PARADIGM SHIFT IN MUNICIPAL SOLID WASTE TREATMENT AND DISPOSAL TECHNOLOGY: A REVIEW

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Abstract: The rapid urbanization has exerted heavy pressure on land and water resources in Indian cities resulting in serious environmental and social problems. Population growth and industrialization contribute to enormous amount of solid waste generation in the urban environment. Municipal Solid Waste Management (MSWM) plays an important role in sustainable development and pollution minimization. Recently a paradigm shift in solid waste management practices have incorporated with updated technologies to tackle modern challenges in the field of municipal solid waste management. This review has briefly described about the latest municipal solid waste treatment and disposal technologies and innovations. The current practices of the uncontrolled dumping of waste on the outskirts of cities have created a serious environmental and public health problem. The decadal growth rate of urban population in India is 3.90 % and rate of generation of solid waste increases exponentially by 5% (Census of India 2011). Unscientific dumping pollutes the environment to a greater extent and hence it is difficult to find the balance between economic growth and environmental protection. The dumping of municipal solid waste causes changes in the Geo technical properties of the soil and the quality of ground water. This review specially focused over a paradigm shift for MSW disposal and treatment with reference to current scenario.

INDEX TERMS: MSW, Paradigm, Landfills, Leachate, Bio reactor, Pyrolysis, Plasma Gasification and MECs

INTRODUCTION:

The Municipal Solid Waste (MSW) includes commercial and residential wastes generated in municipal areas, in either solid or semi-solid form, excluding industrial hazardous wastes, but including treated biomedical wastes (MoEF 2000). The dumping of MSW without proper source segregation adds to the complexity of the issue. The most commonly adopted method to manage solid waste disposal in developing countries is to dispose in open dumps which causes serious environmental problems including health hazards (Ball and Denhann 2003). Areas near the dumpsites have a greater possibility of environmental problems such as land, surface water and groundwater contamination because of the potential pollution source of Leachate originating from the site. Such contamination poses a substantial risk to the local resource user and to the natural environment. The most important impact of landfill leachate is the surface and groundwater contamination which has given rise to a number of studies in recent years (Walker 1969, Chian and DeWalle 1976, Kelley 1976, Flyhammar 1995, De Rosa et al 1996, Christensen et al 1998, Looser et al 1999, Abu-Rukah and Al-Kofahi 2001, Saarela 2003, Mor et al 2006, Jaskelevicius and Lynikiene 2009, Bhalla et al 2011, Sholichin 2012). The MSW disposal and treatment problem and the environmental issues due to dumping can be solved not only by designing proper sanitary landfills and application of modern treatment and disposal techniques but also involvement of stakeholders is important to achieve meaningful solution.

Sustainable MSWM involves proper management starting from production of non–biodegradable products, usage, waste generation, disposal at user level, collection, transportation, and disposal in dumpsites, post disposing effects on land, air and water. In the chain of solid waste generation and disposal, the local communities are not adequately considered. Land and water contamination need to be studied to understand the magnitude of contamination the solid waste creates in the environment. In this review an attempt is made to priorities modern disposal practices over ancient MSW disposal systems.

The amount of MSW is expected to increase significantly in the future due to rapid population explosion and economical potential of cities (Central Pollution Control Board (CPCB), 2000, Sharma and Shah, 2005, Hazra and Goel, 2009). The waste generation in India is more than 42 million tons annually and the rate of solid waste generation vary from 0.2 kg/d to 0.8 kg/d (Sharholy et al., 2008, Ogwueleka, 2009, Rana et al., 2015). It is reported from the literature study that the decadal increase in MSW generation in India is around 5% (Sharholy et al., 2008, Kumar et al., 2009). It was estimated that the MSW generation is 127,486 tonnes per day (TPD) in India in 2011 (Rana et al., 2017). Out of the total waste generated in India, 89,334 TPD of MSW was collected and 15,881 TPD was recycled (TERI, 2015). At present, about 960 million tonnes of solid waste is being generated annually as by-products during municipal, industrial, mining, agricultural and other processes in India. Out of this, 350 million tonnes is organic waste from agricultural sources, 290 million tonnes is inorganic waste of industrial and mining sectors, and 4.5 million tonnes is hazardous in nature (Pappu et al., 2007). Metro cities in India generate approximately 30,000 tonnes of solid waste every day, and Class 1 cities generate about 50,000 tonnes every day (Sujatha et al., 2013).

Lack of proper management of solid waste in Indian cities is very common with the absence of appropriate data including volume of generation, collection, transportation and disposal of solid wastes generated (Shekdar, 2009). In India, the current status of MSW management is not very satisfactory. For example, a matrix method of evaluation of Tricity showed the efficiency of less than 40% for the existing system (Rana et al., 2015, Rana et al., 2017).

No.	Year	Waste generated per capita (kg/d)	Waste generated (TPD)
1	2011	0.356	127,458.1
2	2021	0.406	17,728,107
3	2031	0.463	239,240
4	2041	0.529	313,839.7

Estimated waste generation rate in projected years in India (CPCB, 2000)

Generally, MSW is disposed of in low-lying areas without taking any precautions or operational controls, being the major cause of soil and groundwater pollution(Nayak et al., 2007, Amadi et al., 2012). Therefore, MSW management is one of the major environmental problems for Indian cities. When rainfall occurs, rain comes in contact with solid waste and forms leachate which finds its way to percolate into aquifers and soil strata. Leachate may contain a large amount of organic content, heavy metals and inorganic salts (Renou et al., 2008, Aziz et al., 2010, Aziz and Maulood, 2015, Mojiri et al., 2016). Unscientific disposal causes an adverse impact on all components of the environment and human health (Jha et al., 2003, Sharholy et al., 2008). The waste disposal sites and landfills that are neither properly designed nor constructed become point sources for pollution of aquifers and soils. MSW disposal is at a critical stage of development in India. There is a dire need to develop facilities for the disposal of drastically increased amount of MSW. More than 90% of the waste in India is believed to be dumped in an unsatisfactory manner. It is reported from the literature study that an area of approximately 1400 km^2 was occupied by waste dumps in 1997 and it is expected to increase substantially in the near future (Goswami and Sarma, 2008, Sharholy et al., 2008). In this context, it is suggested to construct properly engineered waste disposal facilities to improve public health and prevent environmental resources including surface water, groundwater, air and soil from being polluted (Nanda et al., 2011, Musa, 2012).

OBJECTIVE OF THE REVIEW:

The aim of this review study to understand current scenario and shift in paradigm for MSW treatment and disposal practices adapted for MSW to enhancing more sustainable cleaner and greener cities.

CURRENT PRACTICES FOR THE MSW TREATMENT:

Current treatment strategies are directed towards reducing the amount of solid waste that needs to be land filled, as well as recovering and utilizing the materials present in the discarded wastes as a resource to the largest possible extent. Different methods are used for treatment of solid waste and the choice of proper method depends upon refuse characteristics, land area available and disposal cost they are as follows.

[A]Incineration
[B]Compaction
[C]Pyrolysis
[D]Composting
[E] Landfiling

[A]Incineration

It is a controlled combustion process for burning solid wastes in presence of excess air (oxygen) at high temperature of about 1000 C^0 and above to produce gases and residue containing non-combustible material. One of the most attractive features of the incineration process is that it can be used to reduce the original volume of combustible MSW by 80–90%.

[B]Compaction

The Municipal Solid Waste is compacted or compressed. It also breaks up large or fragile items of waste. This process is conspicuous in the feed at the back end of many garbage collection vehicles. Deposit refuse at bottom of slope for best compaction and control of blowing litter.

[C]Pyrolysis

Pyrolysis is defined as thermal degradation of waste in the absence of air to produce char, pyrolysis oil and syngas, e.g. the conversion of wood to charcoal also it is defined as destructive distillation of waste in the absence of oxygen. External source of heat is employed in this process. Because most organic substances are thermally unstable they can upon heating in an oxygen-free atmosphere be split through a combination of thermal cracking and condensation reactions into gaseous, liquid and solid fraction.

[D]Composting

Composting is the most responsible technical solution for many developing countries especially, where the climate is arid and the soil is in serious need of organic supplements. It is the bio conversion of organic waste in the presence or absence of oxygen, bacteria producing rich manure as end product.

[E] Landfilling

Dumping of MSW by Urban Local Bodies (ULBs) within its serviced area at pre designated place generally a low lying area close to river or any natural stream is known as Landfills and process of dumping municipal solid and non hazardous waste is termed as landfilling. Landfills have been the most common method of organized waste disposal and remain so in many places around the world. Now a days it is treated an unhealthy practices due to promoting air pollution, ground water pollution, Soil fertility effects, visual and health impacts etc.

PARADYGM SHIFT IN DISPOSAL AND TREATMENT TECHNOLOGIES:

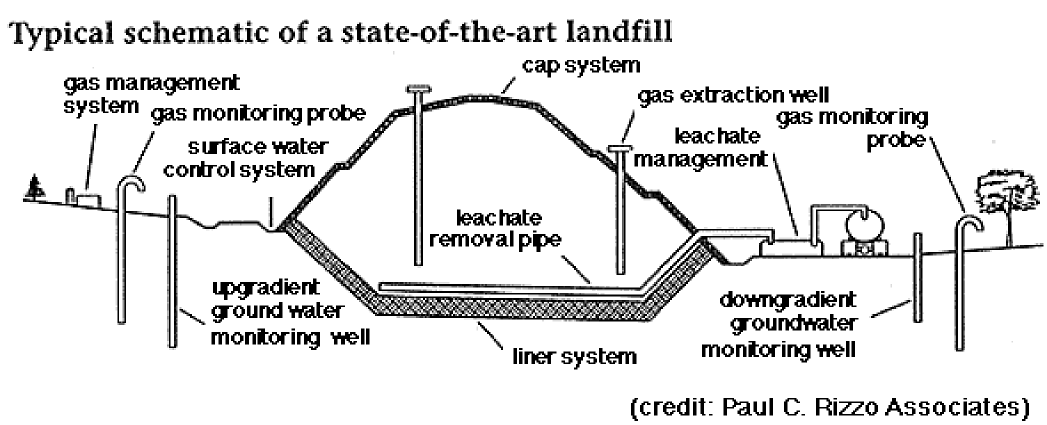
The common and old methods of municipal solid waste disposal were open dumping (Landfilling), composting and incineration. The process of open dumping leads to water and air pollution in the form of land litter, particulates and toxic gases. Methane gas and solid residues are also produced from burning process. American and European countries were famous for the incineration of waste with instant energy recovery; the technology became less common due to high operational cost. Disposal is the last step of MSWM, where the remaining trash after recycling, processing, and WTE are disposed off. Disposal is the most technical step of waste management. Experts are encouraged to introduce technologies to lessen the amounts disposed of annually. In developing countries even today most of the disposal sites are open dumps they have no proper leachate treatment and landfill gas utilization system. Methods like open dumping were responsible for causing many aesthetic and other environmental issues. Following are modern MSW disposal technologies through which the experts can avoid issues regarding leachate leaking, water contamination, and landfill gas explosion.

1. Sanitary Landfill

Sanitary Landfill is a professionally engineered depression in low population area, for the final disposal of left over MSW after all the previous steps of integrated waste management. Waste is buried in that depression is providing liners in its bottom with leachate collection facility in order to avoid any hydraulic connection between trash and environment including air and water. Landfill is mostly preferred because it has the widest range of capabilities and is least expensive method of waste disposal. In Malaysia 80% of the waste is disposed of in landfill, this could cause serious issue in near future because the present landfill sites are left with very less capacity while the new sites are still under construction. While comparatively in developing countries landfill is the least desirable option while most desirable option is WTE.

2. Landfill Gas Recovery Technologies

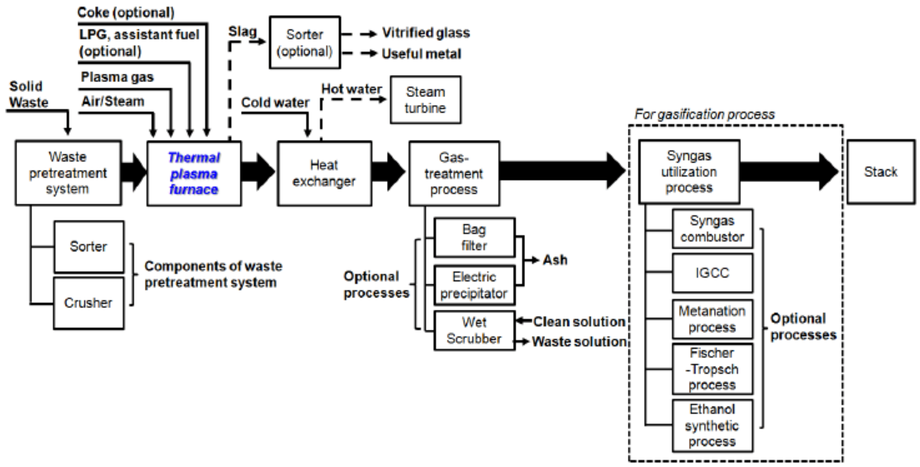
The landfill gas emissions are greatly varied due to geological, hierological and Geo technical properties which have environmental impacts. The biotic and a biotic factor lead to generation of gas at landfill which is the combination of CH_4 and CO_2 this is known as biogas. Oxidation produces a biotic gas in the presence of water and metals like Aluminum. Al produces leachate which further undergoes redox reaction to produce of hydrogen gas. Metallic aluminum hydration and bottom ash results in gas production. If mismanaged this gas can cause explosion of landfill or gradual leaking can cause global warming as both the gases (CH_4 and CO_2) are greenhouse gases.



3. Plasma Gasification and Vetrization (PGV)

The main reason for energy crisis today is fossil fuels cost and burning of fossil fuels. The high rates of fossil fuels and conflicts in oil producing regions and high demand in countries have led to need of alternative sources of energy. Green-house gases have also caused a change in climate and global warming. Alternative sources of energy that are sustainable, environmentally friendly and easily available should be found. Municipal solid waste is considered one source of renewable energy and plasma gasification technology is a good technology to harness this energy.

Plasma gasification uses extremely high temperatures (15000-20000ºC) in an oxygen-starved environment to completely decompose waste material into very simple molecules in a process similar to pyrolysis. Because the feed stocks reacting within the gasifier are converted into their basic elements, even hazardous waste becomes a useful syn-gas. Inorganic materials in the feed stock are melted and fused into a glassy-like slag, which is non-hazardous and can be used in a variety of applications, such as road-bed construction and roofing materials. It is used commercially as a form of waste treatment and has been tested for the gasification of biomass and solid hydrocarbons, such as coal, oil sands, and oil shale.



Schematic flow diagram of PGV Technology (Image credit: ResearchGate.net)

4. Microbial Electrolysis Cells (MECs)

MECs is a smart green technology to overcome the global warming and energy demand, which is characterized by electrochemically energetic bacteria to convert MSW into H_2 and chemicals like methane (CH_4), hydrogen peroxide, ethanol, acetate, and formic acid. This method similar to MFCs except the cathode of MECs is not open to air. Currently MEC has gained acute attentions a capable source for obtaining clean and legitimate energy from wastes. Furthermore, MEC has higher hydrogen recovery and substrate assortment than to dark photo fermentation and MFC. MECs could change any biodegradable waste into hydrogen, bio fuels and other valuable products. Electrons are transferred to the cathode to reduce the protons for hydrogen production. This approach brings a way for comprehending hydrogen production to pass through the endothermic barrier forced by the microbial fermentation products and the potential required is comparatively low related to the theoretically posed voltage. MEC gains above 90% of hydrogen revival against 33% with the fermentation process. MEC showed an ability to change a variability of soluble organic matter to H_2 or CH_4 with immediate wastewater treatment. According to the MEC stage holds excessive potentials for future waste bio refinery. MECs mutate biodegradable waste into valuable energy and bio products, making the system energy-positive and carbon-less. The yield and rate of MECs are increased when integrated with the fermentation process. Exploitation of reactor configurations incorporating new material scoots are often reduced and system efficiency gets enhanced.

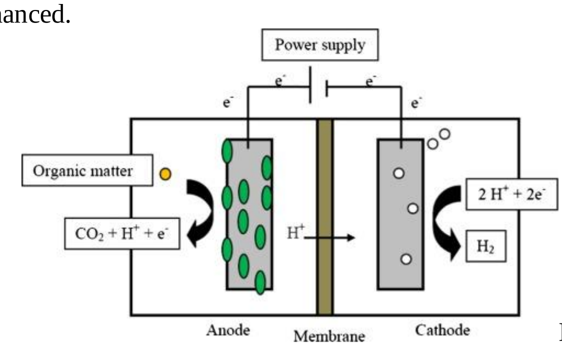


Image credit: sciencedirect.com

5. Leachate Recirculation in Bioreactor

Bio reactor landfill is a solution for the above mentioned problems. They speed up the rate of decomposition thus resulting in the decrease in volume of biodegradable waste components. It can be a very effective tool in dealing problems of increasing solid waste generation that would require extra land to be disposed. Bioreactors can be aerobic, anaerobic or hybrid depending upon the conditions provided.

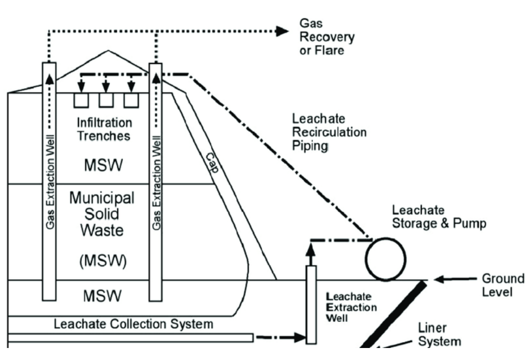


Image credit: leachat.info

RECOMMENDATIONS:

The main reason for energy crisis today is fossil fuels cost and burning of fossil fuels. The high rates of fossil fuels and conflicts in oil producing regions and high demand in countries have led to need of alternative sources of energy. Green-house gases have also caused a change in climate and global warming. Alternative sources of energy that are sustainable, environmentally friendly and easily available should be found. MSW is considered one of best source for renewable energy. Here are a few basic recommendations to achieve our green goal and to meet out future energy demand of country without compromising sustainability and maintaining economic growth level.

- By adopting Plasma technology which is an economic and abundant source of energy and a reliable source of power and helps to minimize cost and environmental pollution. It is effective in producing large amount of renewable source of energy.
- Landfill gas recovery technology is very useful which is able to curtail green house gases (CH_4 and CO_2) directly imitated to the environment.
- MECs could change any biodegradable waste into hydrogen, biofuels and other valuable products, which shows its important role to play for producing futuristic energy.
- Priority should be given to Engineered Landfills with leachate collection and treatment facilities and the receiving amount of MSW should be limited only 10% of total generation of waste for a city.

CONCLUDING REMARKS:

Serious environmental degradation occurs due to open, uncontrolled and poorly managed waste dumping in many metropolitan cities of developing countries, where approximately 90% of the waste is disposed of in open dumping areas. Recently developed countries have implemented the visionary concept of zero waste which is encouraging latest technologies of MSWM. While on the other hand in most developing countries like India waste management is a matter of least concern, which is causing severe environmental and health issues.
The sustainable management of municipal solid waste can reduces the short and long term environmental and human health hazards. The paper concluded that proper implementation of latest technologies or its combination with ancient to modern practices in the sector of MSW management can play a very important role in providing pollution free and sustainable environment. It also recommends source segregation and efficient utilization of resource recovery simultaneously use of WTE to optimize load of landfill sites.

ACKNOWLEDGEMENT:

Author communicates his sincere thanks to Integral University and its administration for giving him incredible support and encouragements to publish this paper.

Manuscript Communication No. **IU/ R&D/ 2019-MCN 000541**

Data accessibility: No data were generated from the work, and all supporting material and images were obtained from previously published work available via the net, references and from the output of the international seminar on which the paper is based.

REFRENCES:

[1] Tauqeer Alam[1]*, Ankit Kumar[2]et al Recent Progress In Waste Management System Of Lucknow City: A Minor Review, Www.Confrenceworld.In Isbn : 978-93-87793-15-6, April **2018**

[2] G. Siva Praveena, P.V.V. Prasada Rao, et al, IMPACT OF LEACHATE ON SOIL PROPERTIES IN THE DUMPSITE (A CASE STUDY OF GREATER VISAKHAPATNAM International Journal of Engineering Research and General Science Volume 4, Issue 1, January-February, **2016** ISSN 2091-

[3] Ajai Kumar Rai, Brajesh Mishra, GEOTECHNICAL PROPERTIES BASED CHARACTERIZATION OF CLOSED DUMPSITE: A CASE STUDY OF LUCKNOW CITY OF UTTAR PRADESH, ISSN (Print) : 2347-6710 IJIRSET, Vol. 5, Issue 3, March **2016**

[4] Sadhan Kumar Ghosh, SWACHHAA BHARAT MISSION (SBM) – A PARADIGM SHIFT IN WASTE MANAGEMENT AND CLEANLINESS IN INDIA, Procedia Environmental Sciences 35 (**2016**) 15 – 27

[5] Shaoli Dea, Biswajit Debnathb, PREVALENCE OF HEALTH HAZARDS ASSOCIATED WITH SOLID WASTE DISPOSAL- A CASE STUDY OF KOLKATA, INDIA, International Conference on Solid Waste Management, 5IconSWM 2015, Procedia Environmental Sciences 35 (**2016**) 201 – 208.

[6] Dubey, M. Chakrabarti, D. Pandit LANDFILL MINING AS A REMEDIATION TECHNIQUE FOR OPEN DUMPSITES IN INDIA, International Conference on Solid Waste Management, 5IconSWM 2015 Procedia Environmental Sciences 35 (**2016**) 319 – 327

[7] Eshanthini. P1, Padmini.T.K1, IMPACT OF LEACHATE ON GROUND WATER QUALITY NEAR KODUNGAIYUR DUMPING SITE,CHENNAI, TAMIL NADU, INDIA, International Journal of PharmTech Research, CODEN (USA): IJPRIF, ISSN: 0974-4304,Vol.8, No.10, pp 171-179, **2015**

[8] J Environ Stud, EFFECTS OF OPEN DUMPSITE LEACHATE ON GROUNDWATER QUALITY: A CASE STUDY OF ALAKAHIA DUMPSITE IN PORT HARCOURT, NIGERIA, November **2015** Vol.:1, Issue:1

[9] Archana1*, Daoud Ali2, Mohammad Yunus1 and V. Dutta1 et, al ASSESSMENT OF THE STATUS OF MUNICIPAL SOLID WASTE MANAGEMENT (MSWM) IN LUCKNOW – CAPITAL CITY OF UTTAR PRADESH, INDIA, IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT) e-ISSN: 2319-2402,p- ISSN: 2319-2399.Volume 8, Issue 5 Ver. II (May. **2014**), PP 41-49 www.iosrjournals.org www.iosrjournals.org

[10] Archana* and V. Dutta, SEASONAL VARIATION ON PHYSICO-CHEMICAL CHARACTERISTICS OF LEACHATE IN ACTIVE AND CLOSED MUNICIPAL SOLID WASTE LANDFILL SITE IN LUCKNOW, INDIA, G- Journal of Environmental Science and Technology 1(4): (**2014**) ISSN (Online): 2322-0228 (Print): 2322-021X

[11] Barjinder Bhalla1*, M.S. Saini2, M.K. Jha, ASSESSMENT OF MUNICIPAL SOLID WASTE LANDFILL LEACHATE TREATMENT EFFICIENCY BY LEACHATE POLLUTION INDEX,International Journal of Innovative Research in Science, Engineering and Technology, Vol. 3, Issue 1, January **2014**

[12] Gawsia John1, Harendra K. Sharma1, Vikas Vatsa2, IMPACT OF MUNICIPAL SOLID WASTE DUMP ON GROUND WATER QUALITY AT DANDA LOKHAND LANDFILL SITE IN DEHRADUN CITY, INDIA, international journal of environmental sciences volume 5, no 3, **2014**

[13] SELECTION OF SUITABLE SITE FOR SOLID WASTE MANAGEMENT IN PART OF LUCKNOW CITY, UTTAR PRADESH USING REMOTE SENSING, GIS AND A.H.P. METHOD, Virendra Kumar, Kamal Yadav, V. Rajamani, International Journal of Engineering Research & Technology (IJERT) March - **2014**

[14] Nitin Kamboj* and Mohrana Choudhary, IMPACT OF SOLID WASTE DISPOSAL ON GROUND WATER QUALITY NEAR GAZIPUR DUMPING SITE, DELHI, INDIA, Journal of Applied and Natural Science 5 (2): 306-312 (**2013**)

[15] PERVEZ ALAM & KAFEEL AHMADE, IMPACT OF SOLID WASTE ON HEALTH AND THE ENVIRONMENT, Special Issue of International Journal of Sustainable Development and Green Economics (IJSDGE), ISSN No.: 2315-4721, V-2, I-1, 2, **2013**

[16] *Christopher Oluwakunmi AKINBILE*, ENVIRONMENTAL IMPACT OF LANDFILL ON GROUNDWATER QUALITY AND AGRICULTURAL SOILS IN NIGERIA,Soil & Water Res., 7, **2012** (1): 18–26

[17] Rajkumar Nagarajan1*, Subramani Thirumalaisamy2 et, al, IMPACT OF LEACHATE ON GROUNDWATER POLLUTION DUE TO NON-ENGINEERED MUNICIPAL SOLID WASTE LANDFILL SITES OF ERODE CITY, TAMIL NADU, INDIA, Iranian Journal of Environmental Health Sciences & Engineering **2012**, 9:35

[18] 1Shaikh Parveen R.*, 2Bhosle Arjun B., 3Yannawar Vyankatesh B, THE IMPACT OF LANDFILL ON SOIL AND GROUNDWATER QUALITY OF THE NANDED CITY, MAHARASHTRA,.http://www.sciencepub.net/researcher

[19] Mohammed Saidu, EFFECT OF REFUSE DUMPS ON GROUND WATER QUALITY, Pelagia Research Library, Advances in Applied Science Research, **2011**, 2 (6):595-599

[20] N.Raman* and D.Sathiya Narayanan, IMPACT OF SOLID WASTE EFFECT ON GROUND WATER AND SOIL QUALITY NEARER TO PALLAVARAM SOLID WASTE LANDFILL SITE IN CHENNAI , Vol.1, No.4 (**2008**),828-836

[21] Umesh Kumar Singh & Manish Kumar, ASSESSMENT OF THE IMPACT OF LANDFILL ON GROUNDWATER QUALITY:A CASE STUDY OF THE PIRANA SITE IN WESTERN INDIA, Environ Monit Assess (**2008**) 141:309–321, DOI 10.1007/s10661-007-9897-6

[22] Martine Vrijheid, HEALTH EFFECTS OF RESIDENCE NEAR HAZARDOUS WASTE LANDFILL SITES: A REVIEW OF EPIDEMIOLOGIC LITERATURE, Environmental Epidemiology Unit, Department of Public Health and Policy, London School of Hygiene and Tropical Medicine, London, United Kingdom, Environmental Health Perspectives * Vol 108, Supplement l * March **2000**

[23] Wajeeha Saleem, Ayesha Zulfiqar Et Al, Latest Technologies Of Municipal Solid Waste Management In Developed And Developing Countries: A Review, International Journal Of Advanced Science And Research Issn: 2455-4227, Volume 1; Issue 10; October 2016.

[24] Pervez Alam & Kafeel Ahmade, Impact Of Solid Waste On Health And The Environment,Special Issue Of International Journal Of Sustainable Development And Green Economics (Ijsdge), Issn No.: 2315-4721, V-2, I-1, 2, 2013

[25] Tozlu A, Özahi E, Abuşoğlu A. Waste To Energy Technologies For Municipal Solid Waste Management In Gaziantep. Renewable And Sustainable Energy Reviews. 2016; 54:809-815

[26] World Bank, What a Waste: Global Review of Solid Waste Management, 2012.

[27] Shekdar A. Sustainable solid waste management: An integrated approach for Asian countries. Waste Management 2009; 29(4):1438-

[28] Ahmed A. Environmental Properties of Waste and By-Product Materials Used in Constructions. J solid waste technol mngmnt. 2014; 40(2):160-169

[29] Idowu A, Adagunodo E, Esimai O, Olapade T. Development of A Web based GIS Waste Disposal Management System for Nigeria. International Journal of Information Engineering and Electronic Business. 2012; 4(3):40-48.

[30] Rada E, Ragazzi M, Fedrizzi P. Web-GIS oriented systems viability for municipal solid waste selective collection optimization in developed and transient economies. Waste Management. 2013; 33(4):785-792.

[31] Arebey M, Hannan M, Basri H, Begum R, Abdullah H. Integrated technologies for solid waste bin monitoring system. Environmental Monitoring and Assessment. 2010; 177(1-4):399-408.

[32] Metcalfe A, Riley M, Barr S, Tudor T, Robinson G, Guilbert S. Food waste bins: bridging infrastructures and practices. The Sociological Review 2012; 60:135-155.

[33] Gutberlet J. Waste, poverty and recycling. Waste Management 2010; 30(2):171-173.

[34]. Kanat G. Municipal solid-waste management in Istanbul. Waste Management 2010; 30(8-9):1737-1745.

[35] Narayana T. Municipal solid waste management in India: From waste disposal to recovery of resources. Waste Management 2009; 29(3):1163-1166.

[36]. Bosmans A, Vanderreydt I, Geysen D, Helsen L. The crucial role of Waste-to-Energy technologies in enhanced landfill mining: a technology review. Journal of Cleaner Production. 2013; 55:10-23.

[37]. Lombardi L, Carnevale E, Corti A. A review of technologies and performances of thermal treatment systems for energy recovery from waste. Waste Management. 2015; 37:26-44.

[38]. Gupta R, Garg V. Potential and possibilities of vermicomposting in sustainable solid waste management: a review. International Journal of Environment and Waste Management. 2011; 7(3/4):210.

[39] Kothari R, Tyagi V, Pathak A. Waste-to-energy: A way from renewable energy sources to sustainable development. Renewable and Sustainable Energy Reviews 2010; 14(9):3164-3170