. Some wastes may need to be treated to remove hazardous components such as mercury or arsenic. Each category of waste has to undergo treatment appropriate to its composition before it may be safely discharged into the environment, especially near inhabited areas or water bodies. Treatment processes are also so designed as to help in recycling of wastes to the utmost extent.

The capacity of particular land, water or air bodies and the density of generation of particular wastes in the area also determine the limits to what the wastes may contain specific pollutants before being finally disposed off. For example, motor vehicular exhausts which may be allowed in areas far away from cities may not be permissible in the cities, or thermal power houses may require installing fly-ash precipitators before the chimney exhausts may be allowed near cities, or certain industrial effluents just may not be permitted to be discharged into flowing rivers near towns and cities. Delhi presents a typical example in regard to the use of the Yamuna river for discharge of its liquid wastes. Delhi constitutes only 2% of the Yamuna basin catchment area, yet contributes about 80% of its pollution load over its 48 km stretch within its territory by discharging nearly 1393 mld (million litres/ day) of treated and untreated sewage and about 2200 mld of wastewater. While the Yamuna water at its entry into Delhi area is fit for drinking after treatment, and has 7.5 mg/l DO (Dissolved Oxygen), 2.3 mg/l BOD, and coliform count 8506/100 ml, at the exit its DO is 1.3 mg/l, BOD 16 mg/l, and coliform count 3,29,312/100ml!

Treatment of toxic/ hazardous wastes before these may be disposed off presents special and at times serious management problems. For example, lead commonly used in manufacture of petrol (now unleaded petrol also being made), lead pencils, paints, batteries, water pipes, sealing cement, vermillion and many modern toys has serious health implications, particularly for children. Hence, regulation by Governments of its removal before disposal of such wastes is essential. CFLs are being recommended these days in place incandescent bulbs etc. in order to reduce electrical power consumption in lighting. But there are rising concerns over mercury pollution (exposure to elemental mercury in vapour form occurs when products containing it break and expose mercury to air) which is absorbed through lungs and has serious health hazards. Hence, the Government has decided to set up 50 facilities across India where CFLs can be safely disposed of and mercury in these safely recovered.

Similarly, Central Pollution Control Board has estimated that over 1.46 lakh tonnes of electronic waste (e-waste) is generated in India annually. It consists of broken or unwanted electrical or electronic appliances such as computers and cell-phones. It is a serious health and environmental hazard as it contains toxic substances. It is also a fast growing waste category (over 25 million computers and nearly 250 million cell-phones already there in India). Among the toxic but valuable elements present in e-waste are lead, cadmium, mercury, hexavalent chromium, plastics including PVC, and barium. No wonder, already numerous informal and some formal enterprises have come up to handle and treat these wastes. However, urgent action is needed to legislate an adequate regulatory mechanism assisted by institutional support in the science and technology areas in order to ensure satisfactory management of the growing quantum and variety of e-waste.

## 7. Important Implications of Waste Management

For a sound Waste Management System, suitable process parameters and methods, and performance indicators, norms and standards, both qualitative and quantitative, require to be established, covering technological, environmental, social, financial and institutional aspects. The basic objectives would remain minimization of waste generation and optimization of waste reuse and recycling, and efficient waste collection and effective waste treatment and disposal.

The subject of waste management has crucial implications also in regard to resource conservation, sustainable development, and environmental protection. For example, it is closely related to the subject of scarce energy resources and how to improve the efficiency of energy consumption in buildings and in transportation sector. In each major industrial sector, efficiency in production processes can be considerably improved to minimize the inputs of energy and certain material resources. Reuse and recycling of industrial wastes to recover usable energy and materials resources has a tremendous scope. Recycling of fly-ash (Indian coals typically have 40% ash content), which otherwise presents massive waste disposal problems, for uses such as brick manufacture is an important example.

In the case of many large-scale wastes, out-of-box thinking and research is needed to evolve suitable alternatives to the traditional treatment and disposal methods as these involve an enormous cost in terms of lost material and energy resources. Management of human waste is a typical example. There are numerous options, such as, a) the flush-cum-long distance sewer transportation plus massive sewage treatment systems; b) decentralized septic tank type solutions; c) decentralized aqua-privies (bio-latrines) type solutions; d) composting. The choices made involve significant resource, cost and health implications. Each major waste management area will require comprehensive and on-going studies for socially acceptable and affordable as well as efficient and appropriate waste management systems.

Traditionally, 'cost' of a waste would cover only the direct cost of its 'management' (including the costs of collection, treatment and disposal). However, for a realistic perspective, it is necessary to know the 'total' cost involved in the management of a waste. The 'total' cost would include both the direct as well as the various 'external' (or 'indirect') costs, which include: (i) 'environmental' costs of pollution and other environmental damage, (ii) 'social' costs to cover health hazards and other effects of insanitation, and (iii) 'resource' costs to account for the loss of scarce resources (which may be minimized by recovery of reusable and recyclable resources). Most of the 'external' costs, being 'notional', need to be carefully worked out. It is, thus, necessary to develop appropriate costing and accounting systems for both the direct and indirect costs of various processes involved in management of different categories of wastes.

## 8. Main Categories of Wastes

Management of different categories of wastes requires varied and different approaches and solutions suited to the specific origin, nature, extent and composition of respective waste categories. While detailed and precise categorization of the wastes in India will require nationwide surveys and documentation, based on common considerations, following main categories may be easily distinguished:

I. Municipal or 'Sanitation' Wastes
  - Human Wastes
  - Municipal Solid Wastes
  - Drainage Wastes
  - Hospital (Bio-medical) Wastes
  - Wastes from large Hotels, Restaurants, and Canteens
  - Other Municipal Wastes

II. Plant Wastes
  - Agricultural (Farm) Wastes
  - Forest and Garden Wastes
  - Agricultural and Forest Processing Industry Wastes

III. Animal and Dairy Wastes

IV. Industrial Wastes (Differentiated Industry-wise, e.g. wastes related to Iron & Steel, Cement, Textile, Jute, Sugar, Pulp & Paper, Motor Vehicle Manufacturing, and Food & Beverages, industries)

- Large-scale Industry Wastes
- Medium Factory Wastes
- Small-scale (scattered) Industry Wastes
- Cottage Industry wastes
- Industrial Effluents

V. Mining Wastes (Differentiated Mineral-wise, e.g., coal and lignite, iron ore, bauxite, and uranium mines)

VI. Wastes Related to Energy Production Complexes

- Thermal Power Stations
- Petroleum Refining and Processing Wastes
- Nuclear Power Plants and Other Nuclear Establishments
- Hydro-power Plants
- Other Energy Production Wastes

VII. Motor Vehicular Wastes

VIII. Electronic Equipment and Allied Wastes (e-Wastes: becomingly increasingly important due to the fast growing use of computers, cellphones and other electronic equipment)

IX. Plastic Wastes

X. Equipment and Machinery Wastes

XI. Building and Construction Wastes

XII. Other Wastes

**9. <u>Proposal for Setting Up an 'Indian Institute of Waste Management' (IIWM)</u>**

From the foregoing, the need for having an adequate institutional set up to provide academic, science and technology, R&D, surveys, data collection and analysis, management and other institutional services for the multi-faceted and vast subject of waste management in India becomes obvious. There are a number of institutions, units, and departments, in both the Government and non-Government sectors in India, which are working on technical and management aspects of wastes in specific fields. Each such institution, unit or department has its own limited scope and range or area of activity and objectives. For obvious reasons, it would not be concerned with the comprehensive and holistic issues related to the overall subject of waste management in India, and particularly the related issues of resource conservation, of the scope for waste prevention and reduction, of reuse and recycling of wastes, of appropriate collection, treatment and disposal technologies and systems in the national context, and of determination of the 'indirect' costs of generation of every kind of waste to the nation.

Therefore, for building up all-India perspectives in respect of all aspects of generation and management of different categories of wastes, for functioning as a comprehensive store-house of information and documentation and as an institutional medium of survey, research and development in every field of waste management, and for ensuring that in India the policies and practices pursued for waste management are socially, environmentally and financially sustainable, it is essential that an Indian Institute of Waste Management (IIWM) is set up as early as possible. The proposed IIWM will function and perform as an apex and multi-functional coordinating and consultancy and R&D centre in the country in the field of waste management. As the population and urbanization as well as the economy grow, the proposed IIWM will have to function and perform on an even bigger scale.

'*Aims and Objects*': The 'aims and objects of the proposed IIWM will include the following:

(i) Conducting studies and surveys of both general and specialized categories of wastes being generated in India in order to build up an all-India information, database, and documentation and analysis resource centre in the field of waste management.

(ii) Building up necessary reference and Library systems and providing information, inquiry and documentation services in respect of various aspects of waste management.

(iii) Formulation of qualitative and quantitative norms and standards, procedures and evaluation benchmarks in the field of waste management.

(iv) Development of associated costing and pricing regimes, including 'external' or 'indirect' costs, for various operations in the field of waste management.

(v) Functioning as a policy advisory body to the Central and State Governments, Local Bodies, industries, and other agencies involved in waste management.

(vi) Functioning as a coordinating body for the numerous agencies engaged in different aspects of the management of various wastes, and as an apex body for promotion and carrying out of R & D activities for the development of appropriate, affordable and sustainable waste management systems including undertaking research for up-gradation and integration of current technologies, development of newer technologies and systems for waste management, and for recycling and developing value-added products.

(vii) Creating appropriate waste management options in India by providing a customized platform for synergizing the numerous individual, isolated, and institutional efforts being made in various aspects of waste management.

(viii) Providing consultancy and technology transfer services to Government and non-Government sectors in the field of waste management. Functioning in partnership with other agencies and also with users of its services in various industrial and non-industrial sectors.

(ix) Creating manpower expertise and excellence in the field of waste management through regular Degree and Post-graduate courses, specialized short-term courses, and in-house training courses and programmes.

(x) Creating public awareness through campaigns, seminars, conferences and workshops about waste generation, waste reduction, waste reuse/recycling and other aspects of waste management; functioning as a primary advocacy group in the field of waste management.

xi) Promotion of environmentally sustainable and resource-conserving options in municipal, transportation, agricultural, industrial, building and construction, and energy production sectors.

xii) Developing linkages with agencies outside India both for collection of information and knowledge as well as for providing services abroad in the field of waste management.

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