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Potential Utilization of Municipal Solid Waste of Gwalior City, India

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Abstract: ***This paper aims at determining the recent composition of municipal solid waste of Gwalior city and provide sa notion to take action and proposed economical & viable waste management technologies and techniques for effective utilization of waste. In this study, MSW samples were collected from the Kedarpur landfill site situated at Shivpuri link road and were analyzed for physical composition. The study reveals that Gwalior city produces a high quantity of biodegradable waste (58.03%) with high moisture content (68.60%) and plastic waste (15.96%). Waste composition and characterization disclosed that vigorous segregation is required before dispatching the waste for different treatment processes or landfilling. Based on this study, we may conclude that the combined mechanism of planning and implementation of waste-to-energy (WTE) technologies and treatment such as Anaerobic Digestion/ Bio-methanation, Material recovery facility (MRF), and Bio-remediation/Bio-mining for old existing waste and new generating waste is needed for upgrading the waste management scenario of the city.***
Keywords: Municipal solid waste (MSW), Kedarpur Landfill site, Composition & Characteristics, Waste to Energy, Anaerobic Digestion, Bio-Mining, Recycling & Materials Recovery Facility (MRF)

I. INTRODUCTION

Solid Waste Management is an integral part of modern society and a smart city. It involves basic elements such as waste generation and handling, sorting, and segregation at source, collection, and processing, sorting and transforming, and transfer of waste to a disposal site [9]. As modernization and development of cities are happening at a fast pace, leads to high waste generation in urban areas which is creating health issues and destroying the land area of the country that can be used for a different purpose. The total urban waste was 6 Mt in 1947, 31 Mt in 2001, and 48 Mt in 2011 so at this rate of generation, the total urban MSW by 2030, 2041, and 2050 will be 165 Mt, 230 Mt, and 436 Mt respectively [3]. In our country, a high organic fraction (biomass) of waste (>50%) are found than in other countries[4] and the total fraction of recyclables are higher in foreign countries such as United Kingdom (44.5%), United States (34.6%) and European nations like France (41.7%), Germany (66.2%), Poland (44%) [3]. The Organic fraction of waste has a high capability to emanate Greenhouse gases (GHGs) which should be treated properly[14].Improper management of solid waste and practices of dumping waste and lack of knowledge, awareness, willpower, and infrastructure is disrupting our ecosystem badly[12].

The city of India is facing several challenges in managing this huge amount of waste generating daily but managing this solid waste could mitigate the risk to some extent. Waste Management technologies solely depend upon the composition of solid waste [3] so the precise knowledge of the composition and characteristics of the area is important in deciding the technologies &treatment methods that will be cost-effective and viable. The integrated solid waste management system (ISWM) hierarchy can solve the problem in which the most preferred option for waste management is source segregation, recycling, composting, and waste to energy before landfilling [1],[3].On other hand, conventional sources of energy like fossil fuels and petroleum are depleting at a rapid rate [6] so there is a need to implement waste to energy technologies and treatment methods such as incineration, gasification, pyrolysis, anaerobic digestion, composting, and recycling facilities to derive some value out this solid waste (new resource) which is a renewable source of energy. Anaerobic digestion is considered as the most sustainable biochemical conversion process as an option for treating an organic fraction of MSW [4] and incineration is thermal conversion becomes a less suitable treatment method due to high moisture content in waste [12].

According to Energy Statistics, 2021 report which states that there is a high potential for the generation of renewable energy from numerous sources like wind, solar, biomass, hydro, and cogeneration bagasse in India. The estimated potential for generating energy from Biomass is 17,536 MW (1.6%) and 2554MW (0.23%) from Waste to Energy. The population, urbanization, and economy are growing very fast demanding an efficient and dynamic approach towards managing the Municipal Solid Waste of every city of our country.

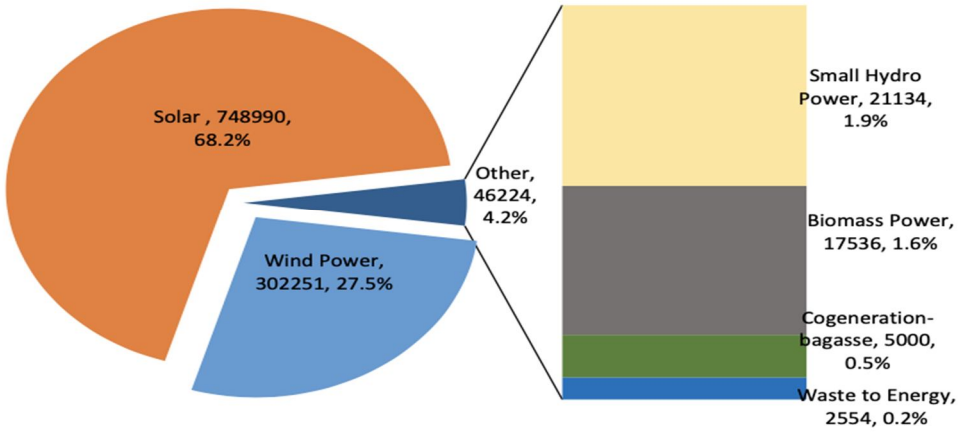

Fig: 1 Source-wise estimated potential of Renewable energy in India

II. CITY PROFILE: GWALIOR

Gwalior, a city in the state of Madhya Pradesh is located at Latitude: 26° 14′ 32″ N, Longitude: 78° 12′ 10″ E has a sub-tropical climate and is a heritage & tourist city. The city has a population of about 10,69,276 (as per census, 2011) and is administered by the Gwalior Municipal Corporation (GMC). The city is divided into 66 municipal wards and the area is around 423.35 Km^2.

III. PRESENT SCENARIO

The Gwalior city generates more than 500 tonnes of waste daily in which around 400-450 tonnes of waste was collected and transported in vehicles like tipper trucks, hydraulic trucks, or open trucks from door point of residential areas, from commercial areas, and industrial areas directly to Kedarpur Landfill site in mixed form without being segregated. Solid waste from different wards is getting dumped in an improper and unscientific manner creating health and environmental issues in nearby vicinity areas.
There is a lack of appropriate planning, technologies& treatment process available to mitigate the problems of solid waste emerging in Gwalior city.

IV. METHODOLOGY

The Gwalior city has 66 municipal wards and wastes are collected from wards and transferring to the Kedarpur landfill site. Waste has been collected at the endpoint that is at the kedarpur landfill site from the vehicles reaching the site. Waste samples were collected for six different wards such as wards no. 19, 22, 29, 55, 58,and 65 to determine the composition by categorizing the waste into organic waste, plastics, paper, metal, inert material, textiles, etc of MSW in the field and brought to the laboratory to analyze certain parameters such as moisture content and pH value through oven drying machine and Auto pH meter respectively. After examining the attributes of MSW the suitable method of the treatment process is selected for the maximal utilization of solid waste.

A. Study Area

The Study area is the Kedarpur landfill site which is situated at Shivpuri link road where the entire waste of the region is coming through various vehicles. A sampling of waste was done by using the Quartering method.

Fig: 2 Location of Kedarpur Landfill site

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V. WASTE COMPOSITION OF GWALIOR CITY

Waste composition of Gwalior city at Kedarpur landfill site was determined by the quartering method of sampling of solid wastes from six different wards. The ward-wise composition of Gwalior city is tabulated and the weighted average of composition was calculated and samples were brought to the laboratory for examining the moisture content and pH value.

Table: 1Ward-wise Physical Composition of Gwalior City

WAST TYPE&FRACTION(%) / WARD NO.	19	22	29	55	58	65
Organic waste	56.2%	68.89%	59.2%	40.02%	58.9%	64.57%
Plastics	10.17%	10.51%	13.99%	28.4%	20.99%	11.19%
Paper	7.3%	5.1%	8.89%	5%	3.05%	8.38%
Metals	5.04%	3.82%	2.01%	3.9%	2.3%	0.87%
Inert	11.2%	7.03%	8.31%	16%	5.7%	10.82%
Clothes	7.1%	4.0%	6.9%	6.1%	6.4%	2.77%
Miscellaneous	2.99%	0.65%	0.3%	0.08%	2.66%	1.4%

Table: 2Average Physical Composition of Gwalior City

S.NO.	WASTE TYPE	AVERAGE PERCENTAGE (%)
1.	Organic Waste	58.03%
2.	Plastic	15.96%
3.	Paper	6.37%
4.	Metal	2.99%
5.	Inert	9.82%
6.	Textile	5.54%
7.	Miscellaneous	1.34%

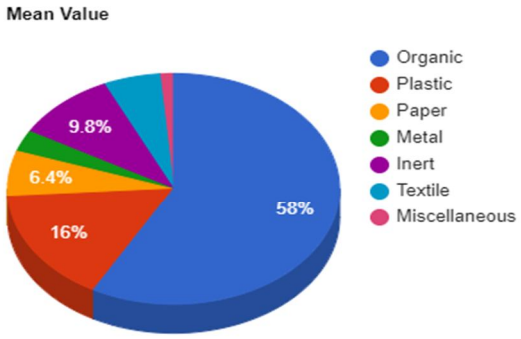

Fig: 3 Pie-Chart for Average Physical Composition

Table: 3 Comparison of Physical Composition of MSW of the present study with other cities [14]

Waste Fractions	Varanasi	Lucknow	Pune	Mumbai	Chennai	Kochi	Gwalior (present study)
Organic matter	52	40	55	40	44	58	58.03
Plastics	10	4	5	2	3	1.1	15.96
Paper	3	4	5	10	10	4.9	6.37
Metals	-	1	-	-	-	-	2.99
Textiles	4	2	-	3.6	5	-	5.54

All values are shown in weight percentage

VI. RESULTS AND DISCUSSIONS

By obtaining the average composition of solid waste for Gwalior city and analyzing the data, various parameters were determined like density, moisture content, and pH value as per standard procedures recommended by Central Public Health and Environmental Engineering Organization (CPHEEO) manual 2016, I.S 9235 – 9179: Methods of Physical analysis and determination of moisture from solid waste excluding industrial waste and I.S 10158 - 1982: Methods of analysis of solid waste (excluding industrial solid waste). Therefore, with the help of the above data and analysis suitable waste management techniques and treatment processes are proposed which shall be applied to minimize the solid waste of the city.

A. Proposed Solid Waste Management System

1) At Initial Stage

a) Public Participation/ Awareness: Public Participation is an essential part of Solid waste management. Creating awareness among residents involving common man, teachers,and students of various institutions and workers about solid waste and its management practices. The Gwalior Municipal corporations should organize programs and campaigns to educate and spread awareness about source-level segregation. Regular meetings should be held with municipal authorities and the local public at suitable intervals for discussions to encourage active participation[1], [3], [12].

b) Segregation: Segregation of solid waste into dry and wet waste is the key to Recycling and realizing waste to wealth. Many wastes to energy plants had failed due to improper segregation or no segregation of waste [4], [12].

c) Importance of Segregation: As it is the first footstep of Solid waste Management and helps in reducing the huge amount of waste to abandon in landfills and enable various types of materials to reuse in another form and preserve scarce resources of the planet by minimizing the contamination of land, water, and air[4].

2) *At Final Stage:* As we have observed that Gwalior city has a high amount of organic waste that is 58.03%, the moisture content is 68.60%, pH value is also found to be in the suitable range of 5.72 and plastic waste surged from 11.25% (ICLEI survey, 2015) to 15.96%. By keeping these values into account following treatment processes can be adopted:

a) *Waste to Energy Technique (WTE):* The economical and viable energy recovery technique for Gwalior city is a biological process that is Anaerobic digestion/ Bio-methanation plant. As per CPCB, 2015 the biological conversion techniques requires 20°C - 55°C [3] and biological treatment methods display positive solution in managing MSW in India[4]. Bio-methanation is the process involving micro-organisms for the decomposition of an organic proportion of waste and results in the formation of methane (CH_4) and carbon dioxide (CO_2) called Biogas which can be used as fuel (CNG, cooking gas), to generate electricity and leftover residues can be used as manure and as a soil conditioner. It's a closed and controlled system of treating the organic fraction of waste makes it eco-friendly and very cost-effective prevents the emission of greenhouse gases (GHGs).

b) *Material Recovery Facility (MRF):* SWM Rules, 2016 mandates the efficient use of MRF as it helps in recovering the materials for reuse purposes. Recycling of various items like plastics, metals, paper, glass, electronic waste, and construction and demolition wastes shall be done by establishing the recycling or recovery facilities around the Gwalior city. This can be possible by encouraging and training the informal recyclers and waste pickers[3], [5], [8].

c) *Bio-mining/ Bio-remediation:* Under the SWM rules, 2016 provisions have been made to manage the old dumps of solid waste by taking the necessary action to bio-mine or bio-remediate the landfill site. The excavation of old dumped waste and windrow is formed by segregating the biodegradable matter, recyclables, combustible and inert materials along with the use of composting bio-cultures to stabilize the waste through bio-remediation. Hence bio-remediation of the kedarpur landfill site could be done to deal with old wastes[1], [8].

VII. CONCLUSIONS

The study identified the potential of generating energy that can meet the future demand of electricity and fuel from municipal solid waste (biomass) and provides an opportunity to local decision-makers to choose the economical and viable technologies and treatment methods for the processing of Gwalior city waste based ona composition of MSW.

The physical composition of waste indicates that the MSW of Gwalior city is rich in biodegradable wastes and plastics which can be utilized strategically for the benefits of society and the environment. This paper provides various combinations of alternatives and with the help of the public-private partnership (PPP) model that shall be implemented to achieve efficient solid waste (Resource) Management system.

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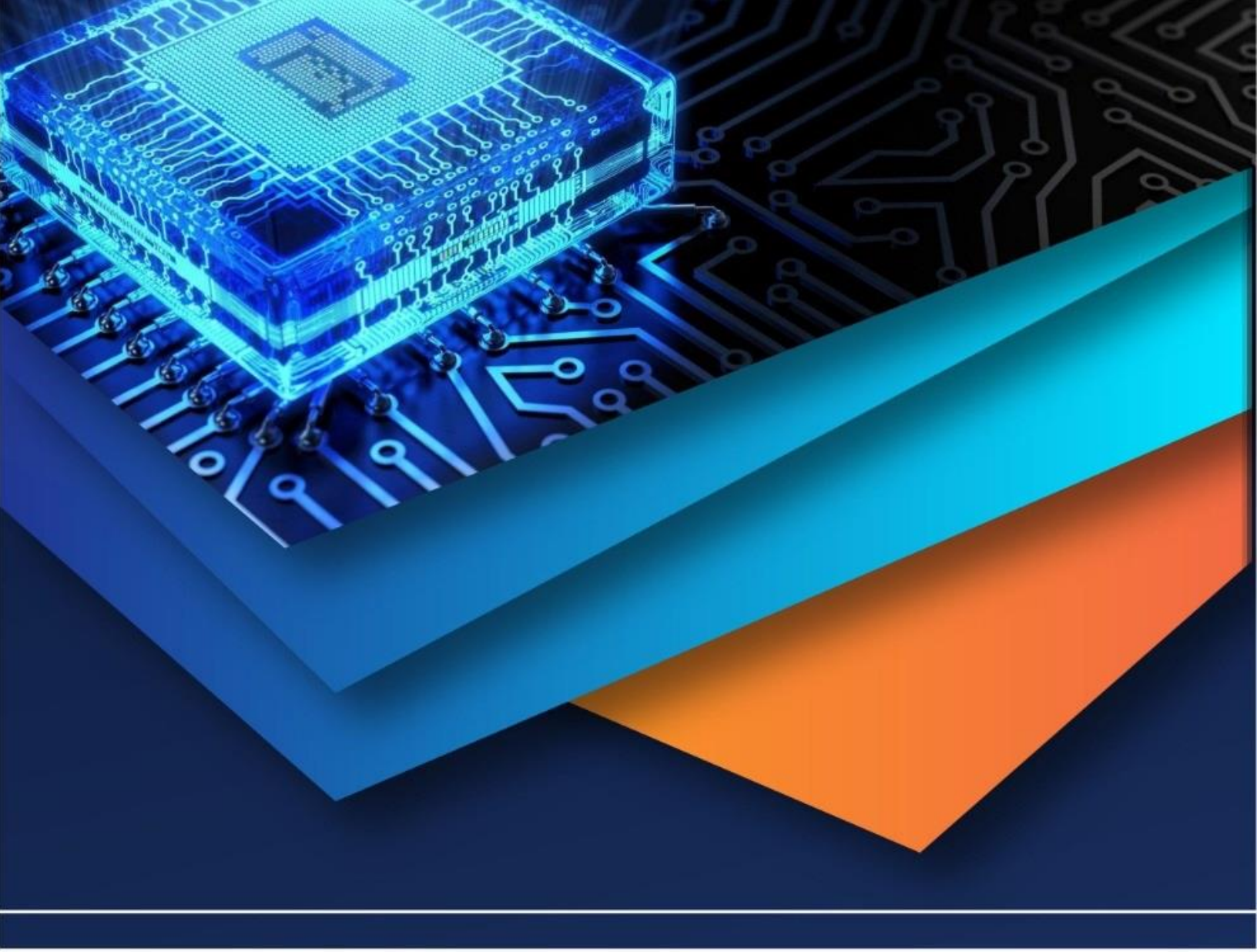

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