Waste to Resources

A Waste Management Handbook

CSO Forum
Chief Sustainability Officers'

teri | BCSD
Business Council for Sustainable Development

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Published by
TERI Press
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Printed in India

Contents

Introduction

Waste has always been a perennial problem and its management remains a big predicament up to this day, since the amount of solid waste increases as populations rise and economies develop. Today, the total amount of waste generated annually worldwide (municipal, industrial, hazardous) is more than 4 billion tonnes, the municipal solid waste is between 1.6 to 2.0 billion tonnes. [1] Also, the global impacts of solid waste are growing fast as solid waste management costs will increase from today's annual $205.4 billion to about $375.5 billion in 2025. [2]

Basel Convention by UNEP define wastes **"as substances or objects, which are disposed of or are intended to be disposed of or are required to be disposed of by the provisions of national law"**. Our daily activities give rise to a large variety of different wastes arising from different sources. Cleaning up of waste contamination is much more expensive in the long term as compared to its prevention at source. Countries are facing an uphill challenge to properly manage their waste with most efforts to reduce the final volumes and generate sufficient funds for waste management.

Waste management is needed for these countries which is the joint responsibility of the Citizens, Industries, the local governments and the pollution control boards. Waste management comprises a collective activity involving segregation, collection, transportation, re-processing, recycling and disposal of various types of wastes. Different wastes and waste-management activities have varying impacts on energy consumption, methane emissions, carbon storage, ecological and human health. For example, recycling reduces greenhouse gas emissions by preventing methane emissions from landfills or open dumps and preventing the consumption of energy for extracting and processing raw materials.

Improper Waste Management is one of the main causes of environmental pollution. The World Health Organization (WHO) estimates that about a quarter of the diseases faced by mankind today occur due to prolonged exposure to environmental pollution. Most of these environment related diseases are not easily detected, and may be acquired during childhood and manifested later in adulthood. Also, there are social implication of waste due to deficiencies in waste management, disproportionately affect poorer communities as waste is often dumped on land adjacent to slums. This unsound waste management has health implications. Millions of waste pickers are exposed to hazardous substances as they try to secure their and their families' survival. Lead, mercury and infectious agents from healthcare facilities—as well as dioxins and other harmful emissions released during the recovery of valuable materials from e-waste—not only affect the health of waste pickers, but also contribute to air, land and water contamination.

With growing public awareness about waste-related problems and with increasing pressure on the government and urban local bodies to manage waste more efficiently, the concept of waste as "a material which has no use" is changing to "a resource at a wrong place". Cleaning up of waste is much more expensive in the long run as compared to its prevention at source. Mixed waste is useless as a resource until waste separation at source is practiced. Society has to think of ways to minimize and put waste to other uses.

Industry-based waste management is one of the most elaborate Waste Management procedures. It has an annual turnover above $433 billion and engages around 40 million workers (including informal recyclers), the industry covers a huge variety of operations for different waste streams and different phases of the waste life-cycle. It is considered that the industry will further grow, especially in developing countries, and recycling business will

be the cornerstone of it. Waste Recycling is one of the most important sectors in terms of employment creation and currently employs 12 million people in just three countries—Brazil, China and the United States In the waste sector, landfill methane is the largest source of GHG emissions, caused by the anaerobic degradation of organic material in landfills and unmonitored dumpsites. If present waste-management trends are maintained, landfilled food

Two tropical typhoons ravaged parts of the Philippines causing severe flooding and deaths. In the capital Manila, a huge municipal garbage dump, ironically named the "Promised Land" by locals, became a sodden, unstable mass and then collapsed and burst into flames on July 10, 2000. An avalanche of mud and rubbish crashed down upon a group of more than 100 shacks and huts, which were homes to around 800 families. The actual death toll will never be known, firstly because officials have no idea how many people were living alongside the dump. Local residents say that up to 500 were buried under the rubbish, while local officials put the number at just 140. Some 44 per cent of the 10 million population of Manila live in poverty, in garbage dumps, by polluted waterways, under highway and railway bridges and on the sides of rail tracks. The poorest among these live near or at garbage dumps, defying disease and the stink and scavenging in the garbage to eke ou-t a living.

– ABC International News

At present, India produces more than 62 million tonnes of solid waste annually, of which 80 per cent is disposed of indiscriminately at dump yards in an unhygienic manner by the municipal authorities leading to problems of health and environmental degradation.

—Report on Task Force on Waste to Resource: Planning Commission, May 2014

waste is predicted to increase the landfill share of global anthropogenic Greenhouse Gas emissions from 8 to 10 per cent.[1]

Classification of Waste

Managing waste in an environmentally sound, socially satisfactory and a techno-economically viable manner is Sustainable Waste Management. It is achieved through strategic planning, institutional capacity building, fiscal incentives, techno-economically viable technologies, public-private partnerships and community participation. Waste management approaches differ for different types of wastes and also for wastes in different geographical locations such as urban, rural and hilly areas. While there are many ways to classify waste, for the purpose of this paper we will classify waste based on its source stream. Wastes such as domestic and industrial ones can be classified under the heads of urban, industrial, biomedical and e-waste as shown in *Figure 1*. These are generated during the extraction of raw materials, manufacturing and processing of raw materials into intermediate and final products, the consumption of final products, and other human activities.

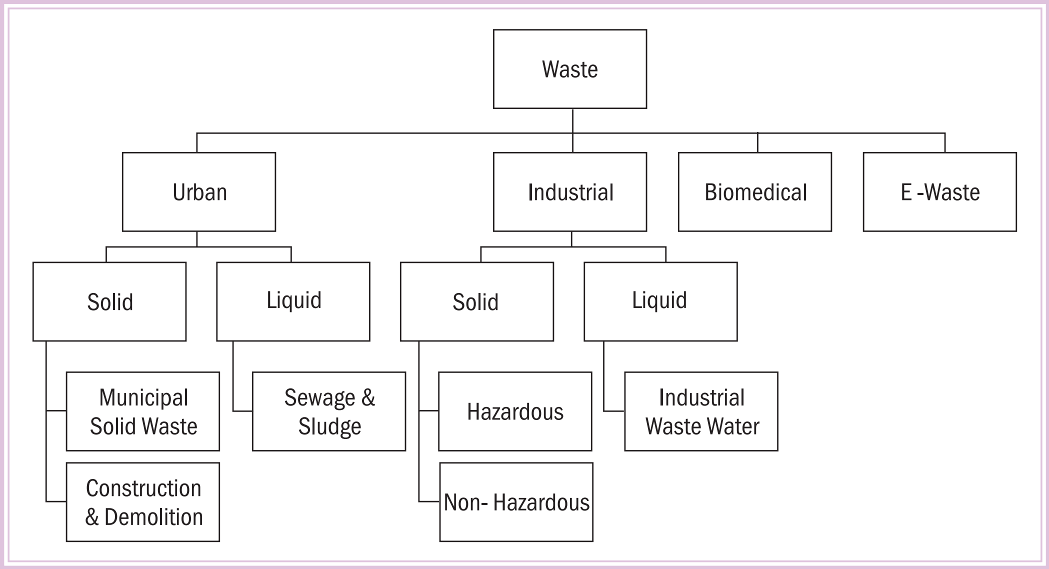


Figure 1: Classification of Waste

Urban waste

Urban Waste comprises of Municipal Solid Waste (MSW), Sewage Sludge and Construction & Demolition waste.

Municipal Solid Waste

Municipal Solid waste comprises of recyclable, biodegradable as well as inert waste as shown in *Figure 2*.[5] The biodegradable waste streams from urban hotspots dominate the bulk of MSW mainly due to exorbitant food and yard wastage from households. Recycling is the recovery of useful materials, such as paper, glass, plastic, and metals, from the trash to use to make new products, reducing the amount of virgin raw materials needed. Waste is the kind of waste that is neither chemically and biologically

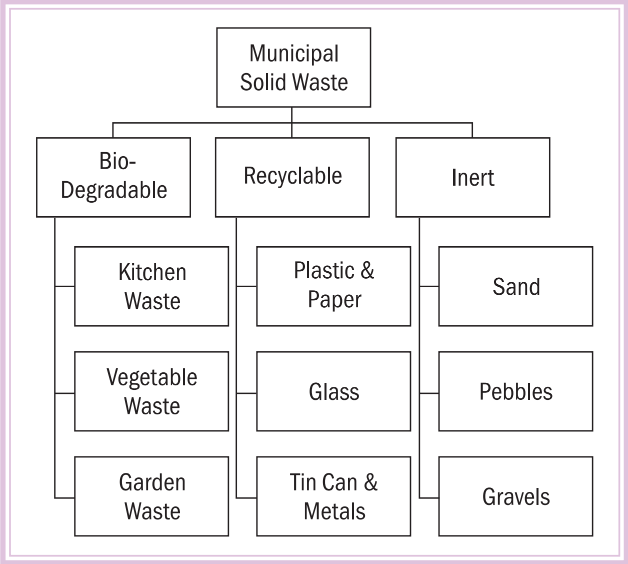


Figure 2: Municipal Solid Waste

reactive, nor undergoes decomposition. In most of the Indian cities, the MSW collection, segregation, transportation, processing and disposal is carried out by the respective municipal corporations and the state governments enforce regulatory policies.

To minimize the quantum of waste for disposal by optimal utilization of the potential of all components, MSW is done by adopting the "concept of 5-R"—Reduce, Reuse, Recover, Recycle and Remanufacture Municipal Solid Waste Management generates energy and other useful products and ensures safe disposal of residual waste.[4]

A major fraction of urban MSW in India is biodegradable (51 per cent), recyclable (17.5 per cent) and inert (31 per cent). If the current 62 million annual generation of MSW continues to be dumped without treatment, it will need 3,40,000 cubic meter of landfill space everyday (1,240 hectare per year). Considering the projected waste generation of 165 million tonnes by 2031, the requirement of land for setting up landfill for 20 years (considering 10 meter high waste pile) could be as high as 66 thousand hectares of precious land, which our country cannot afford.[4]

Indian Scenario for Municipal Solid Waste

Municipal areas in the country generate 1,33,760 metric tonnes per day (TPD) of MSW, of which only 91,152 TPD waste is collected and 25,884 TPD treated. Considering that the volume of waste is expected to increase at the rate of 5 per cent per year on account of increase in the population and change in lifestyle of the people, it is assumed that urban India will generate 2,76,342 TPD by 2021, 4,50,132 TPD by 2031 and 1,195,000 TPD by 2050. The challenge is in managing this waste which is projected to be 165 million by 2031 and 436 million by 2050. The CPCB report also reveals that only 68 per cent of the MSW generated in the country is collected of which, 28 per cent is treated by the municipal authorities. Thus, merely 19 per cent of the total waste generated is currently treated. The untapped waste has a potential of generating 439 MW of power from 32,890 tonnes per day of combustible wastes including Refused Derived Fuel (RDF), 1.3 million cubic metre of biogas per day or 72 MW of electricity from biogas and 5.4 million metric tonnes of compost annually to support agriculture.

—Central Pollution Control Board (CPCB Report 2012–13)

Sewage & Sludge

Solid waste going into landfills has a serious impact on the environment, but disposal is not our only concern. Waste water also needs to be managed in order to reduce threats to public health, safety and the environment. Sewage is a water-carried waste, in solution or suspension, it is more than 99 per cent water and is characterized by volume or rate of flow, physical condition, chemical constituents and the bacteriological organisms that it contains.

Sludge is the semi-solid precipitate produced in wastewater treatment plants originating from their process of treatment. Due to the physical-chemical processes involved in the treatment, the sludge tends to concentrate heavy metals and poorly biodegradable trace organic compounds as well as potentially pathogenic organisms (viruses, bacteria, etc.) present in waste waters. Sludge is, however, rich in nutrients such as nitrogen and phosphorous and contains valuable organic matter that is useful when soils are depleted or subject to erosion. The organic matter and nutrients are the two main elements that make the spreading of this kind of waste on land as a fertiliser or an organic soil improver suitable.[9]

Construction & Demolition Waste

Construction & Demolition (C&D) waste is defined as the solid waste generated by the construction, remodeling, renovation, repair, alteration or demolition of residential, commercial, government or institutional buildings, industrial, commercial facilities and infrastructures such as roads, bridges, dams, tunnels, railways and airports. Source based generation of construction and demolition is shown in *Figure 3*. Construction & demolition waste is considered as high volume, low risk. It is commonly understood that

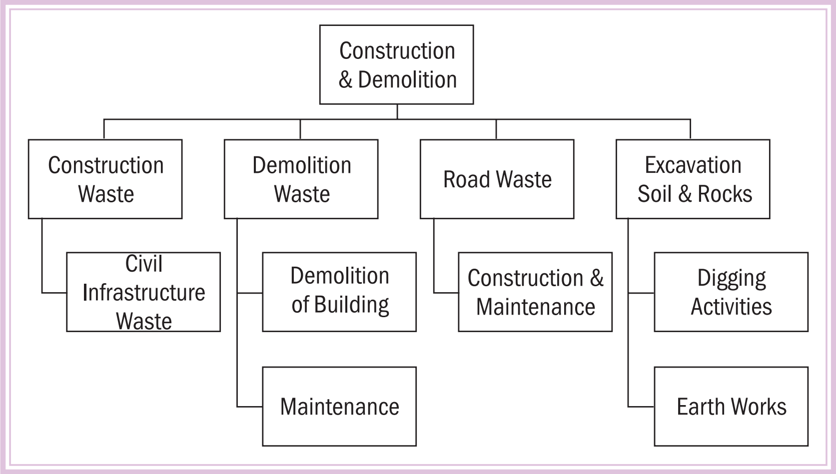


Figure 3: Construction & Demolition Waste

this waste can be considered a resource, either for reuse in its original form or for recycling or energy recovery. If suitably selected, ground, cleaned and sieved in appropriate industrial crushing plants, these materials can be profitably used in concrete. Despite this, most C&D waste ends up in landfills in developing countries. C&D waste constitutes a major portion of total solid waste production in the world. C&D waste is generated whenever any construction/ demolition activity takes place, such as building, roads, bridges, flyover, subway, remodeling, etc., this waste is heavy, has high density, often bulky and occupies considerable storage space either on the road or communal waste bin. It is not uncommon to see huge piles of such waste stacked on roads especially in large projects, resulting in traffic congestion and disruption.[10]

Indian construction industry is highly employment intensive and accounts for approximately 50 per cent of the capital out lay in successive five year plans of our country. The projected investment in this industrial sector continues to show a growing trend.

Central Pollution Control Board has estimated current quantum of municipal solid waste generation in India to the tune of 62 million tonnes/annum of which waste from construction industry accounts for 25 per cent. Thus the total quantum of waste from construction industry is estimated to be 12 to 14.7 million tonnes per annum.

Industrial Waste

Industrial Waste can be classified as Hazardous, Non-Hazardous and Waste Water. It can be discarded commercial products, like cleaning fluids or pesticides, or the by-products of manufacturing processes.

Hazardous Waste

Hazardous waste is divided into listed wastes, characteristic wastes, universal wastes and mixed waste as shown in *Figure 4*. Waste Identification Process details about the process for identifying, characterizing, listing and delisting hazardous wastes.

Listed Wastes: Wastes that Environmental Protection Agency (US) has determined are hazardous are termed as Listed Wastes. The lists include the **F-list** (wastes from common manufacturing and industrial processes), **K-list** (wastes from specific industries), **P-list** and **U-list** (wastes from commercial chemical products).

The **F-list** (non-specific source wastes). This list identifies wastes from common manufacturing and industrial processes, such as solvents that have been used in cleaning or degreasing operations. Because the processes producing these wastes can occur in different sectors of industry, the F-listed wastes are known as wastes from non-specific sources.

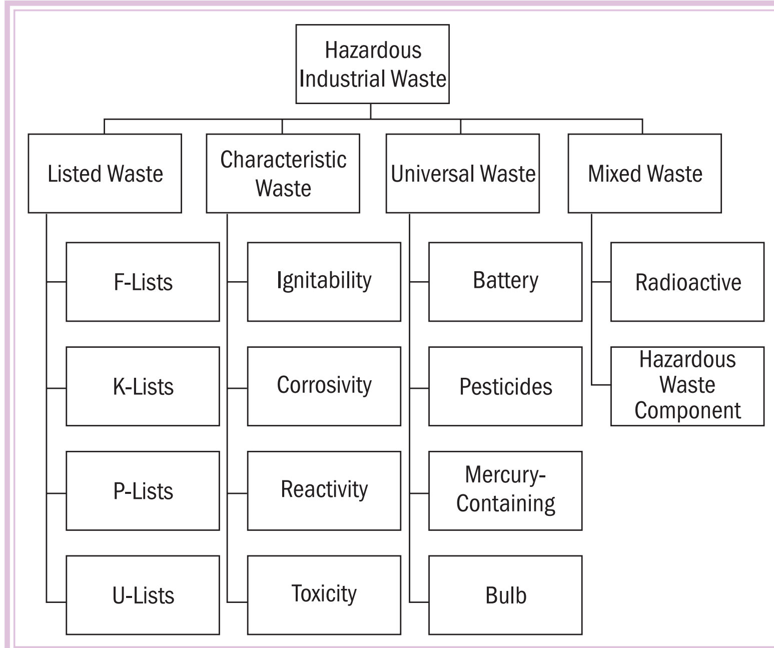


Figure 4: Hazardous Industrial Waste

The **K-list** (source-specific wastes). This list includes certain wastes from specific industries, such as petroleum refining or pesticide manufacturing. Certain sludges and wastewaters from treatment and production processes in these industries are examples of source-specific wastes.

The **P-list** and the **U-list** (discarded commercial chemical products). These lists include specific commercial chemical products in an unused form. Some pesticides and some pharmaceutical products become hazardous waste when discarded.

Characteristic Waste: Wastes that have not been specifically listed may still be considered a hazardous waste if they exhibit one of the four characteristics as defined below.

Ignitability: Ignitable wastes can create fires under certain conditions, are spontaneously combustible, or have a flash point less than 60 °C (140 °F). Examples include waste oils and used solvents.

Corrosivity: Corrosive wastes are acids or bases (pH less than or equal to 2, or greater than or equal to 12.5) that are capable of corroding metal containers, such as storage tanks, drums and barrels. Battery acid is an example.

Reactivity: Reactive wastes are unstable under "normal" conditions. They can cause explosions, toxic fumes, gases or vapours when heated, compressed, or mixed with water. Examples include lithium-sulphur batteries and explosives.

Toxicity: Toxic wastes are harmful or fatal when ingested or absorbed (e.g., containing mercury, lead, etc.). When toxic wastes are land disposed, contaminated liquid may leach from the waste and pollute ground water. Toxicity is defined through a laboratory procedure called the Toxicity Characteristic Leaching Procedure (TCLP). The TCLP helps identify wastes likely to leach concentrations of contaminants that may be harmful to human health.

Universal Wastes: Universal waste is the kind of waste which includes batteries, pesticides, mercury-containing equipment and bulbs (lamps).

Mixed Wastes: Waste that contains both radioactive and hazardous waste components.

These industries contribute majorly to the hazardous waste which are cyanides, complex aromatic compounds, heavy metals, pesticides & high chemical reactivity. Due to wide geographical spread of industrial unit in the country it becomes critical to handle these hazardous waste as they lead to public health problems, environment contamination and degradation of natural resources.

Indian Scenario for Hazardous Waste

Inventorization of hazardous wastes generating units and quantification of wastes generated in India are being done by the respective State Pollution Control Boards (SPCBs). Ministry of Environment & Forests, Government of India, in order to simplify the procedures, has categorize the industrial projects on the basis of the severity of pollution from a specific industry. These industries are categorized as Red, Orange and Green in decreasing order of severity of pollution.

Seventeen industries are listed as Red for heavily polluting and are covered under Central Action Plan such as Distillery including Fermentation Industry, Sugar, Fertiliser, Pulp & Paper (Paper manufacturing with or without pulping), Chlor alkali, Pharmaceuticals, Zinc smelter, Copper smelter, Aluminium smelter, Cement, Tanneries, Dyes, Pesticides, Oil Refinery & Iron and Steel.

Also industry Manufacturing following products or carrying out following activities are under Red categories: Tyres and tubes (Vulcanisation/Retreading/ moulding), synthetic rubber, glass and fibre glass production and processing, Industrial carbon including electrodes and graphite blocks, activated carbon, carbon black, paints and varnishes (excluding blending/mixing), pigments and intermediates, synthetic resins, petroleum products involving storage, transfer or processing, lubricating oils, greases or petroleum based products, synthetic fibre including rayon, tyre cord, polyester filament yarn, surgical and medical products involving prophylactics and latex, synthetic detergent and soap, photographic films and chemicals, chemical, petrochemical and electrochemical including manufacture of acids such as sulphuric acid, nitric acid, phosphoric acid, industrial or inorganic gases, chlorates, perchlorates and peroxides, glue and gelatin, etc.

Twenty-five Industries are identified under 'ORANGE" Category such as mirror from sheet glass and photo framing, Cotton spinning and weaving, Automobile servicing and repairs stations, hotels and restaurants, flour mills (excluding domestic aatta chakki), malted food, food including fruits and vegetable processing, pulping and fermenting of coffee beans, instant tea/coffee, coffee processing, non-alcoholic beverages (soft drinks), fragrances and industrial perfumes, food additives, nutrients and flavours, fish processing, organic nutrients, surgical and medical products not involving effluent/ emission generating processes, laboratory-wares, wire drawing (cold process) and bailing straps, stone crushers, etc.

Green category industry are small scale, cottage/village category suggested under notification of the State Government/Union Territory. All those industries or processes which are not covered under the "Red" and/or "Orange" category are in Green category such as: wasting of used sand by hydraulic discharge, steeping and processing of grains, mineralised water, dal mills, bakery products, biscuits confectionery, chilling plants and cold storages, cotton and woolen hosiery, apparel making, shoelace manufacturing, gold and silver smithy, leather footwear and leather products excluding tanning and hide processing, musical instruments manufacturing, bamboo and cane products (only dry operations), cardboard or corrugated box and paper products (paper or pulp manufacturing excluded), etc.[11]

Non-Hazardous Waste

Non-hazardous or ordinary industrial waste (recyclable and non-recyclable) is generated by industrial or commercial activities, but is similar to household waste by its nature and composition such as fly ash, packaging waste, lime sludge, metal scrap, glass, etc. It is not toxic, presents no hazard and thus requires no special treatment. These non-hazardous waste can be is either recycled & reused or treated & disposed, safeguarding the environment, in compliance with the statutory and regulatory requirements for quality, environment and Occupational, Health & Safety (OHS).

Industrial Waste Water

The liquid waste generated from Industrial Source can be classified into four categories according to nature of pollutant.

Organic pollution

Effluents generated from industries like dairies, distilleries, tanneries, polymer processing units, vegetable oil and food processing units, sugar industries are rich in organic contents. Municipalities and Domestic wastes are also rich in organic constituents. They have High Biological oxygen demand (BOD) value and low Chemical Oxygen Demand (COD) value.

- Dissolved Solids generated from Chemical Industry, Fertilizer, Pharmaceutical and Pesticides
- Toxic Chemicals from Electroplating, Coke –oven, Tannery & Dye
- Cooling Water from Thermal Power Plants, Cable, Rolling Mills, Plastic Mounting [12]

Biomedical Waste

Biomedical waste (BMW) comprises waste generated from hospitals, healthcare facilities and health research laboratories. BMW is estimated to be only a small fraction of the MSW generation. About 80 per cent of this waste – called "general waste" – is non-infectious and if segregated can be managed as MSW. However, the remaining 20 per cent is infectious and hazardous and hence is required to be treated in dedicated facilities.

E-Waste

E-waste or electronic waste, broadly describes loosely discarded, surplus, obsolete, broken, electrical or electronic devices. The problem of e-waste has become an immediate and long-term concern as it can lead to major environmental problems endangering human health. The Information Technology industry in India has witnessed unprecedented growth in recent years and has revolutionized the way we live, work and communicate bringing countless benefits and wealth to all its users. It has also led to unrestrained resource consumption and an alarming waste generation. [13]

Both developed countries and developing countries like India face the problem of e-waste management. The rapid growth of technology, upgradation of technical innovations and a high rate of obsolescence in the electronics industry have led to one of the fastest growing waste streams in the world which consist of end of life electrical and electronic equipment products. It comprises a whole range of electrical and electronic items such as refrigerators, washing machines, computers and printers, televisions, mobiles, i-pods, etc., many of which contain toxic materials.

E-Waste Statistics in India

A 2010 report by UNEP (United Nations Environment Programmeme) forecasted that by 2020, E-waste in India from old computers will jump by 500 per cent from 2007 and discarded mobile phones, televisions will add to the numbers. According to the Assocham study, Bangalore generated over 37,000 metric tonne (MT) of electronic waste in 2012 and stands third in the country after Mumbai and Navi Mumbai generating 61,500 MT followed by NCR (National Capital Region) generating 43,000 MT of e-waste. The study of Assocham showed that as many as 8,500 mobile phones, 5,500 TVs and 3,000 personal computers are dismantled in Delhi every day for reuse of their component parts and materials. In the capital alone, it is estimated that over 150,000 workers are employed in official and unofficial e-recycling units. There are 97 authorised e-waste recyclers in India (27 in Karnataka,18 in Maharashtra, 15 in Uttar Pradesh, 11 in Tamil Nadu, 6 in Rajasthan, 5 in Gujarat) [14]

Evolution of Laws

India is the first country in the world which has provided for constitutional safeguards for the protection and preservation of the environment. Environmental law, post-independence, started growing its roots in India in the early 70's. Inspired by the Stockholm conference, India represented by its head of state, the only nation to do so, various laws were passed. The Wildlife (Protection) Act 1972 was the first such statute to be promulgated. [16]

The laws concerning Waste Management in India are:

Year	Law
1974	The Water (Prevention and Control of Pollution) Act
1975	The Water (Prevention and Control of Pollution) Rules
1977	The Water (Prevention and Control of Pollution) Cess Act
1978	Water (Prevention and Control of Pollution) Cess Rules
1981	The Air (Prevention and Control of Pollution) Act
1986	The Environment (Protection) Act
1989	The Manufacture, Storage and Import of Hazardous Chemical Rules
1991	The Public Liability Insurance Act
1995	The National Environment Tribunal Act
1997	The National Environment Appellate Authority Act
1998	The Bio-Medical Waste (Management and Handling) Rules
2001	Batteries (Management and Handling) Rules
2008	Hazardous Waste (Management, Handling & Transboundary Movement) Notified 2008
2010	National Green Tribunal Act
2011	The Plastic Waste (Management and Handling) Rules
2011	E-Waste (Management and Handling) Rules

The Water (Prevention and Control of Pollution) Act, 1974 was an effort to reduce and stop pollution in rivers. **The Air (Prevention and Control of Pollution) Act**, 1981 is made on similar lines as the Water Act but it goes a few steps forward in terms of details. It was made to take appropriate steps for the preservation of the natural resources of the earth which, among other things, includes the preservation of the quality of air and control of air pollution. It became the first environmental act to not only put into words the complete spectrum of environmental issues affecting the air pollution in one act, but also gave guidelines to not only protected the air but to also improved its quality. [15]

The Environment (Protection) Act (EPA), 1986, is the first Indian legislation to deal with environment protection and its components in a holistic way. The Environment (Protection) Act (EPA) was purportedly framed to give effect to the decisions taken at the UN conference on the human environment held in 1972; however, many critics say that it was the Bhopal tragedy that precipitated the enactment of the legislation. The EPA provided a framework for management of hazardous substances, prior assessment of the environmental impact of major developmental projects, discharge of industrial pollutants and effluents into the environment, guidance for industrial sitting and management of chemical accidents. [15]

The Public Liability Insurance Act, 1991 came on the heels of the Bhopal Gas tragedy. Its main aim was to provide relief to victims of industrial disaster victims. It became obligatory for industrial set-ups to obtain insurance which was equivalent to the capital needed to establish the industry.[15]

The Ministry of Environment & Forest notified the **Municipal Solid Wastes (Management and Handling) Rules** in 2000, making it mandatory for municipal authorities to set up waste processing and disposal facilities, identify sanitary landfill sites, and improve existing dumpsites. The compliance however remains low, mainly because of the inability of municipalities to implement waste segregation, and lack of institutional and financial means to implement waste processing and disposal schemes. Efforts have been initiated for bringing the informal waste recycling sector into the formal stream for waste collection and segregation to form a cooperative/society and then get registered with the CPCB.

To address industrial waste issues, the Ministry notified the **Hazardous Wastes (Management and Handling) Rules** in 1989 (amended in 2000 and 2003) and Hazardous Wastes (Management, Handling and Transboundary Movement) Rules in 2008. The 1989 Rules were drafted to enable regulatory authorities to control the handling, movement and disposal of hazardous wastes generated within the country. The amendment in 2000 and 2003 were largely aimed at harmonizing the definition of hazardous waste with provisions of the Basel Convention. The 2008 Rules bring issues of e-waste management into the ambit of hazardous waste management. [7]

The Biomedical Waste (Management and Handling) Rules were issued in 1998 (amended in 2000 and 2003). The Rules are based on the principle of segregation of general waste from BMW (Biomedical Waste). They lay out colour codes for containers, and treatment and disposal options for 10 categories of waste. The state governments have taken initiatives for setting up of Common Biomedical Waste Treatment Facilities (CBWTFs) for processing and disposal of waste. For treatment and disposal of Biomedical waste (BMW) generated in the country, there are 177 common treatment and disposal facilities in operation which were developed by the private entrepreneurs. These are in addition to the 11,921 captive treatment and disposal facilities developed within health care facilities (HCFs). For effective management of bio-medical waste generated from HealthCare Facilities (HCFs), Government of India promulgated Biomedical Waste (Management & Handling) Rules in July 1998 (hereafter referred as BMW Rules) under the Environment (Protection) Act, 1986. In June 2010 the National Green Tribunal (NGT) Bill was passed. It heralded a new dawn in environmental protection. The court has been set in Bhopal and five benches spread around the country with the sole mission to quickly dispose of environmental protection cases. [7]

> Goa State Pollution Control Board has shut down 101 industrial units and hotels for flouting environmental rules and granted consent to establish to nearly 230 new units. The closure notices were issued to units for either working without obtaining Consent to Operate, and Establish, under Water and Air Acts, for creating water and air pollution in the vicinity and for failing to install effluent treatment plant (ETP) and sewage treatment facility.
>
> **—Oheraldo News Article, May 28, 2014**

The E-waste (Management & Handling) Rules were notified in May 2011, which became operational from May 2012. Concept of Extended Producer Responsibility was introduced in this rule, making producers responsible for environmentally sound management of their end of life products including collection and their channelization to registered dismantler or recycler. These rules will apply to every producer, consumer or bulk consumer involved in the manufacture, sale and purchase and processing of electrical and electronic equipment or components as specified in Schedule I, collection centre, dismantler and recycler of E-waste. [17]

The Ministry of Environment and Forests notified the draft "**Plastics (Manufacture, Usage and Waste Management) Rules**, 2009" to replace the Recycled Plastics Manufacture and Usage Rules, 1999 (amended in 2003) to regulate the manufacture and usage of plastic carry bags. The draft rules were widely published for public comments. An expert committee was constituted by the Ministry to examine these comments and to suggest economic instruments. These Rules were finalized as Plastic Waste (Management and Handling) Rules 2011 and notified on February 4, 2011. [17]

Highlights

The Water (Prevention and Control of Pollution) Act, 1974 (As Amended in 1978 and 1988)

- Specifying standards for sewage and industrial effluents discharge into water bodies
- Inspection of sewage or industrial effluent
- Pollution Control Board (PCB) has the Right to obtain any information regarding the construction, installation or operation of an industrial establishment or treatment and disposal system
- PCB's can issue orders restraining or prohibiting an industry from discharging any poisonous, noxious or polluting matter in case of emergencies, warranting immediate action.
- PCB's power to issue directions for
  - Closure, prohibition or regulation of any industry, operation or process
  - Stoppage or regulation of supply electricity, water or any other service to industry in the prescribed manner.

The Air (Prevention and Control of Pollution) Act, 1981 (Amended in 1987)

The provisions of the Air Act state that no person can establish or operate any industrial plant in an air pollution control area without obtaining the consent from the concerned State Board.

The Water (Prevention and Control of Pollution) Cess Act, 1977 Amended in 1991)

- The Water Cess Act provides for the levy of a cess on water consumed by specified industries given in Schedule-I of the Act and also local authorities entrusted with the duty of supplying water under the laws by or under which they are constituted at the rates specified in Schedule-II of the Act.
- An industry which installs and operates its effluent treatment plant is entitled to a rebate of 25 per cent on the cess payable.

The Environment (Protection) Act, 1986

- Restricts areas in which any industries, operations, processes may not be carried out or shall be carried out subject to certain safeguards
- Lays down safeguards for prevention of accidents and take remedial measures in case of such accidents
- Lays down procedures and safeguards for handling hazardous substances
- Non-compliance would lead to stoppage of supply of electricity, water or any other service for the Industry.
- The industry, operation or process requiring consent under Water (Prevention and Control of Pollution) Act, 1974 (6 of 1974) and/or under Air (Prevention and Control of Pollution) Act, 1981 (84 of 1981) are required to submit the Environmental Statement in prescribed "Form-V", for the Financial Year ending 31st March to the concerned State Pollution Control Boards/Pollution Control Committees in the Union Territories on or before 30th September every year.

The Manufacture, Storage and Import of Hazardous Chemical (Amendment) Rules, 1989

- Identifies the chemical which have acute toxicity owing to their physical & chemical properties and are capable of producing major accidents hazards
- Records should be maintained for importing hazardous chemicals as specified in Schedule 10 and the records so maintained shall be open for inspection by the concerned authority at the State or the Ministry of Environment and Forests or any officer appointed by them in this behalf
- Threshold Quantity has been identified for hazardous chemical for the storage at isolated place.
- Safety norms and documentation have been identified for the storage and Import of Chemicals.

The National Environment Tribunal Act, 1995

- An Act which provides for strict liability for damages arising out of any accident occurring while handling any hazardous substance and for the establishment of a National Environment Tribunal for effective and expeditious disposal of cases arising from such accident, with a view to give relief and compensation for damages to persons, property and the environment and for matters connected therewith or incidental thereto.
- Whoever fails to comply with any order made by the Tribunal, he shall be punishable with imprisonment for a term which may extended to three years, or with fine which may extend to ten lakh rupees, or with both.

The Public Liability Insurance Act, 1991

- A mandatory policy to be taken by owners, users or transporters of hazardous substance as defined under Environment (Protection) Act 1986 in excess of the minimum quantity specified under the Public Liability Insurance Act 1991.
- The Act casts on the person, who has control over handling any hazardous substance, the liability to give the relief specified in the Act to all the victims of any accident which occurs while handling such substance.

Hazardous Waste (Management, Handling & Transboundary Movement) Notified 2008

- Gives procedure for handling hazardous wastes defining the responsibilities, grants as well as authority to cancel authorization if failed to comply. Apart from this, various standards for recycling the hazardous waste, Transboundary movement of hazardous waste in form of import & export procedure are mentioned which is to be approved by central government.
- Thirty-six processes (industrial operations using mineral, petroleum refining, healthcare product, electronic industry, chemical, paper industry, leather, etc.) have been identified for generating 107 hazardous waste. Waste management criteria for TSDF (Transfer, Storage & Disposal Facility) criteria have been given.
- Categories of hazardous waste are mentioned along with their permissible generation quantity. Industries generating any of these waste beyond the regulatory limits are required to seek authorization from the concerned state pollution control board for its temporary storage in the premises and its disposal.

National Environment Appellate Authority 1997

An Act to provide for the establishment of a National Environment Appellate Authority to hear appeals with respect to restriction of areas in which any industries, operations or processes or class of industries, operations or processes shall not be carried out or shall be carried out subject to certain safeguards under the Environment (Protection) Act, 1986 and for matters connected therewith or incidental thereto.

The Bio-Medical Waste (Management and Handling) Rules, 1998

- The act mandates that the Bio-medical waste shall be treated and disposed of in accordance with Schedule I (Human Waste, Chemical waste, Liquid waste are to be incineration, Disinfection of chemical Treatment, deep burry respectively) and in compliance with the standards prescribed in Schedule V (standards for treatment and disposal of bio-medical wastes)
- The prescribed authority may cancel or suspend an authorisation, if for reasons, to be recorded in writing, the occupier/operator has failed to comply with any provision of the Act or these rules.

Batteries (Management & Handling) Rules 2001

- Responsibilities of manufacturer, importer, assembler & re-conditioner are metioned such as used batteries to be collected back and sent only to registered recyclers.
- Importers should get Register under the Ministry of Environment & Forests.
- Custom clearance of imports of new lead acid batteries shall be contingent upon valid registration with Reserve Bank of India, one time registration with the environment and Forests and undertaking in a Form.

National Green Tribunal (NGT)

- The National Green Tribunal Act 2010 mandates effective and expeditious disposal of cases relating to environmental protection and conservation of forests and other natural resources including enforcement of any legal right relating to environment and giving relief and compensation for damages to persons and property.
- It is a specialized body equipped with the necessary expertise to handle environmental disputes involving multi-disciplinary issues.

Plastic Waste (Management and Handling) Rules, 2011

- Use of plastic materials in sachets for storing, packing or selling *gutkha*, tobacco and *pan masala* have been banned.
- In the new rule, food will not be allowed to be packed in recycled plastics or compostable plastics.
- Recycled carry bags shall conform to specific BIS standards

E-waste Management & Handling Rules, 2011

- Rules shall apply to every producer, consumer or bulk consumer, collection centre, dismantler and recycler of e-waste involved in the manufacture, sale, purchase and processing of electrical and electronic equipment or components as specified in Schedule I.
- Responsibilities of the producer is to collect e-waste generated during the manufacturing and channelizing it to the recycler.
- In case of non-compliance the SPCB/PCC may cancel or suspend the authorization issued under these rules for such period as it considers necessary in the public interest.

Future Environmental Legislations

Municipal Solid Waste (Management and Handling) Rules, 2013 (Draft Stage)

Ministry of environment and forests (MoEF) has come up with draft rules for management and handling of municipal solid waste. After its implementation, it will become mandatory for the municipalities in the state to develop landfills and submit annual reports to state government and pollution control board. Municipal Solid Waste (Management and Handling) Rules also have detailed guidelines and specifications for setting up landfills.

Landfill sites shall be set up as per guidelines of Ministry of Urban Development. As per the draft existing landfill sites which are in use for more than five years shall be improved and the landfill site shall be large enough to last for at least 20–25 years. Municipal authority responsible for implementation of rules and for the necessary infrastructure development for collection, storage, segregation, transportation, processing and disposal of municipal solid waste. State Pollution Control Board and Pollution Control Committee will monitor the progress of implementation of Action Plan and the compliance of the standards regarding ground water, ambient air, leachate quality and the compost quality. The new rules will also make it mandatory for the municipal authority to prepare solid waste management plan as per the policy of the state government. [18]

Source: http://greencleanguide.com/2013/09/01/draft-municipal-solid-waste-management-and-handling-rules-2013/

Bio Medical Wastes (Management and Handling) Rules 2011 (Draft Stage)

Ministry of Environment and Forests has revised the Bio Medical Waste (Management and Handling) Rules promulgated under the Environment Protection Act of 1986. The Rules now called the Bio Medical Wastes (Management and Handling) Rules 2011 has been notified for information of the masses and feedback received from all fronts would be considered by the Central Government. The new Rules are elaborate, stringent and several new provisions have been added in it. These are not applicable for the radioactive waste, hazardous waste, municipal solid waste and battery waste, which would be dealt under the respective rules.

In the new rule, every occupier (hospital, nursing home, clinic, etc.) generating BMW (Bio Medical Wastes), irrespective of the quantum of wastes is required to obtain authorization. Prior to these rules, only occupiers with more than 1000 beds required to obtain authorization. Proper training has to be imparted by the occupier to the healthcare workers engaged in handling BMW. The operators (person who controls or own the facility) now have to ensure that the BMW is collected from all the Health Care Establishments (HCEs) and is transported, handled, stored, treated and disposed in an environmentally sound manner. The operators also have to inform the prescribed authority if any HCEs are not handing the segregated BMW as per the guidelines prescribed in the rules.

The previous rules merely instructed the occupiers and operators to submit an annual report to the Prescribed Authority but no information on data to be furnished in the report was mentioned. A detailed format for Annual Report has thus been included in the new Rules. [19]

Source: http://www.cseindia.org/node/3702

Hazardous Substances (Classification, Packaging and Labeling) Rules, 2011 (Draft Stage)

Hazardous Substances Rule identifies the key responsibilities and obligations of consigner, consignee, occupiers and other stakeholders. Every Hazardous substances are classified in one or more hazardous class with divisions as given in the rule. A detailed packaging & labelling processes are identified for the hazardous substance. Any activity involving hazardous substances must use the proper shipping name (shipping name), packaging and label match report for chemical hazard classification, and to provide for the transportation of chemicals and identification updates chemical safety data sheets (SDS). [20]

The projections made by Planning Commission as well as Ministry of Power upto 2031–32 indicate that two-third of power generation in the country would continue to depend on coal. The annual generation of fly ash is expected to be around 225 million tonnes by end of XII Five Year Plan Period and around 500 million tonnes by 2031–32. The ***Fly Ash Utilization Notification*** was issued by Ministry in September 1999 to regulate the disposal of fly ash and ensure its proper utilization. Restriction was imposed to the extent that all brick kilns within the radius of 50 Kms from coal/lignite based thermal power plants should use 25 per cent flyash while making the bricks. A second Notification making amendments was issued in August, 2003 increasing the radius from the thermal power plants to 100 kms. [7]

Technology Factsheet

Municipal Solid Waste

Type	Components of Waste	Process	
Biodegradable	Kitchen, Garden and Food Waste	Biological Treatment	Aerobic processes, Anaerobic processes
		Thermal treatment	Incinerations, Pyrolysis systems, Gasification systems
		Transformation	Mechanical Transformation, Thermal Transformation
Recyclable	Plastic	Plasma Pyrolysis Technology (PPT), Alternate Fuel as Refuse Derived Fuel RDF	
	Paper	Dissolution, Screening, De-inking, Sterilization and bleaching process	
	Glass	Vitrification Technology	
Inert	Sand	Landfilling: Jaw & Pulse Crusher	
	Pebbles & Gravels		

Table 1: Municipal Solid Waste

The MSW contains organic as well as inorganic matter. The latent energy of its organic fraction can be recovered for gainful utilization through the adoption of suitable waste processing and treatment technologies. Table 1 shows the process associated with different components of Municipal Solid Waste. A few options could be:

- Sanitary landfill
- Incineration
- Gasification
- Biodegradation processes
- Composting
- Anaerobic digestion

Sanitary Landfill

Landfill implying the final disposal of the MSW on land has several merits and demerits.

Merits

- Reduces emission of methane and toxics
- Lowers land and water table contamination
- Reduces menace of birds and rodents
- Controls fire hazards
- Curbs the problem of bad odour in the inhabited area

Demerits

- Involves high initial cost of design and commitment
- Public may object to the site selected
- Emits obnoxious gases in the atmosphere
- Results in a loss of real estate value of the nearby areas
- Pressure of rodents and birds remains
- Site selection depends upon the availability of land at economically transportable distances.

- If the landfill site is not properly maintained, it becomes source of uncontrolled emission of landfill gas.

Incineration

It is a process of direct burning of waste in presence of excess air oxygen, at temperatures of about 800 °C and above, liberating heat energy, inert gases and ash. The net energy yield depends upon the density and composition of wastes, relative percentage of moisture and inert material (adding to the heat loss), ignition temperature, size and shape of the constituents, design of the combustion system (fixed bed/fluidized bed), etc. In practice, about 65–80 per cent of the energy content of the organic matter can be recovered as heat energy, which can be utilized either for direct thermal application or for producing power via steam turbine generation (with conversion efficiency of about 30 per cent). *Figures 5 and 6* shows the how energy can be recovered by incineration and pyrolysis.

Merits

- Reduction in the size of waste reduces the problems of its dumping
- Complete sterilization prevents the outbreak of epidemics
- Biologically hazardous waste is reduced to ash.

Demerits

- Air pollution cannot be avoided even in highly sophisticated plants.
- It is a high-investment system.
- Additional cost inputs are required for complete pollution control.
- Dioxins and furan emissions are hazardous.
- Treatment of ash for pollutants is expensive.
- High maintenance cost

Gasification

Gasification involves the thermal decomposition of organic matter at high temperatures in presence of a limited amount of air, producing a mixture of combustible and non-combustible gases carbon monoxide and carbon dioxide.

Merits

- Handling of gas is easier than solid fuel.
- Reduction in volume reduces dumping
- Ash production is lesser as compared to incineration.
- There is no emission of hazardous gases.

Demerits

- Plant requires regular maintenance.
- Operation and maintenance is very costly.
- It releases tar and volatile poisons into the environment.

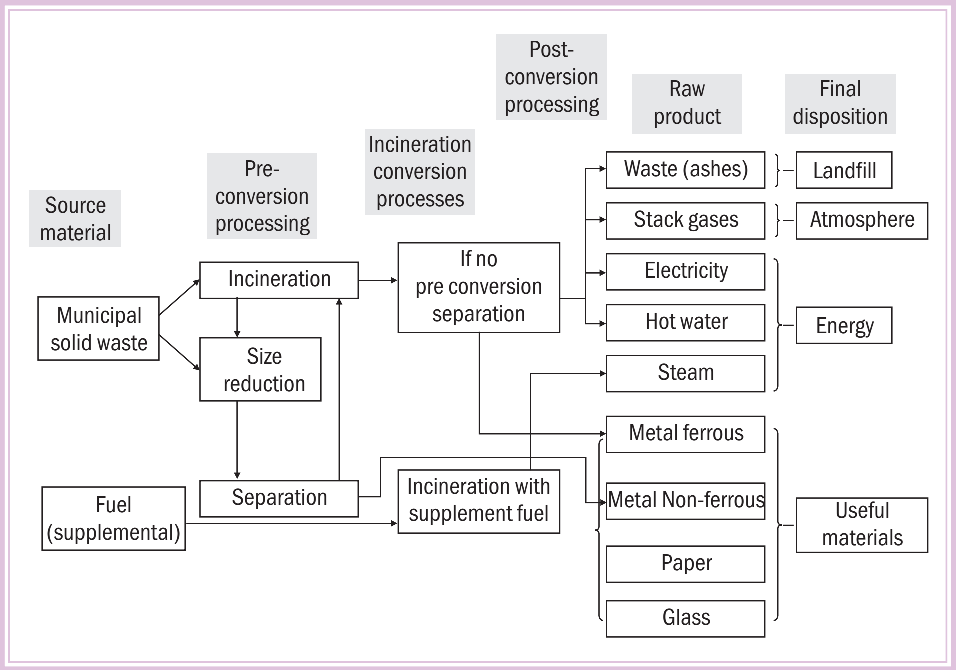


Figure 5: Refuse Incineration Routes with Energy Recovery

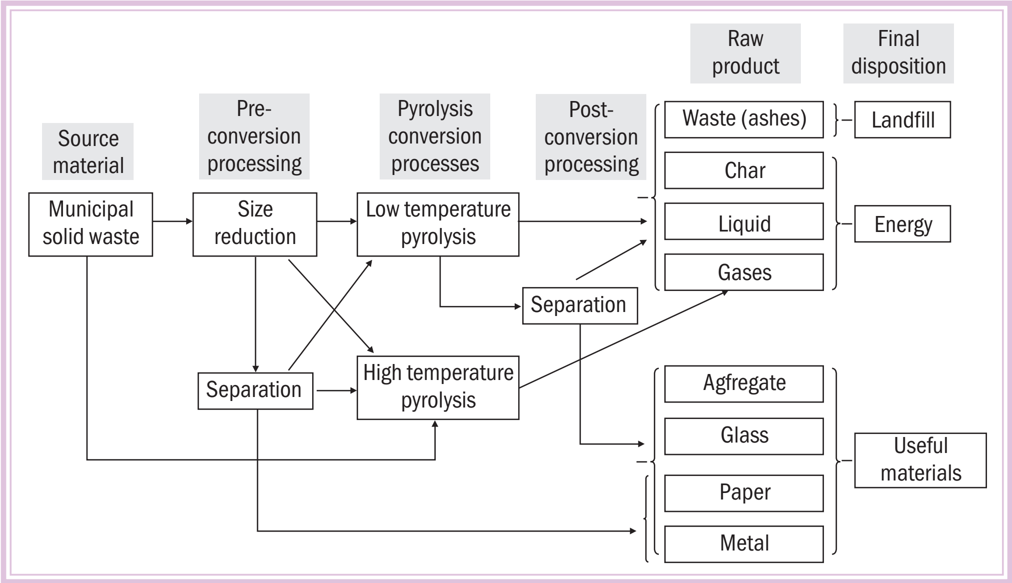


Figure 6: Pyrolysis of Refuse

Biodegradation Processes

Biodegradation can be defined as the reduction of refuse using organic methodology. Organic methods are divided into two general categories. Direct reduction of refuse by biological organisms, including aerobic and anaerobic conversion is the first one. Second is the reduction of refuse by biochemical methods, including chemical processing, and/or the selected extraction from specific species of protozoa or fungi. Refere *Figure 7*.

In the aerobic degradation process, organic material is oxidized to give a humus product commonly called compost, which can be used as a fertilizer. As the aerobic degradation process involves decay of the organic material, such as garbage, leaves, manure, etc., the process takes a considerable time. Anaerobic digestion leads to a highly marketable product called methane. The first step is to break down the complex organic materials present in the refuse into organic acid and CO_2. The second step involves the action of

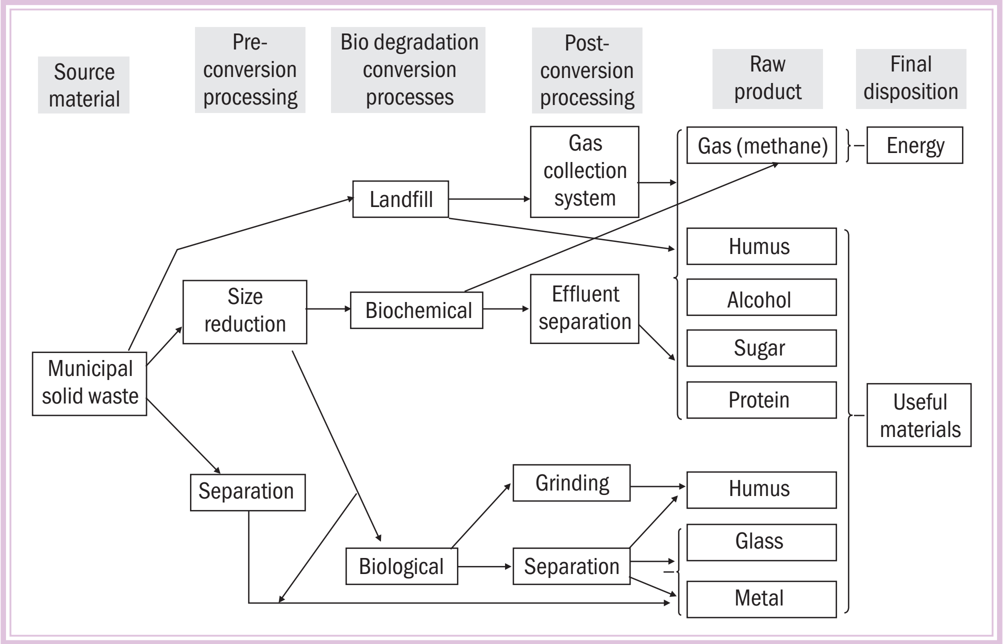


Figure 7: Biodegradation of Refuse

bacteria known as methane formers on the organic acid to produce methane & carbon dioxide.

Biochemical conversion leads to either a reduction in refuse or the conversion of cellulose, and in many applications both aspects may exist.

Composting

Composting involves the breakdown of organic Waste in the presence of microorganisms, heat and moisture. This can be carried out on a small scale in households or on a large scale depending upon the quantity of waste to be processed. Three types of microorganisms are involved in the process of composting—bacteria, fungi and actinomycetes, that act upon the waste to convert it into sugars, starch, and organic acids. These, in turn, are acted upon by high-temperature bacteria, which prevail in the compost heap and help to promote the stabilized compost.

Composting has the following advantages:

- Recycling of waste by the generation of useful manure, which is organic in nature
- Reduction in volume of waste to be disposed of on land
- No requirement of any high-end technical expertise.

Some technologies for composting waste are listed below:

Windrow compositing: Triangular piles of waste are created to allow diffusion of oxygen and retention of heat. The piles are occasionally turned by means of specific equipment consisting of paddles to increase the porosity and facilitate diffusion of air. Waste should preferably be piled under a roof to prevent exposure to rain, which can cause a run-off.

Aerated static pile composting: Mechanical aeration of waste piles is done by placing them over a network of pipes connected to a blower. The blower supplies air for composting and hence creates a positive as well as a negative pressure. Air circulation provides 0_2 and prevents heat build-up. Optimum temperature and moisture are maintained for microbial action. As the piles are not turned during the process, in order to achieve complete destruction of the pathogens, a layer of stabilized compost is placed over the pile to maintain the desired temperature. The retention time for completion of composting is 6–12 weeks.

In-vessel composting: This is a controlled process of composting where aeration, moisture, and temperature requirements for composting are maintained in a chamber or vessel. The time taken for composting is 1–4 weeks. The advantages of this system over others are that there is control of the environmental conditions for rapid composting as they occur inside a closed building, and the problems of malodour and leachate generation are minimal.

Vermicomposting: This is a process, in which food material and kitchen waste including vegetables and fruit peelings, papers, etc., can be converted into compost through the natural action of worms. An aerobic condition is created by the exposure of organic waste in air.

Anaerobic Digestion

Various types of organic wastes, such as animal dung, sewage sludge and organic fraction of the MSW, can be anaerobically digested to give biogas and manure. Anaerobic Digestion involves the breakdown of organic compounds by microorganisms in the absence of oxygen to produce biogas, which is a mixture of methane and carbon dioxide. The optimum temperature for anaerobic digestion is 37 °C and the pH is 7. In addition to waste treatment, anaerobic bio degradation is advantageous due to the generation of clean fuel, which can be used for various thermal applications for power generation and for use of digested sludge as manure.

The feasibility of biogas generation from the organic fraction of the MSW was known as early as the 1950s. Since then research efforts were directed towards enhancing the biogas yield by the adoption of various mechanisms, including modification of digester designs and use of thermophilic conditions. Research on the degradation of municipal waste and biogas generation is at different levels and on different types of digestion processes.

The various types of anaerobic digestion processes include conventional slurry digestion, dry digestion and two-phase digestion. Segregation and pre-processing for separation of biodegradable and non-biodegradable fraction is the foremost step in almost all categories of the anaerobic digestion processes.

Conventional Digestion

The process is popular for biogas generation from animal dung and sewage sludge at a TS (total solids) concentration of 3–l0 per cent. The homogenous slurry prepared by mixing the solid with water is introduced into the digester and an equivalent amount of digested slurry is withdrawn, the volume of which is dependent on the retention time for digestion. Application of this design for the MSW does not appear to be feasible due to the mixing of very large volumes of water to attain the desired TS content. Moreover, pre-processing is required to make homogenous slurry. In addition to this, mechanical mixing of the contents may be required during digestion to prevent the floating of partially digested material and the trapping of biogas. Some of the processes based on continuous digestion have been used in more large-scale demonstration facilities for waste treatment in other countries.

RefCom process: RefCom (refuse conversion to methane) process was demonstrated by the Waste Management, Inc. at Florida, for the conversion of 50–100 tonnes/day of municipal wastes and sewage sludge to biogas. In this process, after mechanical segregation of the biodegradable organic material from waste, the waste was mixed with sewage sludge and water obtained from the dewatering of the digested sludge. The mixture was fed into parallel digesters of 1300 m^3 capacity. The system had an operational problem due to the inefficient separation and multiple components in the separation process. However, with the modified screen separation, the process was successful in thermophilic conditions of 58–60 °C, and could operate at a maximum TS concentration of 4.8 per cent with the agitation. The monitoring of the system performance indicated an optimal retention time of 10–15 days with a gas yield of 0.34 meter cube/kg VS added. It was necessary to maintain a pH of over 7 to prevent souring of the digester.

WMC process: The WMC process was developed by WMC Resources Recovery Ltd, UK, which developed a plant of 5–7 tonnes/day for treating the municipal refuse. After the initial screening and shredding for separation of non-biodegradable components, the waste is treated under mesophilic conditions at a TS concentration of 10 per cent with a retention time of 15 days. The gas is used for mixing the contents. In addition to biogas, the digested sludge, after dewatering, is converted into manure after the stabilization process. Alternatively, the digested solids are blended with coal dust and are used as fuel pellets for various industrial and commercial applications.

Cal recovery process: The cal recovery process is again based on the digestion of segregated biodegradable waste for municipal wastes at Los Angeles. The maximum organic loading rate at a retention time of 15 days was 4 kg VS/m^3/day. The major operational problem experienced during this process was the formation of the scum layer due to insufficient mixing of the digester contents.

Waste biogas process: In this process, the waste biogas, after the shredding and separation process, is digested under mesophilic conditions at a concentration of 5–l0 per cent after mixing with the sewage sludge. At an average Total Solid (TS) concentration of 7 per cent, and loading rate of 1.5 kg VS/meter cube/day, and a retention time of 28 days, the methane yield was 0.16 meter cube /kg TS added. The digested sludge after drying can be used as a soil conditioner.

Dry Anaerobic Digestion Process

This is a novel process for anaerobic degradation of solid Wastes at higher TS concentration. The features of this process are

- TS concentration of 30–35 per cent
- No requirement of mechanical agitation
- No scum formation

Three different types of processes are popularly used under dry anaerobic conditions: dry anaerobic composting process, VALOGRA process, the IBVL process.

Dry anaerobic composting process (dry anaerobic composting) DRANCO involves the pretreatment segregation step for isolation of biodegradable components, which are anaerobically digested under thermophilic conditions. After the process of digestion at a TS concentration of 30–35 per cent, further stabilization occurs in 2–3 days. The overall retention time for the process is 21 days and the biogas yield is 125–180 m^3 per tonnes of input. As in the continuous process, sludge dewatering provides Water for making up the initial TS concentration and the dried digested sludge is used as a soil conditioner after suitable processing to reduce the size. The compost quality is high due to the absence of pathogens as a result of processing at thermophilic conditions and a high C:N ratio 15:1.

VALOGRA process This process can handle the TS content of the slurry in the range of 35–40 per cent with the agitation of the reactor contents by occasional supply of biogas under a pressure of 6–7 bars.

Biogas production in this case is 4 m^3/m^3 of reactor/day, as compared to the conventional process of 1 m^3/m^3 reactor per day at a retention time of 15 days under the mesophilic conditions. The conversion efficiency is 50 per cent and digested sludge is used as the combustion material after further processing.

BIOCEL process: A relatively cheaper and low-maintenance dry anaerobic system is the BIOCEL process where the organic fraction of solid waste in the presence of methanogenic bacteria, is allowed to remain under a plastic cover for 6–8 weeks resulting in methane, yield of 3750 m^3 per tonnes of organic waste. Preliminary experiments and pilot plant studies have been carried out by adopting this process.

Two-phase Digestion

The two-phase digestion process involves the separation of the hydrolysis, acidification and methanation phases that occur during the anaerobic digestion of wastes and provides the optimal conditions for maximum efficiency in both phases. There are three types of two-phase processes that have been developed for solid wastes.

The Hitachi process: The Hitachi process was developed by Hitachi Ltd.

It involves a thermochemical pretreatment process under alkaline conditions at 60 °C and with a pH of 9.8 for 3 hours. The liquefaction step involves a high temperature of 60 °C and an alkaline pH of 7.5 to 8.2. The total retention time for the process is 6–8 days.

The IBVL process The IBVL process was developed for treating organic solid Wastes, particularly agro-based products by the Institute for Storage and Processing of Agricultural Produce, the Netherlands. The system involves liquefaction and acidification reactor and a methanogenic reactor: the up-flow anaerobic sludge blanket (UASB) reactor. The reaction occurs under mesophilic condition. The digested effluent from the methanogenic reactor is recirculated into the liquefaction/acidification reactor resulting in the conversion of the volatile fatty acids (VFA) into methane due to the presence of methane-producing microbes in the effluent of the UASB. During this period, the methanogenic reactor handles the acids being produced from a just-started liquefaction/acidification reactor. The rate of degradation becomes constant after a period of 10–14 days. The digested residue is subjected to aerobic composting before being used as a soil conditioner. [21]

Sewage and Sludge

The categorization of the sewage treatment technologies has been done on basis of their performance and cost as shown in Table 2. Waste stabilization Pond System (WSPS), i.e. Slow Rate Trickling Filters is used where land availability is not an issue and winter temperature is not very low. Activated Sludge Process (ASP), BIOFOR, Up flow Aerobic Sludge Blanket (UASB) provide high degree of reliability and are used in areas with land constraint. High Rate Trickling Filters, Facultative Aerated Lagoons (FAL) these Technology are adopted wherever the category 2 technology cannot be used. Also few technology are categorized on the basis of marginal performance which are not widely used like UASB system with FPU for downstream treatment.

Waste Stabilisation Pond Systems (WSPS)

Key Features of the Technology

- Simple to construct, operate and maintain
- Does not involve installation of expensive electro-mechanical equipment

Category	Technology
Good Performance, Low Energy & Resource Consumption	Waste stabilization Pond System (WSPS), Slow Rate Trickling Filters
Good Performance, High Energy & Resource Consumption	Activated Sludge Process (ASP) , BIOFOR, Up flow Aerobic Sludge Blanket UASB
Moderate Performance, Moderate Energy & Resource Consumption	High Rate Trickling Filters, Facultative Aerated Lagoons(FAL)

Table 2: Sewage and Sludge

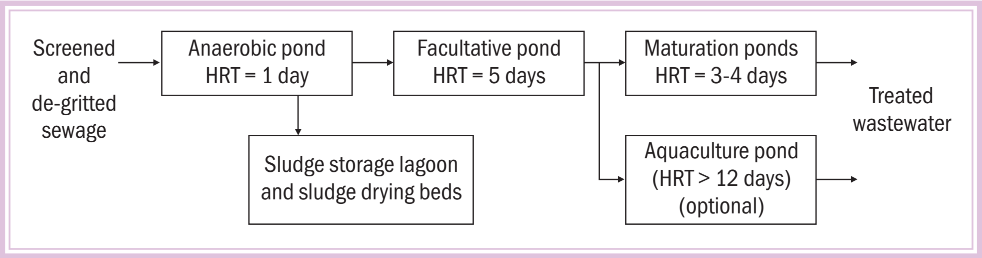


Figure 8: Water Stabilisation Pond System

- Operates on a combination of solar energy and natural forces and thereby has very low O&M costs
- Extremely robust and can withstand hydraulic and organic shock loads
- Effluents from maturation pond are safe for reuse in agriculture and aquaculture

Performance

- Can reliably produce high quality effluent with low BOD, SS, Fecal Coliform and high DO levels
- BOD reduction of the order of 90 per cent and more
- Suspended solids reduction is somewhat less due to possible overflow of algae
- Coliform reduction could be up to 6 log units.
- Total nitrogen removal between 70–90 per cent
- Total phosphorus removal between 30–45 per cent

Specific Requirements

- In case of unlined ponds, soil and geo-hydrological survey during planning stage to assess risk of groundwater contamination
- Sulphate concentration in raw wastewater under 300 mg S04/L to avoid odour nuisance
- Land requirement
- 0.80–2.3 hectares/MLD. 3–4 times the land requirement for ASP

Energy requirement essentially for the operation of screen and grit chamber. Negligible compared to ASP.

Capital costs: ₹1.5–4.5 million per MLD capacity. The higher values are for lined ponds.

O&M costs: ₹0.06–0.1 million/year/MLD installed capacity. Much lower than ASP or TF.

Advantages

- The inherent simplicity of construction offers low cost technology option
- High quality effluent at least operating costs
- Low skill requirement for operation of the plant
- Fish yield from aquaculture ponds around 4–7 tonnes/ha/year

Disadvantages

- Large land requirement
- High cost of lining
- Likelihood of odour nuisance and mosquito breeding in poorly maintained WSPs
- If unlined, likelihood of groundwater contamination in porous and fractured strata

Applicability

- Suitable under warm Indian climatic conditions
- For areas with easy availability of land
- In areas with social preference for aquaculture
- In areas with low, unreliable or expensive power supply

Duckweed Pond System (DPS)

Key features of the technology

- Natural and simple wastewater system involving sheltered pond like culture plots
- A large pond subdivided into smaller cells through floating bamboo or other material to break the wave and wind action
- Extremely rapidly growing floating duckweed vegetation serving as a dynamic sink for organic carbon, dissolved nutrients and minerals
- Thick mat of duckweed out-competing and inhibiting growth of other aquatic plants
- Pond functioning as a facultative lagoon with deeper layers under anaerobic environment
- Retention period in the system 7–21 days
- Shallow water depths from 1.25 m up to 2 m
- Continuous process requiring intensive management for optimum production
- Yield of large quantities of protein matter as fish feed or as a supplement for animal feed

Performance: Can meet Indian discharge standards for BOD and SS. Removal of N and P is also substantial.

- For settled wastewater, BOD and SS below 30 mg/L are attainable at 12 d detention
- High nutrient and mineral removal due to uptake by duckweeds

Specific Requirements

- Primary treatment including screening, grease trap, grit removal and sedimentation
- Preferably the influent BOD, SS and ammonia to be under 80 ppm, 100 pm and 50 ppm, respectively
- A series of smaller cells of around 10 m x 10 m to 10 m x 30 m to break the continuum in the pond (cell size as a function of wind speed, pond size and wave action)
- Cell borders made with floating bamboo mats or PVC profiles to shelter from wind and wave action
- Impermeable lining of clay or artificial liners in case of pervious and fractured strata
- Outlet structure with variable weir height
- Nitrogen loading of around 9 kg/ha/day
- Small size culture ponds for duckweed seedlings and as fish nursery ponds
- Duckweed drying and processing unit in case of large harvest and for sale as animal feed
- In case of downstream aquaculture ponds - introduce suitable species of fishes, e.g., Grass Carp, Common Carp, Silver Carp, Rohu, Mrigal, Cattle and freshwater prawns

Land requirement: 2 to 6 ha/MLD for 7 to 20 days of detention period. Comparable to WSPS.

Options

- Pre-treatment comprising anaerobic pond or primary sedimentation
- In combination with aquaculture pond on downstream to utilise duckweed as fish feed
- Supplementary aeration in aquaculture ponds to augment oxygen supply in summer season

Dos and Don'ts

- Inclusion of downstream aquaculture ponds for resource recovery and financial sustainability
- Feeding only settled sewage into duckweed ponds
- Protection of the ponds against flooding
- Avoid construction on porous soils, fractured strata and on alkaline soils
- Avoid duckweed ponds in cold climatic conditions
- Capital costs: Of the same order as WSP with additional cost of floating cell material

Operation and Maintenance

- Daily harvesting to ensure productivity and health of duckweed colonies
- Avoid breakage of the thick mat of duckweed to
- Prevent piling up or accumulation or weed culture on one side or the pond
- Prevent toxins and extremes of pH and temperature
- Prevent crowding due to overgrowth
- Prevent growth of other vegetation
- Vector control measures
- De-sludging of duck pond once in two years

O&M costs: ₹ 0.18 million/MLD/year. More than WSPS and UAS8. Less than ASP.

Includes: Manpower costs for maintaining the primary treatment section, harvesting duckweed and management of fish ponds.

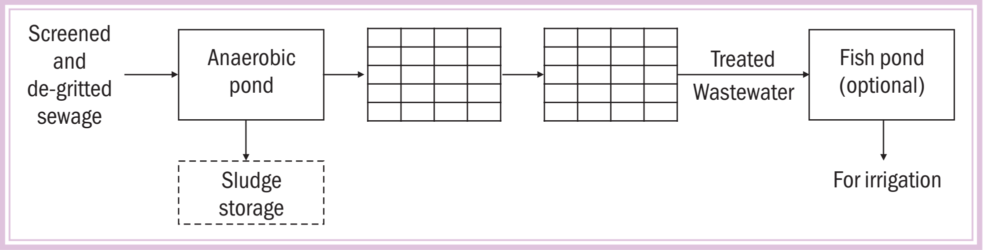


Figure 9: Duckweed Pond Systems

Costs of post processing of duckweed for value addition as a fish teed or as animal feed supplement

Advantages

- Less sensitive to low temperatures, high nutrient levels, pH fluctuations, pests and diseases compared to other aquatic plants.
- Reduced suspended solids in effluent due to elimination of algae
- Simultaneous significant nutrient removal
- Easy to harvest compared to water hyacinth
- Complete cover prevents breeding of mosquitoes and odour nuisance
- Yield of highly protein containing vegetative material (35–45 per cent) as animal feed
- Duckweed as an excellent feed for aquaculture
- Realisation of tangible economic returns from sale of raw or processed weed or fish to Least cost of O&M
- Creation of a micro-enterprise with sustainable income generation potential

Disadvantages

- Low pathogen removal due to reduced light penetration
- Duckweed die off in cold weather conditions

Applicability

- Low strength domestic wastewater or after primary sedimentation with influent 800 < 80 mg/L
- In combination with existing WSP
- Rural and semi-urban settlements with easy land availability
- As a polishing pond for an existing activated sludge plant or other technology based STPs

Facultative Aerated Lagoon

Key Features of the Technology

- Simple flow scheme without primary or secondary settling and sludge recirculation
- Deep lagoon with anaerobic bottom layer and aerobic top layer
- Simultaneous degradation of sludge in the bottom and dissolved organics in the top layer
- Lower energy input corresponding to requirement for maintaining only desired DO levels in the top layer and not for creating completely mixed conditions

Performance

As per the information in literature based on Indian experience the following performance is expected from a well-functioning facultative aerobic lagoon:

- BOD removal 70–90 per cent
- Suspended solids removal 70–80 per cent
- Coliform removal 60–99 per cent

Specific Requirements

- Typical hydraulic detention time of 3 days or more
- Depth between 2–5 m depending on local soil and groundwater conditions
- Effective outlet structure with baffles and stilling basin to prevent solids overflow
- Land requirement: Between 0.27 to 0.4 ha/MLD (higher than ASP)
- Power requirement: 18 KWh/ML treated. Much lower than ASP. Comparable to UASB

Options

- Grit chamber as a preliminary treatment unit
- Multiple cells of lagoons in series for higher pathogen reduction

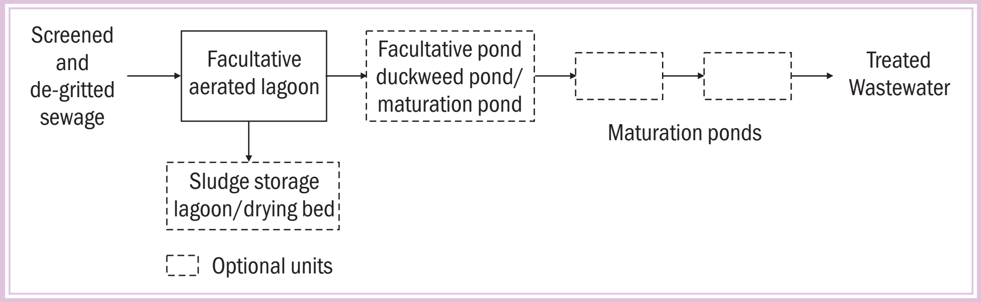


Figure 10: Facultative Aerated Lagoon

- Long narrow layout of lagoon for low dispersion coefficient
- Downstream ponds for polishing (facultative or duckweed and maturation)
- Arrangement for sludge withdrawal without the need for emptying of lagoon
- Provision of sludge storage lagoon

Dos and Don'ts

- Avoid construction on porous soils and fractured strata or provide impervious lining
- Attain a balance between depth of lagoon and number of small capacity aerators to create two distinct zones of aerobic and anaerobic conditions in the top and bottom layers

Capital costs: ₹2.2 to 2.9 million/MLD (Comparable to ASP/TF/UASB)

Operation and maintenance: Desludging of lagoon once a year or according to the situation

O&M costs: Between 0.15 to 0.2 million/MLD/yr. Lower than ASP but higher than UASB.

Advantages

- Simple operation of the plant requiring lower skilled manpower
- Minimum civil, electrical and mechanical installation
- Scheme devoid of primary and secondary settling tanks as well as sludge digestors
- Lower energy costs compared to other aerobic processes
- Lower O&M cost

Disadvantages

- Possibility of groundwater contamination in porous and fractured strata
- High cost of lining

Applicability

- Standalone system for sewage treatment
- As a pre-treatment unit for WSP
- As an up-gradation option for overloaded WSPs

Activated Sludge Treatment

Key features

- Proven and tested for more than 7–8 decades all over world
- Several modifications/advances possible to meet specific requirements

Performance

Very good performance in terms of BOD and SS. Treated effluent can most often satisfy the current Indian effluent discharge standards. Performance is critically dependent on sludge settling characteristics and design of secondary clarifier. Sludge settling characteristics are typically influenced by bio-flocculation which in turn depends on growth rate of microorganisms. Growth rate is generally controlled by controlling biological solids retention time/food to micro-organism ratio.

Specific Requirements

- Un-interrupted power supply for aeration and sludge recirculation
- Maintenance of biomass concentration in the aeration tank

Dos and Don'ts

- Carefully monitor the reactor sludge levels and sludge withdrawal
- Regular painting/coating of corrosion susceptible materials/exposed surfaces

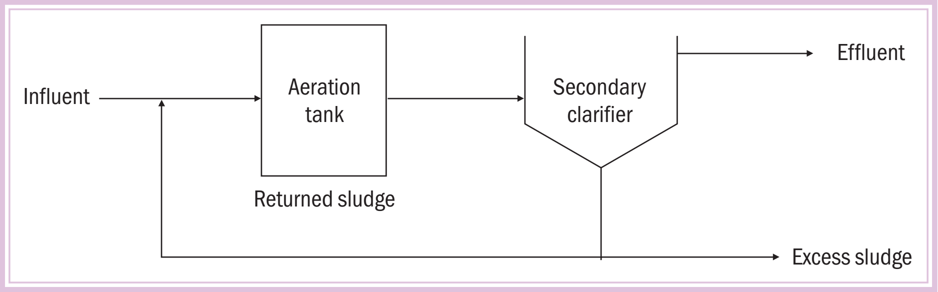


Figure 11: Activated Sludge Treatment

Capital cost: The capital cost is in the range of ₹2–4 million per MLD capacity. Approximately 55 per cent cost is of civil works and remaining 45 per cent is for electrical and mechanical works

Operation and Maintenance

- Careful monitoring and control of sludge quantity in the aeration tank
- Regular maintenance of aeration and recycle system

O&M Costs: The O&M costs based on the data collected from various Indian plants varies in the range of ₹ 0.3–0.5 million/year/MLD installed capacity

Land Requirement: 0.15–0.25 ha/MLD installed capacity

Energy Requirement: 180–225 Kwh/ML treated

Advantages

- Performance is not significantly affected due to normal variations in wastewater characteristics and seasonal changes.
- Less land requirements

Disadvantages

- High recurring cost
- High energy consumption
- Performance is adversely affected due to interruption in power supply even for a short period
- Foaming, particularly in winter season, may adversely affect the oxygen transfer
- Requires elaborate sludge digestion/drying/ disposal arrangement

Applicability

The most widely used option for treatment of domestic wastewater for medium to large towns where land is scarce.

BIOFOR (Biological, Filtration & Oxygenated Reactor) Technology

Key Features of the Technology

- Enhanced primary treatment with addition of coagulants and flocculants
- High rate primary tube settlers and integrated thickening offering space economy
- Two stage high rate filtration through a biologically active media and with enhanced external aeration
- Co-current up flow movement of wastewater and air enable higher retention and contact
- Treatment scheme excluding secondary sedimentation but recycling of primary sludge
- Deep reactors enabling lowland requirements
- A compact and robust system

Performance

- Suspended solids and BOD removal of 90 per cent and 70 per cent respectively in the primary clarifier
- High quality effluent with BOD under 10 mg/L and total system efficiency of 94–99.9 per cent
- Low turbidity with suspended solids under 15 mg/L and total system efficiency of 98 per cent
- Pathogen removal of 2 on the log scale

Specific requirements

- Addition of alum as coagulant (~ @ 60 ppm)
- Polyelectrolyte for high rate sedimentation (~ @ 0.2–0.3 ppm) in tube settlers
- Special and patented granular filter media ‘Bioloite’ made of clay
- Backwash of BIOFOR bed and recycle of the wastewater
- Treatment (digestion) and disposal of sludge from clarifier (not provided at the STPs due to space limitations)

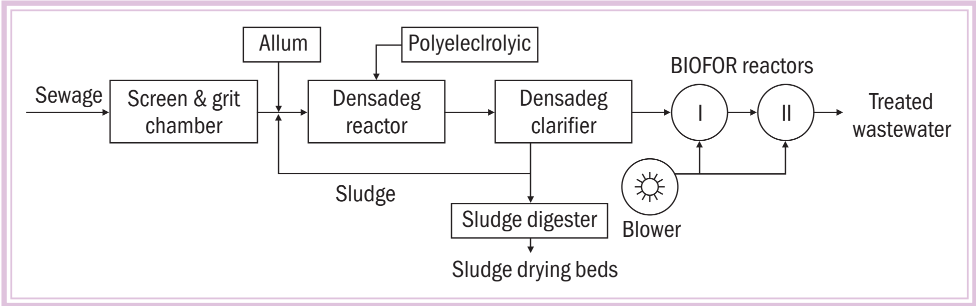


Figure 12: BIOFOR Technology

Energy Requirement: 220–335 kWh/ML treated. Approximately double of ASP

Land requirement: 0.04 ha per MLD installed capacity (excluding land requirement for sludge drying beds). Much lower than ASP.

Sludge production: Thickened sludge @ 1000 kg/MLD wastewater treated (about 14.5 m^3/MLD)

Capital costs: ₹6.5–8.1 million per MLD capacity. More than double that of ASP.

Operation & Maintenance costs: ₹0.86 million/year/MLD installed capacity (does not include the full cost of sludge disposal). Much higher than ASP.

Advantages

- Compact layout as a result of high rate processes
- Higher aeration efficiency through co-current diffused aeration system
- Space saving as secondary sedimentation is dispensed
- Able to withstand fluctuations in flow rate and organic loads
- Compliance with stricter discharge standards
- Effluent suitable for industrial applications, e.g., cooling water or ground water recharging
- Effluent suitable for UV disinfection without filtration
- Absence of aerosol and odour nuisance in the working area
- Absence of corrosive gases in the area
- Lower operation supervision enables lesser manpower requirement

Disadvantages

- Continuous and high chemical dosing in primary clarification
- Undigested sludge from primary clarification requiring post treatment[22]

Construction & Demolition

Construction & Demolition Waste			
Types	**Sectors of origin**	**Components**	**Processes & Technology**
Construction waste	Waste coming from maintenance and/or construction activities of buildings and civil infrastructure works	Concrete (pre-stressed or normal) cement and various mortars conglomerates, bricks, tiles and blocks excavation soil wood paper, cellulose and polystyrene	Crushing & Reuse: Onsite or offsite
Demolition waste	Waste coming from the maintenance and/or from the partial or total demolition of buildings and civil infrastructure works		Magnetic Separation Recycle: Onsite or off site processing for to recover high valuable saleable products. Screen Technology
Roads waste	Waste coming from road maintenance and construction works	Conglomerates and mixed bituminous excavation soil concrete wood metals	Landfilling: Jaw Crusher & Pulse Crusher Reuse Onsite
Excavation soil and rocks	Waste coming from earthworks for the construction of civil works and/or excavation	Excavation soil wood	Magnetic separation Incineration

Table 3: Construction & Demolition Waste Technology

Recycling of Construction & Demolition Waste

Construction and Demolition Waste Management may be defined as the discipline associated with the proper storage, collection and transportation, recovery and recycling, processing, reusing and disposal in a manner that is in accord with the best principles of human health, economic, engineering, aesthetics and other environmental considerations. The management approaches as shown in *Table 3* are different from one country to another, as are the levels of environmental protection. *Figure 13* shows how C&D waste generated at site is managed. Most of the Construction and Demolition management systems are reviewed on the following basis:

Construction and Demolition waste management includes following steps.

- Storage and segregation.
- Collection and transportation.
- Recycling and reuse.
- Disposal.

Storage and Segregation

Construction and Demolition wastes are best stored at source, i.e., at the point of generation. If they are

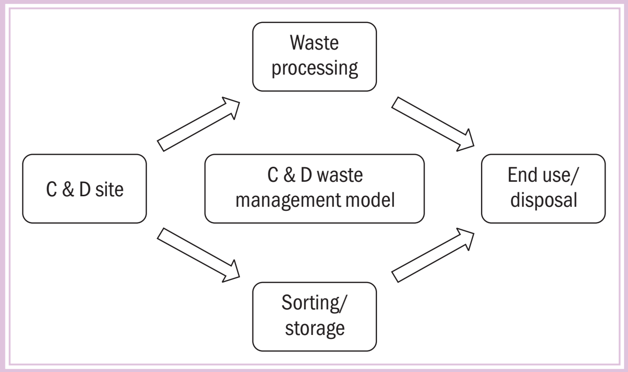


Figure 13: C&D Waste Management Model

scattered around or thrown on the road, they not only cause obstruction to traffic but also add to the work load of the local body. A proper screen should be provided so that the waste does not get scattered and does not become an eyesore. Segregation can be carried out at source during Construction and Demolition activities or can be achieved by processing the mixed material to remove the foreign materials. Segregation at source is most efficient in terms of energy utilization, economics and time. Gross segregation of Construction and Demolition wastes into road work materials, structural building materials, salvaged building parts and site clearance waste is necessary. Additional segregation is required to facilitate reuse/recycling of materials like wood, glass, cabling, plastic, plaster board and so on before demolition in order to produce recycled aggregate that will meet the specification.

Collection and Transportation

The Construction and Demolition debris is stored in skips. Then skip lifters fitted with hydraulic hoist system are used for efficient and prompt removal. In case, trailers are used, then tractors may remove these. For handling very large volumes, front-end loaders in combination with sturdy tipper trucks may be used so that the time taken for loading and unloading is kept to the minimum.

Recycling and Reuse

Construction and Demolition waste is bulky and heavy and is mostly unsuitable for the disposal by incineration/ composting. The growing population and requirement of land for other uses has reduced the availability of land for waste disposal. Reutilization or recycling is an important strategy for management of such waste. Apart from mounting problems of waste management, other reasons which support adoption of reuse/recycling strategy are reduced extraction of raw materials, reduced transportation cost, improved profits and reduced environmental impact. Above all, the fast depleting reserves of conventional natural aggregate have necessitated the use of recycling/ reuse technology, in order to be able to conserve the conventional natural aggregate for other important works. In the present context of increasing waste production and growing public awareness of environmental problems, recycled materials from demolished concrete or masonry can be profitably used in different ways within the building industry. The study survey indicates the major components of the Construction and Demolition waste stream are excavation material, concrete, bricks and tiles, wood and metal.

Concrete appears in two forms in the waste. Structural elements of building have reinforced concrete, while foundations have mass non-reinforced concrete. Excavations produce top soil, clay, sand and gravel. Excavation materials may be either reused as filler at the same site after completion of work, in road construction or in stone, gravel and sand mines, land fill construction, structural fill in low lying areas to assist in future development, in garden and landscaping. Concrete and masonry constitute more than 50 per cent of waste generated. It can be reused in block/ slab form. Recycling of this waste by converting it to aggregate offer dual benefit of saving landfill space and reduction in extraction of natural raw material for new construction industry. Basic method of recycling of concrete and masonry waste is to crush the debris to produce a granular product of given particle size. Plants for processing of demolition waste are differentiated based on mobility, type of crusher and process of separation.

The three types of available recycling plants are: Mobile, Semi-Mobile and Stationary Plant

Mobile Plant: In the mobile plant, the material is crushed and screened and ferrous impurities are separated through magnetic separation. The material is transported to the demolition site itself and is suited to process only non-contaminated concrete or masonry waste. Refer *Figure 14.*

Semi-Mobile Plant: In the semi-mobile plant, removal of contaminants is carried out by hand and in the end product is also screened. Magnetic separation for removal of ferrous material is carried out. End product quality is better than that of a mobile plant.

Above plants are not capable to process a source of mixed demolishing waste containing foreign matter like metal, wood, plastic, etc.

Stationary plants are equipped for carrying out crushing, screening as well as purification to separate the contaminants. Issues necessary to be considered for erection of stationary plants are: plant location, road infrastructure, availability of land space, provision of Weigh Bridge, provision for storage area, etc.

Different types of crushers are used in recycling plant namely jaw-crusher, impact crusher, impeller-impact crusher.

Applications of C&D Waste

Recycled aggregate can be used as general bulk fill, sub-base material in road construction, canal lining, playground, fills in drainage projects and for making new concrete to less extent. While

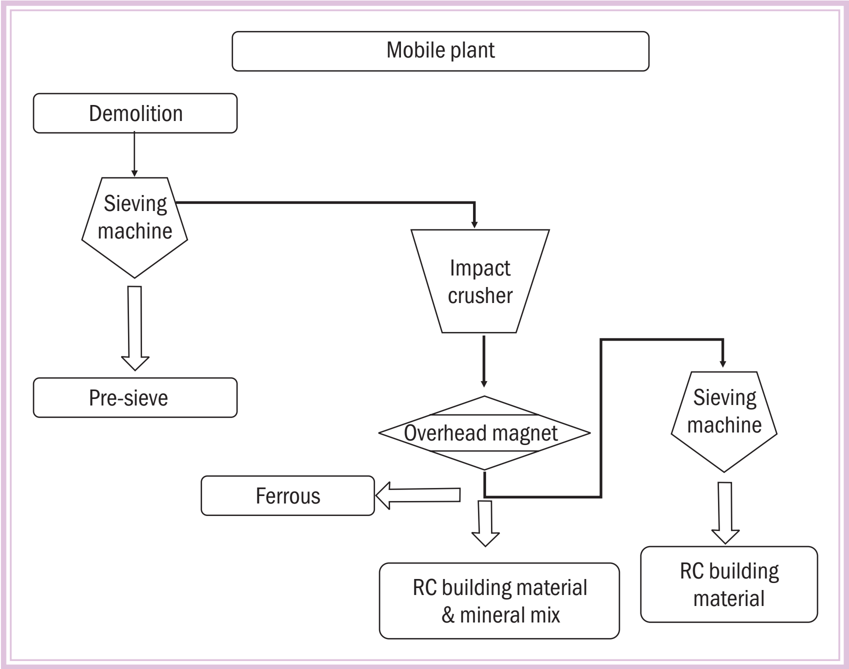


Figure 14: Mobile Plant

using recycled aggregate for filler application, care must be taken that it is free of contaminants to avoid risk of ground water pollution use of recycled aggregate are sub-base for road construction is widely accepted in most of countries.

Bricks and masonry arise as waste during demolition. These are generally mixed with cement, mortar or lime. It is used in the construction of road base and drayage layer, and mechanical soil stabilizers due to its inertness after crushing and separation.

Tile materials recycling are almost identical to bricks. Tile is often mixed with brick in final recycled product. Metal waste is generated during demolition in the form of pipes, light sheet material used in ventilation system, wires and sanitary fittings and as reinforcement in the concrete. Metals are recovered and recycled by re-melting. The metals involved onsite separation by manual sorting or magnetic sorting. Aluminium can be recovered without contamination, the material can be directly sold to a recycler.

Wood recovered in good condition from beams, window frames, doors, partitions and other fittings is reused. However, wood used in construction is often treated with chemicals to prevent termite infestation and warrants special care during disposal other problems associated to wood waste are inclusion of jointing, nails, screws and fixings. In fact, wood wastes have a high market value for special reuses (furniture, cabinets and floorings). Lower quality waste wood can be recycled/burned for energy recovery. Scrap wood is shredded in-site/in a centralized plant. Shredded wood is magnetically sorted for scrap metal. Wood chips are stored so as to remain dry and can be used as fuel. Also, it is used in the production of various press boards and fiber boards and used for animal bedding. Bituminous material arises from road construction, breaking and digging of roads for services and utilities. Recycling of Bituminous material can be carried out by hot or cold mixing techniques either at location or at a central asphalt mixing plant it offers benefits like saving in use of asphalt, saving of energy, reduction in aggregate requirement, etc. Other miscellanies materials that arise as waste include glass, plastic, paper, etc., can be recovered and reused.

Disposal

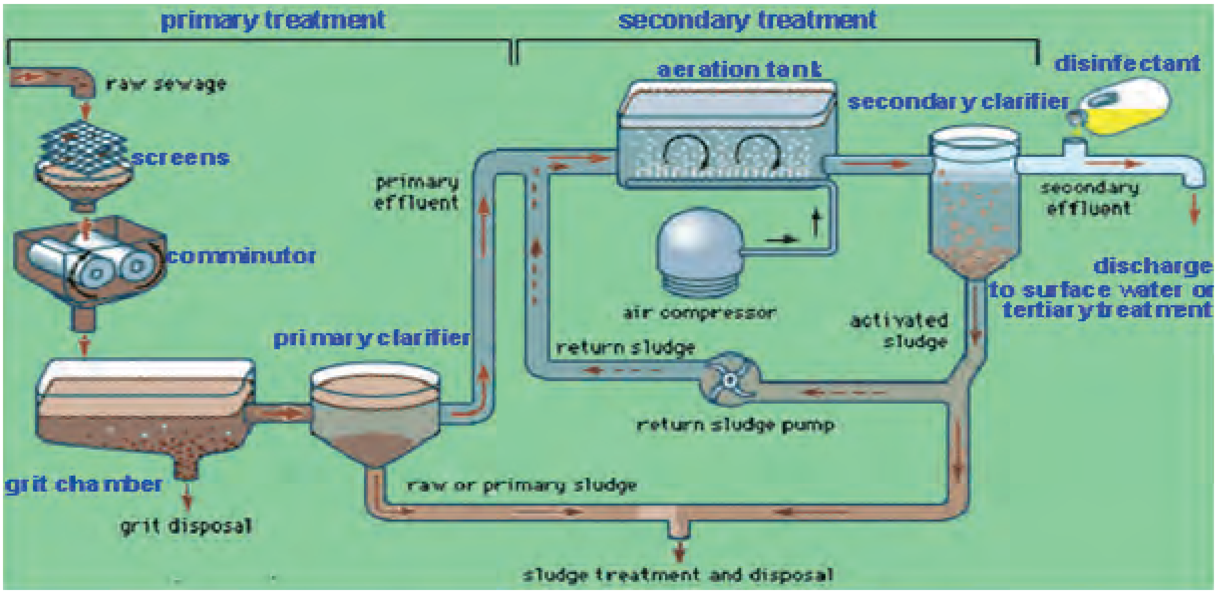
Being predominantly inert in nature, C&D waste does not create chemical or bio-chemical pollution. Hence maximum effort should make to reuse and recycle them as explained above. The material can be used for filling/leveling of low-lying areas. In the industrialized countries, special landfills are sometimes created for inert waste, which are normally located in abandoned mines and quarries. [10]

Hazardous Waste & Industrial Waste Water

Industrial Waste Classification	Oxidation	Reduction	Precipitation	Neutralization	Blending	Separation	Incineration	Filtration	Stabilization	Landfill
Cyanide wastes	✓		✓	✓				✓	✓	✓ 1
Metal finsing wastes	✓	✓	✓	✓				✓	✓	✓ 1
Waste containing water sol. Pb, Cu, Zn, Cr, Ni, Se, Ba, Sb			✓	✓				✓	✓	✓ 1
Hg, As, Th, Cd bearing wastes			✓	✓				✓	✓	✓ 1
Non-halogenated hydrocarbons including solvents					✓		✓ 2		✓	✓ 1
Halogeneated hydrocarbons including solvents					✓		✓ 2		✓	✓ 1
Wastes from paints, pigments, glues, varnishes & printing inks					✓		✓ 2		✓	✓ 1
Waste from dyes and dye intermediates (containing inorganic compounds)	✓		✓	✓				✓	✓	✓ 1
Waste from dyes and dye intermediates (containing organic compounds)	✓		✓	✓				✓	✓	✓ 1
Waste oils and oil emulsions					✓	✓	✓ 2			
Tarry wastes from refining and tar residues from distillation or pyrolytic treatment							✓ 2			✓ 1
Sludges arising from treatment of waste waters containing heavy metals, toxic organics, oil emulsions and spent chemical and incineration ash			✓	✓				✓	✓	✓
Phenols					✓		✓ 2			✓ 1
Absetos										✓
Wastes from manufacturing and formulation of pesticides and herbicides					✓ 3		✓ 3, 2			✓
Acid/alkaline slurry wastes			✓	✓				✓	✓	✓ 1
Off-specification and discarded products	as per constituents									
Discarded containers and container liners of hazardous and toxic wastes	as per contents									

Table 4: Hazardous Waste & Industrial Waste Water

Note: 1. Treatment residues to landfill after optional stabilization
2. Either dedicated incinerator or cement kiln
3. Some are amenable to alkaline hydrolysis.



Picture 2: Sludge Treatment

Source: http://water.me.vccs.edu/courses/env108/lesson1_2.htm

	Technology/ Processes	
Industrial Waste Water	Primary Treatment for Solid Removal	Screening, Grit Chamber
	Secondary Treatment for BOD Removal	Biological Digestion Process
	Tertiary Treatment for Meeting Specific Discharge Requirement	Coagulation, Oxidation, Sedimentation

Table 5: Industrial Waste Water

Primary Treatment helps in removing 90–95 per cent settable solids and 50–65 per cent suspended Solids. Removable of Soluble particles is done by Secondary Treatment. Refer *Picture 2* and *Table 5*. These soluble particles are mostly organic loads like Biological oxygen demand (BOD) from waste water. Coagulation that neutralizes repulsive forces between the particles is used as tertiary treatment for meeting specific discharge limits as set by pollution control board.

Oxidation Processes

May destroy certain compounds and constituents through oxidation and reduction reactions.

Advanced oxidation is chemical oxidation with hydroxyl radicals, which are very reactive, and short-lived. The radicals need to be produced on site, in a reactor where the radicals can contact the organics in the wastewater. Hydroxyl radicals may be produced in systems using: ultraviolet radiation/hydrogen peroxide, ozone/hydrogen peroxide, ultraviolet radiation/ozone, Fenton's reagent (ferrous iron and hydrogen peroxide), titanium dioxide/ultraviolet radiation and through other means.

Advantages

- Takes care of contaminants with fast reaction rates
- Potential to reduce toxicity and possibly complete mineralization of organics treated
- Reactions do not produce excess materials like "spent carbon" or chemical sludge
- Non-selective process can take care of wide range of organics
- Used to floc and disinfect portable water preferably better than chlorine because it does not add T.D.S (dissolved solids) and chemicals
- The combination of ozone and UV is good for colour, bacteria, odor, viruses, iron and microbial growth
- EPA is trying to replace chlorine with Ozone as chlorine is linked to cancer

Limitations

- Expensive
- Chemistry of this process must target specific types of contaminants
- Can demand large amounts of peroxide
- Tampering with this process can lead reduction in the chemical's effectiveness in the future.
- The combination of ozone and UV does not solve all water problems, they dont remove lead or calcium.
- The process only removes organic material.

Reduction/Oxidation

Redox reactions chemically convert hazardous contaminants to nonhazardous or less toxic compounds that are more stable, less mobile and/ or inert. Redox reactions involve the transfer of electrons from one compound to another. Specifically, one reactant is oxidized (loses electrons) and one is reduced (gains electrons). The oxidizing agents most commonly used for treatment of hazardous contaminants are ozone, hydrogen peroxide, hypochlorite, chlorine and chlorine dioxide. Chemical reduction/oxidation is a short-to-medium-term technology.

Chemical redox is a full-scale, well-established technology used for disinfection of drinking water and wastewater, and it is a common treatment for cyanide (oxidation) and chromium wastes. Enhanced systems are now being used more frequently to treat hazardous wastes in soils.

The target contaminant group for chemical redox is inorganics. The technology can be used but may be less effective against non-halogenated VOCs and SVOCs, fuel hydrocarbons and pesticides. Chemical redox is commercial technology used for disinfection of drinking water and wastewater. It is a common treatment for cyanide (oxidation) and chromium (reduction of hexavalent chromium to trivalent chromium prior to precipitation) wastes.

Limitations

Factors that may limit the applicability and effectiveness of the process include:

- Incomplete oxidation or formation of intermediate contaminants may occur depending upon the contaminants and oxidizing agents used.
- The process is not cost-effective for high contaminant concentrations because of the large amounts of oxidizing agent required.
- Oil and grease in the media should be minimized to optimize process efficiency.

Chemical Precipitation

Metals do not degrade in the environment. Chemical precipitation is a widely used, proven technology for the removal of metals and other inorganics, suspended solids, fats, oils, greases and some other organic substances (including organophosphates) from wastewater. The ionic metals are converted to an insoluble form (particle) by the chemical reaction between the soluble metal compounds and the precipitating reagent. The particles formed by this reaction are removed from solution by settling and/ or filtration.

The effectiveness of a chemical precipitation process is dependent on several factors, including the type and concentration of ionic metals present in solution, the precipitant used, the reaction conditions (especially the pH of the solution) and the presence of other constituents that may inhibit the precipitation reaction.

The specific approach used for precipitation will depend on the contaminants to be removed be it metal removal, removal of fats, oils and greases, suspended solids, phosphorus removal.

Before deciding whether chemical precipitation meets the needs of a municipality, it is important to understand the advantages and disadvantages of this methodology.

Advantages

- Chemical precipitation is a well-established technology with ready availability of equipment and many chemicals.
- Some treatment chemicals, especially lime, are very inexpensive.
- Completely enclosed systems are often conveniently self-operating and low maintenance, requiring only replenishment of the chemicals used. Often times, a sophisticated operator is not needed.

Disadvantages

- Competing reactions, varying levels of alkalinity and other factors typically make calculation of proper chemical dosages impossible. Therefore, frequent jar tests are necessary for confirmation of optimal treatment conditions. Overdosing can diminish the effectiveness of the treatment.
- Chemical precipitation may require working with corrosive chemicals, increasing operator safety concerns.
- The addition of treatment chemicals, especially lime, may increase the volume of waste sludge up to 50 per cent.
- Large amounts of chemicals may need to be transported to the treatment location.
- Polymers can be expensive.

The purpose of neutralization is to adjust the pH value to meet the requirements of the different processing units in the waste water treatment system.

Neutralization

May be used in order to treat acid wastewaters containing metals, the method comprising increasing the pH of the acid waste by addition of an alkaline reagent, to form a precipitate and collecting the precipitate. This way the incoming solution is pH adjusted to the optimum range for precipitating metals as hydroxides.

Blending

The waste-derived fuel is burned in related cement kilns. This fuel blending and thermal destruction process safely rids the environment of hazardous waste. It conserves non-renewable natural resources and fossil fuels by recovering the energy value from the waste.

Bioremediation

Uses Advanced Bio-Technology for Industrial Wastewater Treatment. The use of microbes or bacteria to naturally consume oils and other contaminants in wastewater breaking them down into harmless CO_2 and H_2O.

Advantages

All-natural, very environmentally friendly.

Disadvantages

The waste stream needs dwell time as well as a constant organic food source, such as grass clippings or emulsified oils, to feed the microbes. This imposes limits to the volume of water that can be treated.

Filtration

Filtration techniques are used for very specific applications in the field of industrial waste water treatment. The three main types of membrane-based filtration technologies include reverse osmosis, nanofiltration and ultrafiltration. Although categorized as different technologies, the three types of membrane filtration have a great deal in common. All three act as membranes created by coating a thin layer of a very porous polymer, or plastic, onto a backing material. The end result is the finest form of filtration presently known, with reverse osmosis being the smallest, nanofiltration being a slight step larger and ultrafiltration being a bit larger again.

Advantages

- Material reliability
- Less chemicals required
- Relatively simple follow-up, once the installation is correctly set
- Efficient use of energy
- No change in state of aggregation necessary

Disadvantages

- High purchase price of the membranes
- Residue (very concentrated filtrate) has to be collected or further treated

Mechanical Filtration

This is a process in which contaminants in a waste stream are filtered or screened out. This method is effective in preventing particles, even very tiny ones like mud and sludge, from moving downstream. The downside is that solids build up on the filtering media and restrict the water flow requiring some type of maintenance, such as purging or backwashing. Also, mechanical filtration is not an effective method for dealing with emulsified oils.

There are three main types of filtration methods—(1) indexing paper filters, (2) cartridge filters and (3) media filters. A description of each along with the pros and cons is as follows:

Indexing Paper Filters: A very fine paper filter continuously unrolls while the waste stream flows through the paper filter.

Advantages

Very effective when there's not a lot of dirt or solids in the waste stream.

Disadvantages

Solids plug up the paper quickly requiring you to use (buy) a lot of paper; plus you have to find a way to dispose of the contaminated paper safely.

Cartridge Filters is placed inside a canister or enclosed tank.

Advantages

Provides excellent filtration even down to 5 microns in size.

Disadvantages

As with indexing paper filters, they can plug quickly and, depending on the dirt load, must be removed often to clean or replace.

Media Filters: Other media, like sand or carbon, are used to filter contaminants in the water.

Advantages

It provides reasonable removal of solids without plugging up.

Disadvantages

It requires regular maintenance such as backwashing.

Oil-water separation: Oil-water separation is a process that enhances the natural separation of oil from water so the oil floats on the surface of the water.

Advantages

It effectively removes or skims "free" oils from the water surface.

Disadvantages

It is not effective in removing emulsified oils that are often trapped within the water molecules by detergents or other cleaning agents.

Wastewater Evaporation

Like a pan of water on the stove, wastewater subjected to heat is evaporated leaving the pollutants to be skimmed off or disposed of as sludge. It short, wastewater evaporators safely and naturally eliminates the water portion of a waste stream leaving behind only the gunk—usually about 5–10 per cent of the total volume—to dispose of.

The technology use in wastewater evaporators is typically either through immersion heating (pan on a stove) or submerged combustion (sending the heat into a tube immersed in water). Water Maze has systems with both technologies.

Advantages

It effectively minimizes the wastewater so there's only a fraction left to dispose of.

Disadvantages

It still requires disposal of hazardous wastes plus heating fuel costs can be expensive.

Electro-coagulation

This is a very effective process that removes suspended solids, emulsified oils and heavy metals from wastewater. Electro-coagulation uses low-voltage DC current to effectively neutralize the charges of the contaminants allowing them to coagulate and separate from the waste stream.

Uses advanced electro-coagulation combined with chemical flocculation to enhance and speed up the process of removing constituents from waste water.

Advantages

When combined with other technologies, it produces exceptional water quality with very little maintenance. It successfully treats a very broad range of waste streams and requires very little maintenance.

Disadvantages

Only a few manufacturers of environmental systems truly understand this process and even fewer know how to combine it with other water treatment technologies.[23]

E-Waste – Technology Fact Sheet

	Level 1	Output	Level 2	Sub-level 2	Output	Level 3	Output
		Segregated hazardous wastes like CFC, Hg, Switches, bateries and capacitors		Density Media Sparation Cyclone Process	Sorted Plastic	Chemical/ Thermal Process Recycling, Incineration	Plastic Product, Energy Recovery
E-waste	Decontamination, Dismantling, Segregation	Segregated non-hazardous E-waste like plastic, CRT, circuit board and cables	Hammering, Shredding, CRT, Electromagnetic separation, Eddy current separation Density separation	Splitting technology Thermal shcok, NiChrome hot wire cutting, Laser cutting, Magnetic & eddy current separation	Ferrous & nonferrous metal scrap, Sorted plastic, Glass fraction, Lead	Breaking, Recycling, Separation and Distillation	Copper/ Aluminium, Iron, Glass Cullet
				Dismantling Pulverization/ Hammering, Density separation using water	Ferrous & Nonferrous metal scrap, Lead, Mercury, Oil	Separation and Distillation	Oil recovery/ energy, Copper/ Aluminium, Iron

Table 6

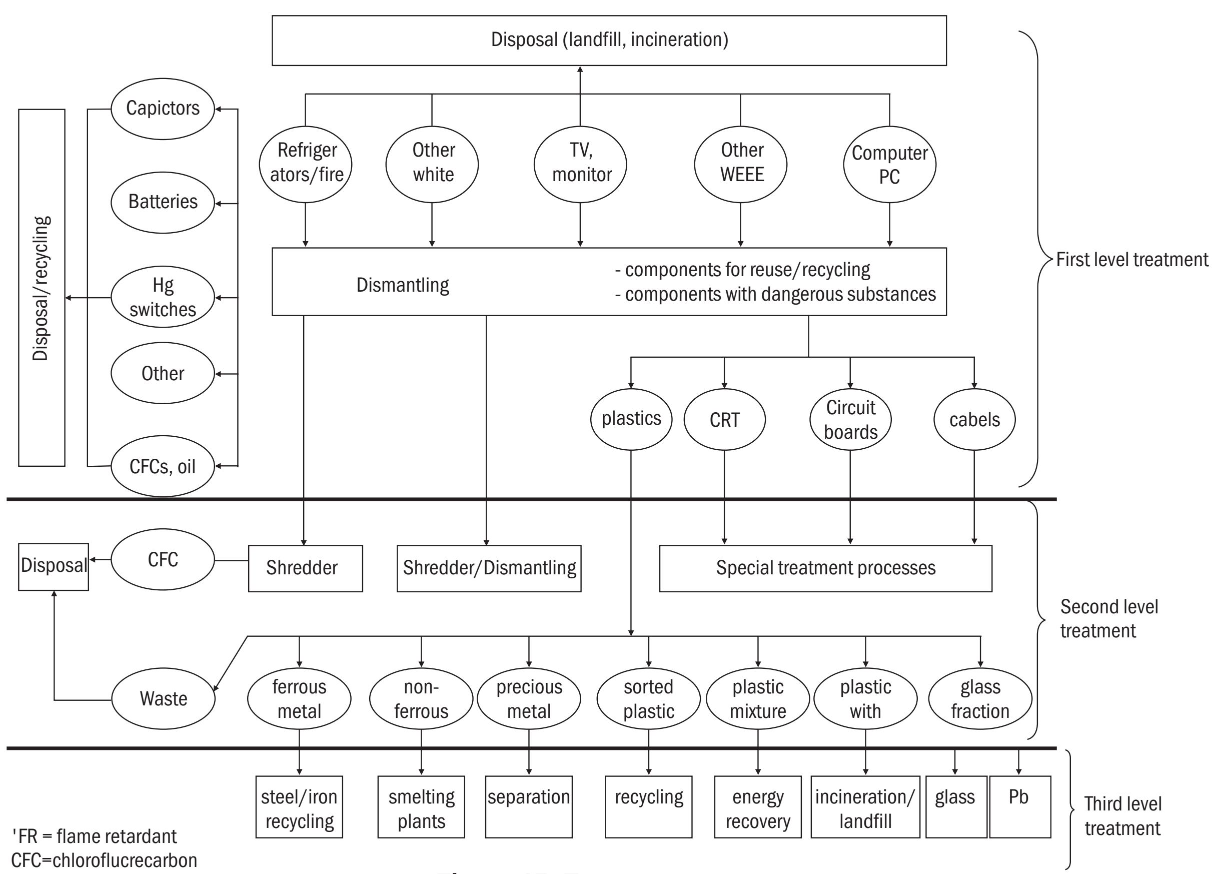


Figure 15: E-waste treatment

Source: Prepared by modifying Figure 6.1 from the report "Waste from electrical and electronic equipment (WEEE) — quantities, dangerous substances and treatment methods", EEA Copenhagen, 2003

E-waste treatment technologies are used at the following three levels:

- 1st level treatment
- 2nd level treatment
- 3rd level treatment

All the three levels of e-waste treatment are based on material flow. The material flows from 1st level to 3rd level treatment. Each level treatment consists of unit operations, where e-waste is treated and output of 1st level treatment serves as input to 2nd level treatment. After the third level treatment, the residues are disposed of either in TSDF or incinerated. The efficiency of operations at first and second level determines the quantity of residues going to TSDF or incineration.

1st Level Treatment

Unit operations operations at first level of e-waste treatment are:

- Decontamination: Removal of all liquids and Gases
- Dismantling: manual/mechanized breaking
- Segregation

2nd Level Treatment

Unit operation at second level of e-waste treatment

- Hammering
- Shredding
- Special treatment Processes comprising of
  - CRT treatment consisting of separation of funnels and screen glass
  - Electromagnetic separation
  - Eddy current separation
  - Density separation using water

Hammering and shredding objective is size reduction. The third unit operation consists of special treatment processes. Electromagnetic and eddy current separation utilizes properties of different elements like electrical conductivity, magnetic properties and density to separate ferrous, nonferrous metal and precious metal fractions.

CRT segregated after first level WEEE/ E-waste treatment. Refer *Figure 16(a) & (b)*. CRT is manually removed from plastic/ wooden casing. De-pressurization and Splitting: Picture tube is split and the funnel section is then lifted off the screen section and the internal metal mask can be lifted to facilitate internal phosphor coating. Different types of splitting technology used are given below:

- NiChrome hot wire cutting: A NiChrome wire or ribbon is wrapped round a CRT and electrically heated for at least 30 seconds to causes a thermal differential across the thickness of the glass. The area is then cooled (e.g., with a water-soaked sponge) to create thermal stress which results in a crack. When this is lightly tapped, the screen separates from the funnel section.
- Thermal shock: The CRT tube is subjected to localized heat followed by cold air. This creates stress at the frit line where the leaded funnel glass is joined to the unleaded panel glass and the tube comes apart.
- Laser cutting: A laser beam is focused inside and this heats up the glass. It is immediately followed by a cold water spray that cools the surface of the glass and causes it to crack along the cut line.
- Diamond wire method: In this method, a wire with a very small diameter, which is embedded with

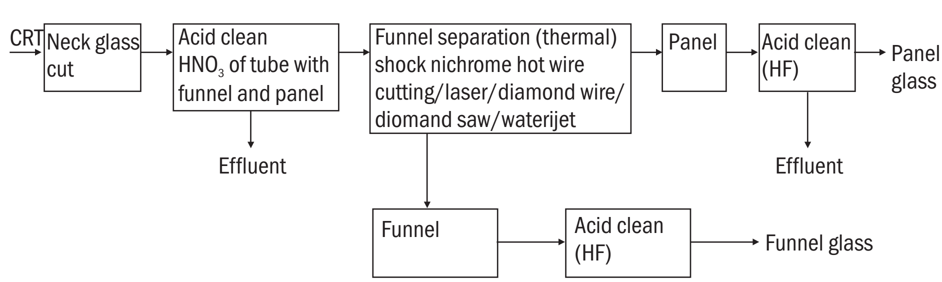


Figure 16(a): CRT treatment options used in India

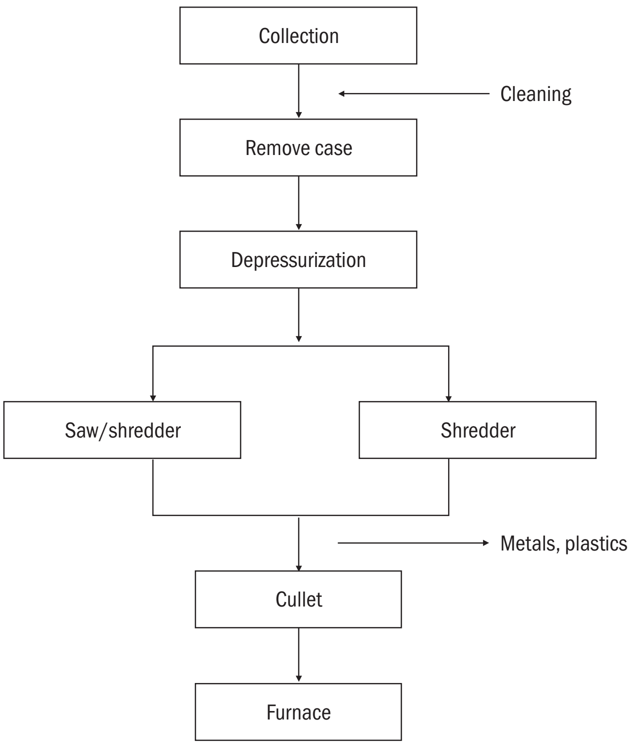


Figure 16(b): Process flow diagram for recycling of CRTs

industrial diamond is used to cut the glass as the CRT is passed through the cutting plane.

- Diamond saw separation: Diamond saw separation uses either wet or dry process. Wet saw separation involves rotating the CRT in an enclosure while one or more saw blades cut through the CRT around its entire circumference. Coolant is sprayed on to the surface of the saw blades as they cut. This is to control temperature and prevent warping.
- Water-jet separation: This technology uses a high-pressure spray of water containing abrasive, directed at the surface to be cut. The water is focused through a single or double nozzle-spraying configuration set at a specific distance.

3rd Level Treatment

The 3rd level E-waste treatment is carried out mainly to recover ferrous, nonferrous metals, plastics and other items of economic value.

Plastic Recycling

There are three different types of plastic recycling options, i.e., chemical recycling, mechanical

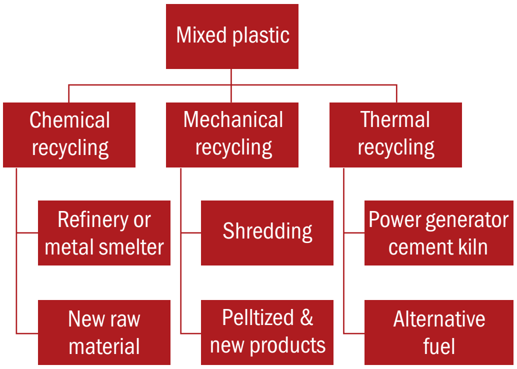


Figure 17: Mixed Plastic

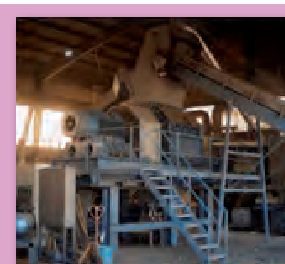
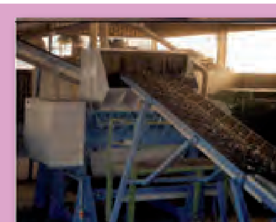
recycling and thermal recycling. Refer *Figure 17*.

In chemical recycling process, waste plastics are used as raw materials for petrochemical processes or as reluctant in a metal smelter. In mechanical recycling process, shredding and identification process is used to make new plastic product. In thermal recycling process, plastics are used as alternative fuel.

The two major types of plastic resins, which are used in electronics, are “thermosets” and “thermoplastics”. Thermosets are shredded and recycled because they cannot be re-melted and formed into new products, while thermoplastics can be re-melted and formed into new products.

Mechanical Recycling Process

Contaminated plastic such laminated or painted plastic are removed by are grinding, cryogenic method, abrasion/abrasive technique, solvent stripping method and high temperature aqueous based paint removal method. Magnetic separators are used for ferrous metals separation, while eddy current separators are used for nonferrous metals separation. Air separation system is used to separate light fractions such as paper, labels and films. Resin identification can be carried out by using a number of techniques like turboelectric separator, high speed accelerator and X-ray fluorescence spectroscopy. In hydro cyclones separation technique, plastic fractions are separated using density separation technique, which is made more effective by enhancing material wettability. In turboelectric separation technique, plastic resins are separated on the basis of surface charge transfer phenomena.

Equipment used in second level WEEE/E-waste treatment	
Shredder For size reduction into a size enabling the majority of the ferrous material to be separated from the non-ferous/insulation and plastic fraction	
Eddy Current Separator 1 For separation of the heavy mixed metal fraction	
Heavy Pre-Granulator For size reduction of the material prior to separation in the Eddy Current Separator 2	
Eddy Current Separator 2 For separation of the light mixed metal fraction	
Heavy Granulaor For final size reduction of the material	
Sepration Table For final separation of the remaining fraction into a plastic (organic) fraction and a mixed metal fraction	

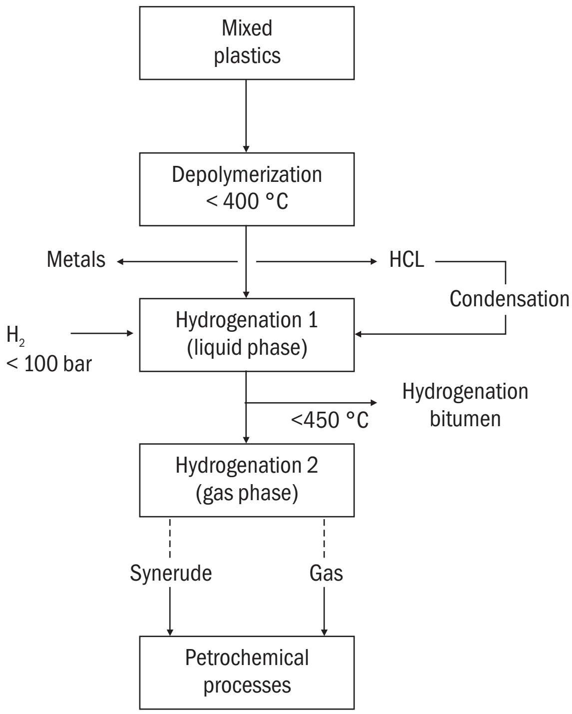


Figure 18: De-polymerization of plastics and conversion processes

Chemical Recycling Process

Chemical recycling process is shown in figure. This process was developed by the Association of Plastic Manufacturers in Europe (APME). Refer *Figure 18*.

The different steps in this process are given below.

- Mixed plastic waste is first de-polymerized at about 350–400 °C and dehalogenated (Br and Cl). This step also includes removal of metals.
- In hydrogenation unit 1, the remaining polymer chains from depolymerized unit are cracked at temperatures between 350–400 °C and hydrogenated at pressure greater than 100 bar. After hydrogenation, the liquid product is subjected to distillation and left over inert material is collected in the bottom of distillation column as residue, hydrogenation bitumen.
- In hydrogenation unit 2, high quality products like off gas and sync rude are obtained by hydro-treatment, which are sent to petrochemical process.

Thermal Recycling Process

In thermal recycling process, plastics are used as fuel for energy recovery. Since plastics have high calorific value, which is equivalent to or greater than coal, they can be combusted to produce heat energy in cement kilns. APME has found thermal recycling of plastic as the most environmentally sound option for managing WEEE/ E-waste plastic fraction.

Metals Recycling

Metals recycling has been described below in terms of lead recycling, copper recycling and precious metals recycling. After sorting of metal fractions at second level WEEE/E-waste treatment, they are sent to metal recovery facilities. These metal recovery facilities use the following processes to recover metals.

Lead Recovery

Reverberatory furnace and blast furnace are used to recover lead from WEEE/ E-waste fraction. Refer *Figure 19*. The process is shown in figure and involves the following steps:

- A reverberatory furnace is charged with lead containing materials and reductants. In this furnace, the reduction of lead compounds is carried out to produce lead bullion and slag. Lead bullion is 99.9 per cent while slag contains 60–70 per cent wt. per cent lead and a soft (pure) lead product.
- Slag in reverberatory furnace is continuously tapped onto a slag caster. It consists of a thin,

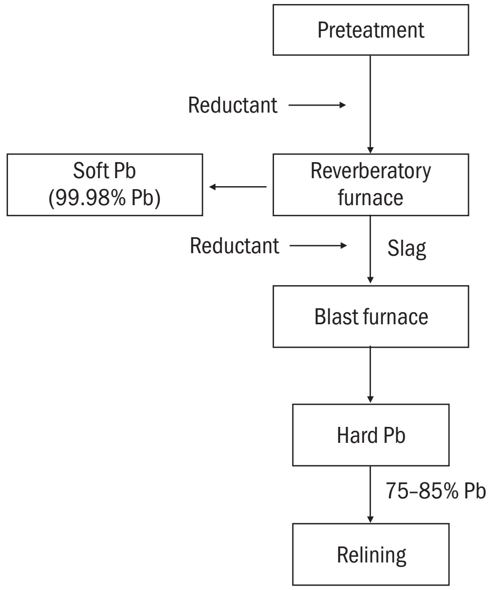


Figure 19: Processes flow for secondary lead recovery

fluid layer on top of the heavier lead layer in the furnace.

- Lead bullion is tapped from the furnace when the metal level builds up to a height that only small amounts of lead appear in the slag.
- Lead is recovered from the slag by charging it in blast furnace along with other lead containing materials and fluxing agents like iron and limestone.
- Hard lead is recovered from the blast furnace.
- Flue gas emissions from reverberatory furnace are collected by bag house and feedback into the furnace to recover lead. Slag from blast furnace is disposed of in hazardous waste landfill sites.

Precious Metals Recovery

It involves the steps shown in the flow chart. The anode slime recovered from copper electrolytic process shown in figure is used for precious metal recovery. Refer *Figure 20*. The process involves the following steps.

- Anode slime is leached by pressure.
- The leached residue is then dried and, after the addition of fluxes, smelted in a precious metals furnace. Selenium is recovered during smelting.
- The remaining material from smelter is caste into anode and undergoes electrolysis to form high-purity silver cathode and anode gold slime.
- The anode gold slime is further leached and high purity gold, palladium and platinum sludge are recovered.

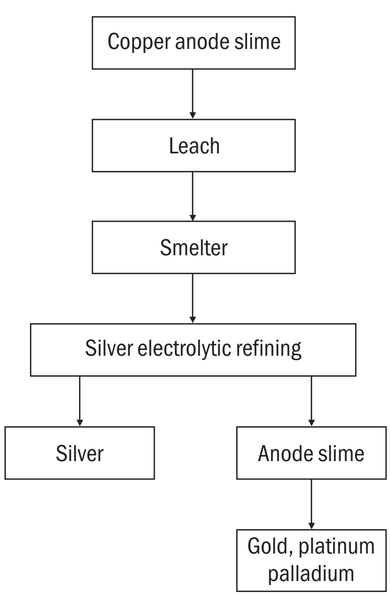


Figure 20: Precious metals recovery process

Integrated Solid Waste Management

Integrated solid waste management (ISWM) refers to the strategic approach to sustainable management of solid wastes covering all sources and all aspects such as generation, segregation, transfer, sorting, treatment, recovery and disposal in an integrated manner, with an emphasis on maximizing resource use efficiency. An effective ISWM system considers how to prevent, recycle and manage solid waste in ways that most effectively protect human health and the environment. ISWM involves evaluating local needs and conditions, and then selecting and combining the most appropriate waste management activities for those conditions. The major ISWM activities are waste prevention, recycling and composting, and combustion and disposal in properly designed, constructed, and managed landfills.

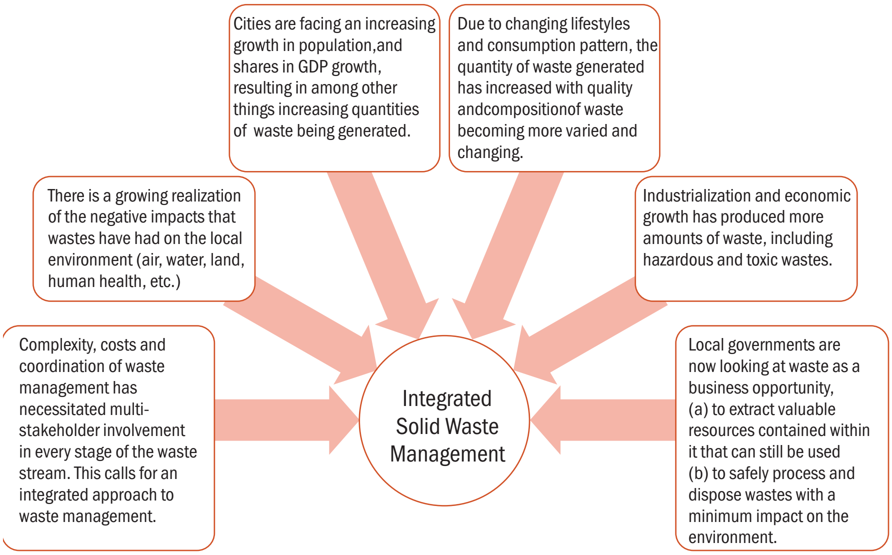
The selection of the most appropriate waste management systems and sustainable technologies is also needed to deliver an optimum and sustainable ISWM system. In combination with economic and social considerations, this approach would help waste managers to design more sustainable solid waste management systems.

Thus, for the management of solid waste, the following is the preferred hierarchy of approaches

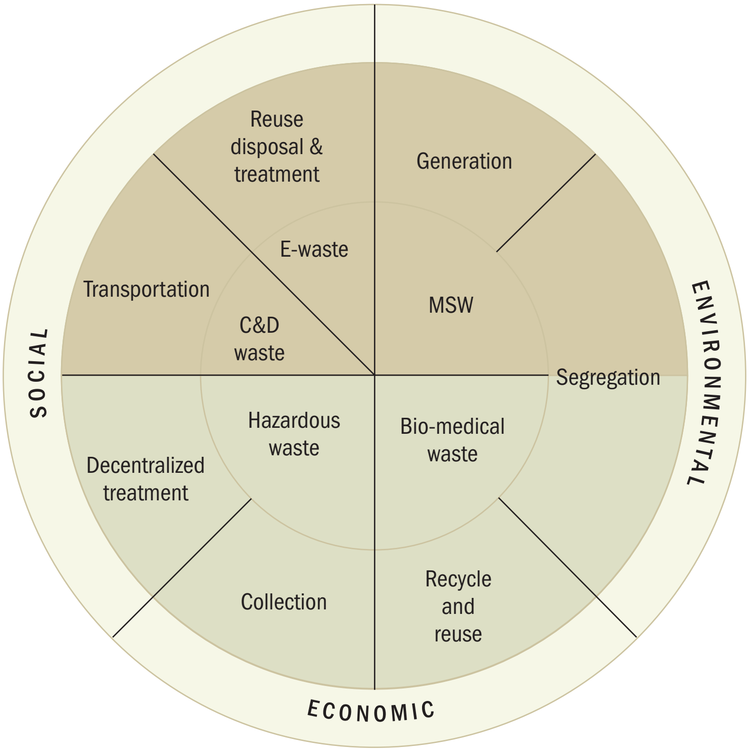
- Reduction at source: meaning incorporation of the tenets of waste management at every stage of consumption from design, manufacture, purchase, or use of materials to reduce the amount or toxicity of waste generated.
- Environmentally suitable reuse and recycling: to conserve natural resources and energy through systematic segregation, collection and reprocessing.

ISWM concept has to be adapted with a view that effective management schemes need the flexibility of design, adaptation and systems which can best meet current social, economic and environmental conditions. These are likely to change over time and vary by location.

ISWM with respect to three perspectives are lifecycle, waste generation and waste management.



Need for Integrated Solid Waste Management



Concept of Integrated Solid Waste Management

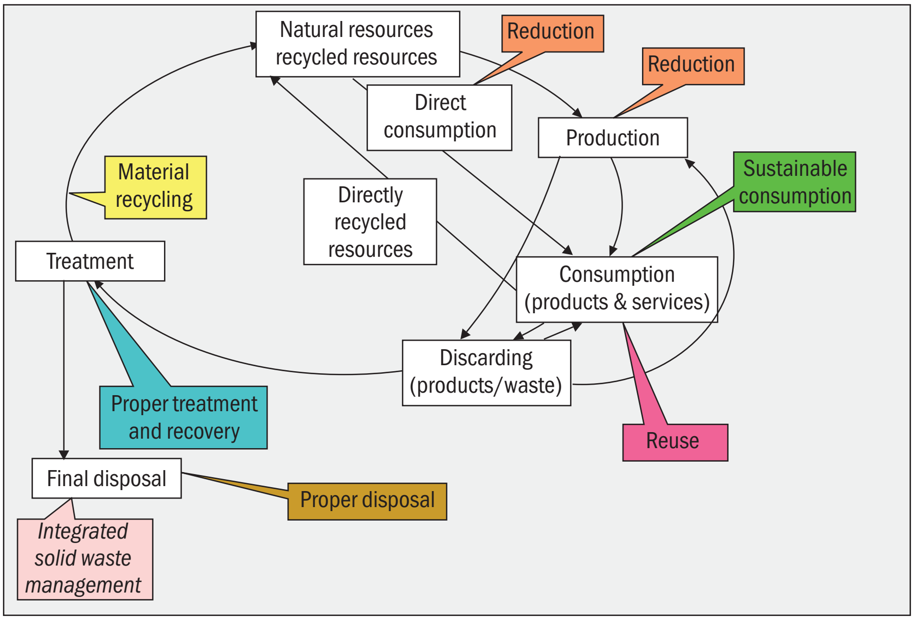


Figure 21: Lifecycle-based Integrated Solid Waste Management

Life-cycle Based Integrated Solid Waste Management

The first concept of ISWM is based on lifecycle assessment of a product from its production and consumption point of view. The reduction in consumption, and utilization of discarded products within the production system as a substitute for new resources, can lead to reduced end-of-cycle waste generation; thus, less efforts and resources would be required for the final disposal of the waste.

Generation-based Integrated Solid Waste Management

The second concept of ISWM is based on its generation from different sources including domestic, commercial, industrial and agriculture. This waste could be further classified as hazardous and non-hazardous waste. The former has to be segregated at source and treated for disposal in accordance with the strict regulations. 3R approach (reduce, reuse and recycle) is applicable both at source as well as at the different levels of solid waste management chain including collection, transportation, treatment and disposal.

Management-based Integrated Solid Waste Management

The third concept of ISWM is based on its management which includes regulations and laws, institutions, financial mechanisms, technology and infrastructure, and role of various stakeholders in the solid waste management chain.

Benefits of Integrated Solid Waste Management

- Cleaner and safe neighbourhoods
- Savings in waste management costs due to reduced levels of final waste for disposal.
- Holistic approach to all waste streams thus maximizing synergetic benefits in collection, recycling, treatment & disposal
- Maximize the opportunities for resource recovery at all stages—from generation to final disposal
- Accommodate aspirations of all stakeholders—from waste generators to waste management and service providers
- Facilitate life-cycle view of products and materials; thus, promoting greater resource use efficiency
- Integrate different response functions such as technical, managerial, financial, policy, etc.

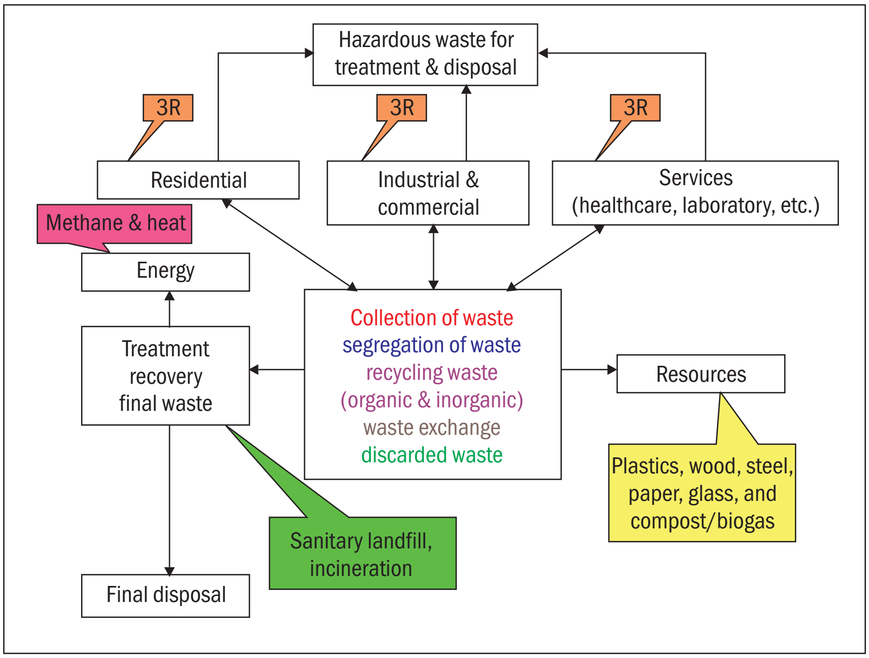


Figure 22: Generation-based Integrated Solid Waste Management

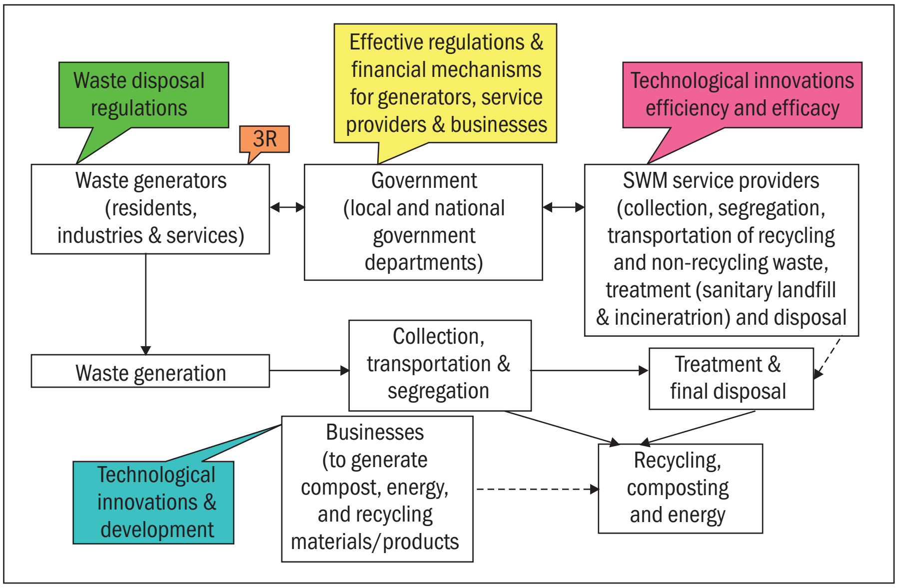


Figure 23: Management-based Integrated Solid Waste Management

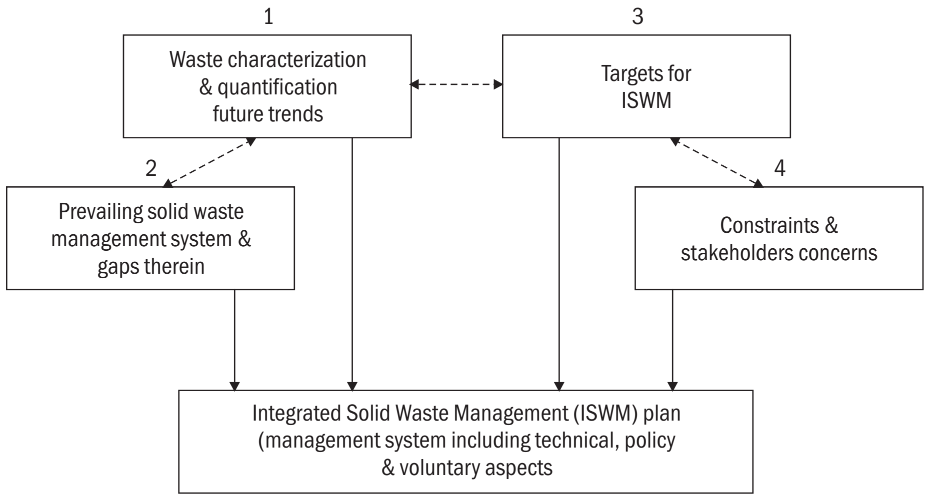
- Greater local ownership & responsibilities/ participation through a consultative approach

ISWM Plan

The objective of the ISWM plan is to develop waste management approach covering MSW, Biomedical, Industrial hazardous, Construction & Demolition (C&D) and Electronic-waste. The plans would cover all the aspects of ISWM chain including collection, segregation, transportation, recycling, treatment and disposal.

An ISWM Plan per se is a package consisting of a Management System including:

- Policies (regulatory, fiscal, etc.)
- Technologies (basic equipment and operational aspects)



Outline of ISWM Plan

- Voluntary measures (awareness raising, self-regulations)

Management System covers all aspects of waste management from waste generation through collection, transfer, transportation, sorting, treatment and disposal. Data and information on waste characterization and quantification (including future trends), and assessment of current solid waste management system for operational stages provide the basis for developing a concrete and locality-specific management system.

Elements of ISWM Plan

- Baseline data on waste characterization and quantification with future trends and baseline data on prevailing waste management systems and gaps therein.
- A list of targets to be achieved through the ISWM System.
- A Plan with details of the Management System covering policies, technologies (and voluntary measures
- Implementation Aspects such as time schedules, costs, institutional requirements, etc.
- Monitoring and feedback mechanism.

Steps for ISWM Plan

- Targets are set for each operational level (generation, collection and transportation, sorting and material recovery, treatment and resource generation, and final disposal) and for coverage and efficiency of services, as well as for efficiency of efforts and management system.
- Identification of technical, socioeconomic and policy constraints—which should be kept in mind when designing the elements of an ISWM System.
- Identifying the issues of concerns of the stakeholders: financial, social, technical and environmental—which are consider as very important to be addressed while designing the ISWM system.
- Designing the elements of the ISWM System—policies (regulatory, fiscal, etc.), technologies (basic equipment and operational strategies) and voluntary measures (awareness raising, self-regulation, etc.)—and their technical feasibility, economic viability and implementability.
- Developing an implementation strategy including financing strategy, human resources, institutional aspects and timeline (schedule of implementation).
- Developing a monitoring and feedback system for periodic feedback to improve the ISWM system and its implementation or to modify the targets.
- Developing detailed schemes based on strategic action plan.

Source: UNEP

Case Studies

Reduction of Industrial Waste Generation by Proper Handling and Management of Waste Materials

Mahindra REVA

Site of the Intervention

Bommasandra Industrial Area, MREVA Manufacturing Plant

Type of Intervention

Handling & Managing Waste Materials

Industry

Automobile

Company Profile

Mahindra Reva Electric Vehicles Private Limited, formerly known as the Reva Electric Car Company, is an Indian company based in Bangalore, involved in designing and manufacturing of compact electric vehicles. Reva was acquired by Indian conglomerate Mahindra & Mahindra in May 2010.

Business Challenge as Opportunity

Mahindra Reva strives to manage and reduce waste material generated by the plant, which would in turn cut down their environmental impact. Mahindra Reva's waste management processes aims to treat maximum amount of waste within the plant premises by segregating waste material into categories, handling scrap through proper identification, recycling and reusing leading to cost benefits and also management hazardous waste material with care to protect environment from pollution and degradation.

Strategy Employed

- Segregation of waste material into different categories
- Proper identification of scrap material
- Waste materials generated during construction was disposed off within plant premises.
- Management of hazardous waste conducted in accordance with all applicable legal other requirements.

Devising the Intervention

Mahindra Reva strives to align all processes and resources with proper handling of waste, thereby effectively reducing all forms of waste in everyday function through the medium of various waste management initiatives.

The major intervention were:

- Within the plant colour coded bins are used to segregate wastes into different categories like bio degradable, non-bio degradable, metallic and hazardous wastes.
- All scrap materials are declared as scrap material only with approval.
- All chemicals are kept in separate containers and handled separately.
- All wastes are disposed through approved waste disposal agencies.
- Records are maintained for date of scrap disposal, agency name, scrap quantity, type, etc.

Intervention Description & Business Case

Segregation of Waste Materials for Efficient Waste Management

With the help of segregation different types of wastes are categorised and managed differently. Also, proper identification of scrap, made documentation became easier. Recycled materials used reduces the cost during construction.

The cost incurred through the course of intervention is ₹15,42,000 and financial savings of ₹1,54,200 were accrued over a period of two years. Disposal of waste through approved waste disposal agencies helped in reducing the impact on the surrounding environment by preventing toxic wastes from the plant from contaminating the surrounding water bodies and endangering aquatic life.

For more information, please contact:

Chandrahasa, Mahindra Reva

Jaganur Sangamesha, Mahindra Reva; Email: Jaganur.Sangamesha@mahindrareva.com

Reduction of Industrial (Non Hazardous & Hazardous) Waste Generation

Brakes India Limited

Site of the Intervention

Sholinghur, Tamil Nadu

Type of Intervention

Alternative Use of Foundry Process Residues, Reuse Of Discard Silica Sand for Construction Activities, Reduction in Generation & Disposal of High TDS Water

Industry

Foundry (Ferrous)

Company Profile

The Foundry Division of Brakes India, located at Sholinghur in Tamil Nadu, manufactures permanent mould grey iron castings, high pressure sand moulded spheroidal graphite iron/grey iron castings/other graded castings. The castings are widely used in automotive, farm machinery and refrigeration industries.

Business Challenge as Opportunity

Brakes India Limited is one of the forefront companies in sustainability and waste management. Foundry Division has long established a robust Integrated Management System comprising of the ISO: 14001 and OHSAS: 18001 where resource conservation and waste minimization form the forefront of its objectives. Proactively addressing the reuse the process residues or materials to the most possible extent, there were a list of opportunities identified where the waste/process residues could be reused both inside and outside the factory.

Strategy Employed

- Mapping the material flow and waste generation, listing down opportunity for improvement which will improve material balance and waste handling facilities.
- Reuse of the process reject or from waste from the industry, reducing waste quantity and disposal to landfill.
- List possibilities in reusing the waste outside the premises in other processes (construction, road laying, cement manufacturing, etc.)
- Reuse of rejected water for scrubbing operation that will reduce the fresh water consumption by 1800 kL/ annum.

Devising the Intervention

The Foundry Division of Brakes India ensures the organizations growth in sustainability with respect to waste management measures are taken from relooking at the material flow and material balance of the plant including the process residues and waste. The major wastes were listed down with the present modes of handling and disposal and suggested possibilities of reuse in the other processes. Most of the interventions were planned and designed so as not to affect the existing system and operation to a major extent. By this way, the cost implication was kept in control and in few cases new installations and the process were redesigned.

The list of interventions are as follows:

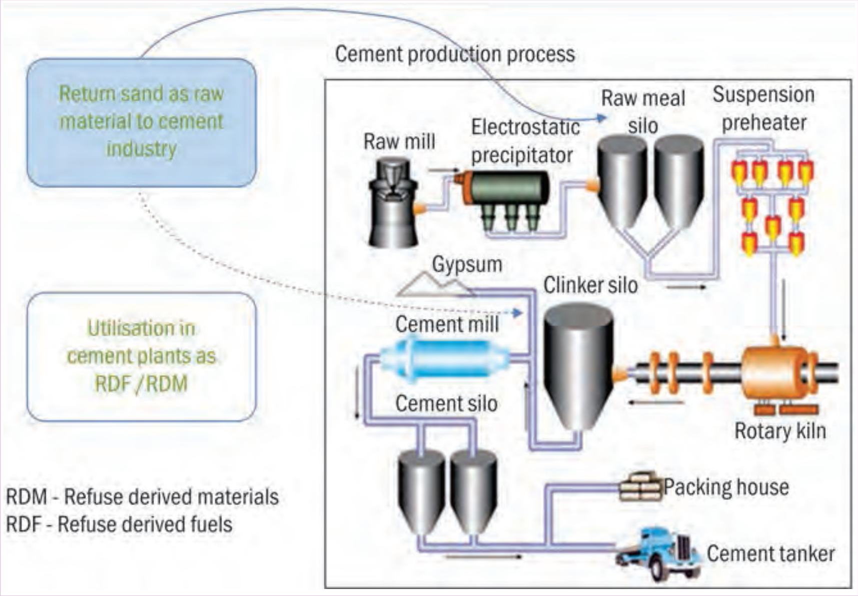
1. Use of dust collector fines in cement manufacturing as AFR/RDM.

2. Use of refuse sand for construction purposes/road laying
3. Reuse of High TDS water for scrubbing operation

All the interventions save considerable amount of fresh resource/materials required for respective processes besides improvising the waste management.

Intervention Description & Business Case

Alternative Use of Foundry Process Residues



When the sand is conveyed through the belt conveyors, a filter is used to collect the fugitive emissions at the transfer points. The material collected from these filters are "Dust Fines" which are non-hazardous in nature. These fines were disposed off to landfills with associated costs involved.

An alternative use was thought of and the use of fines in "Cement Manufacturing Process" was found to be apt and mutually beneficial. The fines collected have been analysed with the requirements of the cement manufacturing process in laboratory and was cleared to be used a raw material in the cement plants. The fines collection, storage and disposal system from the plant on to the truck has been partly automated, reducing human intervention in the process.

The dust fines are added up to an extent of 2–3 per cent in the cement mill, which saves equivalent amount of raw material that cement plants use. This was implemented on April 2013 with the total investment of ₹20 lakh. More than 300 T of fines were dispatched to various cement plants, with few other major companies to whom the trials and discussions are in various stages.

For more information, please contact:

Mr Sundaresan S, Vice President – Operations; Email: sundaresan.s@brakesindia.co.in

Reuse of Discard Silica Sand for Construction Activities

Administrative Block

X-Ray Building

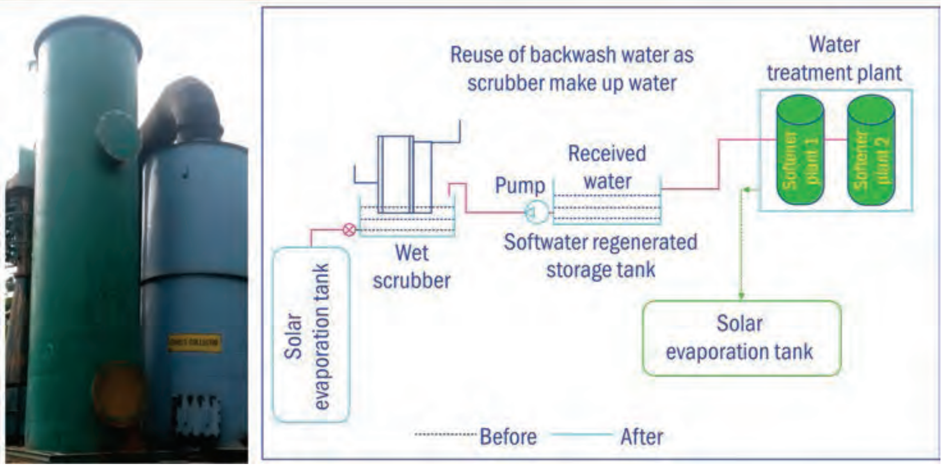
Brakes India Limited Foundry Division

The sand foundry operation discards on an average of 10 T/day of silica sand per foundry. This sand was used for construction of various buildings in the foundry and the Vidyapeetam School, MATRIX technical institute. This reduces the cost of the construction and also gives increased comfort inside the building.

For more information, please contact:

Mr M Rajendran, Manager-Civil; Email: Rajendran.m@brakesindia.co.in

Reduction in Generation and Disposal of High TDS Water



Brakes India Foundry Division Substituted waste water in place of fresh water in selected process, such as Cupola gas scrubbing. The scrubbing operation has a potential to use up to 6 kL/day of waste water in place of fresh water. The water treatment plant (WTP) in the facility has a water softening plant which is used to remove the Ca and Mg ions in the ground water. This water is primarily used for cooling systems in furnaces and other heat exchangers. During the process of water softening, huge quantity of reject water with average TDS of 5000 is rejected. This was being sent to the solar evaporation tank (No.1). The generation of soft water is done daily to cater the plant requirements.

Brakes India also operate cupola furnace which is connected with a scrubbing system. The scrubber fluid used is water, which mostly evaporates and the water after scrubbing is being collected and pumped to the solar evaporation tank (No. 2) near the unit, based on the quality checks. The total quantity of the water used for scrubbing operation was 6 kL/day.

While looking at fresh water substitution opportunities, the scrubbing fluid was selected and trials were conducted with the high TDS reject water from the water treatment plant to the wet scrubber plant. Due to the corrosive nature of both the gas and scrubbing fluid, the shell of the scrubber was replaced from Mild steel to Stainless steel to ensure longer life.

The average evaporation from the scrubber is 6 kL and the make up for the same volume is made from the reject water from the WTP, reducing the intake of fresh water required.

This Project was implemented in March 2014. The total investment of ₹7.5 lakh has the saving potential of about ₹0.65 lakh per Annum with the reduction in the quantity of the high TDS water by about 75 per cent sent to Solar evaporation tank.

For more information, please contact:

Mr Sundaresan S, Vice President – Operations; Email: sundaresan.s@brakesindia.co.in

Municipal Solid Waste and Hazardous Waste Management by Polycrack Technology & CFL Crusher

Site of the Intervention

Bangalore

Type of Intervention

Polycrack technology & CFL crusher

Industry

IT and Consulting

Company Profile

Infosys is a global leader in consulting, technology and outsourcing solutions. As a proven partner focused on building tomorrow's enterprise, Infosys enables clients in more than 30 countries to outperform the competition and stay ahead of the innovation curve. Infosys help enterprises transform and thrive in a changing world through strategic consulting, operational leadership and the co-creation of breakthrough solutions, including those in mobility, sustainability, big data and cloud computing.

Business Challenge as Opportunity

Certain categories of waste are challenging to manage due to lack of adequate treatment facilities and inappropriate disposal methods. Treating unsegregated solid waste and ensuring hazardous waste like CFLs and tube lights is being disposed in an environment friendly way, stand as a major challenge for most corporates. Infosys focuses to minimize environment impacts and derive value out of waste, through innovative technologies to find solutions for mixed waste, hazardous waste, recyclable plastic waste, etc.

CFLs contain around 3.5–6 mg of mercury per lamp. Mercury exposure has ill effects on human health, adversely affecting the central nervous system, lungs, kidneys, skin and reproductive system. Hence, it was a challenge for Infosys to dispose CFLs and tube lights in a safe and healthy manner and mitigate related carbon emissions. To counter this, the CFL crusher system were installed in Bangalore campus, the first potable crusher in this sector.

In order to extract maximum value from waste Infosys identified significant opportunity in treating municipal solid waste using Polycrack Technology. This technology produces valuable by products that can be used as alternative sources of fuels for industrial and other purposes.

Strategy Employed

Polycrack Technology

Advantage

- Reduces waste going to landfills
- Minimizes emissions from waste
- Produces reusable products from waste- oil, gas and char
- Oil can be used in furnace burners and boilers
- Further refinement of oil to separate kerosene, petrol, and diesel
- Gas can be used as fuel
- Char can be used as soil conditioner

Disadvantages

- Char produced from waste treatment contains impurities and requires further processing for reuse.
- The catalyst in polycrack needs to be replaced after three batches of recycling.

CFL crusher

Advantage

- Recycles more than 99 per cent hazardous mercury vapours in CFLs and tube lights
- Prevents intoxication of air, water and soil by mercury
- Minimizes the adverse health effects caused due to mercury exposure
- Portable equipment

Devising the Intervention

Polycrack technology converts municipal solid waste into products like gas, char and oil that can be reused for varied purposes. This technology differs from other pyrolysis technologies in multiple unique ways. For example, it has the ability to process both segregated and unsegregated municipal solid waste and process composite non-recyclable materials such as biscuit, chips wrappers, etc. It also makes the separation of metal from input feed convenient as the operating temperature does not exceed 400 °C. Waste is converted into valuable products which can be further utilized for fuelling vehicles, heating, in boilers, etc., adding value to waste.

CFL crushers separate hazardous mercury from CFLs and tube lights which have inherent adverse effects if not disposed cautiously. They are often damaged during transportation and their breakage leads to the release of mercury vapour into the atmosphere, which is highly toxic and may prove to cause severe health and environment damages. The CFL crusher is a portable equipment which can be installed in decentralized facilities, thus reducing the risk of release of mercury during transport. This technology has the ability to erode the ill-effects caused due to mercury contamination and in turn reduce the greenhouse gas emissions (GHG) emissions. This is one of the first portable crusher installed in this sector.

The main purpose of implementing these novel technologies is to eliminate the harmful environmental damages caused due to disposing waste unscientifically, minimize our carbon emissions and ensure a healthy environment for all.

Intervention Description & Business Case

Polycrack & CFL Crusher for Municipal Solid Waste

Polycrack technology

The Polycrack technology is used to convert waste such as plastics, rubber, composites, biomass and other municipal solid wastes into usable forms such as oil, gas and char. This is a 100 kg per day capacity processing unit and has two reactors of 50 kg capacity each.

Waste is fed into the reactors and is heated by induction using electricity. Temperature is slowly increased from room temperature to about 400° over a period of 3–4 hours. The waste in the reactors vapourizes and passes through a catalyst which performs the function of cracking the molecular chains, scrubbing elements such as chlorine, sulphur, etc. and recombines them to form hydrocarbon chains. The vapour then passes through a condenser where heavier fraction condenses to form oil, the lighter fraction comes out as gas.

CFL Crusher

Polycrack

After the process is complete and the reactor cools down, char is obtained from the reactor. Since the process temperature doesn't exceed 400°, metals in the waste don't melt and are obtained along with the char in the reactor.

The char produced can be used as a soil conditioner or can be activated further to form activated carbon. The by-product oil can be used as furnace oil or in boilers and can also be refined further to separate fractions of petrol, kerosene and diesel. Gas also has a hydrocarbon composition and can be used as a fuel. In larger units, this can be used back in the system for heating purposes.

CFL crusher

CFL crusher is used to separate hazardous materials that are present mainly in the form of mercury in CFLs and tube lights. Mercury has a low vapour pressure of 2 x 10–3 mm (at 25 °C) and readily vapourizes at room temperature. Mercury emissions in liquid and vapour can cause serious environmental and health hazards. Mercury toxicity is known to cause several disorders related to nervous system, respiratory tract, skin and eyes.

The CFL crusher consists of a motor fitted with chains mounted on a GI (Galvanized Iron) drum. When the equipment is turned on, the motor rotates at high speeds and creates a vacuum. Inlets for feeding tube lights and CFLs are separate.

The tube lights and CFLs are crushed by the rotating chains and hazardous mercury vapour that is released is sucked under vacuum into a bag filter, then into a HEPA filter, and lastly by an activated carbon filter. In the first stage, about 99 per cent of the dust and larger particles from air are removed. In the second stage, the remaining small particles are filtered out and then the mercury vapours are adsorbed by the activated carbon. The crushed materials such as glass, plastic and metal are collected in the drum which can be treated and recycled separately. The mercury that is adsorbed on the filters can be recovered and recycled. Thus, this system ensures complete recycling of the hazardous components in the CFLs and tube lights.

Cost of Polycrack Technology machine is ₹15 lakh and CFL Crusher is ₹6.27 lakh. Saving occurred from the project considering output of waste treatment by polycrack technology (Using 10 kgs of hard plastics as input waste feed):

Oil (4 kg) = ₹140 (Considering 35 ₹ Per litre)

Gas (3 kg) = ₹225 (Considering ₹75 per kg)

Carbon (3 kg) = ₹30 (Considering ₹10 per kg)

Infosys' efforts in waste management are helping us divert considerable amount of waste from landfills leading to reduced cost of transportation as well as carbon emission mitigation, also minimizing the environmental impacts like land degradation, air pollution, groundwater contamination, etc., caused due to the leachate that is generated from the garbage dump.

Treating waste by polycrack technology generates valuable by-products that can be reused for other purposes adding value to waste. Adverse health and environment impacts due to mercury exposure from CFLs and tube lights are being eliminated with the help of the CFL crusher technology. Hence, our initiatives are ensuring better health, improved environment and an enhanced quality of life to the people.

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E-Waste Management—Take Back & Recycling

Site of the Intervention

Pan India

Type of Intervention

Take Back & Recycling

Industry

Telecommunication

Company Profile

Founded in 1975, Microsoft (Nasdaq "MSFT") is the worldwide leader in software, services, devices and solutions that help people and businesses realize their full potential. The Microsoft Devices Group includes award-winning hardware used by over a billion people around the world, including Lumia smartphones and tablets, Nokia mobile phones, Xbox hardware, Surface, Perceptive Pixel products and accessories.

Business Challenge as Opportunity

E-waste is one of the most significant and exponentially growing waste streams across the world. Recycling as a concept is still not very well understood in India amongst the masses. The term often gets confused with reuse.

Nokia's Global Research (first conducted in 2007 and then repeated) reveals that:

- 44 per cent of old mobile phones are lying in drawers at home and not being recycled
- only 3 per cent of the people around the world recycle their old mobile phones

The major challenge in India with regards to e-waste recycling is that consumers do not completely understand the term recycling and even if they do, they do not associate recycling with mobile phones. Moreover, there is an intrinsic attitude of clinging to old/unused items and storing them in closets because of emotional attachment. Hence, the major issue today is to spread awareness on the benefits of recycling and the good it does to our environment and bring about a behavioural change in the consumers.

With over 1.3 billion customers using Nokia devices, Microsoft Mobile Oy (erstwhile Nokia) believe that they are in a unique position to effect positive environmental and social change around the world. Microsoft Mobile Oy intends to go beyond managing the life-cycle environmental and social impacts of the products and leverage their global reach, brand trust, local presence and mobile technology expertise to engage and enrol people to adopt greener and sustainable lifestyles.

Strategy Employed

- The largest mobile phone recycling scheme through robust Take Back campaigns established in 2009
- Campaign aims of driving behavioral changes amongst consumers and educating mobile phone users on importance of recycling.
- Presently, take back initiatives have a 360° approach targeting different sections of the society , with 900 collection points are set up across India and have launched a number of take back and awareness campaigns.
- The old mobile phones and accessories collected from these Collection Points are sent to Tamil Nadu Pollution Control Board authorized recycler for dismantling and recycling.

Devising the Intervention

Nokia staff members take the environment into account in all operations and in products they make, starting from the selection of materials and ending with a globally leading take-back and recycling programme.

Nokia ensures the highest standard across operations, taking the legal requirement as the minimum starting point. Also, they strive to minimize the environmental impact of their products, solutions, and operations, and collaborate with suppliers to improve the environmental performance of our supply chain.

With a user base of more than one billion people, gives them a unique opportunity to have an impact that goes beyond their activities. Nokia aim to offer people products and solutions that help them make sustainable choices and reduce their own environmental footprint.

Intervention Description & Business Case

In India, Nokia (now Microsoft Mobile Oy) started its take-back and recycling activities in 2009 and running over 1000 recycling points at Care Centres and retail outlets. People can drop old phones and accessories of any brand at Nokia recycling points. First Take Back awareness campaign started in 4 cities in January 2009 encouraging consumers to drop their unused mobile phones, chargers and accessories in to recycling bins placed at any of the Nokia Care Centres or Priority Stores.

The response to the Take-back campaign has been extremely positive since the start in 2009. During the first 45 days of the campaign in 2009, we collected 3 tonnes of old phones and batteries for recycling. Nokia has collected over 170 tonnes of old mobile phones and accessories since the start of the programme. In 2013 alone, approx. collection of 10 tonnes of e-waste was achieved through take-back programmes. This campaign evolved with time across multiple phases. In 2010, “Planet Ke Rakhwale” campaign which featured Shahrukh Khan in TV, print and radio commercials aimed at inspiring young minds to spread the recycling message. As part of the campaign, Nokia promised to plant a tree for every handset dropped in the recycle bin. So far, Nokia had planted and taken care of 100,000+ tress in partnership with 5 NGOs as a part of this campaign. Recycling initiatives include:

Take back and recycling Campaign from Nokia-owned Channels – With the aim to increase consumer awareness on recycling, offer superior recycling in all markets and promote the recycling of used devices through specific initiatives and campaigns. The backbone of Nokia’s take-back programmes are the collection points of used devices in 5000 Nokia care centres in more than 85 countries. In India, Nokia has over 1000 collection points. Collection points are Nokia Priority Stores and Care Centres where secured recycle bins are placed for people to drop their old phones and accessories for recycling. To extend mobile phone recycling programme beyond Care and Retail Stores efforts were made to engage with people who have access to, handle and manage most amount of e-waste from phones.

Take back and recycling

Responsible Recycling with Informal Sector (Kabadiwalas) – In India, 90 per cent of e-waste finds its way to the informal recyclers (via kabadiwalas) whose recycling practices are very rudimentary, highly unsafe and cause severe environmental contamination. In Delhi NCR, a pilot project was started with a Delhi based NGO – Chintan Environmental Action and Research Group, to leverage the reach/collection strength of the *kabadiwalas* (the informal sector) and the recycling technology of responsible recyclers. Nokia and NGO partner trained waste collectors (*kabadiwals*) and are reaching out to a larger number of households via these waste collectors. To further establish responsible recycling, Nokia partnered with GIZ in 2013 for a two-year public-private partnership programme. The initiative aims at setting up an engagement with the informal sector waste collectors in Ahmedabad (Gujarat) and Kolkata (West Bengal).

Recycling Engagement with Small Retail/Repair Shops

A very significant number of old mobile phones after going through multiple ownership end up in small repair stores across the country who have very little knowledge on e-waste management. Nokia started a programme in 2011 in partnership with Humana People to People India to reach out to such stores, educate them on e-waste issues and provide them an access to responsible recycling. The enrolment made were over 6000 stores in 25 cities/towns under this programme. Each of these enrolled stores takes responsibility of engaging with their neighbourhood/network mobile phone stores and channel their e-waste to a responsible recycler via us. In the first year of the programme over 50,000 old mobile phones and accessories were recycled.

Viral Campaign

Viral Campaign: Nokia initiated a viral campaign to raise awareness on mobile phone recycling and encourage action via Social Media Engagement, with the aim to engage people via 3 viral movies on YouTube, Facebook and a twitter campaign.

Planet ke Rakhwaale School Programme: This programme, started with 15 schools in Delhi in July 2010, has now reached to over 3000 schools in 25 cities across 14 states. Activity based learning and self-discovery methods involving gamification, arts, etc., to engage with student and create awareness on different environmental issues with special focus on e-waste management. Also, Nokia tied-up with locally trusted NGOs and build their capacities to run this programme. Students are enrolled to discuss ways of greening lifestyles with their parents & neighbours and are encourages to recycle their old mobile phones and accessories. The programme has reached out to over 10,000 teachers, 1,50,000 children directly and over 1 million students indirectly.

Bano Planet Ke Rakhwaale

Create to Inspire School Programme: Launched in Delhi in July 2013 in partnership with the Department of Environment, Government of NCT of Delhi and GIZ. The programme is an out-of-the-box initiative aimed at building environmental leadership in teachers and students. The programme provides a framework for teachers, along with students, to build and run creative environmental campaigns/programmes on the themes of Energy, E-waste, Transportation, Water and Bio-diversity. Via campaigns, students enrol and inspire their peers, parents, relatives and people in their colonies, communities and markets to question existing consumption patterns and take steps towards practicing sustainable living.

Create to Inspire School Programme

Under this initiative, Nokia engaged with teachers and students from 150+ schools from Delhi for a period of 6 months. Teachers were trained and provided with a toolkit to guide and assist teachers with materials that can make them a harbinger of awareness and change. The toolkit comprises of a set of 15 activities on a range of topic related to environment. The activities done by schools ranged from running environmental competitions, creating short environmental films, conducting street plays, engaging with local shops, conducting waste/water/energy audits, and driving e-waste collection. The programme was completed in December 2013. Further it was decided to scale up the programme to 1500 schools in 2014. The Department of Environment, Government of NCT of Delhi has agreed to partner with Nokia (now Microsoft Mobile Oy) for the Delhi - 2014 phase.

The environmental benefits of recycling are immense from reducing carbon footprints to ensuring conversation of natural resources.

If every mobile phone user across the world recycled just one unwanted phone at the end of its life, it could prevent nearly 240,000 tonnes of raw materials from being mined and result in saving energy & reducing greenhouse gases by as much as taking 4 million cars off road for a year.

Environmental benefits from our various programmes are provided below:

Take Back and Recycling from Nokia Owned Channels:

Total quantity of e-waste collected and recycled

- Since 2009: 460 tonnes
- In 2013 alone: 59 tonnes

Responsible Recycling with Informal Sector (Kabadiwalas):

- Over 6000 stores from 25 cities/towns have been enrolled under this programme. Each of these enrolled stores takes responsibility of engaging with their neighbourhood or network mobile phone stores and channel their e-waste to a responsible recycler via us.
- We recycled over 200,000 old mobile phones and accessories

Planet ke Rakhwaale and Create to Inspire School Programme:

- Over the last three years, this school programme in various avatars has reached out to 3000+ schools in more than 25 cities across India
- Worked with over 8,000 teachers
- Engaged and inspired over 650,000 students

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E-Waste & Hazardous Management

RICOH

Site of the Intervention

Pan India

Type of Intervention

Reduce, Reuse & Recycle

Industry

IT

Company Profile

Ricoh is a global technology company specializing in office imaging equipment, production print solutions, document management systems and IT services. Headquartered in Tokyo, Ricoh Group operates in about 200 countries and regions.

Business Challenge as Opportunity

More than 300 k empty toner bottles used on Ricoh photocopier are going to landfill every year through unauthorized recyclers. It is also estimated that 30 per cent of these empty bottles are refilled with spurious toner by local vendors.

The ink & toner used in the cartridges as well as the plastic that is used to create the outside of the cartridge contains toxic chemical. These are dangerous to human health & environment & hence have been classified as hazardous.

Strategy Employed

Ensuring toner bottle pickups from the customer premises utilizing our resources. Based on the quality check done, almost 60 per cent of the toner bottles get refilled using state of the art technology. The balance toner bottles are safely disposed off through authorized recycling partners.

Devising the Intervention

Ricoh is commitment to reduce environmental impact and hence as a responsible corporate, ensures the toner bottle pick up from the customer premises and its safe disposal by authorized recycler to avoid environmental and health implications of failing to do so. Ricoh uses its own resources for the pickups to local offices and further transport it to the authorized recyclers.

In this process customers & channel partners are encouraged to get involved in the programme and hence, contribute towards environmental conservation.

Intervention Description & Business Case

To overcome the effect of e-waste generated by its products & services, Ricoh takes measures right from the beginning by designing environment friendly products-using environment efficient materials at production at factory to safe toner refilling. Further customers are encouraged to use green products & services and contribute in the proper disposal of the machines & toner bottles. In this drive, Ricoh facilitates Collection of empty toner bottles from customers through Meter readers, Service engineers and delivery boys directly as well as through channel partners. These collected Toner bottles are transported to facility at Gandhinagar where quality check is done.

Total investment of ₹1 crore were made over 3 years which led to the savings of about ₹35 lakh. As 60 per cent of tonner bottles were refilled that saved 81 K kg of plastic from going to landfill and cost & resources for the manufacture of same.

The project benefited the environment and people from the harmful effect of hazardous e-waste, contributed to restrict the supply of empty toner bottles to spurious toner vendors and improve business of genuine supplies and lastly it engaged customers and business partners in the programme that helped them become environmental conscious.

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Integrated Municipal Solid Waste Management

LAVASA

Site of the Intervention

Lavasa, Pune

Type of Intervention

Integrated Municipal Solid Waste

Industry

Construction

Company Profile

Lavasa Corporation Limited (LCL) is a city development and management enterprise involved in the development, construction and management of Lavasa, a private hill station development project in India. Once complete, the city will house residential, institutional, recreational, educational and tourist facilities. LCL's objective is to develop the hill city into a sustainable city which offers world-class facilities and infrastructure in a sustainable manner.

Business Challenge as Opportunity

The Waste Management at Lavasa is based on the Municipal Solid Waste (MSW) Rules – 2000, the Bio Medical Waste Rules 1998, revised up to 2003 and Hazardous wastes (Management, Handling and Transboundary movement) Rules in 2008. Integrated Municipal Solid Waste Management (MSWM) is based on power sweeping of roads & public areas, collection & transfer of MSW, and public awareness among citizens for garbage handling at source. Managing MSW from door to door/point to point at the point of generation and transportation of the same to the processing site (SWM treatment Facility) and disposal of rejects & residues at sanitary engineered landfill site is the challenge. Till the sanitary landfill site is sanctioned and constructed, the recyclable waste is being disposed off through MPCB authorized agency.

In case of BMW Rules 1998, revised up to year 2003, the Generator/Occupier of the medical facility are directly responsible for implementation of the BMW Rules 1998/revised up to 2003 and local authority or developing agency has to monitor that BMW does not get mixed with MSW and help the BMW generators in discharging their duty of disposal of the BMW. CMS, Lavasa is playing the same role for BMW management.

Managing International standard HDPE Bins, colour code for respective type of waste are in Lavasa which are closed, aesthetically acceptable, user friendly and have easy access and waste is segregated at source by generator as biodegradable, recyclable, debris & construction waste and green waste as per the mandate of MSW (M & H) 2000. Collection of construction waste is on demand service. Garbage bags not less than 50 micron thicknesses of respective colour are placed in bins. Multi handling of waste is avoided and covered vehicle is used for collection of waste so that waste is neither visible to public nor open to environment and waste does not litter even during collection & transportation. Thus, the entire policy is extremely environment friendly.

Strategy Employed

- Dedicated garbage collection vehicles collecting garbage according to a definite collection schedule. Two bin system is introduced in Lavasa.
- Garbage collection is monitored or ensured – checklist in each vehicle counter signed by the security or housekeeping in-charge of the garbage collection point.

- Information about delays or change in the garbage collection schedule sent to citizens through Citizen Contact Centre.
- Regularized mechanical road sweeping on all black top roads with wet scrubbers to avoid dust.
- Online request processing for collection of construction debris.
- Regular housekeeping of public spaces, water body and ravines.
- Intermediate hazardous waste & e-waste collection cum storage centers to help citizens to dispose of their wastes according to mandatory eco-friendly ways.

Devising the Intervention

For overall cleanness & to reduce landfill sites, integrated solid waste management has been incorporated at Lavasa that will save lot of money and time and will produce a good quality of organic manure.

Intervention Description & Business Case

Segregation of Garbage at Source

Segregation is achieved by the two-bin system in multi-storey apartments and three compartment stainless steel bins in Villas.

Two- Bin System

The housekeeping attendant of the respective multi-storey apartment collects garbage – wet in green garbage bag and dry in black garbage bag from the Residents. The garbage bags are of the size 1000 mm x 1000 mm and thickness not < 50 μ. After collection the housekeeping attendant places the wet (green bag) and dry (black bag) garbage into green garbage bin and blue garbage bin respectively.

In villas, the resident places the wet garbage (contained in a plastic liner) in the litterbin compartment designated (stickered) as ***food / wet waste*** and dry garbage in the compartment designated as ***Dry waste***. Other wastes like batteries, outdated medicines, etc., are placed in the litterbin compartment designated as ***other wastes***.

Public awareness programmes for Garbage segregation at source

Public awareness programmes are conducted for the housekeeping teams of both residential entities and commercial establishments, village shops, labour colonies once in a month. The Solid Waste Management (SWM) officer coordinates with the housekeeping in charge and the date and time of the awareness programme is decided. According to the schedule the residents and the shop owners are informed to attend. The awareness programme is more of an interactive programme than a mere lecture. Live demonstrations of segregations are shown to each participant.

Garbage Segregation checks

After successful public awareness programmes, validating the results of the programmes is an essential task. This is achieved through intermittent checks for effective garbage segregation at source.

For instance, the garbage segregation check is carried out by the SWM officer at different garbage collection points and feed back is given to the manager of the commercial establishment.

Collection of Garbage

Continuous Composter (IVT)

Garbage collector picks up the garbage bags from the designated collection point and puts the garbage bags containing waste into the garbage collection vehicle. The security guard on duty ensures that the garbage is being picked up by the garbage collection vehicle and logs it in his/her register and confirms it by affixing his/her signature in the register of pick-ups with the driver of the garbage collection vehicle.

All the garbage collected by the garbage collector is put into the garbage collection vehicle and sent to SWM facility for further processing. Wet/food waste (in green bags) is converted into useful manure by the SWM facility (OWC & In vessel technology machines) and the dry/recyclable waste (in black bags) is segregated into paper, plastics, glass, metal etc. and placed in the designated place/point in the SWM facility. Litter is picked up on the road side and public area on daily basis and the waste is segregated into wet and dry in separate designated bins.

Solid Waste Treatment

Organic Waste Converter

Presently Lavasa is using Organic waste Converter (OWC) and Continuous Composting machine (In-vessel Technology) for processing bio-degradable waste. The OWC set-up contains mainly an OWC machine, double shredder machine and curing rack system.

The end product is stabilized organic manure which can be used for application to plants or any other mode of usage of manure in agriculture. Thus, the entire process is extremely environment friendly.

The organic manure is analyzed once in a quarter to ensure the nutrient availability and is free from contaminants according to the MSW (M&H) rules 2000.

Transportation of Recyclables

Recyclables are further segregated into papers, plastics, glass, metals, etc., at designated points in the SWM facility. The recyclables sent to Pune through a MPCB authorized agency.

Organic waste converter costs ₹18.25 lakh & Continuous Composting machine (In-vessel Technology) ₹15.77 lakh. Out of the total waste generated approx. 10 per cent of the waste is inert. Rest all waste generated are used at the site. Further manure is generated at the OWC which is used for the city itself and the recycler are not charged for collecting the recycled waste at the site. Waste generated in the last three Years:

Sl No	Waste Type	Method of disposal	Units	2010–11	2011–12	2012–13
1	Steel scrap	Recycling	tonnes	240	252	0
2	Empty cement bags	Recycling	MT	19	0	10
3	Construction debris	Landfilling	MT	952	258	0
4	Bio degradable waste	Composting	MT	430	764	616

5	Recyclable waste	Recycling	MT	279	245	377
6	Inert Waste	Landfilling	MT	100	120	85

With this intervention 10 per cent of the waste is left, which decreases the use of land at site there by reducing carbon sequestration. Practices followed help to segregate waste at source and improved collection efficiency. Regular housekeeping measures kept the place clean and unwanted insects like mosquitos are controlled.

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Great Giant Pineapple: Soil Health Management

ibcsd

Site of the Intervention

Jakarta

Type of Intervention

PT Great Giant Pineapple

Industry

Integrated Pineapple Plantation and Pineapple Cannery

The Business Case

GGP has emerged as the fastest growing producer in the pineapple Industry, supplying 14 per cent for Canned Pineapple & 4 per cent for Pineapple Juice Concentrate of global demand from the plantation in Lampung, with an integrated operation in 32,000 Ha of land (divided in 2 locations: 20,000 Ha and 12,000 Ha).

GGP have already implemented green practices for over 20 years.

The Issue

In their business, GGP aware that they have to cope with several challenges such as the world demand or requirement on sustainability, climate change and high dependency on environmental carrying capacity, as well as the customer requirement on green products, development of government regulations or requirements on sustainability and environmental aspect by customers, communities and NGOs, development or changes of social aspects or communities around the company, and efficiencies where in some cases, sustainability can help to achieve efficiencies.

The Response

GGP's pursuit of sustainability is to balance and continuously improve the three elements of our performance, which are economic, environment and social.

As the response to the challenges, GGP develops a Commitment to Agriculture Sustainability Farming scoping the production yield, GHG emission reduction, soil health and environmental issues which was driven by:

1. Waste to Worth Initiative

   - Biogas - The large amount of waste water from pineapple and tapioca factory requires a sizeable land to treat the waste and meet government environmental standard. Converting into biogas as renewable energy can help company reduce 100 per cent of HFO in tapioca drying and 7 per cent of Coal use in power plant. This initiative is also reducing the GHG by approx. 40,000 tonne CO_2 eq.

- Compost – Cattle dung if not treated can become an environmental issues and polluting public rivers. Through composting initiative cattle dung can become a nutritious fertilizer that help plant grows better and reducing chemicals fertilizers use in plantation.

2. Soil Fertility – As the result of long-term application of chemical fertilizer soil fertility become degraded and cannot sustain the agriculture farming. Soil biodiversity, chemicals and physical structure are affected. Along with compost, company has built and produces Organic Fertilizer in Liquid form (called Liquid Organic Fertilizer -LOB). This fertilizer consists of rhizo-bacteria that help plant to uptake nutrients from soil and also produce *phyto-hormones* which is very useful to plant growth.

GGP applies modern agriculture rather than traditional and green agriculture, which is understood as the practice of farming using principles of ecology to increase biological, physic and chemistry quality of soil with integrated and closed cycle approaches. The closed cycle approaches can generate nearly Zero Waste where the solid waste is used to feed the cattle and the manure from cattle is used as organic fertilizer.

The objectives from applying Good Practices Agriculture are:

1. Achieving High Yield, Reducing Waste
2. Comply with Environmental Regulations and Customer Requirements
3. Participate to Global Warming Prevention by Reducing Green House Gases Emission

GGP also set their goal to improve and sustain plantation production yield, reducing chemical fertilizer use, and for better environmental management with objective in 2018 to reduce 30 per cent non-renewable energy, reduce 40 per cent of chemical fertilizers, and in 2020 to increase plantation yield 50 per cent.

Activities

GGP works on waste to energy programme, renewable energy and clean development management; underground water consumption is reduced and replaced with surface water and also social responsibility programme.

To achieve their energy reduction objectives, in 2011 a biogas plant was constructed followed by composting plant that was constructed in 2013 and the last but not least is the Liquid Organic Bio Fertilizer that was constructed in 2012 and was expanded in 2013.

As part of Good Agriculture practices for Sustainable Agriculture, the farming uses principles of ecology. It uses bio fertilizer and organic fertilizer application as well as the biological or organic pest controller, nutrient conservation, soil conditioner, plant rotation and nutrient storage.

Papaya farmers and tapioca farmers are involved in alliance to produce more and improve their income.

The Results

As result of the initiative are:

1. Reduction of 100 per cent HFO in tapioca drying and 7 per cent coal in power plant.
2. Maintain or improve soil health and fertility.
   - Improve soil structure will make better roots development.
   - Increasing cation exchange capacity will make better nutrient uptake.
   - Increasing water holding capacity will make better water availability in the soil during dry season.
   - Increasing biodiversity in the soil

- Increasing nutrients for the plant in the soil
- Reduce chemical fertilizers

It is expected that farmers in Lampung and GGP can get the benefit from this activities through better production output. Improved environmental standard compare to business as usual is believe will make the business more sustain.

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Waste Management

Site of the Intervention

Jakarta

Type of Intervention

PT Great Giant Pineapple

Industry

Integrated Pineapple Plantation and Pineapple Cannery

The Business Case

Great Giant Pineapple (GGP) was established in 1979 and is located in Lampung, South Sumatra, Indonesia. GGP has a total of approx. 31.000 ha of land and planting pineapple and others rotation crop. It has 5 major plants for cannery, can making and drum, labeling, juice concentrate, and can process 2,000 tonnes of fresh pineapples each day. The annual pineapple harvest is more than 500,000 tonnes of pineapples annually, making it the third largest producer of canned pineapple products and pineapple juice concentrate in the world.

The company's primary products are canned pineapples, pineapple juice concentrate and canned tropical fruit salad. All of Great Giant Pineapple's products are exported to over 50 countries in Asia Pacific, North America, South America, Middle East and Europe. GGP promotes its self with the motto “The Green Company”.

The Issue

GGP is aware that the agriculture business of their scale generates massive amount of waste, but on the other hand, they have to maintain and fulfill world demand on sustainable and green agricultural products. Another challenge for GGP is that they should have a role of reducing the factors that promotes climate change and impact toward the surrounding environment as required by the government regulations, NGOs, customers and communities.

The Response

GGP has already practiced green agriculture for more than 20 years, and their pursuit of sustainability is to balance and continuously improve the three elements of their performance which are social, economic and environment, following the Triple Bottom Line Approach that focused on people, planet and profit. GGP has a fully integrated operation, where they are involved from the development of improved seed varieties, through cultivation, harvesting, processing and packaging, to final shipment of the finished product. This integration gives GGP an edge in quality control and traceability of products, and environmental sustainability through synergy in waste management. GGP’s plan is the “magic formula” ratio 30:40:50, which are decreasing fossil fuel usage by 30 per cent by replacing it with renewable energy, decreasing the use of inorganic fertilizer by 40 per cent, and increase the quality and yield by 50 per cent.

Activities

Sustainable Agriculture can be done by changing agriculture practice used in traditional agriculture and green revolution to modern agriculture. According to the World Wildlife Fund (WWF) Indonesia, as one of the world's largest fully integrated pineapple plantations and processing facilities, PT Great Giant Pineapple (GGP), in Terbanggi Besar, Central Lampung, is the only company in the country to have applied the "Blue Economy" initiative, which generates profit by being environmentally responsible, other than reducing emission.

GGP realizes that the challenge is how to implement reduce, reuse and recycle (3R) of wastes by applying traditional agricultural practices, in order to reduce environmental damage. Their main green agriculture activities in waste management are to create a closed loop as follows:

1. In 1984 established their own cattle-fattening business and feeding them using the residue of the pineapple processing. Later on it became its own company, Great Giant Livestock (GGL), which includes the facility to produce cattle meal by processing the pineapple peel, for internal use and being exported.
2. Developed the fertilizer plant utilizing the manure from the cattle farm and use it in the pineapple plantation.
3. Established biogas plant using Upflow Anaerobic Sludge Blanket (UASB) methane reactors, to process the liquid waste from the pineapple and tapioca factory, generating electricity for the plantation complex, reducing the use of fossil fuel for the thermal boiler and the cogen boiler, also reducing the methane emission by flaring the excess gas. In addition, GGP established Liquid Organic Biofertilizer (LOB) plant, as the source of soil microbes for the plantation.
4. Established composting facility by utilizing the solid waste from the tapioca, cow dung and solid waste from the bromelain enzyme factory, and using the compost as fertilizer for the pineapple plantation.
5. Good designing of the waste treatment facilities is resulted in high performance of waste water treatment plant, with high COD (Chemical Oxygen Demand) and BOD (Biological Oxygen Demand), achieving above 90 per cent removal.
6. For the efforts of good waste management and reducing GHG emissions, GGP performance is audited by third party in order to be verified and monitored periodically, to calculate their total carbon emission reduction.
7. Performed energy audits to identify possible of energy savings and use the bio-gas for tapioca drying and power generation.
8. Proper disposal and management of hazardous and chemical waste.

The Result

All of the joint efforts from the people of the company culminated significant results, due to the scale of the operations. GGP has been awarded ISO 14000, SA: 8000 certification, and also 2004 KEHATI award. Now GGP produces more than 25,000 Nm^3 of methane biogas a day to supplement and replace fuel oil and partly coal used in its starch dryer and steam boilers. By using biogas as renewable energy, GGP can reduce 100 per cent of HFO and 5–6 per cent of coal as fossil fuel consumption for Tapioca Thermal Oil Boiler and Coal Fired Power Plant. The integration of chain of production processes and closed loop waste system resulted in significant efficiency in cost, raw materials, fossil fuel usage and reduction of waste disposal.

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Sintesa Group: Optimizing Waste of Natural Gas in Fulfilling Electricity Demand

Site of the Intervention
Meppogen

Type of Intervention
Electric power generation

Industry
Sintesa Group

The Business Case

PT MEPPOGEN, the company was established in 2006 and commenced its business activities in environmental friendly electric power generation ever since.

PT MEPPOGEN started its business on electric power generation as an environmentally friendly Independent Power Producer (IPP). Nowadays, in 2013, PT MEPPOGEN operates PLTGU Gunung Megang with capacity of 110 MW (Blok-1, COD Add-On 1 x 30 MW is planned on 2013) located on Jalan Raya Palembang - Muara enim km 152 Subdistrict of Gunung Megang, Regency of Muara Enim, Province of Sumatera Selatan.

The Issue

Electricity demand in Indonesia continues to outpace supply growth. Indonesia is in inability to meet the rising energy needs. A World Bank report for 2011 ranks Indonesia 161st among 183 countries in the ease of businesses getting reliable electricity supply, down three places from the previous year. In this category, Indonesia has received worse grades than Congo and Albania.

The National Electricity Policy has targeted that Indonesia is committed to reduce its emission to 26 per cent without international support and 41 per cent with international support by 2020.

To address the challenge, PT MEPPOGEN started its business where generating and optimizing a clean energy is embraced as a value of the company as a form of responsible business.

The Response

PT MEPPOGEN creates an environmental friendly electric power generation, a combine cycle technology, utilizing waste of natural gas which is considered more sustain. This project is considered as a more environmentally friendly due to the usage of natural gas instead of more polluted sources as the source of fuel.

Activities

PT. MEPPOGEN has contributed in providing and supporting economic development since it has made a Power Purchase Agreement with PT. PLN on October 11, 2011 for capacity of 110 MW with add on combined cycle system.

However, since the beginning of operations of PT. MEPPOGEN has been operating as an environmentally friendly power plant (gas), and has established itself to carrying the spirit of renewable, green, and clean energy through a Combined Cycle Power Plant power generation from the combined cycle system.

The generator extracts the waste of natural gas to re-generate the energy power. Though it is not benefiting much recently, the initiative is believed will be more crisis proof, and will sustain the business in a long run.

Combined Cycle Technology

In electric power generation a combined cycle is an assembly of heat engines that work in tandem from the same source of heat, converting it into mechanical energy, which in turn usually drives electrical generators. The principle is that the exhaust of one heat engine is used as the heat source for another, thus extracting more useful energy from the heat, increasing the system's overall efficiency. This works because heat engines are only able to use a portion of the energy their fuel generates (usually less than 50 per cent). In an ordinary (non combined cycle) heat engine the remaining heat (e.g., hot exhaust fumes) from combustion is generally wasted.

Combining two or more thermodynamic cycles results in improved overall efficiency, reducing fuel costs. In stationary power plants, a widely used combination is a gas turbine (operating by the Brayton cycle) burning natural gas or synthesis gas from coal, whose hot exhaust powers a steam power plant (operating by the Rankine cycle). This is called a Combined Cycle Gas Turbine (CCGT) plant, and can achieve a thermal efficiency of around 60 per cent, in contrast to a single cycle steam power plant which is limited to efficiencies of around 35–42 per cent. Many new gas power plants in North America and Europe are of this type. Such an arrangement is also used for marine propulsion, and is called a combined gas and steam (COGAS) plant. Multiple stage turbine or steam cycles are also common.

Other historically successful combined cycles have used hot cycles with mercury vapour turbines, magneto hydrodynamic generators or molten carbonate fuel cells, with steam plants for the low temperature "bottoming" cycle. Bottoming cycles operating from a steam condenser's heat exhaust are theoretically possible, but uneconomical because of the very large, expensive equipment needed to extract energy from the small temperature differences between condensing steam and outside air or water. However, it is common in cold climates (such as Finland) to drive community heating systems from a power plant's condenser heat. Such cogeneration systems can yield theoretical efficiencies above 95 per cent.

In automotive and aeronautical engines, turbines have been driven from the exhausts of Otto and Diesel cycles. These are called turbo-compound engines (not to be confused with turbochargers). They have failed commercially because their mechanical complexity and weight are less economical than multistage turbine engines. Stirling engines are also a good theoretical fit for this application. A turbocharged car is also a combined cycle.

The results

Although the initiative is quite young, the combine cycle generator is believed has generated electricity and has been distributed to the Sumatra 150 kV system, and create employment in area of Sumatera Selatan.

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