APPROPRIATE MANAGEMENT OF SOLID WASTE BY PROPER COLLECTION AND MOBILITY FOR INDIAN CONDITION – A REVIEW

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***Abstract*— Solid waste management is a major concern over the world due to increase in population every year. Inadequate handling of generated solid waste causes serious hazards to environment as well as living beings. In most communities around the world, people are much aware of serious consequences of improper solid waste management practices, but the negative attitude of implementation gives rise to chaotic situations. Awareness in society is necessary for minimization of solid waste generation. Municipal solid waste (MSW) provides a major contribution to the total amount of solid waste. But e-wastes are the most frequently growing waste which is also an efficient source of various toxic elements. The total amount of solid waste (SW) is enhancing day by day and as consequence proper solid waste management (SWM) methods are necessary which could minimize the total amount of SW as well as its hazardous effect on environment. In this paper, attempts have been made to provide review the characteristics, generation, collection, transportation, disposal and techniques of SWM starting from conventional tools to modern techniques as the various researcher's work has been discussed.**

***Keywords*— Solid waste, disposal, management, waste generation.**

I. INTRODUCTION

India is the second largest growing economy and the second most populated country in the world. Here about 852 M people live in rural areas and 325 M live in urban areas. The level of urbanization of the country has increased from 26.5% to 38% in last 50-60 years and is expected to rise by 44% by year 2026. The biggest challenge as a developing country we are facing is generation of waste material. Waste is anything what is no longer in deemed useful and is dumped.

The problem of management of solid waste is becoming serious day by day because we are not having proper technology by help of which solid waste can be decomposed, we are still using techniques like landfilling, incineration, pyrolysis, composting etc. which are not environmentally friendly. According to a survey, big cites collect about 70 - 90 % of municipal solid waste, whereas in smaller cities and towns collect less than 50 % of waste generated. More than 90 % of the municipal solid waste collected formally is landfilled on open lands and dump yards.

Burning of solid waste produces harmful gases like carbon monoxide, hydrocarbons, particulate maters, nitrogen oxide, sulphur oxide etc.

II. PAGE STYLE

LOKESH KUMAR VENKITEELA (2020),
Tirupati being a tourist place must suffer a lot because of generation of solid waste, current population of Tirupati as per 2011 census is 3,82,934 with generation of 194.36 tonne solid waste per day. The population forecast for the 2051 year is 8, 21,145 who will be generating 649.52 tonne waste per day. All waste collected from Tirupati is moved to a removal site at Ramapuram which is about 18 km away from Tirupati. Method adopted to deal with solid waste is decentralized management, according to which a clean and hygienic environment can be provided by reducing the amount of waste at the source. Some of the recommendations are: - categories of municipal solid waste, lack of appropriate level funding, enforcement of rules at sub level, resistance of new landfill site, lack of coordination in decision making , involving organized sector . Available solid waste treatment methods are: - composting, bio-mining, waste to energy, gasification, incineration, bio-methanation etc. To achieve all these methods policies like door-to-door collection of solid waste, proper separation of waste at house level are being implemented etc. Some of the key points affecting proper management of solid waste according to study are Categories of municipal solid waste, lack of appropriate level funding, enforcement of rules at sub level, resistance of new landfill sites, lack of coordination in decision making and involving organized sectors.
M.A. HANNAN, M.S. HOSSAIN LIPU, MAHMUDA AKHTAR, R.A. BEGUM, MD ABDULLAH AL MAMUN, AINI HUSSAIN, M.S. MIA, HASSAN BASRI (2020)
This paper gives a detailed description of Solid Waste Collection (SWC) system. Number of research and development in SWC Model and technologies are mentioned which contribute to lowering the cost, route, time, labour and carbon emission. Different constraints of SW along with their equation and solution to each restricted condition are provided. M.A. Hannan along with his members analyzed that ten out of 17 Sustainable Development Goals (SDGs) can be achieved by the latest innovation in SWC.

Advanced technologies Radio Frequency Identification (RFID), General Packet Radio Service (GPRS), Global Positioning System (GPS) etc along with smart bins and different sensors are introduced for development of an intelligent SWC system.

PRASAD PINUPOLU, HEMANTHA RAJA KOMMINENI (2020)

The purpose of this paper is to find the best method of MSWM for Vijayawada city, Andha Pradesh. There is no proper dumping and disposal of Solid Waste which causes air, land and water pollution and produces fuel smell and bacteria. Although government and Urban local bodies (ULBs) are taking steps for proper management of solid waste in the region by providing bins, containers, dumping day to day collection by tricycles and installed treatment plants and hygienic landfill. The author introduced an automated plastic separation machine to deal with Municipal Solid Waste and Public Private Partnership Model for tracking solid waste, to generate income and get rid of unhygienic living and head towards the good nature of life and development for the current situation of the city.

USHA RANI AND B.W. PANDEY (2020)

In this paper an attempt has been made to analyse the state of municipal solid waste in Meerut city. Observation's method and discussion was conducted with Meerut Nagar Nigam (MNN) officials to study the current situation of solid waste management in Meerut city. It was observed that per capita of MSW was 0.46 kg per capita/per day in 2006 which touched the figures of 0.53 kg per capita/per day. The street sweeping and collection of garbage are carried by the sanitary worker of civic agency in Meerut. It was observed that mixed waste is reaching landfill sites and even residents throw garbage improperly without segregation. The connection infrastructure, storage and transportation is not upto the mark and needs upgrading. To overcome problems, the management sector, segregation, composting and waste to energy projects should be promoted. MMC should increase fun and side by side public awareness and community participation should be encouraged for achieving a healthy hygienic and livable environment and sustainability in Meerut city.

LOUISE GUIBRUNET (2019)

The purpose of this paper is to analyze the work of informal street sweepers replacing Municipal collection service. Case of Municipal Solid Waste collection in a urban Mexican neighborhood is presented. There is a need of more complex understanding of government in waste management research not as homogenous entity, governing through planning and regulation, but rather regulate with diverse competencies, rationalities, and levels of power. Informal servants who are hired by another civil servants who are hired by another civil servant, are refused. Moreover, they are governed through strategies which go beyond planning and implementing program. It is necessary to improve the working conditions and to maintain informal worker's role in urban waste management which can only be achieved by understanding of how informalities currently operate. It is suggested that waste management policy need to consider that informal waste work may be sustaining the Municipal waste collection system and enable through an informal governance system involving local authorities.

LUCIA BOTTI, DARIA BATTINI, FABIA SGARBOSSA, CRISTINA MORA (2019)

To solve the problem of solid waste in Italy door to door waste collection methods have been adopted by several municipalities. The main purpose of door-to-door collection of solid waste is to achieve higher rates of sorted waste. The approach requires a waste collector to handle a high number of small waste containers during their work shift especially in urban areas and historic city centers. As waste management is the one of the most important concepts at the core of sustainable development so proper awareness is to be spread related to it so that proper management of solid waste can be done. With the help of the local municipality Italy has achieved the 88.5% rate of sorted waste collection in 2018. The municipality requires the citizens to collect and separate the MSW in different type containers, according to the waste fraction. In Italy small containers are used so that the handling of containers is easy, and waste can be sorted out easily. These small containers are collected by collection vehicles (small size trucks). Their focus is to separate waste generated properly so that its proper treatment can be done.

PRIYABRATA BANERJEE, ABHIJIT HAZRA, PRITAM GHOSH, AMIT GANGULY, NARESH CHANDRA MURMUR AND PRADIP K. CHATTERJEE (2019)

In today's world one of the most important issues is protection of the environment and the survival of human beings, for that solid waste management needs major attention. In India, the rate of production of municipal solid waste is 0.2-0.5 Kg per capita per day. Increasing demands of human beings are the major reason for generation of solid waste at such a high rate. Harmful effect of solid waste is due to improper management of solid waste. Waste can be further classified into different categories such as: - Municipal solid waste (India MSW generation is eight times higher than 1947), Radioactive solid waste (commercial nuclear power plant generate 290,000 tons of heavy metals per year and only 30% of heavy metal are generally recovered) , Electronic waste (from 1998 use of household appliance increases by 53.1%) , Agriculture solid waste (every year food processing units produces almost two millions tons of solid waste in which 40% is vegetable waste in USA), Hospital solid waste (depending upon the total amount of hospital waste in India , the percentage of infectious waste may vary from 15-30%) . Management of solid waste can be done by following methods: - Landfilling, Composting, Vermicomposting, Anaerobic digestion, and Bio methanation, Incineration, Pyrolysis, Gasification, Refuse derived fuel etc.

FRANCESCO DI MARIA, ELENA LOVAT AND MARCO CANIATO (2018)

For management of solid waste, a survey and preliminary comparison were conducted between the waste management system and schemes implemented in region of Umbria (Italy) and the west bank (Palestine). From economic point of view the incidents of the cost for waste collection and management with respect to per capita GDP was 0.82% for the region of Umbria and 1.2%

for the west bank. The main concept followed to deal with solid waste is using the process of 3R's (reduce, reuse, and recycle). According to Marshall and Farahbakhsh (2013) progress in waste management can be done by controlling six main factors: public health, environment, waste value, climate change and public awareness. The major two factors affecting the scenario is day by day more waste is generated and improper collection of waste and its disposal. In this study both lab scale and full-scale studies were done which was followed by field visits. This paper gives two methods of collection of waste: door to door collection, proximity collection. This study includes many stakeholders, mainly the University of Perugia and many NGOS etc. For calculating the data per capita MSW generated is calculated, and to minimize the MSW attitude was changed regarding waste generated, separation process, efficiency of the collection system. These all factors help in minimizing the MSW and proper management of MSW.

MUHAMMAD AMIR, ROLA POLA ANTO (2018)

The study was conducted to analyze the policy implementation of waste management in Konawe Regency by using qualitative approach. The policy implementation of waste management in Konawe Regency has existing organizational structure. The implementers work according to SOP and based on their position in organizational structure. The area is still lacking in facilities, working area condition, public awareness, low knowledge and participation of community. So, implementers should work hard to improve hygiene, public health and environmental conditions.

ABHISHEK NANDAN, BIKARAMA PRASAD YADAV, SOUMYADEEP BAKSHI, DEBAJYOTI BOSE (2017)

This paper focuses on the relation between rate of industrialization and rate of generation of solid waste. This paper clears that rapid increase in urbanization and per capita income lead to a high rate of municipal solid waste generation. Solid waste collection in India is around 70%, while it is almost 100% in developed countries. Today also a large portion of waste is dumped into land which pollutes the environment. This paper reveals that out of total solid waste, 80% can be utilized again either by recycling or reusing, but we are unable to do so, because we do not have proper technology for segregation of solid waste. Currently 1,27,486 tons per day of municipal solid waste is being generated due to various household activities and other commercial and institutional activities. Elements of hierarchy involved in the process of solid waste management are: - source reduction, recycling of materials, combustion, landfilling. The processes involved in the study are: source reduction, recycling of materials, combustion, landfilling. Previously very little attention was given to waste management but after implementation of Hazardous Waste Management Rules (1989) under Environment Protection Act – 1986 has changed the attitude of local governments and local authorities towards waste collection and management. Some of the methods adopted are: community bin collection, house to house collection,

Collection on a regular interval, scheduling by using bell ringing of musical vehicle (without exceeding the noise levels). In this study various methods of solid waste treatment are discussed such as: composting, biomethanation, incineration, pyrolysis, landfilling etc.

GAURAV SUTHAR AND PRAVEEN BABU (2017)

In this study, focus was kept on the gap and solution for municipal solid waste management. It is seen that the major factors which are responsible for increase in solid waste are: urbanization, industrialization and population growth. Areas near the landfilling sites are facing problems related to air pollution, groundwater contamination etc. By proper management of solid waste, we can also reduce the amount of greenhouse gas in the environment as worldwide landfills are considered as the 3rd largest man-made methane source, by reducing the content of greenhouse gases in the environment the problem of global warming can be also controlled. In India the generation of MSW lies between 0.3-0.6 Kg per capita per day and it has been increasing at the rate of 1.33 percent per capita per day.

To control the problem of solid waste focus is kept on four stages:

- ✓ Reduction
- ✓ Recycling
- ✓ Reuse
- ✓ Recovery

Methods which can be used for solid waste management are incineration, pyrolysis, gasification and composting. It is seen that 25% of MSW is not collected due to inadequate transport capacity in 70% of the Indian cities. It is also seen that public awareness also plays a major role in proper management of solid waste, more the no. of will get aware, the chances to manage waste generated increases.

S. GODWIN BARNABAS, G.D. SIVAKUMAR, G. SATISH PANDIAN, K. ARUN VASABTHAGEETHAN, S. PRASANNA KUMAR, P. PRITHVIRAJ EVAN AND P. DHEEPAN KUMAR (2017)

This paper focuses on the facts that the major cause of increase in solid waste over the past is due to increase in population globally. In this paper various processes involved in the management of solid waste have been discussed like: - characteristics , generation , transportation , disposal and treatment technologies of solid waste management over the world . In this paper various cities, nations are studied, and data related to population boost up and increase in generation is plotted. This paper gives a direct relation between the increase in population and waste generated. According to the study the factors that influence the volume and composition are average level of income, population, climate, social behavior, industrial production and market of waste material. The study explains the correlation analysis of different factors of municipal solid waste and the objective is to

assess the future municipal solid waste streams in Asian developing countries. In this several authors predicted the future quantity of solid waste generated in rural as well as urban areas by the help of statistical analysis software minitab. Future analysis of solid waste generated helps various responsible bodies to make prior arrangements and come out with a suitable and effective method of dealing with solid waste generated. Future prediction of solid waste helps in proper management of solid waste.

TWUMASI A. K (2017)

In this paper a study was conducted to obtain baseline information about waste management practices among the residents of Winneba in the Effutu municipality of Ghana. According to the survey 120 people were chosen randomly and information related to management of solid waste was taken from these people it was found that 50% of the respondent were not aware of principles of waste minimization as well as segregation. 75% of the respondent lack awareness about e-wastes and its management, less 50% of the people were committed to waste minimization, also more than 60% of the respondent threw their household waste outside their homes while only few people did not. So, it was found that proper management of solid waste can be done by adopting the method 3R's {reduce, reuse, and recycle}. Proper management of solid waste can be only achieved by changing the bad attitude of people related to waste generated and its management, proper awareness must be spread so that people can be made aware of various techniques related to management of solid waste.

VANDANA BHARTI, JASPAL SINGH AND A.P. SINGH (2017)

In this paper, solid waste management methods and practices in India are mentioned .This paper focuses on Municipal Solid waste as Municipal Solid Waste also known as 'Solid waste' is the waste which can be managed properly without any harm to other species and can be managed properly without any harm to other species and causes any pollution .This paper deals with the various methods to manage the solid waste from organic composting to generate energy. The SWM sector in India progressed in the right direction after the introduction of Jawaharlal Nehru National Urban Renewal Mission (JNNURM) by the government of India (GOI). But it is still suffering due to lack of financial and managerial resources and public awareness. Changes expected in disposal of MSW in the future are increase in formal system
from the informal waste sector, increase in the construction of composting facilities, sanitary landfill facilities.

EBIKAPADE AMASUOMO AND JIM BAIRD (2016)

The present paper seeks to examine what exactly is a waste? This paper is based upon secondary data from other papers which describe the term waste in their own words. Waste can be defined as the useful product produced by human activities which physically contain the same substance that is available in the useful product. Over the past population has increased by a great margin so because of that the amount of land available for decomposing waste generated has decreased. It is seen that a substance considered as a waste by one person might be considered as useful by another person. Waste can be classified on the basis of its state, source, environmental impact etc. Some of the major sources of solid waste are:

1. Industrial waste
2. Agricultural waste
3. Commercial waste
4. Retail waste
5. Open market waste
6. Hotel and restaurants waste
7. Constructional waste

It is concluded that for proper management of solid waste, waste generated is needed to be collected and segregated properly in separate bins , then by easiest modes of transport these bins are needed to be transported on a composting site or waste landfill site or recycling industry depending upon type of waste .

SUDARSHAN KUMAR, SOMENDRA SHARMA, SURAJ JALUTHRIYA (2016)

This paper studies the obstacles and prospects of Solid waste in Jaipur. A comprehensive study regarding collection, transportation, handling, storage, disposal, treatment of solid waste was done in Jaipur city. Data related to SWM was collected through site visits and interaction with people. The study concluded that there is no proper mechanism in the city for treatment of SW generated which leads to dumping of waste in open areas leading to various problems to environment and humans living in that vicinity. It is found that formal sector carries out their duty effectively and on time but few complaints from citizens about interaction with waste service providers. There are still many areas for improvements, reduction of corruption, updated technology, with growing population, MSW is rising.

MANSI KHADKE (2015)

The focus of this research paper is on financial aspect of solid waste management. Challenges faced in SWM, sustainable SWM, integrated approach to SWM, importance of public private partnership in SWM are covered in this paper. The problem of Solid Waste will multiply and become disaster for the world if not handled carefully. All the cities and their citizens should together create sustainable lifestyle and an ecological civilization in which people and environment coexist in harmony.

V. SANJEEVI AND P. SHAHABUDEEN (2015)

The aim of this paper is to review papers on municipal solid waste management systems. A new word is given in this paper which is Performance Indicator {PI}, various policies and methods are made by researchers as well as the government and their

effectiveness related to management of solid waste is seen by the help of performance indicators. We can say that performance indicators are measurement tools used by organizations to evaluate the success or failure of a given activity. The UN conference also classified the SWM model into two groups:

1. The model relating to minimization of waste generated.
2. The resource needed to manage waste.

Most of the research work on SWM may be classified under two major divisions: one dealing with environmental science related subjects such as recycling, reprocessing, handling of hazardous waste, composting, landfill, technology, energy recovery etc. The other dealing with application of general management techniques such as operations research, supply chain system, transport system, regulation by government agencies, productivity tools etc. Efforts are made by the government and various agencies and benchmarks related to management of solid waste is set. Those countries whose management technique is below the mark set by the government are ordered to bring their level of management above the benchmark.

A. AHSAN, M. ALAMGIR, M.M.EL-SERGANY, S.SHAMS, M.K. ROWSHON AND N.N.NIK DAUD (2014)

This paper represents a few basic steps of municipal solid waste management practice in the six main cities of Bangladesh. Some of the major factors which are affecting management of solid waste are: high population growth rate , economic activities in the urban areas of developing countries , lack of training in modern solid waste management technique . It is seen that in developing countries the amount of waste generated is less as compared to developed countries but in other developed countries are having better facility of management of solid waste generated as compared to developing countries. Waste generated in Bangladesh is collected by government bodies as well as NGOs, community-based organizations and private organizations. These bodies are responsible for door-to-door collection of solid waste. Solid waste collected is sent to the decomposing site and its treatment is done depending upon type of waste and its source. It is seen that despite efforts made by several bodies for collection of solid waste people take very limited interest in collection of solid waste, so proper awareness is spread among people of Bangladesh about management of solid waste so that its proper management can be done more effectively.

ARTI PAMNANI, MEKA SRINIVASARAO (2014)

In this paper, the current scenario of India with respect to MSW quantity, quality and its management is provided. Brief overview of MSWM in major cities, medium scale towns and small-scale towns is presented. Interesting results on MSWM of small-scale towns and their surrounding villages is also presented. It is concluded that overall MSWM practices which are adapted in India are inadequate. Efforts were made to improve MSWM in major cities, but no attention was paid to MSW of medium and small-scale towns. Current regulations (MSWM rules, 2000) are very stringent. Various deficiencies are identified in the implementation of policy. Optimization studies to explore feasibility of integrated waste management should be carried out.

RISHI RANA, RAJIV GANGULY, ASHOK KUMAR GUPTA (2014)

This paper deals with the relation between rate of solid waste and rate of growth of population, urbanization, and industrialization. Due to rapid increase in the production and consumption processes, societies generate as well as reject solid material regularly from various sectors like agriculture, commercial, domestic etc. This paper focuses on that more than 90% of the total municipal waste generated is disposed of in an unsatisfactory manner. By the year 2021, urban population is set to increase 41% of the overall population. To tackle the waste generated urban local bodies should invest 35 - 50 % of its funds on solid waste management. This paper summarizes the solid waste management practices, strategies, processes, and methods used to manage the municipal solid waste in Chandigarh, a top tier – II city. According to the study quantity estimation and characteristics of municipal solid waste and its forecasting over the planning period is the key to its successful management plan. Some of the major sources of solid waste are agriculture, commercial, domestic, industrial and institutional. According to the study the municipal solid waste generated in terms of Kg/capita/day has shown a positive correlation with economic development at world scale .In Chandigarh dustbins were placed at small distances but people use to throw waste out on the road instead of throwing it in dustbins , So responsible body decided to place dustbin on major locations only and they gave 1/5 of the area of the city to the private company for door to door collection by help of sweepers , which eventually lead to proper collection of waste generated .

EBNA FORHAD MONDOL, MD. ROKON HASAN, MD. SAYED RAHMAN, SALMAN ALAM, SM. ARIFUR RAHMAN &TANISA TASMIN SINTHIA (2013)

This study helps in knowing the existing management process of solid waste management in Khulna city, and introduces a proposal of management process to abate environmental pollution. According to this study management of solid waste especially market waste can be treated on the bases of following points.

1. Study the location and area covered by the market area.
2. The quantity and type of waste produced in the market is analyzed.
3. The storage capacity and the collection techniques are analyzed.
4. Management techniques like {recycling, Viennese, BOD pending} proposed.

The method adopted in the city previously was found to be ineffective and fell short of international standards. It was found that a sustainable management process for market solid waste is beneficial in economic consideration. A proper study was done, about six markets in Khulna city were analyzed, and it was found that about 13-15 tons solid waste is generated per day in these

markets. This waste consists of 83% food waste, 6% paper, 5% plastic, 2% ferrous metals, 1.5% wood, 0.7% glass, 0.6% cardboard, 0.5% textiles, 0.4% rubber, 0.3% leather is produced total of waste per day in each market. To manage solid waste much effectively, a new method was according to which waste is collected in two parts one consist of residual waste and other consist of bio waste , residual waste is transferred to incineration plant and bio waste transformed into compost.

MUFEED SHARHOLY, KAFEEL AHMAD, GAUHAR MAHMOOD, R.C. TRIVEDI (2008)

In this paper, an attempt has been made to provide a comprehensive review of the characteristics, generation, collection and transportation, disposal and treatment technologies which are practiced in India. This study is related to MSWM for Indian cities to evaluate the status and identity the major problems. Various treatment technologies which are adopted are reviewed with their advantages and limitations. Few fruitful suggestions are concluded in this study to encourage the researchers to work towards future improvement of the system. In comparison to thermal and chemical treatment, biological treatment is a better option. MSWM rules 2000 (current regulations) are very stringent. Norms are developed to ensure proper MSWM system. But it came to know that there is a large between policy and implementation. The main barriers in MSWM are lack of resources such as financing, infrastructure, and suitable planning and data leadership. Due to lack of resources, increase of service demands are putting a huge strain on existing MSWM system.

III. CONCLUSIONS

Increasing SW has brought in pressure on researchers, academics, and administrative systems of city management for improvements. Worldwide, 4 million metric tons of SW are generated annually, and this volume is increasing year after year. Change in bad attitude of people towards solid waste management, institutional strengthening as well as intensive education on e-waste management will enhance the nation's quest for sustainable development. A systematical approach to reduce the waste generation and increase the performance requires the participation of each person, NGOs, institutions, and communities. Lack of adequate infrastructures, economic budget and citizen awareness are the main causes for the low level of efficiency of waste management in developing countries. The absence of a fully implemented market for the recycling industry limits the investment and the interest of the private sector. The reduction in the amount of waste to be collected can increase the budget of municipalities for improving the collection of other recyclable fractions. It is important to note that this goal is difficult to achieve without an adequate level of citizen awareness and political support. Due to lack of technical knowledge, lack of awareness, lack of funds, accountability, enforcement of rules & policy implementation were the major reasons for MSWM failures. NGOS should be involved in various components of waste management including public awareness. Public involvement in management of solid waste is significant. Local authorities should start working with their partners to promote source separation. While this is being achieved and recycling is increased, provisions should be made to handle the non-recyclable wastes that are and will be generated in the future.

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