GREEN COMPUTING

PROJECT

CASE STUDY

On

SUSTAINABLE WASTE MANAGEMENT

OF

INDIA

Introduction to sustainable waste management

- What is sustainable waste management?

Waste management which can be effectively implemented for several times is known as sustainable waste management(or **waste disposal**) are the activities and actions required to manage waste from its inception to its final disposal. This includes the collection, transport, treatment and disposal of waste, together with monitoring and regulation of the waste management process.

Arising quality of life, and high rates of resource consumption patterns have had a unintended and negative impact on the urban environment - generation of wastes far beyond the handling capacities of urban governments and agencies. Cities are now grappling with the problems of high volumes of waste, the costs involved, the disposal technologies and demonstrated by good practices from many cities around the world. Methodologies, and the impact of wastes on the local and global environment.

But these problems have also provided a window of opportunity for cities to find solutions - involving the community and the private sector; involving innovative technologies and disposal methods; and involving behavior changes and awareness raising. These issues have been ampl

There is a need for a complete rethinking of "waste" - to analyse if waste is indeed waste.

“WASTE to become WEALTH”

“REFUSE to become RESOURCE”

“TRASH to become CASH “

There is a clear need for the current approach of **waste disposal** that is focused on municipalities and uses high energy/high technology, to move more towards **waste processing** and **waste recycling** (that involves public-private partnerships, aiming for eventual **waste minimization** - driven at the community level, and using low energy/low technology resources. Some of the defining criteria for future waste minimization programmers will include deeper community participation, understanding economic benefits/recovery of waste, focusing on life cycles (rather than end-of-pipe solutions), decentralized administration of waste, minimizing environmental impacts, reconciling investment costs with long-term goals.

Humans are the only part of ecosystems that generate waste - but its sustainable management can create jobs and cut greenhouse gas emissions, the head of UN Environment’s Almaty Office has underlined during a major conference on waste recycling and green energy

Every year, an estimated 11.2 billion tonnes of solid waste is collected worldwide. Of all waste streams, that from electrical and electronic equipment containing new and complex hazardous substances presents the fastest-growing challenge in both developed and developing countries.


Waste reduction
Recycling
Anaerobic composting
Aerobic composting
only for source separated organics
Waste-to-energy
Modern landfill recovering and using CH4
Modern landfill recovering and flaring CH4
Landfills that do not capture CH4
Unsanitary landfills and open burning

E-waste definition

Definition - Green computing is the environmentally responsible and eco-friendly use of computers and their resources. In broader terms, it is also defined as the study of designing, manufacturing/engineering, using and disposing of computing devices in a way that reduces their environmental impact.

E-Waste for short - or Waste Electrical and Electronic Equipment - is the term used to describe old, end-of-life or discarded appliances using electricity. It includes computers, consumer electronics, fridges etc which have been disposed of by their original users.

"E-waste" is used as a generic term embracing all types of waste containing electrically powered components. e-Waste contains both valuable materials as well as hazardous materials which require special handling and recycling methods. This guide covers all categories of e-waste but emphasizes categories which contain problematic, scarce and valuable or otherwise interesting materials.

Examples: Computers, LCD / CRT screens, cooling appliances, mobile phones, etc., contain precious metals, flame retarded plastics, CFC foams and many other substance

Green computing is the study and practice of using computing resources efficiently. The goals are reduce the use of hazardous materials, maximize energy efficiency during the product's lifetime, and promote recyclability or biodegradability of defunct products and factory waste.

Many IT manufacturers and vendors are continuously investing in designing energy efficient computing devices, reducing the use of dangerous materials and encouraging the recyclability of digital devices and paper. Green computing practices came into being in 1992, when the Environmental Protection Agency (EPA) launched the Energy Star program.

Green computing is also known as green information technology (green IT).

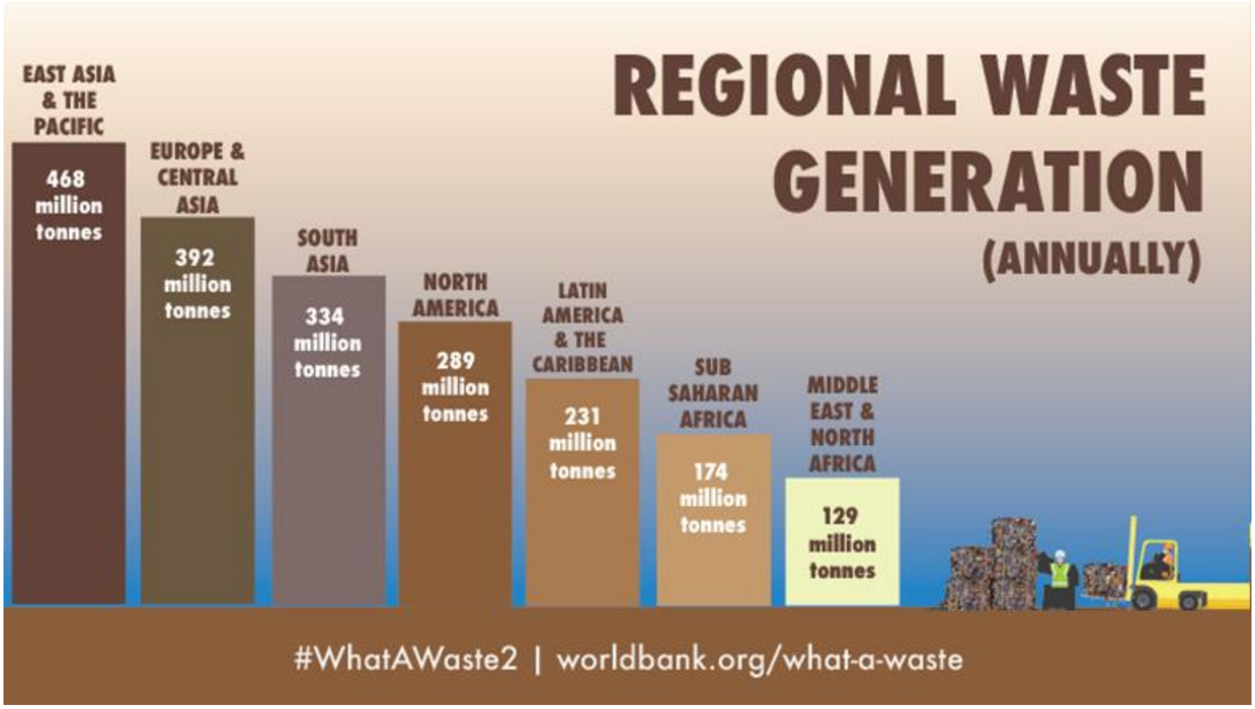
History of Green computing

The idea of green computing has been around a good time, the government themselves play a role in it. For example, the Environmental Protection Agency (EPA) launched the 'energy star' program in the 90s, to promote energy efficient methods. The EPA today still plays an active role by providing not only energy effective methods, but also cost effective methods for the consumers. In 2006 the EPA established a way to save U.S. households and businesses money; "With an eye to saving U.S. households and businesses more than $1.8 billion in energy costs over the next 5 years, today EPA announced new Energy Star specifications for computers and related equipment. These new modifications are also expected to prevent greenhouse gas emissions equal to the annual emissions of 2.7 million cars."(Jones, 2006) Though the EPA is a recognizable agency, they are not the only ones who promoting new ways of going green in the technological aspect. Organizations such as European Union and TCO Certification are one of the leading groups in green computing.

Concept of Green Computing

Green computing, or green IT, aims to attain economic viability and improve the way computing devices are used. Green IT practices include the development of environmentally sustainable production practices, energy efficient computers and improved disposal and recycling procedures.

To promote green computing concepts at all possible levels, the following four complementary approaches are employed



Advantages and Disadvantages of Green Computing

Advantages:- Energy saving - Environmentally Friendly - Cost-effective (pays over time) - Save more money per year - can give you a tax right off

Disadvantages:- High start up cost - Not readily available - Still in experimental stages - Sacrifice performance for battery life - Not for everyone Potential Benefit

The ever rapid growth of technologies and innovations brings forth many ways on how green computing will have a positive impact, along with great benefits. The benefits of green computing are large, not only from just the consumer, or business, or country's standpoint, but a global benefit. Green computing helps reduce energy demands, waste, and money of how we use technology which positively effects the environment, and our costs. Overall the benefits of green computing will result in saving money, reducing costs, and conserving energy, along with helping the environment

E-Waste management practices comprise of various means of final disposal of end-of-life equipment which have different impacts on human health and the environment. It can be distinguished between state-of-the-art recycling technologies, which comply with high environmental and occupational health standards and hazardous technologies that bear a great risk for both health and the environment and are often applied in countries, where no strict standards exist.

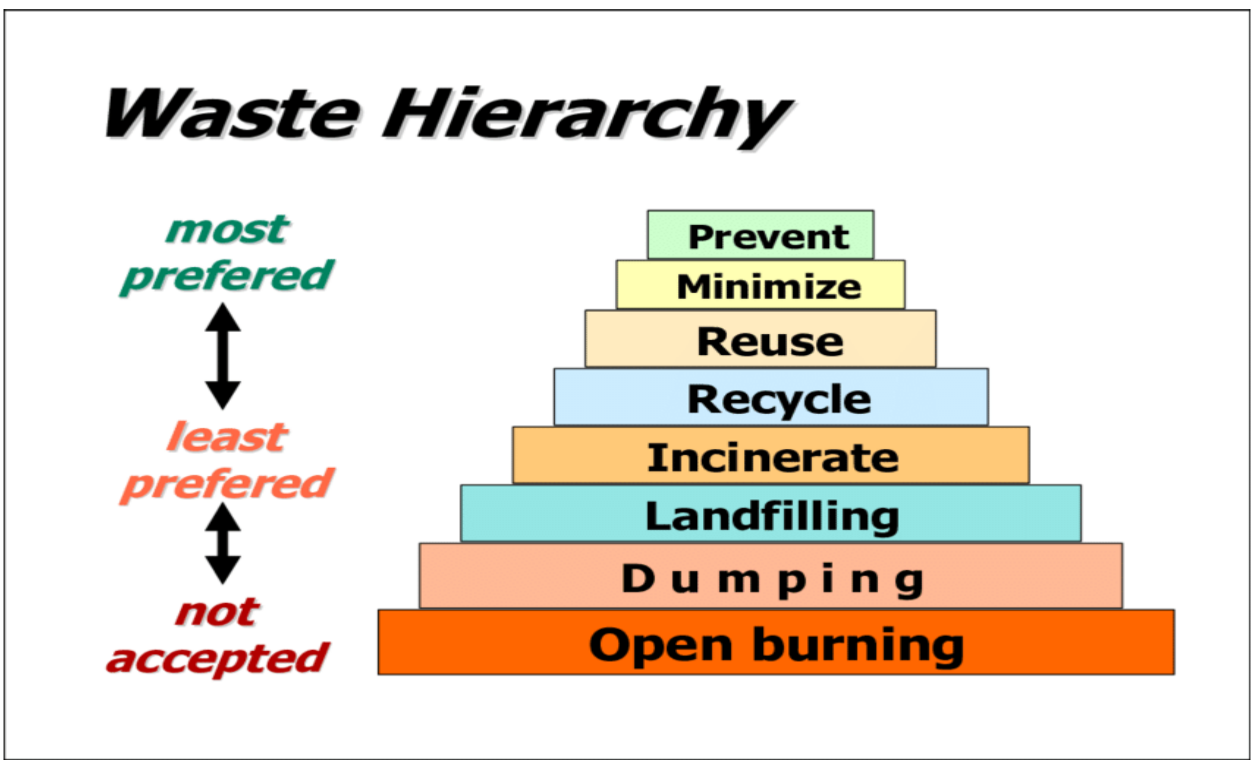
Hazardous Technologies

Incineration: Incineration is the process of destroying waste through burning. Because of the variety of substances found in e-waste, incineration is associated with a major risk of generating and dispersing contaminants and toxic substances.

Open Burning: Since open fires burn at relatively low temperatures, they release many more pollutants than in a controlled incineration process at an MSWI-plant. Inhalation of open fire emissions can trigger asthma attacks, respiratory infections, and cause other problems such as coughing, wheezing, chest pain, and eye irritation. Often open fires burn with a lack of oxygen, forming carbon monoxide, which poisons the blood when inhaled.

Land filling: Land filling is one of the most widely used methods of waste disposal. However, it is common knowledge that all landfills leak. The leach ate often contains heavy metals and other toxic substances which can contaminate

State-of-the-art Recycling Technologies



The state-of-the-art recycling of e-waste comprises three steps

Detoxication The first step in the recycling process is the removal of critical components from the e-waste in order to avoid dilution of and / or contamination with toxic substances during the downstream processes. Critical components include, e.g., lead glass from CRT screens, CFC gases from refrigerators, light bulbs and batteries.

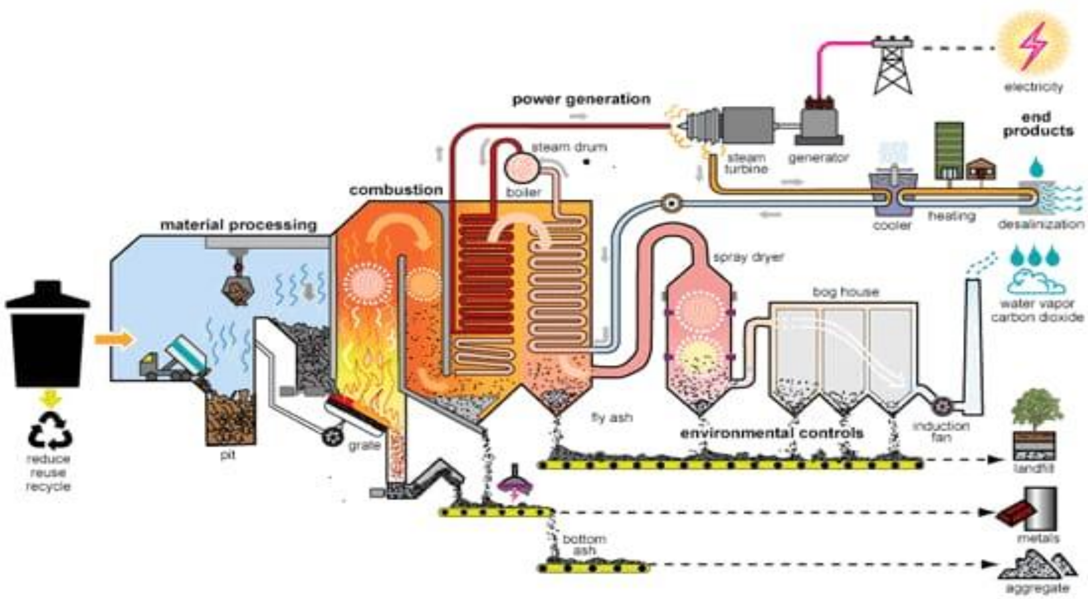
Shredding Mechanical processing is the next step in e-waste treatment, normally an industrial large scale operation to obtain concentrates of recyclable materials in a dedicated fraction and also to further separate hazardous materials.

Refining The third step of e-waste recycling is refining. Refining of resources in e-waste is possible and the technical solutions exist to get back raw with minimal environmental impact. Most of the fractions need to be refined or conditioned in order to be sold as secondary raw materials or to be disposed of in a final disposal site, respectively. During the refining process, to three flows of materials is paid attention: Metals, plastics and glass.

Waste-To-Energy Combustion

Waste-to-Energy combustion (WTE) is defined as a process of controlled combustion, using an enclosed device to thermally breakdown combustible solid waste to an ash residue that contains little or no combustible material and that produces, electricity, steam or other energy as a result (24). Even though both WTE combustion and RDF combust MSW, the objective of WTE combustion is treating MSW to reduce its volume. Generating energy and electricity only adds value to this process. As discussed in Section 2.4.1, combusting the organic fraction of MSW (a bio-fuel) and releasing carbon dioxide as the end product is a net zero emissions process (Section

4.7). Due to the dominance of organic waste in MSW, MSW is considered as a bio-fuel which can be replenished by agriculture. Also, bio-fuels are renewable. In India, urban MSW contains as much as 60% organic fraction and 10% paper. Therefore, potentially, 70% of energy from WTE plants is renewable energy. Therefore, WTE is recognized as a renewable energy technology by the Government of India (GOI). Australia, Denmark, Japan, Netherlands and the US also recognize WTE as a renewable energy technology (15). Thermal waste to energy technologies are the only solutions to handling mixed wastes. In whatever way mixed wastes are treated, the impurities in it will pollute air, water and land resources. By aerobically composting mixed wastes, the heavy metals and other impurities leach into the compost and are distributed through the compost supply chain. In contrast, WTE is a point source pollution control technology, where the impurities in the input mixed waste are captured using extensive pollution control technologies (Table 18) and can be handled separately. The bottom ash from WTE combustion contains nothing but inert inorganic materials and minerals which could be used to make bricks and other construction material. The fly ash from WTE contains pollutants from the input stream and needs to be disposed off in sanitary landfills. By controlling the types of materials fed in to the boiler, European and Japanese WTE plants are known to have achieved nearly zero emissions in the fly ash too. WTE combustion decreases the volume of wastes by up to 90%. Such reduction in volume would prolong the life of a 20 years landfill to 200 years. However, MSW should be combusted after all possible recycling and composting has been done. The input to WTE plants should be the rejects from material recovery and/or composting facilities. Such an integrated system can decrease the amount of wastes landfilled and prolong the life of landfills further. Therefore, WTE combustion is placed below recycling, aerobic and anaerobic digestion on the hierarchy of sustainable waste management.



SANITARY LANDFILLING

United Nations Environmental Program (UNEP) defines sanitary landfilling as the controlled disposal of wastes on land in such a way that contact between waste and the environment is significantly reduced and wastes are concentrated in a well defined area. Sanitary landfills (SLFs) are built to isolate wastes from the environment and render them innocuous through the biological, chemical and physical processes of nature. UNEP also recognizes three basic conditions to be fulfilled to be designated as an SLF: a) Compaction of the wastes, b) Daily covering of wastes (with soil or other material) and c) Control and prevention of negative impacts on public health and environment. On the hierarchy of waste management, sanitary landfilling is expanded into three different categories a) SLFs recovering and using methane (CH4) b) SLFs recovering and flaring CH4 c) SLFs without any CH4 recovery SLFs are categorized depending upon their ability to control and prevent negative impacts on environment, from a climate change perspective. They occupy the three positions after WTE technologies on the hierarchy of waste management (Figure 10). Handling CH4 generated during anaerobic digestion of organics dictates where each type of landfill is placed on the hierarchy of waste management. Organic waste in landfills undergoes both aerobic and anaerobic digestion depending upon oxygen availability. Majority of the waste on the top undergoes aerobic digestion due to greater oxygen availability.

Waste which is inside SLFs undergoes anaerobic digestion due to reduced oxygen availability. The final gaseous product of aerobic digestion is CO2, which results in a net zero emission (Section 4.7). However, the final gaseous product of anaerobic digestion is CH4, which if captured can be used as a fuel, generating renewable energy and converting the carbon in CH4 to CO2, thus resulting in a net zero emissions. In a business as usual scenario (BAU) in India and elsewhere, the CH4 is let out into the atmosphere and not captured. CH4 is a greenhouse gas (GHG), with twenty-one (21) times Page | 47 more global warming potential than CO2 (over a long time period). Therefore, every CH4 molecule released from a landfill has 21 times the potential to warm the planet than CO2. Thus, capturing and flaring CH4 is environmentally preferred to sanitary landfilling without capturing CH4. However, landfilling of materials should be the last option considered for disposing wastes in an integrated waste management system. Also, "currently, the implementation and practice of sanitary landfilling are severely constrained in economically developing countries (like India) by the lack of reliable information specific to these countries" .

UNSANITARY LANDFILLING AND OPEN DUMPING

There is no specific definition for unsanitary landfilling. However, it is generally characterized by open dumping of wastes, lack of monitoring of the site, stray animals and birds feeding on the wastes, absence of leachate or methane collection systems and wastes exposed to natural elements. The direct implications of landfilling include burying materials which were extracted by energy and infrastructure intensive and in most cases environmentally harmful methods and in turn depleting earth’s natural resources. From an energy recovery perspective, landfilling is equivalent to burying barrels of oil. Apart from these moral implications, landfilling causes extensive public health and environmental damage. Landfills create unsanitary conditions in the surroundings, attract pests and directly impact human health. Unsanitary landfills also contaminate ground and surface water resources when the leachate produced percolates to the water table or is washed as runoff during rains. Unmonitored landfills catch fires due to methane generation and heat and result in uncontrolled combustion of wastes, releasing harmful gases like carbon monoxide, hydrocarbons and particulate matter into low level atmosphere. In addition to these harmful impacts, unsanitary landfills contribute to Climate Change by releasing methane, a green house gas (GHG) with 21 times more global warming potential than carbon dioxide (in the first year of release, methane is 71 times more potent than carbon dioxide as a GHG

S.No	City	MSW Generated (TPD)	Composting	RDF/ WTE	LFG recovery	Sanitary landfill	Earth Cover	Alignment/ Compaction	Uncontrolled Dumping	Biomethanation
1	Greater Kolkata	12,060	700	NO	NO	NO	YES	NO	YES	NO
2	Greater Mumbai	11,645	370	80*	YES	NO	YES	YES	YES	YES
3	Delhi	11,558	825	NO	NO	NO	NO	YES	YES	YES
4	Chennai	6,404	YES	NO	NO	NO	YES	NO	YES	NO
5	Greater Hyderabad	5,154	40*	700*	NO	NO	NO	YES	YES	NO
6	Greater Bengaluru	3,501	450	NO	NO	NO	NO	NO	YES	NO
7	Pune	2,724	600	NO	YES	YES	YES	YES	YES	YES
8	Ahmadabad	2,636	YES	NO	NO	YES	YES	YES	YES	NO
9	Kanpur	1,839	YES	NO	NO	NO	YES	NO	YES	NO
10	Surat	1,815	YES	NO	NO	YES	YES	YES	YES	NO
11	Kochi	1,431	YES	NO	NO	NO	NO	NO	YES	20**
12	Jaipur	1,426	NO	500	NO	NO	YES	YES	YES	NO
13	Coimbatore	1,311	YES	NO	NO	NO	YES	NO	YES	NO
14	Greater Visakhapatnam	1,250	NO	NO	NO	NO	NO	YES	YES	NO
15	Ludhiana	1,167	NO	NO	NO	NO	NO	NO	YES	NO
16	Agra	1,069	NO	NO	YES	NO	NO	YES	YES	NO
17	Patna	989	YES	NO	NO	NO	NO	NO	YES	NO
18	Bhopal	919	100	NO	NO	NO	NO	YES	YES	NO
19	Indore	908	YES	NO	NO	NO	NO	YES	YES	NO
20	Allahabad	853	NO	NO	NO	NO	YES	YES	YES	YES
21	Meerut	841	NO	NO	NO	NO	NO	NO	YES	NO
22	Nagpur	838	YES	NO	NO	NO	NO	NO	YES	NO
23	Jodhpur	825	216	NO	NO	YES	YES	YES	YES	NO
24	Lucknow	778	YES	NO	NO	NO	NO	YES	YES	YES*
25	Srinagar	747	YES	NO	NO	NO	NO	NO	YES	NO
26	Varanasi	739	NO	NO	NO	NO	NO	NO	YES	NO
27	Vijayawada	720	YES	225*	NO	NO	NO	YES	YES	YES
28	Amritsar	711	NO	NO	NO	NO	YES	YES	YES	NO
29	Aurangabad	702	YES	NO	NO	NO	NO	NO	YES	NO
30	Faridabad	698	NO	NO	NO	NO	NO	NO	YES	NO
31	Vadodara	634	YES	NO	NO	NO	YES	NO	YES	NO

S.No	City	MSW Generated (TPD)	Composting	RDF/ WTE	LFG recovery	Sanitary Landfill	Earth Cover	Alignment/ Compaction	Uncontrolled Dumping	Biomethanation
32	Mysore	578	YES	NO	NO	NO	NO	NO	YES	NO
33	Madurai	568	NO	NO	NO	NO	NO	NO	YES	NO
34	Pimpri Chinchwad	567	YES	NO	NO	NO	NO	NO	YES	NO
35	Jammu	559	NO	NO	NO	NO	NO	NO	YES	NO
36	Jalandhar	554	350	NO	NO	NO	NO	NO	YES	NO
37	Jamshedpur	539	40	NO	NO	NO	YES	YES	YES	NO
38	Chandigarh	509	YES	500	NO	YES	YES	YES	YES	YES
39	Bhiwandi	489	YES	NO	NO	NO	NO	NO	YES	NO
40	Gwalior	477	120	NO	NO	NO	NO	NO	YES	NO
41	Tiruppur	462	YES	NO	NO	NO	NO	NO	YES	NO
42	Navi Mumbai	455	NO	NO	NO	YES	YES	YES	YES	NO
43	Mangalore	424	NO	NO	NO	YES	YES	YES	YES	NO
44	Jabalpur	398	NO	NO	NO	NO	NO	NO	YES	NO
45	Bhubaneswar	373	NO	NO	NO	NO	NO	NO	YES	NO
46	Nashik	345	300	NO	NO	YES	YES	YES	YES	NO
47	Ranchi	340	NO	NO	NO	NO	NO	NO	YES	NO
48	Rajkot	332	YES	300*	NO	NO	YES	NO	YES	NO
49	Raipur	331	YES	NO	NO	NO	NO	NO	YES	NO
50	Thiruvananthapuram	322	150	NO	NO	NO	YES	YES	YES	20 **
51	Guntur	313	NO	275*	NO	NO	NO	NO	YES	NO
52	Kolhapur	305	YES	NO	NO	NO	NO	NO	YES	NO
53	Bhavnagar	266	YES	NO	NO	NO	NO	NO	YES	NO
54	Udaipur	264	YES	NO	NO	NO	NO	NO	YES	NO
55	Dehradun	259	NO	NO	NO	NO	YES	YES	YES	NO
56	Guwahati	258	NO	NO	NO	NO	NO	YES	YES	NO
57	Jalgaon	208	100	NO	NO	NO	NO	NO	YES	NO
	TOTAL TONNAGE	**64,845**	4,361	1,680						
	Count		38	6	3	8	21	24	59	9

UNSANITARY LANDFILLING (DUMPING)

Open Dump near Jaipur: Half of Jaipur City’s MSW Reaches this Site Majority of the MSW collected in India is disposed off on open land or in unsanitary landfills . This is in addition to the irregular and incomplete waste collection and transportation in many cities, which leaves MSW on the streets. Many municipalities in India have not yet identified landfill sites in accordance with MSW Rules 2000. In several municipalities, existing landfill sites have been exhausted and the respective local bodies do not have resources to acquire new land. Such a lack of landfill sites decreases MSW collection efficiency . Unsanitary landfilling pollutes ground and surface waters, emits green house gases and other organic aerosols and pollutes the air. Pests and other vectors feeding on improperly disposed solid wastes is a nuisance and above that a breeding ground for disease causing organisms. For land requirements to landfill MSW,

OPEN BURNING, LANDFILL FIRES & AIR QUALITY DETERIORATION

Open burning is the burning of any matter in such a manner that products of combustion resulting from the burning are emitted directly into the ambient (surrounding outside) air without passing through an adequate stack, duct or chimney. Open burning of wastes is practiced all over India due to reasons like a) open burning by waste-pickers for recovery of metals from mixed wastes; b) open burning in bins by municipal workers or residents to empty MSW collection bins. open burning of plastic wastes by street dwellers for warmth at night (Figure 14). In addition to open burning of wastes, landfill fires are also common at every landfill in India (Figure 13). Landfill fires were observed at Pimpri-Chinchwad (unsanitary), Nashik and Vishakhapatnam (unsanitary) landfills. They are caused due to the build-up of heat inside waste beds due to decomposing (aerobic or anaerobic) organic matter. Sometimes, these fires continue for weeks at a stretch, even after long showers. Figure 12, Open Burning of MSW Inside a Garbage Bin on the Street in a High Density Residential Area in Hyderabad , Landfill Fire at a Sanitary Landfill in India , Waste Picker Burning Refuse for Warmth at Night, Chandni Chowk, Delhi Page | 58 The author observed refuse being used as a fuel by street dwellers to keep warm during nights . Lit refuse fires were observed frequently in Delhi while author was touring the streets in late January,

2011. Refuse and other biomass burning have been on the rise, as large slum populations do not have adequate kerosene and LPG supply at affordable costs. Slum dwellers use all kind of combustible refuse for burning

AIR EMISSIONS FROM OPEN BURNING AND LANDFILL FIRES

"Air Quality Assessment, Emissions Inventory and Source Apportionment Studies: Mumbai" found out that open burning and landfill fires are a major source of air pollution in Mumbai. The study found that about 2% of the total MSW generated in Mumbai is openly burnt on the streets and 10% of the total MSW generated is burnt in landfills by humans or due to landfill fires. In Mumbai, open burning of MSW is 1. the largest emitter of carbon monoxide (CO), particulate matter (PM), carcinogenic hydrocarbons (HC) and nitrous oxides (NOx), among activities that do not add to the economy of the city; 2. the second largest emitter of hydrocarbons (HC); 3. the second largest emitter of particulate matter (PM); 4. the fourth largest emitter of carbon monoxide compared to all emissions sources in Mumbai; and 5. the third largest emitter of CO, PM and HC combined together in comparison to all emission sources in the city . Open burning contributes to 19% of air pollution due to CO, PM and HC in Mumbai

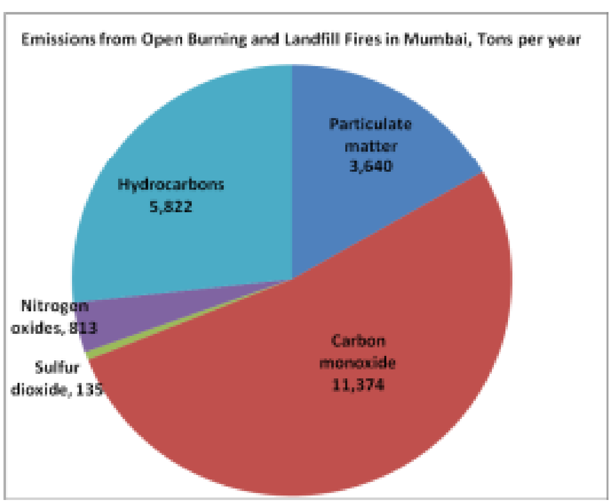


Figure 15, Open Burning of MSW Releases 22,000 tons per year of CO, HCs, PM, NOx, and SO2 into Mumbai's Lower Atmosphere

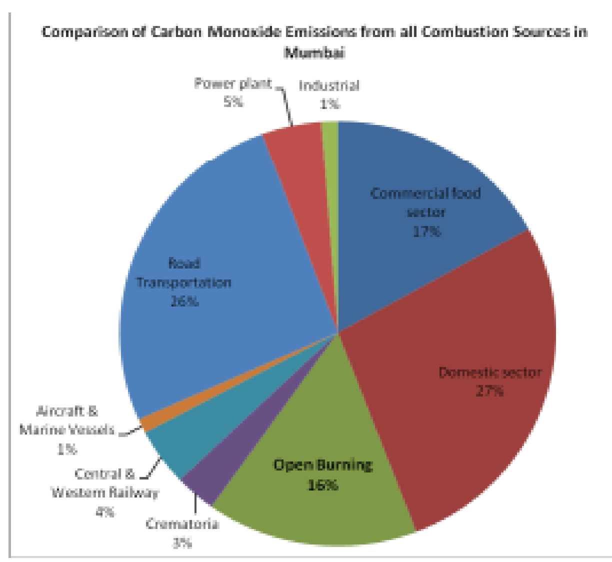


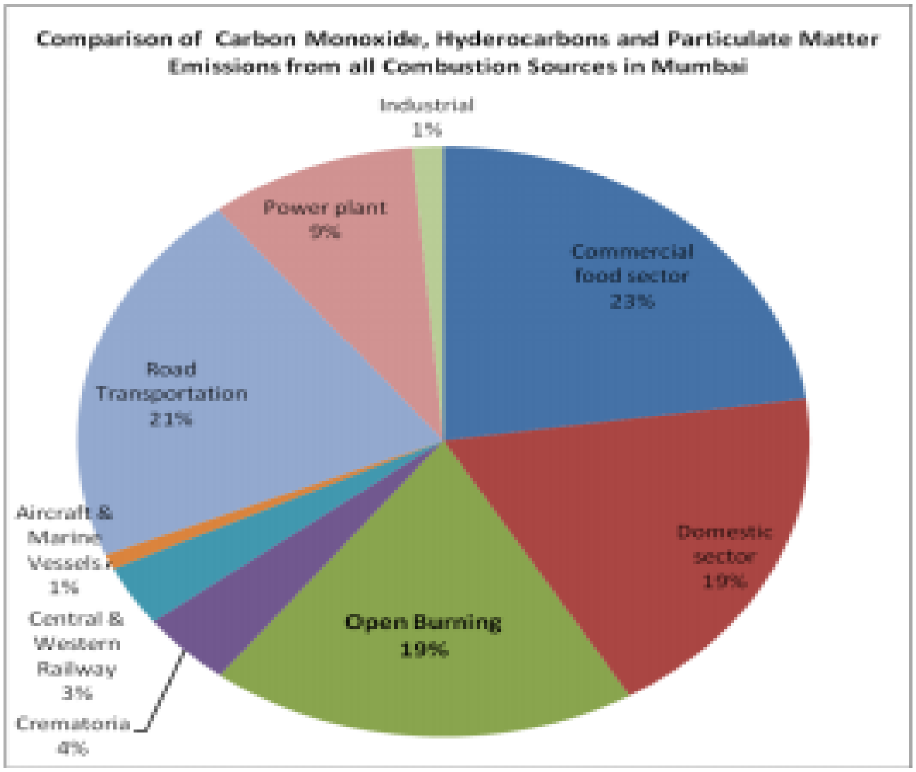
Figure 16, Open burning is a Major Contributor to Carbon Monoxide Pollution in Mumbai

More than twice as much particulate matter is emitted by open burning of MSW as compared to emissions from road transportation in Mumbai. Also, a quarter of volatile hydrocarbons entering the atmosphere in Mumbai are a result of such activity. MSW is combusted on the streets, exposing millions of urban Indians directly to these emissions every day. MSW burning in the landfill happens in areas with lesser population but the activity emits pollutants into the lower atmosphere, where the dispersion of pollutants is very low, increasing the risk of exposure to these harmful emissions.

Open Burning of MSW Releases 22,000 tons per year of CO, HCs, PM, NOx, and SO2 into Mumbai's Lower Atmosphere Figure 16, Open burning is a Major Contributor to Carbon Monoxide Pollution in Mumbai , Open burning is the second largest contributor of Hydrocarbons in Mumbai's atmosphere Figure 18, Open burning of MSW is the Second Largest Source of Particulate Matter Emissions in Mumbai, greater than Road Transportation Commercial food sector 16% Domestic sector 4% Open Burning 24% Crematoria 2% Central & Western Railway 3% Aircraft & Marine Vessels 1% Road Transportation n 10% Power plant 37% Industrial 3% Comparison of Particulate Emissions from all Combustion Sources in Mumbai, Figure 19, Open burning contributes to 19% of Mumbai's Air Pollution due to Carbon Monoxide, Hydrocarbons and Particulate Matter Table 11, Air Emissions Inventory from Open burning and Other Combustion Sources in Mumbai; Source: CPCB, NEERI Source of Emission Emissions (tons/year) PM CO SO2 NOx HC Total

Source of Emission	Emissions (tons/year)					
	PM	CO	SO2	NOx	HC	Total
Commercial food sector	2,429.3	12,271.1	315.4	628.5	10,312.9	**25,957**
Domestic sector	564.9	19,723.7	1,262.0	9,946.9	368.1	**31,866**
Open Burning	**3640**	**11374**	**135**	**813**	**5822**	**21,784**
Crematoria	300.7	2,213.0	7.9	44.4	1,991.9	**4,558**
Central & Western Railway	514.0	3,147.0	1,449.0	19,708.0		**24,818**
Aircraft & Marine Vessels	77.4	791.7	96.7	1,003.4	33.8	**2,003**
Road Transportation	1,544.8	18,856.2	606.4	13,203.1	2,427.1	**36,638**
Power plant	5,628.3	3,215.7	24,473.3	28,944.5	1,266.6	**63,528**
Industrial	503.7	879.7	28,510.2	8,435.2	116.8	**38,446**

The study identifies that open burning of MSW on streets and landfill sites need to be stopped immediately to increase air quality in Mumbai and points out the need for credible solutions to this problem. The study has calculated that 50% reduction in open burning and a 100% reduction in landfill fires are required to reduce PM pollution in Mumbai by 98%, along with many other initiatives. 4.2.2 DIOXINS/FURANS EMISSIONS Open burning of MSW and landfill fires emit 10,000 grams of dioxins/furans into Mumbai's lower atmosphere every year (5) (28) (Appendix 14). Dioxins and Furans are known carcinogenic agents; they can cause cancer in case of long term exposure. The risk of exposure to dioxins/furans is considerably increased due to the fact that MSW is burnt on the streets and landfills which are at ground level, releasing them into directly into ambient surroundings. Also, open burning is a frequent occurrence in some communities, and Landfill fires, once started, go on for weeks at a stretch, increasing human exposure further.



During health studies conducted in Kolkata, waste pickers who are regularly exposed to landfill fire emissions for longer periods were found to have a "Chromosome Break" incidence which was 12 times higher than the control population. Chromosome Break often leads to cancer. Municipality workers were also found to have higher incidence of Chromosome Break compared to control population, but less than that of waste pickers. Health and environmental impacts of open burning are less known to the public and environmental organizations also often ignore open burning as a source of dioxins/furans emissions.

Figure 21, First Stage of Separation of Recyclables into Plastics, Metals and Glass, after Collection by Waste Pickers

Figure 22, Second Stage of Separation of Plastics into Different Types

Figure 23, Plastic Bottles after Second Stage of Separation

Figure 24, Sorted Metal after Second Stage of Separation

WATER POLLUTION

Unsanitary landfills can contaminate ground and surface water resources when the leachate produced percolates through the soil strata into the groundwater underneath or is washed as runoff during rains. Leachate is generally a strong reducing liquid formed under methanogenic (anaerobic) conditions. The characteristics of leachate depend on the content of various constituents in the dumped waste (4). “Studies on Environmental Quality in and around Municipal

Solid Waste Dumpsite” in Kolkata, by Biswas A.K., et al. found moderately high concentrations of heavy metal in groundwater surround the dumpsite. The study found out that the groundwater quality has been significantly affected by leachate percolation

Leachate generally contains organic chemicals formed by anaerobic digestion of organic wastes and heavy metals leached from inorganic wastes. The heavy metals generally observed in Page | 63 leachate are Lead (Pb), Cadmium (Cd), Chromium (Cr) and Nickel (Ni). All these heavy metals are characterized as toxic for drinking water. Due to the reducing property of leachate, during percolation through soil strata, it reacts with Iron (Fe) and Manganese (Mn) species underground and reduces them into more soluble species, thus increasing their concentrations in groundwater (4). Such reactions when they occur, pose a serious drinking water toxic risk. These predictions are substantiated by studies which found high concentrations of Cr, Cd and Mn in groundwater due to leachate percolation. Nitrates present in the environment can also be reduced to nitrites due to leachate. Nitrites consumed through drinking water can oxidize hemoglobin (Hb) in the blood to methemoglobin (met Hb), thereby inhibiting the transportation of oxygen around the body (4). The study clearly establishes that unsanitary landfills in India and elsewhere are potential sources of heavy metals contamination in groundwater sources adjoining the landfills. It also points out that there is an urgent need to adopt credible solutions to control water pollution due to indiscriminate dumping of wastes.

LAND DEGRADATION AND SCARCITY

Landfilling of municipal solid waste (MSW) is a common waste management practice and one of the cheapest methods for organized waste management in many parts of the world (4). This practice of unsanitary landfilling not only occupies precious land resources near urban areas; it also degrades the quality of land and soil in the site. Presence of plastics and heavy metals in the soils make it unfit for agriculture and emissions of methane and structural instability of the land make it unfit for construction activities. It would require massive remediation efforts which are time and infrastructure intensive, to make the land useful. Landfilling occupies vast amount of lands near urban areas. A 1998 study by TERI (The Energy Resources Institute, earlier Tata Energy Research Institute) titled 'Solid Waste Management in India: options and opportunities' calculated the amount of land that was occupied by all the waste that was generated in India post-Independence until 1997. The study compared the land occupied in multiples of the size of a football field and arrived at 71,000 football fields of solid waste, stacked 9 meters high. Based on a business as usual (BAU) scenario of 91% landfilling, the study estimates that the waste generated 1. by 2001 has occupied 237.4 sq.km or an area half the size of Mumbai; 2. by 2011 would have occupied 379.6 sq.km or more than 218,000 football fields or 90% of Chennai, the fourth largest Indian city area-wise; Page | 64 3. by 2021 would need 590.1 sq.km which is greater than the area of Hyderabad (583 sq.km), the largest Indian city area-wise (18) (19

Effects of waste management on E-commerce

Small and medium-sized enterprises (SMEs) in the manufacturing sector contribute a significant role in GDP of a country. In a country like India, manufacturing SMEs contribute to 45% of India's manufacturing output and 17% of India's GDP. Small and medium-sized enterprises

(SME) make up around 90% of the world's businesses (Denis 2011), and they employ 50-60% of the world's population (OECD 2011).

SMEs face problem in their sustainability. SME sustainability comprises of eco nomic, environmental and social aspects. SMEs contribute significantly negative impacts from their business (Hillary 2000).

Companies try to improve the operational and economic front along with the environmental aspects of the sustainability, but they tend to contradict each other (Tajbakhsh and Hassini 2015). Sustainability refers to the social, economic, and environmental practices not just empathizing on the economic profit of the SME.

SMEs struggle from economic constraints, so their major focus is on the economic aspects neglecting the environmental aspects . It is difficult to make priority on one aspect neglecting the other aspects . The researchers claim that the SMEs can only be sustainable in the long run if the environmental aspects of the business are also taken into consideration . Sustainability is considered as an essential criterion for competitiveness of an SME due to the pressure from stakeholders. Stakeholder's theory emphasis is on increasing the stakeholder interest rather than maximizing the stakeholder profit.

Sustainability is being enforced nowadays by the multiple stakeholders .Due to the resource constraint of SMEs, it would be interesting to see the link of the environmental practices (forward and reverse logistics) on the financial performance. Challenges faced by SMEs in environmental and waste management practices are due to the policy and the economic investment required

Studies have looked into the effect of forward logistics (operational and environmental management comprises of "reduce") on the financial performance.

Abstract

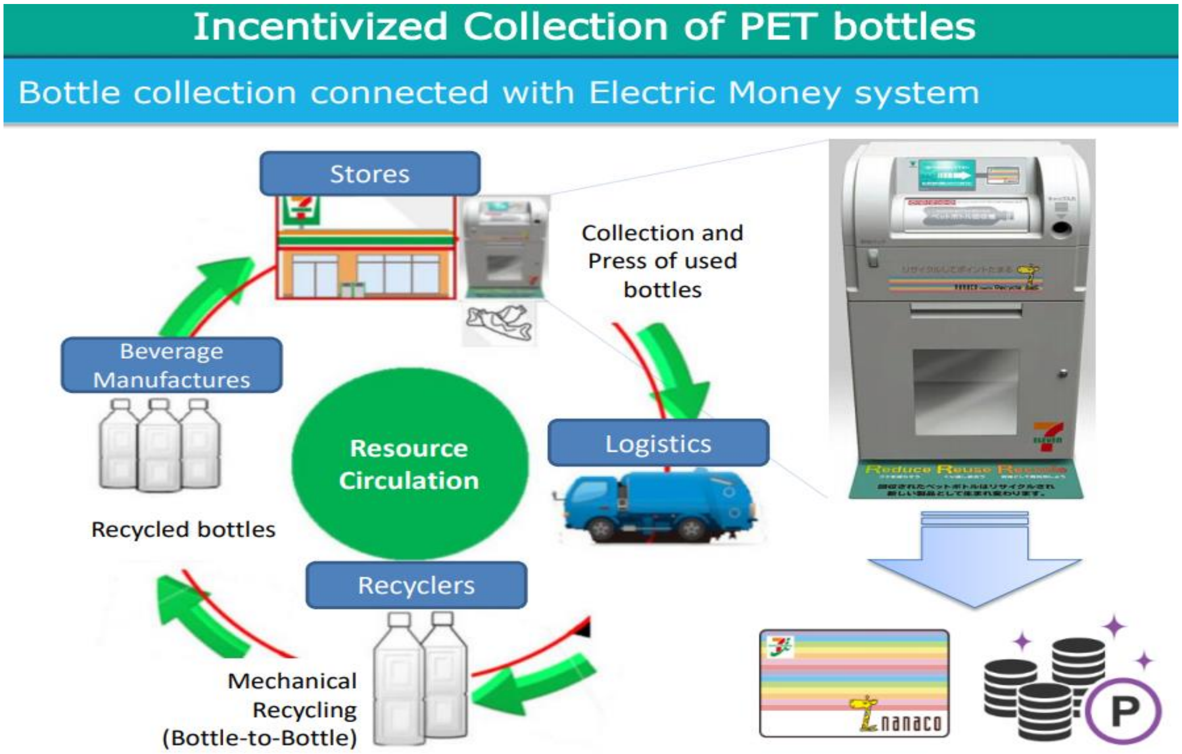
Online shopping, a form of electronic commerce (e-commerce), is a type of business where buyers and sellers interact electronically (using the Internet channel) for the exchange of goods and services and payments of the transaction. E-commerce offers positive environmental effects, for example, greenhouse gas emission reduction due to reduced traveling needs by individual consumers, and other energy use in traditional brick-and-mortar shops. However, online shopping is not entirely free from negative environmental impacts. Packaging waste from e-commerce is one of such concerns. A typical e-commerce parcel may use up to seven types of packaging materials: paper bills, envelopes, cardboard box, plastic bags, woven bags, tape, and buffer materials (bubble wrap, styrofoam). Environmental impacts of online shopping can be categorized into first-order (information and communication technology equipment usage), second-order (changing of processes and markets affecting the logistics system for product fulfillment and delivery), and third-order (rebound) effects. Thai e-commerce market is advancing to become one of Asia's top performers. According to the Electronic Transactions Development Agency, the value of the Thai e-commerce market in 2016 was expected to reach 2,523.99 billion Baht. At present, Lazada is a popular business-to-consumer e-commerce company in Thailand. A survey conducted to identify consumers' awareness and willingness to reduce environmental impacts of online shopping revealed that a 13.8% of the respondents had never purchased anything via the online channel, citing lack of opportunity to touch/feel the product, and fear of deception being the reasons. Of the online shoppers (86.2%), only 11.8% felt that the product arrived with an 'excessive' packaging, and they, however, simply discard those packaging materials. In order to transform e-commerce into Green commerce, companies need to invest in packaging innovation and sustainable supply chain mechanisms including reverse logistics system to promote reuse and recycling, while consumers also need to display sustainable consumption behavior.

Keywords

E-commerce Greenhouse gas Packaging waste Recycling Sustainable consumption

Benefits of recycling

Recycling raw materials from end-of-life electronics is the most effective solution to the growing e-waste problem. Most electronic devices contain a variety of materials, including metals that can be recovered for future uses. By dismantling and providing reuse possibilities, intact natural resources are conserved and air and water pollution caused by hazardous disposal is avoided. Additionally, recycling reduces the amount of greenhouse gas emissions caused by the manufacturing of new products.


Incentivized Collection of PET bottles
Bottle collection connected with Electric Money system
Stores
Collection and
Press of used
bottles
Beverage
Manufactures
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Mechanical
Recycling
(Bottle-to-Bottle)
Reduce Reuse Recycle
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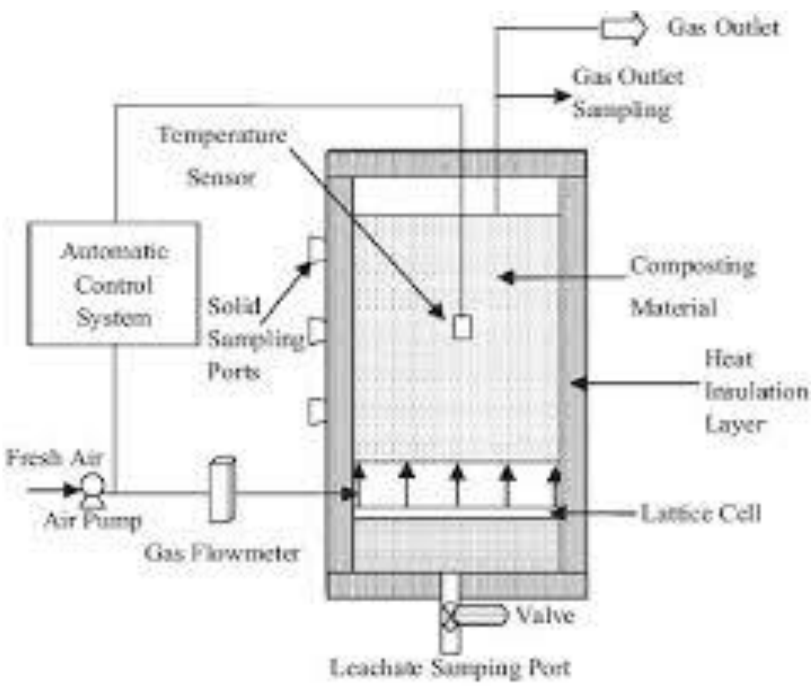
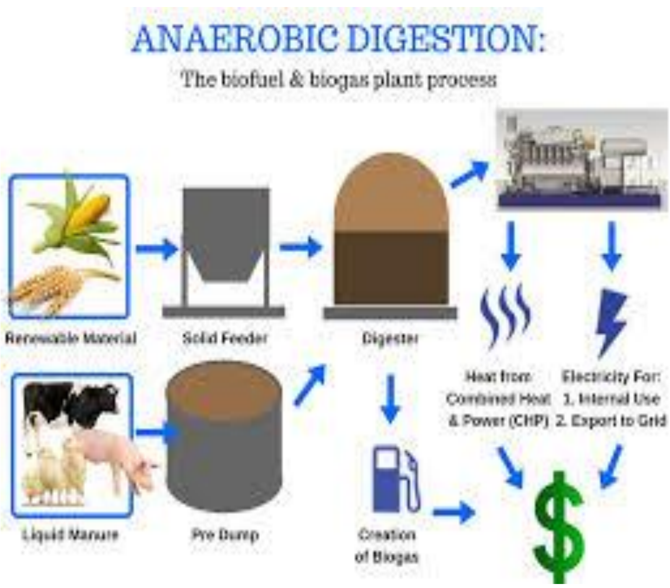
AEROBIC COMPOSTING

Similar to the recycling of inorganic materials, source separated organic wastes can be composted and the compost obtained can be used as an organic fertilizer on agricultural fields. Organic compost is rich in plant macro nutrients like Nitrogen, Phosphorous and Potassium, and other essential micro nutrients. Advantages of using organic manure in agriculture are well established and are a part of public knowledge. United Nations Environment Program (UNEP) defines composting as the biological decomposition of biodegradable solid waste under predominantly aerobic conditions to a state that is sufficiently stable for nuisance-free storage and handling and is satisfactorily matured for safe use in agriculture. Composting can also be defined as human intervention into the natural process of decomposition as noted by Cornell Waste Management Institute. The biological decomposition accomplished by microbes during the process involves oxidation of carbon present in the organic waste. Energy released during oxidation is the cause for rise in temperatures in windrows during composting. Due to this energy loss, aerobic composting falls below anaerobic composting on the hierarchy of waste management. Anaerobic composting recovers energy and compost. Life cycle impacts of extracting virgin raw materials and manufacturing make material recovery options like recycling and composting the most environment friendly methods to handle waste. They are positioned higher on the hierarchy compared to other beneficial waste handling options like energy recovery. However, quality of the compost product depends upon the quality of input waste. Composting mixed wastes results in low quality compost, which is less beneficial and has the potential to introduce heavy metals into human food chain. Aerobic composting of mixed waste results in a compost contaminated by organic and inorganic materials, mainly heavy metals. Contamination of MSW compost by heavy metals can cause harm to public health and environment and is the major concern leading to its restricted agricultural use



Mixed waste composting is therefore not an option for sustainable waste management, but this issue is not a part of public knowledge. Mixed waste composting is widely practiced and is considered better (if not best) (8) in countries like India where more than 91% of MSW is landfilled and there are no other alternatives. It is considered better probably because public health and environmental impacts of unsanitary landfilling are more firmly established by research than those impacts due to heavy metal contamination of MSW compost. Refer to Section 5.2.1 to check the conformance of aerobic composting and mechanical biological treatment in India with the hierarchy of sustainable waste management. 2.4 ENERGY RECOVERY Energy requirements of a community can be satiated to some extent by energy recovery from wastes as a better alternative to landfilling. Energy recovery is a method of recovering the chemical energy in MSW. Chemical energy stored in wastes is a fraction of input energy expended in making those materials. Due to the difference in resources (materials/energy) that can be recovered, energy recovery falls below material recovery on the hierarchy of waste management.

ANAEROBIC DIGESTION



The USEPA defines Anaerobic Digestion (AD) as a process where microorganisms break down organic materials, such as food scraps, manure and sewage sludge, in the absence of oxygen. In the context of SWM, anaerobic digestion (also called Anaerobic Composting or Biomethanation) is a method to treat source separated organic waste to recover energy in the form of biogas, and compost in the form of a liquid residual. Biogas consists of methane and carbon dioxide and can be used as fuel or, by using a generator it can be converted to electricity on-site. The liquid slurry can be used as organic fertilizer. The ability to recover energy and compost from organics puts AD above aerobic composting on the hierarchy of waste management. Page | 44 Similar to aerobic composting, AD needs a feed stream of source separated organic wastes. AD of mixed wastes is not recommended because contaminants in the feed can upset the process. Lack of source separated collection systems, and public awareness and involvement strike off large scale AD from feasible SWM options in India. However, AD on a small scale (called small scale biogas) has emerged as an efficient and decentralized method of renewable energy generation, and waste diversion from landfills. It also reduces green house gas emissions by using methane as an energy source which would otherwise be emitted from landfilling waste. Refer to Section 5.3 to check the conformance of small scale anaerobic digestion in India with the hierarchy of sustainable waste management.

REFUSE DERIVED FUEL (RDF)

Refuse Derived Fuel refers to the segregated high calorific fraction of processed MSW. RDF can be defined as the final product from waste materials which have been processed to fulfill guideline, regulatory or industry specifications mainly to achieve a high calorific value to be useful as secondary/substitute fuels in the solid fuel industry (23). RDF is mainly used as a substitute to coal (a fossil fuel) in high-energy industrial processes like power production, cement kilns, steel manufacturing, etc, where RDF's use can be optimized to enhance economic performance (23). The organic fraction (including paper) in RDF is considered to be a bio-fuel and is thus renewable. Since the carbon dioxide released by burning the organic fraction of RDF arises from plant and animal material, the net green house gas (GHG) emissions are zero (Section 4.7). The overall green house emissions from RDF are however not zero. This is due to carbon emissions from burning the plastics fraction left in RDF. The amount of GHG emissions from RDF depends upon the composition or organics and plastics in the MSW stream it is being processed from. Using RDF prevents GHG emissions from landfills, displaces fossil fuels, and reduces the volume of waste that needs to be landfilled, thus increasing their operating life. On the hierarchy of waste management, RDF is placed below aerobic composting, as a waste to energy technology. It is a slight variant of the waste-to-energy combustion (WTE) technology, which combusts MSW (processed or as it is) to generate electricity. RDF is different because the objective is to increase the calorific value by processing the fuel. Refer to Section 5.4 to check the conformance of RDF technology in India with the hierarchy of sustainable waste management.

IMPROPER SOLID WASTE MANAGEMENT

(WASTE DISPOSAL)

ULBs spend about $10 – 30 (INR 500 – 1,500) per ton on SWM. About 60-70% of this amount is spent on collection, 20-30% on transportation. No financial resources are allotted for scientific disposal of waste (6) (7). Despite the fairly high expenditure, the present level of service in many urban areas is so low as to be a potential threat to the public health and environmental quality (4). A guidance note titled " Municipal Solid Waste Management on a Regional Basis", by the Ministry of Urban Development (MOUD), Government of India (GOI) observes that "Compliance with the MSW Rules 2000 requires that appropriate systems and infrastructure facilities be put in place to undertake scientific collection, management, processing and disposal of MSW.

However, authorities are unable to implement and sustain separate and independent projects to enable scientific collection, management, processing and disposal of MSW. This is mainly due to lack of financial and technical expertise and scarcity of resources, such as land and manpower." Improper solid waste management deteriorates public health, degrades quality of life, and pollutes local air, water and land resources. It also causes global warming and climate change and impacts the entire planet. Improper waste management is also identified as a Page | 54 cause of 22 human diseases (21) and results in numerous premature deaths every year. Indiscriminate dumping of wastes and leachate from landfills contaminates surface and groundwater supplies and the surrounding land resources. It also clogs sewers and drains and leads to floods. Mumbai experienced a flood in 2006 which was partly due to clogged sewers. Insect and rodent vectors are attracted to MSW and can spread diseases such as cholera, dengue fever and plague. Using water polluted by solid waste for bathing, food irrigation, and as drinking water can also expose individuals to disease organisms and other contaminants (21). The city Surat has experienced a city-wide bubonic plague epidemic in 1994 due to improper SWM. Open burning of MSW on streets and at landfills, along with landfill fires emit 22,000 tons of pollutants into the lower atmosphere of Mumbai city, every year.

The pollutants identified in Mumbai due to uncontrolled burning of wastes are carbon monoxide (CO), carcinogenic hydro carbons (HC) (includes dioxins and furans), particulate matter (PM), nitrogen oxides (NOx) and sulfur dioxide (SO2) (5). MSW dumped in landfills also generates green house gases like methane, which has 21 times more global warming potential than carbon dioxide. Improper SWM contributes to 6% of India's methane emissions and is the third largest emitter of methane in India. This is much higher than the global average of 3% methane emissions from solid waste. It currently produces 16 million tons of CO2 equivalents per year and this number is expected to rise to 20 million tons of CO2 equivalents by 2020 (27). The world is moving towards calling wastes as "resources".

Due to the inability to manage these resources in the next decade, India will landfill 6.7 million tons of recyclables (or secondary raw materials); 9.6 million tons of compost (or organic fertilizer); and resources equivalent to 57.2 million barrels of oil. Efforts towards proper SWM were made by ULBs equipped with financial and managerial capacity to improve waste management practices in response to MSW Rules 2000 (9). Despite these efforts to manage wastes, more than 91% of MSW collected is still landfilled or dumped on open lands and dumps (7), impacting public health, deteriorating quality of life and causing environmental pollution. It is estimated that about 2% of the uncollected wastes are burnt openly on the streets; and about 10% of the collected MSW is openly burnt in landfills or is caught in landfill fires (5) (See Section 4.2). The MSW collection efficiency in major metro cities still ranges between 70 - 90% of waste generated, whereas smaller cities and towns collect less than 50% of waste generated .

PUBLIC HEALTH CRISIS

The present level of SWM service in urban areas is a potential threat to public health and environment (4). Inhalation of bioaerosols, and of smoke and fumes produced by open burning of waste, can cause health problems. Also, the exposure to air-borne bacteria is infectious. Toxic materials present in solid waste are determinants for respiratory and dermatological problems, eye infections and low life expectancy (16). The carbonaceous fractions and toxic elements like Cr, Pb, Zn, etc. dominate the fine particle range. As most of the fine particles can possibly enter the human respiratory systems, their potency for health damage is high. Also, these fine particles from open burning which constitute higher fractions of toxics are mostly released at ground level (5). On comparing emissions from open burning to the concentrations and composition of emissions causing indoor air pollution due to bio-fuel burning inside homes (28), it can be concluded that emissions from open burning also cause numerous premature deaths in the populations exposed, but there is no data available on this subject. A less observed side effect of improper SWM in India is the introduction of heavy metals into the food chain. Compost from mixed waste composting plants is highly contaminated with heavy metals. Using this compost on agricultural fields will result in contamination of the agricultural soil with heavy metals. Food crops grown on contaminated agricultural soils when consumed will introduce the heavy metals into the food chain and lead to a phenomenon called “biomaginification”. Biomaginification is defined by United States Geological Survey (USGS) as the process whereby the tissue concentrations of a contaminant (heavy metals) increases as it passes up the food chain through two or more trophic levels (plants and humans or plants, cattle and humans). Heavy metals generally found in mixed waste composts are Zinc (Zn), Copper (Cu), Cadmium (Cd), Lead (Pb), Nickel (Ni) and Chromium (Cr). Long-term exposure to these heavy metals through food can cause severe health damage. Heavy metals in human body are known to cause damage to the central nervous system and circulatory system, liver and kidney dysfunction, anemia, stomach and intestinal irritation and psychological and developmental changes in young children. However additional research is required to properly understand the transport pathways of heavy metals into human bodies through different agricultural crops and meat products. Heavy metal contamination of groundwater due to leachate percolation below unsanitary landfills can also cause biomaginification of heavy metals in humans who drink water from those sources. Long term exposure of populations surrounding dumpsites to open waste disposal can lead to health problems (Box 2). Ill health of municipal workers and waste pickers means a threat to public health. Also, contagious diseases can spread rapidly in densely populated Indian cities posing a bigger threat to public health. Diseases caused due to stray animals, pests and insects attracted to wastes is a threat to public health too. Sewers and drains clogged by solid waste are breeding grounds for mosquitoes. Improper SWM in the city Surat caused a city-wide bubonic plague epidemic in 1994, which later transformed Surat into one of the cleanliest cities in India. Stray animals and insects carry other diseases like cholera and dengue fever (21). 4.6 QUALITY OF LIFE (QOL) The Global Development Research Center, GDRC defines Quality of Life (QOL) as the product of the interplay among social, health, economic and environmental conditions which affect human and social development. QOL reflects the gap between the hopes and expectations of a person or population and their present experience. In a country like India, which aspires to be a global economic giant, public health and quality of life are degrading everyday with the increasing gap between services required and those provided. India is also considered a sacred nation by the majority of its inhabitants but the streets and open lands in Indian cities are filled with untreated and rotting garbage. The present citizens of India are living at a time of unprecedented economic growth and changing lifestyles. Unsanitary conditions on the streets and air pollution in the cities will widen the gap between their expectations due to the rapidly changing perception of their "being" and "where they belong" and the prevailing conditions, resulting in plummeting quality of life. Improper SWM is an everyday nuisance to urban Indians. Uncollected waste on the streets, acts as a breeding ground for street dogs, stray animals and other disease vectors. Urban Indians have to deal with stench on the streets as soon as they leave their homes and have to walk by or drive by open bins and MSW dumps every day. During the rainy season, many urban Indians come across the unpleasant experience of having to walk in ankle height waters mixed with rotting MSW. The author during his research visits in India observed dry solid waste flying with wind, in the streets of Chennai. Living with children in such conditions adds to the trauma of adults that their children have to get exposed to such living conditions. These experiences are very unpleasant and unsettling and they develop a downgraded image of themselves to the citizens. There is a danger that such conditions for a prolonged time impact the sense of community between individuals and encourages indifference to any initiatives taken towards the betterment of the situation (29). Figure 20, Improper SWM is an Everyday Nuisance to Urban Indians Such conditions and experiences cause decrease in the work efficiency and disease. The high disease burden due to improper SWM will result in a degraded QOL and in turn disrupts the citizen's sense of well being. These cumulatively impact the economy of the urban centers negatively.

IMPACT ON CLIMATE CHANGE

Solid waste management is the third largest emitter of anthropogenic methane in the world, contributing to 3% of the world's overall green house gas emissions. In India, SWM is the second largest anthropogenic methane emitter and the largest green house gas emitter among activities which do not add to the economical growth of the country. They contribute 6% to the Page | 68 overall green house gas emissions of 2.4 Giga tons of CO_2 equivalents generated by India (27). Presently, an insignificant fraction of methane emitted from solid waste dumpsites is captured in India, rest of it is left into the atmosphere, not captured and unused. Control of GHGs from SWM is considered an achievable goal in the short term, among many other efforts to avert climate change. Anoxic conditions inside landfills result in the anaerobic digestion of organic wastes which produces methane as the final gaseous product. Due to anaerobic reactions, landfills emit methane throughout their life time and also for several years after closure. Methane has high energy content and if captured economically can act as a renewable energy source. In case of unsanitary landfills which do not have methane capture mechanisms installed, the methane is released into the atmosphere. The organic fraction of MSW is made photosynthetically by plants using carbon dioxide absorbed from the atmosphere. Therefore, at the end of their life cycle, carbon dioxide emissions from organic wastes mean a 'net zero emission'. However, since methane has 21 times more global warming potential as compared to CO_2, methane emissions from organic wastes mean 'net positive emissions'. One ton of methane equals 21 tons of CO_2 equivalents over a long period of time. In short time periods, CH_4 is much more potent than CO_2. During the first year of release, CH_4 is 71 times more potent than CO_2. Therefore, net positive emissions of GHGs in the form of methane warm the planet faster and contribute to global warming and in turn climate change. However, SWM is very infrastructure intensive and expensive and cannot be afforded by all developing nations. Climate change is a problem that will affect every country on this planet and hence it requires concerted efforts. Our planet has reached a position where it is more economical to achieve GHG emission reductions in developing nations as compared to developed nations. This situation has lead to the creation of Clean Development Mechanism (CDM) under the Kyoto Protocol. The countries which have signed the Kyoto Protocol agree to reduce their GHG emissions below certain standards. CDM provides an avenue to developed nations to achieve these standards, by making it easy to buy carbon credits from developing nations. This mechanism therefore has dual benefits of reducing the overall GHG emissions of the planet and also helps improve the facilities in developing nations.

CONFORMANCE WITH THE HIERARCHY OF SUSTAINABLE WASTE MANAGEMENT

Comparison of SWM in India with the hierarchy of sustainable waste management does not show a very bright situation. It indicates a developing country with a huge population and growing economy and scattered but ongoing efforts towards SWM. There is also a definite awareness among local bodies as well as policy makers on SWM. The SWM sector in India has progressed in the right direction during the last few years (7), specifically after the introduction of Jawaharlal Nehru National Urban Renewal Mission (JnNURM) by the Government of India (GOI). However, it still suffers due to lack of managerial and financial resources and public awareness on the issue. The sector has a long way to go. Changes expected in disposal of MSW in the near future are a. more extensive integration of informal waste sector into the formal systems, b. further increase in the construction of composting facilities, c. new RDF, WTE and sanitary landfill facilities and d. capping of some landfills for landfill gas (LFG) recovery Further financial and technical assistance from GOI is expected. Academic and scientific research institutions are also expected to increasingly focus on this sector

Conclusion

Overall the effects of green computing with its benefits, practicality, and uses are all positives. All which are great for not only the individual, but also all around the globe. By going "green" in technology we help promote an ecofriendly and cleaner environment, along with our own.Two decades of economic growth since 1990 has changed the composition of Indian wastes. The quantity of MSW generated in India is increasing rapidly due to increasing population and change in lifestyles. Land is scarce and public health and environmental resources are precious. The current SWM crisis in India should be approached holistically; while planning for long term solutions, focus on the solving the present problems should be maintained. The Government of India and local authorities should work with their partners to promote source separation, achieve higher percentages of recycling and produce high quality compost from organics. While this is being achieved and recycling is increased, provisions should be made to handle the non-recyclable wastes that are being generated and will continue to be generated in the future (20). State Governments should take a proactive role in leveraging their power to optimize resources. Improving SWM in India is imperative. Improper SWM presents imminent danger to public health, India’s environment and the quality of life of Indians. Materials and energy recovery from wastes is an important aspect of improving SWM in India. It not only adds value to SWM projects and makes them economically feasible but is also more sustainable. Diverting MSW from landfills and especially from unsanitary landfills in India to any extent will contribute to the cause. India should choose those options or a combination of them, which will a. best address the issue of overall solid waste management, b. have the least/no impact on public health and environment, c. consume minimal resources and d. be economically feasible. Recycling, composting and waste-to-energy are integral parts of the solution and they are all required; none of them can solve the India’s SWM crisis alone. Policy to include waste-pickers in the private sector must be introduced to utilize their low cost public and environmental service and to provide better working conditions to these marginalized populations. MBT for windrow composting of mixed wastes should be used to separate wastes. Such separation at a later stage allows for managing the wastes better. Compost from such a facility should be used for cash crops/ or lawns or as landfill cover instead of for food crops. Rejects from composting should be combusted to produce energy and reduce their volume. Only the ash from the WTE plants or co-combustion facilities should be landfilled. Such a scenario would divert 93.7% of MSW from landfilling. Page | 117 If Indian WTE industry can exhibit self-responsibility in emissions control with constant emissions monitoring, and reporting and can feedback the results into a loop of selfimprovement, it will lead the way for reforms in implementation of regulations across all other industries. It would have also established itself as a solution to a crisis and a source of comfort to more than a billion people and inspiration to a huge industrial sector, rather than being perceived by some as another problem to fight against. The success of recycling in India depends upon leveraging the advantage India has in the form of informal recycling sector. There is a world-wide consensus that the need of recycled materials will spike in the next decade. The informal sector should be ready to meet this demand. This also increases opportunities for private companies which can aggregate large amounts of waste to supply in bulk. Prevalence of one of these or co-existence depends upon the quality of the product and the quantity (bulk) they can supply. • Informal Sector should be integrated into formal system; • Compost from MBT should be used as landfill cover/ cash crops/ lawns; • RDF and WTE for the rest of the waste from MBT plants; and • Majority source separation should be the target of Municipal corporations Solid Waste Management, its impacts on public health and environment, and prospects for the future should be further researched. The findings should be disseminated into the public knowledge domain more effectively

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