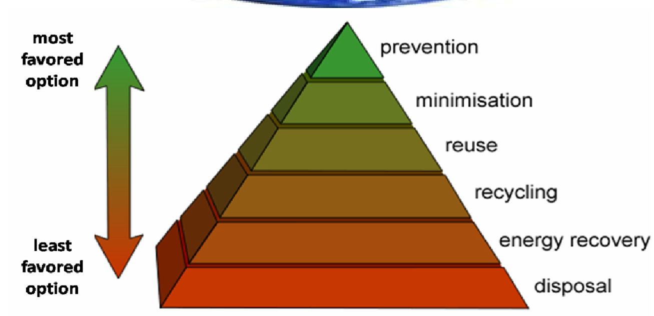
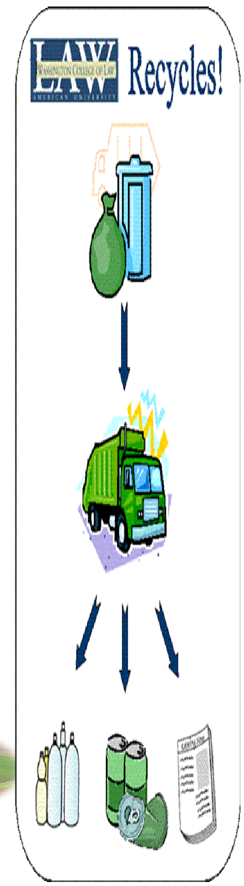
ENVIS CENTRE ON ENVIRONMENTAL BIOTECHNOLOGY

SUPPORTED BY MINISTRY OF ENVIRONMENT AND FORESTS
GOVERNMENT OF INDIA

VOLUME-22 ISSN : 0974 2476 JUNE, 2013

NEWS LETTER





Waste-to-Wealth: Biotechnological Application

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INSTRUCTIONS TO CONTRIBUTORS

ENVIS Newsletter on Environmental Biotechnology is a half-yearly publication publishes articles related to the thematic area of the ENVIS Centre. Popular or easily intelligible expositions of new or recent developments are welcome

Manuscripts should be typewritten (font should be Times New Roman and font size ought to be 12) on one side of the paper in double spacing with maximum of 6-8 typed pages

Figures and typed table should be in separate pages and provided with title and serial numbers. The exact position for the placement of the figures and tables should be marked in the manuscript.

Articles should be sent to

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EDITORIAL

Waste management is recognized as having the dual functions of resource recovery and final disposal. People all over the world are earning revenue from both stages through recovery of recyclable materials and to some extent, conversion of waste to energy. Waste is no longer something that is unwanted. It is now regarded as resources for businesses that generate income. Turning waste into wealth not only makes good environmental sense, but also turns “trash” into “cash”.

In this newsletter (Vol. no. 22). We have attempted to discuss the Waste to Wealth: Biotechnological Application related issues with respect to India.

(S. C. Santra)

IN THIS ISSUE:

Waste-to-Wealth:
Biotechnological Application

Waste is often defined as the unwanted things and has no economic value. Applying different technology the waste can be use as a resource with certain economic values for another user. Waste has always been associated with human activity and is a necessary evil in any developmental process. Today, the quantity and diversity of wastes generated by different industries and municipalities pose serious risks to both human health and the environment. The situation is alarming in developing countries such as India mainly due to their inefficient technologies, ineffectual policies and insensitivity on the part of the industrial sector. It is imperative therefore to create awareness among the people, entrepreneurs, manufacturers, local authorities to adopt varied technologies to treat and recycle wastes and convert it to wealth.

Improved welfare and economic growth is generally accompanied by more waste. The global production of household waste is more than 2 billion tons per year, in addition to the waste from companies, agriculture, forestry and other sectors. The general practice of waste management around the world consists of open dumps and landfills. In many countries waste quite often represents jobs, financial opportunity, raw materials for new products as well as an economic lifeline for some people. Possible "wealth" can be generated from various kinds of waste with appropriate technology.

Chemical waste streams often contain either precious or toxic metals. These streams regularly require treatment to become more environmentally acceptable, but treatment may also be due to the need to recover valuable resources. The recovery and recycling of Platinum Group Metals (PGMs) from catalytic, plating and mining streams are an increasingly essential process. With good reason, strict regulation limits the quantities of numerous toxic and heavy metals that may be released into the environment, notably Cd, Cr, Pb and Hg. The removal of such contaminants may greatly reduce waste processing costs.

Considerable revenue can be generated from waste through:

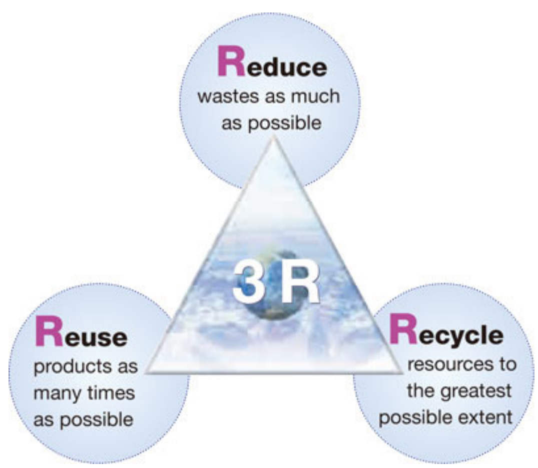
a) Recycling of useful materials from municipal solid waste

b) Generation of energy from municipal or agricultural wastes (such as palm oil empty fruit bunches and animal waste)

c) Production of composts or fertilizer from organic municipal and agricultural waste, or even sludge

d) Other specific technologies to convert wastes to useful materials (such as converting rice husk to charcoal, sludge to bricks, extraction of oil from used plastics, conversion of used tyres to carbon black and rubber granulates etc.)

The **3R**'s of **Reduce, Reuse** and **Recycle** have been considered to be a base of environmental awareness and a way of promoting ecological balance through conscious behaviour and choices. It is generally accepted that these patterns of behaviour and consumer choices will lead to savings in materials and energy which will benefit the environment.



Reduce - To buy less and use less. Incorporates common sense ideas like turning off the lights, rain barrels, and taking shorter showers, but also plays a part in composting/ grass cycling (transportation energy is reduced), low-flow toilets, and programmable thermostats.

Reuse - Elements of the discarded item are used again. Initiatives include waste exchange, hand-me-downs, garage sales, quilting, travel mugs, and composting (nutrients).

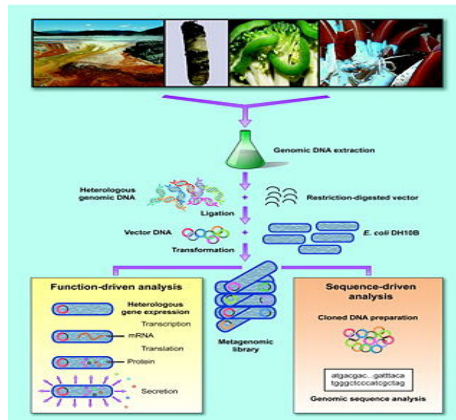
Recycle - Recycling is a resource recovery practice that refers to the collection and reuse of waste materials such as empty beverage containers. The materials from which the items are made can be reprocessed into new products.

Environmental Importance

Recycling is very important as waste has a huge negative impact on the natural environment.

- ✓ Harmful chemicals and greenhouse gasses are released from rubbish in landfill sites. Recycling helps to reduce the pollution caused by waste.
- ✓ Habitat destruction and global warming are some the effects caused by deforestation. Recycling reduces the need for raw materials so that the rainforests can be preserved.
- ✓ Huge amounts of energy are used when making products from raw materials. Recycling requires much less energy and therefore helps to preserve natural resources.
- ✓ No space for waste. Our landfill sites are filling up fast.
- ✓ Reduce financial expenditure in the economy. Making products from raw materials costs much more than if they were made from recycled products.
- ✓ Preserve natural resources for future generations. Recycling reduces the need for raw materials; it also uses less energy, therefore preserving natural resources for the future.

The application of biotechnology on various fields such as industry, agriculture, forestry, waste treatment is very important in view of economic and environmental benefits. In this technology, processing of products is less expensive and product quality is enhanced. It is possible to evaluate various wastes around us by microbiological processes. Today, numerous microbiological waste processing projects can be conducted at high scale. For example, solid and liquid wastes containing high organic substances are used for obtaining methane. Consequently, a new energy resource arises. In the treatment of industrial and municipal wastewaters, various microbiological methods such as activated sludge, trickling filters, oxidation ponds, membrane bioreactors are used successfully. One of the important points of waste processing is to think all direct and indirect expenses and to calculate profitability ratio.

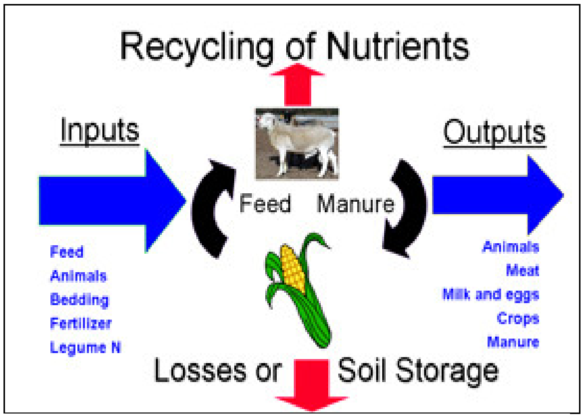


WEALTH FROM DIFFERENT WASTES

1. Utilization of Agricultural Waste

Agricultural wastes are basically unusable substances which may be either liquid or solid produced as result of cultivation processes such as fertilizers, pesticides, crop residues and animal waste. By waste management, all the plant wastes are placed at the right place and right time for the best utilization in order to convert into useful products and pollution control.

Waste from agricultural production can be utilized as fuel for power and heat production. In some agricultural industries large amounts of biomass waste is already concentrated and readily available for utilisation. The palm oil industry, for instance, produces significant amount of empty fruit bunches that can be incinerated. Liquid wastes may also be methanized and can secure a basis for own power and process heat production while delivering excess power to the grid. In the sugar industry, significant amounts of bagasse – the waste after extraction of sugar – is an equally excellent fuel. Rice production may also be industrialized to such an extent that rice husks are available in amounts sufficient for incineration in a boiler, thereby securing a basis for power and heat production.

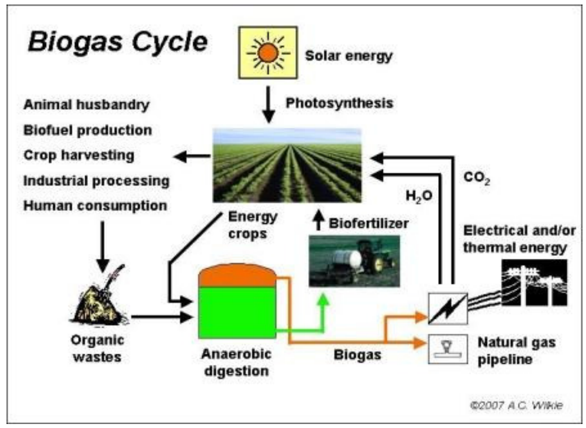


1.1 Reuse of waste straw

Straw is an agricultural by-product, the dry stalks of cereal plants, after the grain and chaff have been removed. Straw makes up about half of the yield of cereal crops such as barley, oats, rice, rye and wheat. It has many uses, including fuel, livestock bedding and fodder, thatching and basket-making. Mushroom cultivation using straw is a good way to generate self employment and better revenue out of the easily available agro-waste, thus, cleaning the environment.

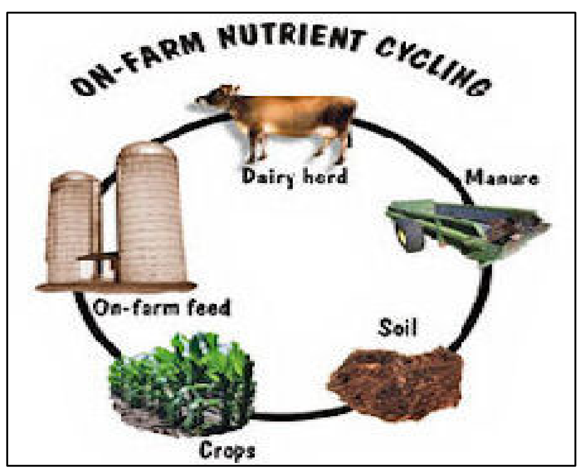
1.2 Biogas production

Biogas is a flammable gas that accrues from the fermentation of biomass in biogas plants. Biogas typically refers to a gas produced by the biological breakdown of organic matter in the absence of oxygen. Biogas is produced by the anaerobic digestion or fermentation of biodegradable materials such as agricultural wastes, biomass, manure, sewage, municipal waste, plant material. Biogas comprises primarily methane and carbon dioxide and may have small amounts of hydrogen sulphide, moisture and siloxanes. The gases methane, hydrogen and carbon monoxide can be combusted or oxidized with oxygen. Biogas can be used as a fuel for any heating purpose, such as cooking. It can also be used in anaerobic digesters where it is typically used in a gas engine to convert the energy in the gas into electricity and heat.



1.3 Biomass hydrolyzing enzymes from the aquatic weed

Water hyacinth (*Eicchornia crassipes*), one of the most productive aquatic plants is also an aquatic pest and a menace creating navigational problems and pollution in water bodies. The use of the renewable plant biomass for the production of cleaner and cheaper fuels has rejuvenated the interest in developing cheaper technologies for large scale production biomass saccharifying enzymes.



1.4 Forest Residues:

In developing countries, biomass - and particularly wood - accounts for approximately 38% of the primary energy use among more than 2billion consumers, many of whom have no access to modern energy services. In the forest industry, large concentrations of biomass waste can be utilized for power and heat production and, thus, provide access to modern energy services. The forest industry is also the foundation for traditional charcoal production. During this process, large amounts of methane with a Global Warming Potential 21times higher than CO_2 are released. This may be reduced, or entirely avoided, by altering the production method or it may be captured for power production. The forest industry also supplies raw material for briquettes production, where sawdust, charcoal dust, degradable waste paper and dust from agricultural production could constitute a final utilisation of waste materials from wood related production.

1.4.1 Sawmill Waste

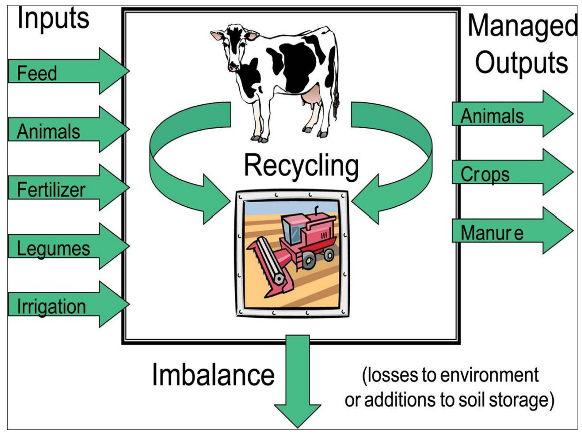
Forests are already the prime source of fuel for households where wood collection is a laborious activity and wood fuel is most often used in inefficient cook stoves. Alternatively, forest residues, sawmill waste or other sources like, twigs, branches and dry leaves may be used for power and heat production. At the sawmills there are obvious utilisation options for the sawdust, which has little value as fuel in household cook stoves.

1.4.2 Charcoal Production

Charcoal production is releasing methane – especially in the traditional open pits process. CDM project activities that aim at reducing methane emissions during the carbonization process entail three phases: ignition, carbonization and cooling. CDM projects are implemented in two different processes: 1) improvement of kiln design for better temperature control and greater control of carbonization variables which reduce methane production, or 2) utilising the released methane to generate electricity in a gas engine or through a boiler, turbine and generator set.

1.5 Biomass Briquettes

Briquettes can be made from all kinds of forest and agricultural residues as well as waste from animal production. It can be manufactured using automatic briquetting machines or it can be made as a household 'industry' with manual presses, compressing the biomass typically in cylindrical shapes with a press that squeezes out liquids from the waste. The briquettes may be used as fuel in domestic stoves or at larger scales for power production, typically replacing fossil fuels.

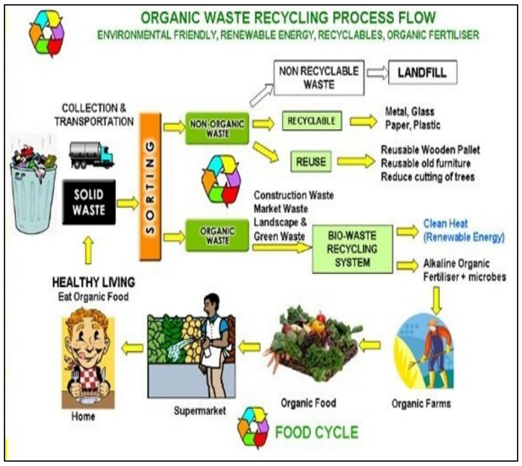


1.6 Wastes in Palm Oil Industries

The palm oil industry produces large amounts of solid waste from empty fruit bunches (EFB), kernels and fibres, as well as liquid waste, normally referred to as POME (Palm Oil Mill Effluent)

1.6.1 (POME) Treatment Methods: Vermicomposting as a Sustainable Practice

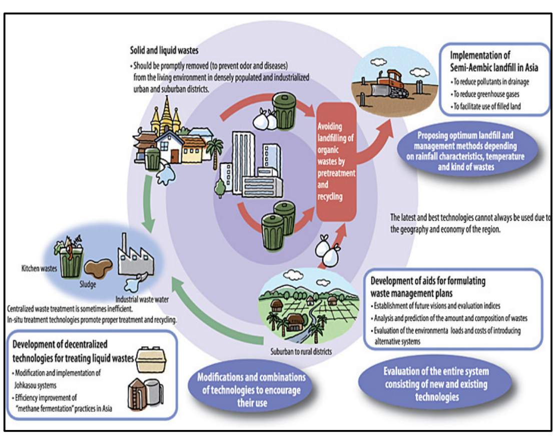
Due to the presence of high total solids in POME, attempts have been made to convert this waste into valuable products such as feed stock and organic fertilizer. Although POME is organic in nature, it is difficult to decompose in natural conditions. Earthworms can digest the POME producing valuable products such as vermicompost. Vermicompost is a useful product rich in nutrients that can be used as fertilizer in oil palm plantations



1.7 Rice Husk

Rice husk is unusually high in ash, which is 92 to 95% silica, highly porous and lightweight, with a very high external surface area. Its absorbent and insulating properties are useful to many industrial applications, such as acting as a strengthening agent in building materials.

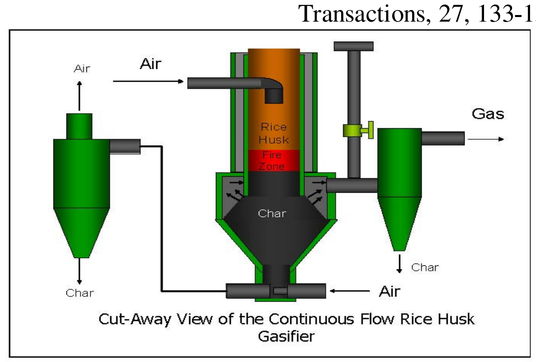
The production of rice leaves rice husks as a waste material, which may be utilised as fuel in a boiler if quantities are sufficient. It takes five tons of rice paddy to produce one ton of rice husk waste, and it takes approximately 100,000 tons of rice husk per year to fuel a 10 MW power plant. Normal yield for rice is 3-4 tons per hectare (although the yield in China is almost double that), thus, requiring approximately 150,000 hectares (1500 square kilometres) to fuel a power plant.

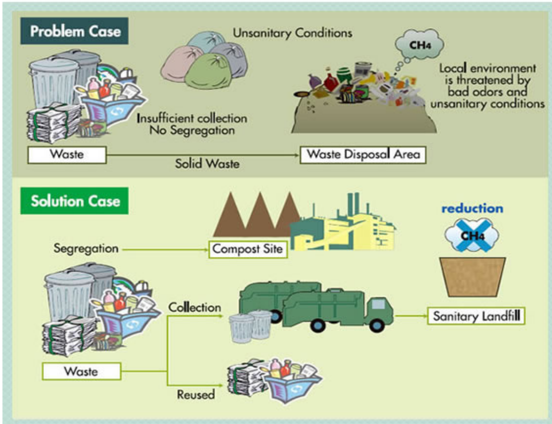


1.7.1 Production of Enzymes from Rice Husks and Wheat Straw in Solid State Fermentation

The agricultural wastes represent a significant potential for the development of biorefineries in different sectors such as cereals. Recovery of phytochemicals as well as the energetic valorization of the plant matrixes needs the demolition of the wall cell plants. Hydrolitic demolition by lignocellulosic enzymes is one of the most studied approach. White rot fungi such as *Pleurotus ostreatus* produce a wide range of extracellular enzymes to degrade complex lignocellulosic substrates into soluble substances that can be used as nutrients. *Pleurotus ostreatus* in solid state fermentation using agro-food wastes as substrates: rice husks and wheat straw. The activities of cellulase, xylanase, peroxidase, laccase, and arylesterase are determinate by specific colorimetric assays. *Pleurotus ostreatus* exhibited a prevalent production of arylesterase activity and, in particular, the contemporary presence of significant xylanase and feruloilesterase activities was probably due to the typical ferulic bond and diferulic bridge in the heteroxylane structure of monocot's plant cell walls such as rice and wheat. Moreover, in terms of yields arylesterase activities for both substrates, are prevalent on other activities. The enzymatic production was strictly dependent to the periodic removal of the produced enzymes. The development of new solid state bioreactor design for a steady state production of enzymes from *Pleurotus ostreatus* could open an interesting industrial approach.

(Masutti et al, 2012, Chemical Engineering Transactions, 27, 133-138)





2. Utilization of Industrial Waste

Industrial waste is the waste produced by industrial activity, such as that of factories, mills and mines.

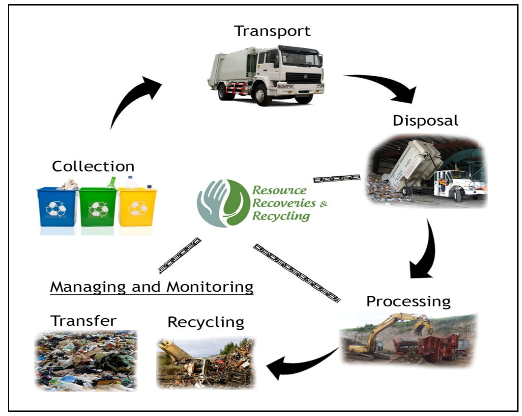
2.1 Industrial Waste-to-Energy

Energy from waste can be generated in two possible ways, namely through the decomposition process of waste and combustion of waste. The bacterial activities in the decomposition process of organic substances in the waste will generate biogas (such as methane gas), which is a source of renewable energy. A common example for waste-to-energy from biogas is landfill gas which can be captured and used to generate electricity.

Anaerobic digestion component of biological treatment plant

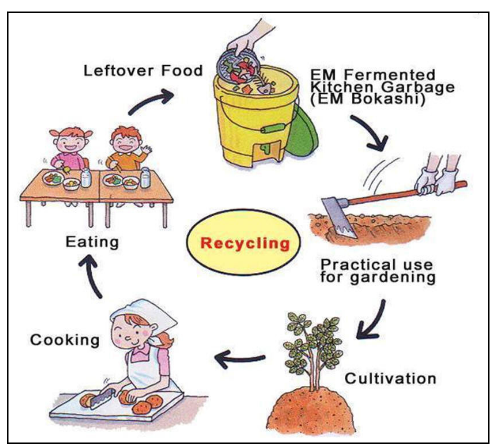
2.2 Recovering valuable metals from industrial waste

Due to rapid industrialization the demand for heavy metals is ever increasing, but the reserves of high-grade ores are diminishing. Therefore there is a need to explore alternative sources of heavy metals. The solid wastes mostly contain Au, Ag, Ni, Mo, Co, Cu, Zn, and Cr like heavy metals. Hence these waste materials are causing serious environmental problems. The valuable metals can be recovered from the wastes.



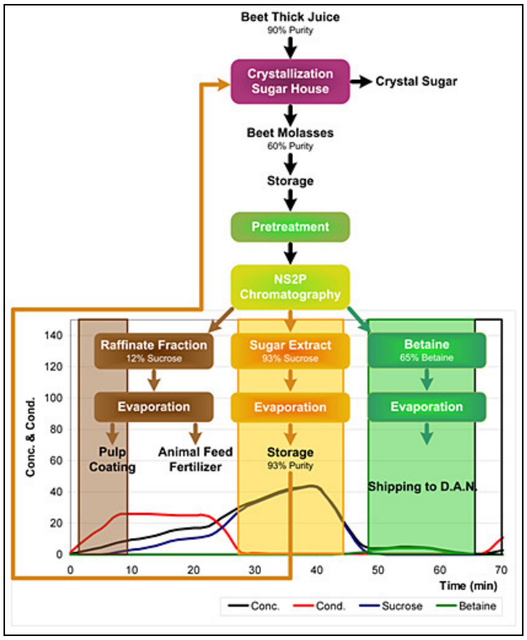
Now the microbiological leaching process has been shifted for its application to recover valuable metals from the different industrial wastes. There are many microrganisms which play important role in recovery of heavy metals from industrial wastes. Among the bacteria *Acidithiobacillus ferrooxidans, Acidithiobacillus thiooxidans, Leptospirillum ferrooxidans*, and *Sulfolobus* sp., are well known for the bioleaching activity while *Penicillium*, and *Aspergillus niger* are some fungi those help in metal leaching process.

(Kurien et al, 2013, International Conference on Waste, Wealth and Health, Bhopal)



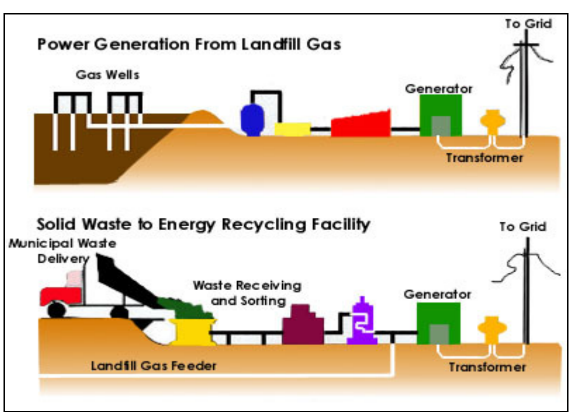
2.3 Wastes in Sugar Industry

In some agricultural industries, large concentrations of biomass waste can be utilized for power and heat production, thereby providing access to modern energy services. The sugar industry produces significant amounts of bagasse that can be incinerated and secure a basis for own power and process heat production while delivering excess power to the grid.



3. Utilization Municipal/ Commercial Waste

Municipal solid waste (MSW), also called Urban Solid Waste, and is a waste type that includes predominantly household waste (domestic waste) with sometimes the addition of commercial wastes, construction and demolition debris, sanitation residue, and waste from streets collected by a municipality within a given area.



3.1 Energy recovery from Municipal Solid Waste

Most of the municipal solid waste produces energy product (generally steam or electricity). The resulting energy reduces the amount needed from other sources, and the sale of the energy helps to offset the cost of operating the facility.

Municipal solid waste (MSW) is one of three major waste-to-energy technologies (the others are anaerobic digestion and biomass). MSW can be directly combusted in waste-to-energy facilities as a fuel with minimal processing, known as mass burn; it can undergo moderate to extensive processing before being directly combusted as refuse-derived fuel; or it can be gasified using pyrolysis or thermal gasification techniques. Each of these technologies presents the opportunity for both electricity production as well as an alternative to landfilling or composting the MSW. In contrast with many other energy technologies that require fuel to be purchased, MSW facilities are paid by the fuel suppliers to take the fuel (known as a "tipping fee"). The tipping fee is comparable to the fee charged to dispose of garbage at a landfill. Another MSW-to-electricity technology, landfill gas recovery, permits electricity production from existing landfills via the natural degradation of MSW by anaerobic fermentation (digestion) into landfill gas. Anaerobic digestion can also be used on municipal sewage sludge.

3.2 Composting

Waste materials that are organic in nature, such as plant material, food scraps, and paper products, can be recycled using biological composting and digestion processes to decompose the organic matter. It is a biological process in which micro-organisms, mainly fungi and bacteria, convert degradable organic waste into humus like substance. The resulting organic material is then recycled as mulch or compost for agricultural or landscaping purposes. In addition, waste gas from the process (such as methane) can be captured and used for generating electricity. Organic matter constitutes 35%–40% of the municipal solid waste generated in India. This waste can be recycled by the method of composting, one of the oldest forms of disposal. Apart from being clean, cheap, and safe, composting can significantly reduce the amount of disposable garbage. Each one MT of wet garbage can yield 200 to 300 kgs of organic fertilizer. It increases the soil's ability to hold water and makes the soil easier to cultivate.

3.3 Vermi-compost

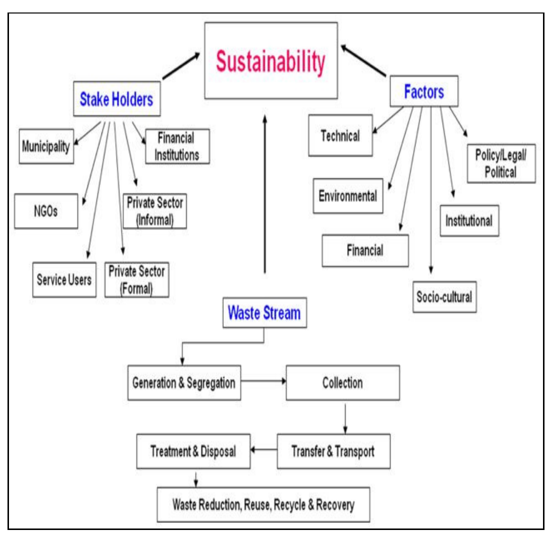
Vermi-composting is very successful at community level but it is yet to develop at commercial scale. Manual composting is carried out in smaller urban centres. Although mechanical composting plants were set up in cities but presently, only few plants out of them continues to be in operation. The high cost of mechanical composting plants and the non utilization of by-products are among the factors which make the process an uneconomic proposition.

3.4 Converting waste plastics into resources

Plastic waste recycling is one of the most established recycling activities in economically developed countries. In most of the situations, recycling of waste plastics is becoming viable in developing countries as well, as it generates resources and provides jobs. The recycling of waste plastics also has a great potential for resource conservation and GHG emissions reduction, such as producing diesel fuel from plastic waste. As raw materials, wastes plastics have attractive potentials for large-scale industries and community-level enterprises. For efficient and effective conversion of waste plastics into a resource, appropriate selection of technologies is one of the vital pre-conditions.

3.5 Waste Plastic Pyrolysis to fuel oil

Another process involves the conversion of assorted polymers into petroleum by a much less precise thermal depolymerization process. Such a process would be able to accept almost any polymer or mix of polymers, including thermoset materials such as vulcanized rubber tires and the biopolymers in feathers and other agricultural waste. Like natural petroleum, the chemicals produced can be made into fuels as well as polymers. RESEM Technology plant of this type exists in Carthage, Missouri, USA, using turkey waste as input material. Gasification is a similar process, but is not technically recycling since polymers are not likely to become the result. Plastic pyrolysis can convert petroleum based waste streams such as plastics into quality fuels, carbons.



4. Utilization E-Waste

E-waste for short – or Waste Electrical and Electronic Equipment (WEEE) – is the term used to describe old, end-of-life or discarded electrical appliances. In this catalogue, “e-waste” is used as a generic term embracing all types of waste that consists of electrically powered components containing Precious Metals (PM) or Base Metals (BM). E-waste contains both valuable materials (PM and BM) as well as hazardous materials which require special handling and recycling methods.

4.1 Metal Extraction from Electronic Waste

Large volumes of electronic goods, such as computers, mobile phones, music players, televisions and cameras, are being disposed every day. These devices contain various metals such as lead (Pb), copper (Cu), gold (Au), aluminum (Al), silver (Ag), palladium (Pd) and ferrous metals, which are often disposed as waste (known as electronic waste or E-waste). These metals are usually extracted by manually sorting and grinding the materials and then separating the metals in smelters. The facilities used for this process are often unsafe, exposing the workers and the environment to toxic gases and metals. E-waste disposal is a prevailing problem in developed countries. Technologies for the recovery of valuable materials from e-waste have been developed to resolve this problem. Current technologies can be broadly categorized as thermal processing, bioleaching and hydrometallurgical processing. There are both regulatory and economic drivers behind the use of these technologies. Developed countries, such as those in the European Union, have passed laws and regulations mandating original equipment manufacturers to collect e-waste from private users and dispose of it in an eco-friendly manner. Developing countries are also taking action. For example, in 2009 the Chinese government revised and supplemented a “List of banned imported solid wastes” to include various categories of e-waste. In addition, with the price of metals such as Cu realizing substantial increases over the past year, the economic advantages of recovering these commodities have correspondingly increased.

4.1.1 *Recovery of metal values from waste printed circuit boards*

Printed circuit boards (PCBs) are currently being dumped in landfills or incinerated which is causing a serious environmental harm in the form of toxic gases or leached hazardous compounds. PCBs contain high amounts of precious metals; about 20 wt% copper, 0.04 wt% gold, 0.15 wt% silver, and 0.01 wt% palladium. The extraction of these metals from PCBs is both profitable and environmentally worthwhile.

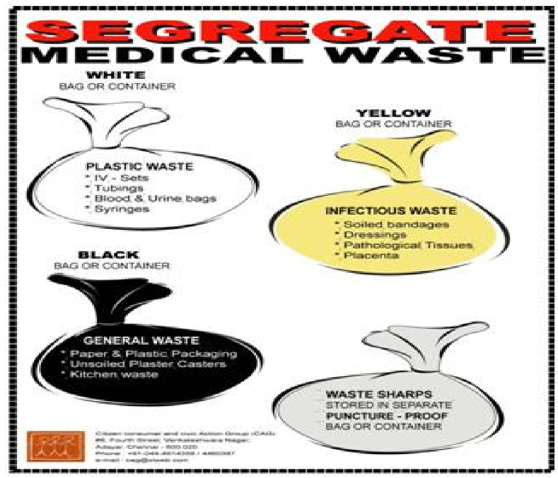
5. Utilization of Biomedical Waste

Medical waste is broadly defined as any solid or liquid waste that is generated in the diagnosis, treatment of immunization of human beings or animals in research pertaining there to, or in the production or testing of biological material.

Biomedical wastes from hospitals and other healthcare and research centers has become an imperative environmental and public safety problem. So, it is necessary that the biomedical wastes should be disposed in a manner which is least harmful to the human beings. Incineration is the most appropriate alternative for reducing the waste volume but generates a new type of waste in the form of fly ash, bottom ash and molten slag.

5.1 In agriculture:

Biomedical waste ash has potential for use in agriculture because it contains almost all macro as well as micronutrients except organic carbon and nitrogen. It may act as chemical fertilizer to increase the yield of various agricultural crops. Effect of these fertilizers depends upon the type of crop as well as the type of soil. The positive effect of ash application was observed on average growth of Fenugreek and Mustard. The yield of Fenugreek and Mustard is increased around 54-55%.



5.2 As a stabilizing agent in road and asphalt pavements:

In Germany 50% of the ash produced from incinerated waste is used for the manufacturing of sound insulation walls at National roads, as well as, sub layers on the streets. 60% of the bottom ash is used for the construction of asphalt and as a sub layer of roads in Netherlands. Above 72% of ash is reused for the manufacture of parking spaces, cycling tracks and other roads in Denmark . The hospital waste in Selangor, Malaysia is incinerated and subsequently melted at 1200°C. Scanning election microscope (SEM)/EDX results showed that the hospital waste incinerator slag produced after melting the incinerator ash contained amounts of SiO_2, CaO, and $Al2O_3$ in excess of 53%, 9%, and 16%, respectively.

5.3 Leachate Analysis

In environmental applications, leaching represents the source term for release of potentially hazardous substances. Assessing the leaching of pollutants to groundwater is one of the key pathways when evaluating the risk of solid wastes on human health and the environment. Leaching of waste generates leachate, a liquid that drains from the landfill and its composition varies widely depending upon the age and the waste contained landfill material.

Waste to Wealth in India

India on the path of Waste Energy

India is the world's second largest nation in terms of population but waste management services and techniques have not improved in the country accordingly, thus, putting health, environment and natural resources at a great risk. According to Ministry of New and Renewable Energy (MNRE) estimates, there exists a potential of about 1460 MW from Municipal Solid Waste (MSW) and 226 MW from sewage. The per capita waste generation rate in India has increased from 0.44 kg/day in 2001 to 0.5 kg/day in 2011, triggered by changing lifestyles and increased purchasing power of urban Indians. There are 53 cities in India with a million plus population, which together generate 86,000 TPD (31.5 million tons per year) of MSW at a per capita waste generation rate of 500 grams/day. The total MSW generated in urban India is estimated to be 68.8 million tons per year (TPY) or 188,500 tons per day (TPD) of MSW. Such a steep increase in waste generation within a decade has severed the stress on all available natural, infrastructural and budgetary resources.

Case studies

Odour Control in Domestic Solid Waste Treatment Plant, Chennai

A decentralized integrated bio-mechanization plant has been implemented near Koyambedu Market in Chennai to utilize vegetable, fruit, flower wastes. The plant generates about 2000 m^3 of biogas and 4 tons of bio-fertilizer from 30 tons of degradable wastes. The biogas is being converted into electricity using biogas engine and connected to Tamil Nadu Electricity Board power grid. For the first time odor control system with bio-filter is implemented with contributions by Ministry of Non-Convention Energy Sources, Govt. of India and Chennai Metropolitan Development Authority. The main sources of odor are from waste storage yard, collection sump, sorting area and minceration unit. The air from these areas is collected through pre-suction pipes and connected to a blower. The inlet of the pipe is covered with anticorrosion mesh to avoid flies and solid particle entry into the pipe leading to bio filter. A bio filter is developed using wooden chips as media. Water is sprinkled occasionally to keep the media under wet condition.

Waste to Wealth programme

Kanoria Chemicals & Industries Limited (KCI) is an ISO 9001, ISO 14001 and OHSAS 18001 certified leading manufacturer of chemical intermediates in India. 'The Waste to Wealth programme is based on unified technology used at KCI's Ankleshwar Chemical Works for gainful utilisation of waste generated from manufacturing processes. The programme has three components, namely Waste to Water, Waste to Energy and Waste to Soil Nutrients.

Waste to Water

In its quest for an effective environmental technology for recovery of recyclable water from effluent, KCI identified Reverse Osmosis (RO) technology as a possible route for achieving the objective of maximum recycle and minimum possible disposal. This technology had hitherto never been used for treatment of industrial effluent in India and for the company it was a calculated risk.

This has resulted in the following benefits for the company:

- Reduction in fresh water consumption as 65-70% recovered water in recycled back to the manufacturing process.
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Waste to Power

The bio-gas produced during treatment of distillery effluent is gainfully used for power generation after removing its H_2S content with the help of "Thiopaq" scrubber technology supplied by Paques Bio-system of the Netherlands. This has reduced Sulphur emission into the atmosphere from 900 kg to 9 kg per day. The technology supplier was awarded the Dutch Environment Award for Industry in 1999 based on the H_2S plant installed at KCI. The project has become an Indian benchmark for similar projects taken up subsequently by other plants.

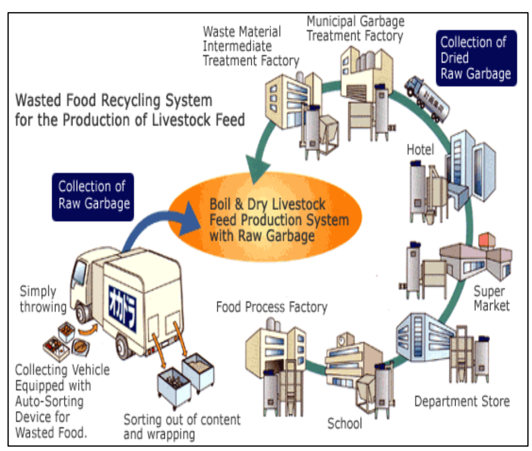
Waste to Soil Nutrients

Initially built on a small piece of land of 7 acres located opposite the distillery plant, a bio-compost manufacturing facility was set up on trial basis. The bio compost manufactured in this plant, was well received by farmers and encouraged by the results, KCI shifted this plant to a much larger plot of land measuring approximately 60 acres and located about 20 kilometres away from the Ankleshwar Works.
The new location of the bio-compost plant not only helped in increasing the production level, but has also made it possible to put up a demonstration farm growing various types of crops such as sugarcane and banana to showcase the effectiveness of bio-compost as good manure. The use of distillery waste in bio-compost results in recycling of nutrients available in the molasses back to the soil, and at the same time reduces the dependence on chemical fertilizers.

Production of single cell protein from pineapple waste using yeast.
Single-Cell Protein (SCP) represents microbial cells (primary) grown in mass culture and harvested for use as protein sources in foods or animal feeds. The pineapple waste which as contains two strains of yeasts, *Saccharomyces cerevisiae* and *Candida tropicalis.* The pineapple hydrolysis enhanced the biomass yield and the protein formation within the yeast cells.
- (Dhanasekeran, et al., 2011).

Ethanol from Cellulose Waste

The conversion of cellulose waste into ethanol rich biofuels. Cellulosic ethanol is a biofuel produced from wood, grasses, or the non-edible parts of plants. It is a kind of biofuel which is generally produced from lignocelluloses. The building block units of lignocellulose are cellulose, hemicellulose and lignin. Lignocelluloses have increasingly favoured as most suitable raw material for the next generation of bio-ethanol around the world. The technology has advantage of diverse and abundant raw materials which are of no use and are easily available but it requires a greater amount of processing to make the monomeric units of sugar for the fermentation of ethanol. These monomeric units of sugar are consumed by the microorganisms in their metabolism as a substrate to convert them into biofuel, ethanol (http://www.wealthywaste.com/ethanol-from-cellulose-waste)



Major success factors

- Use of wealth of technologies owned by local businesses
- Efficient use of existing reclaimed land
- Strong Leaderships in the city government, academia and industry
- High level of citizens' environmental awareness and Dialogue mechanism between the city government and citizens
- City government's support for recyclers

Future prospects

- ✓ Waste reduction needs further research on new and indigenous technologies that decrease waste and waste products.
- ✓ Recycling of liquid wastes presents various alternatives of waste to resource' processes in water-scarce countries.

- ✓ Integrated waste management concept should focus on waste reduction along with recycling and reuse. This can be done by raising awareness towards generation of waste.
- ✓ Government needs to promote adoption of new technologies and processes for waste treatment suitable for the heterogeneous nature of Indian waste.
- ✓ Waste to energy solutions for Indian waste are possible despite lower calorific value and the same need to be encouraged through adoption of emerging technologies like gasification, concord blue tower, co processing among others.
- ✓ Viability of waste-to-energy solutions and other treatment disposal / recycling facilities can be boosted by clubbing smaller municipalities which do not have the financial wherewithal so that a common facility can be created and shared.
- ✓ Private sector participation in waste management needs to be bolstered further which calls for development of suitable framework, capacity building of Urban Local Bodies and proper sharing of risk between the public and private sector.
- ✓ Private participation in the sector also needs to be facilitated through creation of a market for recyclables, raising awareness among citizens to increase willingness to pay and transparent pricing for levying user charges along with billing systems on the lines of electricity and water bills for waste management services.

Waste management continues to be an important environmental challenge facing the humanity in the 21st century. Generation of various types of waste like municipal solid waste, kitchen waste, industrial waste, medical waste and e-waste is a natural attribute of all human activities. However, if not properly managed, wastes can adversely affect the environment, health and safety of human beings. There is a whole culture of waste management that needs to be put in place - from the micro-level of household and neighborhood to the macro levels of city, state and nation

FORTHCOMING EVENTS		
Events	**Date**	**Place & Correspondence**
ICEWM 2013: International Conference on Environment and Waste Management	13th – 14th June 2013	Copenhagen, Denmark
"Waste to Energy as an Integral Part of Sustainable Waste Management"	17th -21st June 2013	Baku, Azerbaijan http://tamizshahar.az
Sustainable Development Conference: Green technology, renewable energy and environmental protection	21st – 23rd June 2013	Bangkok, Thailand, http://www.sdconference.org/
ITU Workshop on Environmentally Sound Management of E-waste	9th July 2013	South Africa, Durban http://www.itu.int/events

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