Journal of Informatics Education and Research
ISSN: 1526-4726
Vol 4 Issue 3 (2024)

Sustainable Waste Management: Approaches Towards Sustainability in India

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ABSTRACT

Environmental sustainability is important to preserve resources like clean air, water and wildlife for future generations. Waste directly impacts the environment and its disposal pollutes the air, water and soil. Waste management reduces greenhouse gas emissions and improves the quality of air and water, and the condition of any area affected by the waste. The environmental benefits of sustainable waste management are profound. By reducing the amount of waste that goes to landfills, greenhouse gas emissions are significantly lowered, mitigating climate change. Furthermore, conserving natural resources through recycling helps preserve biodiversity and maintain ecosystems. The goal of waste management is to increase the product's lifecycle and reuse and recover materials where possible, in order to reduce the total amount of waste that goes into landfill and minimize the environmental burden. Reducing waste will not only protect the environment but will also save on costs or reduce expenses for disposal. In the same way, recycling and/or reusing the waste that is produced benefit the environment by lessening the need to extract resources and lowers the potential for contamination. Waste reduction is anything that reduces waste by using less material in the first place. Reducing waste can be as simple as using both sides of a sheet of paper, using ceramic mugs instead of disposable cups, or buying in bulk rather than individually packaged items. Sustainable waste management is crucial in today's world, where environmental concerns are more pressing than ever. Implementing effective waste management practices not only helps in reducing the ecological footprint but also promotes a healthier and cleaner environment for future generations. It is identified that sustainable waste management provides a suitable decision in adopting a methodology for reducing waste with the involvement of all stakeholders in a community. This study involved a questionnaire survey of 320 participants, utilizing simple random sampling and the study area was New Delhi India's capital. This article delves into the various aspects and benefits and challenges of sustainable waste management.

Key Words: Sustainability, Sustainable Development, Waste Management

INTRODUCTION

Sustainable waste management plays a crucial role in maintaining a healthy environment. It enables us to minimize our environmental footprint and safeguard our natural resources. Additionally, it is vital for the protection of human health and safety, as it aids in the prevention of hazardous materials and chemical waste. India possesses significant potential to emerge as a leader in sustainable waste management due to its substantial population and expanding economy. Another key definition of sustainability that Weinstein appreciates is: "Ensuring that human society operates within ecological limits."

Sustainable development is articulated in the Brundtland Report by the World Commission on Environment and Development as "development that satisfies the needs of the current generation without jeopardizing the capacity of future generations to fulfill their own needs." This definition suggests that contemporary actions should not endanger the cultural integrity or quality of life of communities. The extent to which sustainable development can be realized differs among nations, as they vary in terms of size, wealth, living standards, cultural practices, and political and administrative frameworks.

Waste management is the practice of gathering, processing, and safely disposing of different kinds of waste in a way that is kind to the environment. This includes various tasks like collecting trash, recycling materials, composting organic waste, managing landfills, and recovering energy from waste. The goal is to lessen the harmful effects that waste can have on both our planet and our health. By reducing pollution from improper disposal methods, such as burning waste openly or dumping it in water, we can safeguard our air quality and stop harmful toxins from entering our ecosystems.

NEED OF WASTE MANAGEMENT

Effective waste management necessitates a comprehensive understanding of planning concepts, frameworks, strategies, and emerging components within the field. Proper waste sorting is crucial, as the volume of waste generated today presents significant challenges. It is estimated that a substantial portion of this waste can be recycled, some can be transformed into compost, while only a small fraction constitutes true waste that must be disposed of (Figure - 1).

Figure - 1: Waste Management Hierarchy

Envision a pyramid that serves as a fundamental tool for sustainable waste management. This pyramid, referred to as the Waste Hierarchy, offers a structured approach to waste management, ranking options from the most desirable (prevention) to the least desirable (disposal). This framework is relevant not only for processed materials such as paper, food, and plastics but also encompasses a diverse range of raw materials. All stakeholders, from those who generate waste to those who dispose of it, play a crucial role in implementing the waste hierarchy, which is a legal requirement for businesses. This approach assists companies in adhering to waste regulations and reducing the volume of waste directed to landfills.

The five principles of waste management include: Refuse, Reduce, Reuse, Repurpose, and Recycle. These principles effectively segment the waste lifecycle into distinct phases, enabling businesses to pinpoint specific actions they can implement to minimize waste generation and lessen their environmental impact.

UNDERSTANDING SUSTAINABLE WASTE MANAGEMENT

Sustainable waste management is all about managing waste in a way that helps the environment. It involves three main actions: reducing the amount of waste we create, reusing items whenever possible, and recycling materials. By doing this, we can cut down on the waste that goes to landfills, which helps lower the greenhouse gases that are released and contribute to climate change. Recycling plays a huge role in this process because it lets us use materials again, which saves natural resources and helps keep pollution in check.

Waste management strategies should take into account the complete lifecycle of products, spanning from their production to their eventual disposal. This comprehensive perspective guarantees that waste reduction occurs at each phase. Additionally, effective waste management incorporates creative methods such as composting organic materials, transforming food scraps and yard debris into nutrient-rich compost, thereby enhancing soil quality without the use of chemical fertilizers.

Governments and corporations are increasingly acknowledging the significance of implementing sustainable waste management strategies. Around the world, policies and regulations are being established to encourage waste reduction, recycling, and responsible disposal, underscoring the rising focus on sustainability.

INDIA WASTE MANAGEMENT MARKET OVERVIEW

The India Waste Management Market was valued at USD 12.3 billion in 2022. It is expected to expand from USD 13.1 billion in 2023 to USD 21.7 billion by 2032, reflecting a compound annual growth rate (CAGR) of 6.50% during the forecast period from 2024 to 2032. This growth is primarily driven by rising environmental awareness and an increasing need for efficient waste management solutions in the country.

Figure - 2: India Waste Management Market

Source: Primary Research&Secondary Research, objective MRFR Database and Analyst Review

REVIEW OF LITERATURE

Waste management is seen as a system that includes generating, collecting, and disposing of waste (Seadon, 2010). This system approach helps us understand how waste management connects with other parts of our environment, especially when we want to create more sustainable practices. To build a more sustainable society, we need to be smarter about how we handle waste. Relying on old methods that only focus on one part of the problem isn't enough because they don't allow for flexibility or long-term solutions. A sustainable waste management system should include feedback loops, focus on processes, be adaptable, and keep waste from just being thrown away. To make this shift to a sustainable system, we need to find and use key points that can help us make real changes.

Taiwo (2011) emphasizes that achieving sustainability in waste management necessitates the adoption of environmentally friendly practices. Such approaches should be characterized by their effectiveness, efficiency, and cost-effectiveness compared to alternative methods. In developing countries, solid waste management presents significant challenges due to issues such as poverty, rapid population growth, urbanization, and insufficient governmental funding. While disposal techniques like incineration, landfilling, pyrolysis, and gasification can be effective, they often pose

environmental risks and public health threats. Conversely, when managed appropriately, composting emerges as a sustainable solution, offering benefits such as the generation of bio-fertilizer, minimal air and water pollution, low operational costs, and potential revenue generation. The application of composting for the bioremediation of contaminated soils has gained traction in many developed nations. Nonetheless, if composting systems are poorly designed, they may result in methane emissions, unpleasant odors, and the accumulation of heavy metals in the final product. Consequently, this study examines the sustainability of composting and its various advantages over other waste disposal methods in developing countries.

Marshall and Farahbakhsh (2013) provide a review that highlights the differences between the historical and contemporary frameworks of solid waste management (SWM) practices and policies in developed nations and the ongoing challenges and complexities encountered in SWM within developing countries. In developed countries, factors such as public health, environmental concerns, resource limitations, climate change, and increased public awareness and engagement have served as key motivators for the evolution towards an integrated approach to SWM.

Sin and Chen et al. (2013) this study examines the existing waste management framework in Malaysia and the difficulties associated with integrating sustainability into this system by analyzing previous research. The authors conducted exploratory interviews with six industry professionals from both the private and public sectors in Malaysia. The findings reveal the current waste management practices in the country and the obstacles that impede the adoption of sustainable methods. This research paves the way for a significant transformation in Malaysia's waste management by enhancing current technologies to promote more sustainable practices.

Zurbrügg, Caniato, and Vaccari (2014) examines various assessment methods, providing a detailed discussion of each and highlighting their application in low and middle-income countries as documented in scientific literature. The review indicates that the adoption of comprehensive assessment methods in these regions remains quite limited. It is posited that many formal assessment methods are overly complex, placing an undue burden on the already constrained local capacities designed to implement them. The few instances of application noted were primarily conducted by academic institutions for research purposes. Additionally, the scarcity of resources necessary to gather the extensive data required for certain assessment methods further hinders their practical use. The authors recommend future efforts to enhance the user-friendliness of existing tools, simplify certain methodologies, and develop more suitable assessment approaches.

The increasing volume of construction waste resulting from swift urbanization globally necessitates the immediate creation and execution of sustainable management strategies, as highlighted by Kasthurba et al. (2014). The challenges, opportunities, and strategies for waste management within the construction sector outlined in their work will assist both private and governmental organizations in fostering sustainable building practices.

Reno (2015) highlights how waste materials and waste management processes are crucial for understanding issues related to materiality, ontology, and the roles of marginalized and polluting labour within environmental justice movements. It also critiques the exploitation and unfulfilled promises associated with modernity and imperial structures. There is still much to learn from waste, particularly as ongoing research uncovers how our waste not only affects us but also intertwines with the lives of nonhuman beings and the future of our shared planet.

Amasuomo and Baird (2016) utilized a desktop methodology to address the research objectives outlined in their paper. This approach involved a descriptive analysis to collect data from peer-reviewed sources, including journal articles, reports from environmental organizations, and relevant books. The findings indicated that the concept of waste is largely subjective; a material is considered waste only when its owner designates it as such.

The paper by Kumar et al. (2017) emphasizes the importance of transitioning from dependence on waste dumps, which provide inadequate environmental safeguards, to more effective waste management systems that aim to keep valuable resources within the economic cycle. A critical aspect of this transition is the segregation of waste at its source, along with the utilization of specialized processing facilities to isolate recyclable materials. Furthermore, the disposal of residual waste, following the recovery of material resources, necessitates the development of engineered landfill sites and/or investment in waste-to-energy technologies.

Bhadauriya et al. (2019) indicate that the rising economy and population will likely lead to increased resource consumption and waste production at similar or even higher rates. For a nation that has largely overlooked solid waste management (SWM), it is crucial to acknowledge the severity and expanding scale of these issues. Promoting the separation of municipal solid waste (MSW) and facilitating its direct sale to the informal sector seems to be a more effective approach. Engaging both public and private sectors, including NGOs, could enhance the efficiency of solid waste management efforts. A comprehensive survey should be conducted to assess the generation and characteristics of solid waste in India. The findings suggest that factors such as financing, infrastructure, and effective planning are essential for SWM. The rising demand for services, coupled with insufficient resources for municipalities, is placing significant pressure on the current solid waste management system.

Chaudhary et al. (2021) highlight that a significant portion of the waste produced remains unrecognized by official agencies. The residents of rural India are particularly impacted by the authorities' oversight regarding the waste they generate. Additionally, the waste produced in smaller towns and slum areas frequently goes unnoticed by these agencies.

Chisholm et al. (2021) conducted a review on the sustainability of medical waste management in Africa, aiming to offer robust solutions for safeguarding health and the environment for future generations. Their research highlights policies, recommendations, and sustainable practices related to medical waste management that can assist decision-makers in crafting strategies focused on sustainability. By promoting eco-friendly technologies for effective treatment and disposal of medical waste, this work also aims to connect the healthcare system with policymakers and stakeholders in the development of health policies and programs.

Czekała et al. (2023) conducted a study utilizing search terms associated with contemporary technologies in waste management. This paper outlines a range of innovative solutions that have emerged in recent years and examines their effects on waste management practices. Additionally, it addresses the challenges faced and potential future pathways for waste management within the framework of the circular economy. The implementation of these modern solutions in waste management facilitates the attainment of specific sustainable development objectives.

Sawalkar et al. (2023) introduces a strategic model for sustainable waste management aimed at enhancing environmental sustainability through circular practices. By closing the loops and aligning with sustainable development goals, the research offers valuable guidance for universities in managing waste from various sources. The insights gained can help institutions achieve broader environmental sustainability while promoting circular resource use through the principles of reducing, reusing, and recycling (3R). The study emphasizes the importance of tailoring strategies to meet the unique needs of different universities and institutions. Additionally, researchers are encouraged to further explore and adapt this model as necessary, with potential applications in related fields.

Simpa et al. (2024) conduct a comprehensive review that explores the obstacles and challenges impeding the broad adoption of sustainable practices, focusing on technological, economic, and regulatory factors. This in-depth analysis seeks to provide essential insights for industry stakeholders, policymakers, and researchers, promoting the incorporation of innovative waste management strategies within the dynamic environment of LNG operations.

Dada and Obaigbena et al. (2024) explore the various challenges and opportunities associated with these strategies. The findings highlight the importance of developing adaptive frameworks that align regulations with the socio-economic environment. Although technological advancements show great potential, issues such as economic feasibility, market demand, and societal behaviours present significant obstacles. Nevertheless, adopting innovative waste management practices can lead to transformative outcomes, promoting resource conservation, reducing pollution, and enhancing resilience to climate change. This research provides valuable insights for policymakers, industry stakeholders, and communities as they navigate the evolving field of waste resource management.

Sondh et al. (2024) recognize the global business entities that have embraced the circular economy in their pursuit of sustainability. The paper emphasizes the initiatives taken by well-known organizations to reduce waste and promote material recycling and reuse in their operations and products. This study provides insights into a system that fosters prosperity and harmony within society.

Kwakye et al. (2024) emphasizes the importance of enhancing education and awareness regarding waste management among residents. It also advocates for better access routes to homes and waste disposal facilities. Additionally, it suggests that waste transportation should occur during night-time hours to alleviate traffic congestion.

OBJECTIVES OF THE STUDY

i) To grasping eco-friendly waste disposal practices and the Indian consumer landscape.

ii) To review a summary of India's Waste Management Market, its expansion, and the regulatory structures of market growth, policy frameworks.

iii) To find the benefits and challenges of sustainable waste management.

iv) To study suggested the policy implications of sustainable waste management.

METHODOLOGY

The study is focused on primary and secondary data which were collected through well-designed questionnaires to suit the points of this research. The principal data have been supplemented by secondary sources, a common practice in desktop studies where existing information is analyzed to reach important conclusions. Sampling is the method you use to pick individuals out of the group to study.Stratified random sampling is a method researchers use to sample a population. They divide their sample population into strata, or subgroups.

The study references a variety of specific data sources, including books, journal articles, unpublished papers, government reports, and both organisational and private websites. This research method is particularly useful when there is already a significant body of work on a topic, and the goal is to address specific questions informed by earlier research. For these reasons, this paper adopts this approach to explore the insights various researchers have provided regarding waste, its classification, and management.

DATA ANALYSIS

Table - 1:Reliability Statistics

Reliability Statistics	
Cronbach's Alpha	N of Items
.094	31

Table - 1 show that the Cronbach Alpha is above 0.9, so the survey along with the questionnaire is highly reliable.

Table - 2: Percentage Analysis

Category	**Classification**	**Frequency**	**Percent**
Gender	Male	158	49.4
	Female	162	50.6
	Total	**320**	**100.0**
Age	18-29 Years	111	34.7
	30-44 Years	75	23.4
	45-59 Years	106	33.1
	Above 60 Years	28	8.8
	Total	**320**	**100.0**
Education qualification	Diploma	135	42.2
	Bachelor Degree	90	28.1

	Master Degree	95	29.7
	Total	**320**	**100.0**
Marital Status	Single	175	54.7
	Married	145	45.3
	Total	**320**	**100.0**
Do you ever notice waste in the road, land or public area?	Yes	262	81.9
	No	58	18.1
	Total	**320**	**100.0**
Do you believe that there should be environmental conservation for sustainable development?	Yes	292	91.3
	No	28	8.8
	Total	**320**	**100.0**
Do you have any of the following problems in your area?	Basement flooding	187	58.4
	Water standing in your yard or nearby lots after heavy rains	57	17.8
	Water standing in your yard or nearby lots frequently	33	10.3
	Open drainage	43	13.4
	Total	**320**	**100.0**
What type of mass media component was more effective in generating your awareness in waste management?	Radio	137	42.8
	Television	85	26.6
	Newspaper	31	9.7
	Social media	67	20.9
	Total	**320**	**100.0**
Do you separate different type of waste at your home?	Yes	293	91.6
	No	27	8.4
	Total	**320**	**100.0**
Does your company have a procedure for managing or treating your hazardous and non-hazardous waste, including proper storage facilities?	Yes	274	85.6
	No	46	14.4
	Total	**320**	**100.0**
Has your company undertaken any action in order to reduce, reuse and/or recycle waste at the facility?	Yes	236	73.8
	No	84	26.3
	Total	**320**	**100.0**
How often does waste management team visit your locality for waste collection and disposal?	Daily	120	37.5
	Once a week	122	38.1
	Twice in a week	78	24.4
	Total	**320**	**100.0**
The current waste disposal system is polluting the environment	Wastes are left around the dustbin	133	41.6
	Wastes are left on the drain	112	35.0
	Wastes are left on the road	75	23.4
	Total	**320**	**100.0**

Gender of the Respondents

From Table - 2, is evident that among the gender of the respondents, 48.4 percent have male respondents, followed by female respondents with 50.6 percent.

Age of the Respondents

From Table - 2, it is evident that among the age of the respondents, 34.7 per cent of the respondents are 18-29 Years, followed by 30-44 Years with 23.4 percent, tailed by 45-59 Years of respondents have 33.1% and the remaining age group people have Above 60 Years age people have only 8.8%.

Education Qualification of the Respondents

It can be seen from Table - 2, Education Qualification of the respondents the number of respondents who have a Diploma with 42.2 percent, trailed by Bachelor Degree respondents with 28.1 percent. Master Degree respondents with 29.1 per cent.

Marital Status

Table -2, highlights the respondents' marital status, the number of respondents who have 54.7% are Single, followed by married respondents at 45.3 percent.

Have any problems in your area

Table -2, highlights the respondents, Basement flooding is 58.4%, Water standing in your yard or nearby lots after heavy rains is 17.8%, Water standing in your yard or nearby lots frequently 10.3%, Open drainage 13.4%.

Generating your awareness in waste management

Table - 2, highlights the respondents, Radio is 42.8%, Television has 26.6%, Newspaper is 9.7%, Social media having 20.9%.

Chi-Square Test

H0: There is no significant difference between theever notice waste in the road, land or public area and the age of the respondents

Table - 3: Ever notice waste in the road, land or public area and the age of the respondents

Do you ever notice waste in the road, land or public area? * Age Cross tabulation						
		Age				Total
		18-29 Years	30-44 Years	45-59 Years	Above 60 Years	
Do you ever notice waste in the road, land or public area?	Yes	92	64	79	27	262
	No	19	11	27	1	58
Total		111	75	106	28	320

Chi-Square Tests			
	Value	DF	Asymptotic Significance (2-sided)
Pearson Chi-Square	8.532[a]	3	.036
Likelihood Ratio	9.822	3	.020
Linear-by-Linear Association	.012	1	.913
N of Valid Cases	320		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 5.07.

The chi-square statistic appears in the Value column of the Chi-square Tests table immediately to the right of "Pearson Chi-Square". The value of the chi-square statistic is 8.532. The *p*-value appears in the same row in the "Asymptotic Significance (2-sided)" column (0.036). The consequence is important if this value is equal to or less than the designated alpha level (normally 0.05). In this case, the *p*-value is smaller than the standard alpha value, discarding the valueless theory that asserts the two variables are independent of each other. To put it simply, the outcome is noteworthy – the data suggests that the variables of platformsever notice waste in the road, land or public areaand age of the people notice per day are associated with each other.

H0: There is no significant difference between theBenefits of SWM and the three types of R Waste management

Objective: To find the benefits and challenges of sustainable waste management.

Table 3: Benefits of SWM and the three types of R Waste management

ANOVA						
		Sum of Squares	**DF**	**Mean Square**	**F**	**Sig.**
Environmental protection and pollution reduction	Between Groups	6.908	1	6.908	7.721	**.006**
	Within Groups	284.514	318	.895		
	Total	291.422	319			
Resource conservation	Between Groups	6.497	1	6.497	5.648	**.018**
	Within Groups	365.800	318	1.150		
	Total	372.297	319			
Economic benefits	Between Groups	.298	1	.298	.221	**.639**
	Within Groups	429.902	318	1.352		
	Total	430.200	319			
Enabling a circular economy	Between Groups	1.975	1	1.975	3.754	**.054**
	Within Groups	167.321	318	.526		
	Total	169.297	319			
Reduce Waste in Landfills	Between Groups	4.741	1	4.741	6.547	**.011**
	Within Groups	230.256	318	.724		
	Total	234.997	319			
Reduce Greenhouse Gases	Between Groups	.022	1	.022	.016	.898
	Within Groups	425.325	318	1.338		
	Total	425.347	319			
Reduce Pollution	Between Groups	.080	1	.080	.095	.758
	Within Groups	267.408	318	.841		
	Total	267.487	319			

According to the above table, there is a significant difference between the respondents' Benefits of SWM and the three types of R Waste management for seven factors: Environmental protection and pollution reduction, Resource conservation, Economic benefits, enabling a circular economy, Reduce Waste in Landfills, Reduce Greenhouse Gases, and Reduce Pollution. This difference is observed when the significant value is less than the "P" value (0.05%). The variables are Environmental protection and pollution reduction, Resource conservation, enabling a circular economy, Reduce Waste in Landfills. The null hypothesis is thus disproved.As a result, the null hypothesis is accepted, indicating that, Economic benefits, Reduce Greenhouse Gases, Reduce Pollution.

By using sustainable waste management practices, businesses and communities can save money, protect the environment, and create economic and social benefits. Implementing sustainable waste management practices can help ensure that our communities and businesses are more sustainable and resilient in the future. In India, various organizations are involved in waste management, including the Ministry of Environment, Forest, and Climate Change (MoEFCC), the Urban Development Department (UDD), the Urban Local Bodies (ULBs), and private sector companies.

Table - 4: KMO and Bartlett's Test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.581
Bartlett's Test of Sphericity	Approx. Chi-square	290.824
	DF	55
	Sig.	.000

Table - 4 shows the KMO value of 0.581, which indicates that the degree of common variance among the variable is quite moderate, therefore factor analysis can be conducted.

REASONS FOR CHALLENGES OF SUSTAINABLE WASTE MANAGEMENT- PRINCIPAL COMPONENT ANALYSIS

The principal component analysis has been administered to group the factors of the Reasons for features of warehouse operations. It is a method of data reduction. The proportion of the variance of a particular item due to a common factor is called commonality. The initial value of communality in a principal component analysis is 1. A reason for factors of the Reasons forChallenges of sustainable waste management is placed in the component's column. The extraction communalities estimate the variance in each variable accounted for the factors in the factor solution. The value is less than 0.5 which indicates variable does not fit well with the factor solution and should possibly be dropped from the analysis.

The following table shows the extraction value of the Reasons for Challenges of sustainable waste management.

Communalities	
	Extraction
High cost	.643
Segregation	.514
Unsafe sites	.566
A few waste management solutions	.568
Teaming up and collaboration	.678
Precise segregation	.660
Tracking and assessment	.468
Lack of waste segregation at the source	.569
Inefficient waste collection and transportation system	.181
Inadequate public awareness and participation	.394
Limited infrastructure for waste processing and disposal	.518
Extraction Method: Principal Component Analysis.	

Explicates the variance of the 11 variables ranging from .181 to .678. It shows that the 11 variables exhibit a considerable variance from 18 percent to 78 percent. Hence it is concluded that these entire 11 variables are capable of segmenting themselves concerning the reasons for Challenges of sustainable waste management to form the predominant factors.

REASONS FOR CHALLENGES OF SUSTAINABLE WASTE MANAGEMENT - TOTAL VARIANCE

The total variance analysis is important to know the rotated sum of the square value. The rotated four factors are determined based on the total Eigenvalues if the factor should be greater than one. The total cumulative variance is explained by the total percentage of variance by each retained by four factors. Gives the individual variances of the predominant factors that emerged out of four factors.

Total Variance Explained						
Component	Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.091	19.010	19.010	1.701	15.467	15.467
2	1.393	12.664	31.674	1.478	13.435	28.902
3	1.229	11.174	42.847	1.359	12.357	41.258
4	1.045	9.497	52.345	1.220	11.086	52.345
Extraction Method: Principal Component Analysis.						

Eigenvalues are greater than one for four factors. From this one, it is confirmed that the eleven variables are grouped into four factors. The rotated sum of squared loading should be greater than 99 percent. The 11 variables were reduced into four predominant factors with an individual variance of 19.010, 31.674, 42.847, and 52.345. It is also found that the total variance of the 11 variables is found to be 52.345percent which is greater than the benchmark value of 52 percent. Moreover, it confirms that the factor segment is the meaningful one.

REASONS CHALLENGES OF SUSTAINABLE WASTE MANAGEMENT - ROTATED COMPOUND MATRIX

The rotated sum of the square value indicates the cumulative percentage of the variance is 52.345. Hence the factorization is more suitable for the cost involved in reasons for Challenges of sustainable waste management. The table explains the value of the rotated component matrix for the reasons for preferring Challenges of sustainable waste management.

Rotated Component Matrix[a]				
	Component			
	1	2	3	4
Teaming up and collaboration	.806			
Unsafe sites	.639			
Segregation	.628			
Lack of waste segregation at the source		.726		
Tracking and assessment		.629		
High cost			.666	
Limited infrastructure for waste processing and disposal			.658	
Inadequate public awareness and participation			.579	
Precise segregation				.789
A few waste management solutions				.571
Inefficient waste collection and transportation system				.258
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.				
a. Rotation converged in 6 iterations.				

Shows factor loadings of five factors extracted through factor analysis. The first factor consists of three sub-factors; Teaming up and collaboration, unsafe sites, Segregation. The first factor is called **"Teamwork and collaboration"** as it contains items that explain activities performed by the Challenges of sustainable waste management. The second factor contains two sub-factors; Lack of waste segregation at the source, Tracking and assessment. Hence, it is named **"Waste segregation".**The third factor contains another three factors like High cost, Limited infrastructure for waste processing and disposal, inadequate public awareness and participation. Hence the factor is named **"Processing factor".** The fourth factor contains another three factors like precise segregation, A few waste management solutions, inefficient waste collection and transportation system. Hence the factor is named **"Waste disposal".**

FUTURE TRENDS IN WASTE MANAGEMENT

The outlook for waste management is optimistic, driven by the rise of innovative sustainable practices. A notable shift towards zero waste is occurring, with companies striving to completely eliminate landfill waste. Anticipated policy reforms and heightened environmental consciousness are likely to propel further progress in this sector. The application of circular economy concepts, which regard waste as a valuable resource, will be crucial in influencing the future landscape of waste management. Zero waste initiatives prioritize the redesign of products and processes to minimize waste generation and encourage reuse. Organizations pursuing zero waste objectives are re-evaluating their supply chains to decrease waste at every phase, from product development to final disposal.The concept of a circular economy is increasingly recognized as a sustainable approach to resource management. In this model, products are intentionally designed to be durable, repairable, and recyclable, which helps to prolong their lifespan and minimize waste. Resources are utilized for as long as possible and waste is regarded as a valuable asset that can be reintegrated into the production process.

At both national and international levels, policy reforms are propelling improvements in waste management practices. Governments are enacting more stringent regulations regarding waste disposal and are providing incentives to encourage recycling and waste minimization. International initiatives, such as the European Green Deal, establish

ambitious goals for waste reduction and the shift towards a circular economy. Technological advancements will remain pivotal in shaping the future of waste management. Innovations in artificial intelligence, robotics, and data analytics are set to improve the efficiency and effectiveness of waste management systems. Additionally, emerging technologies like bio-based materials and waste-to-energy solutions present new opportunities for sustainable waste management.

CONCLUSION

Public engagement and awareness are crucial for the success of waste management programs. By actively involving the community and highlighting the significance of waste segregation and proper disposal, Indore achieved remarkable public participation and backing. Effective monitoring and enforcement strategies ensure adherence to waste management regulations. Indore's method of implementing waste segregation and disposal rules, along with routine inspections and penalties, has been successful in keeping the city clean. Investing in advanced waste processing facilities can greatly enhance the efficiency of waste management systems and lessen environmental impacts. Indore's commitment to a cutting-edge waste processing plant enabled the city to handle and dispose of waste more efficiently, resulting in a notable decrease in landfill use and related environmental concerns. Through a thorough and integrated approach to waste management, Indore has effectively tackled its waste challenges and established a model for sustainable urban living. The city's experience offers valuable lessons for other municipalities aiming to enhance their waste management practices and foster environmental sustainability.

An informed society is more likely to make responsible choices regarding consumption, use of materials and waste disposal. Awareness about the negative impacts of waste must be spread at all levels, from schools to companies, from families to communities. Quality and integrity of environment can be preserved by public awareness. Dwindling environment is the biggest threat to the existence of human beings. Loss of valuable natural resources and pollution lead to harmful effects as well as abiotic stress on flora and fauna.

India encounters considerable difficulties in waste management, primarily due to its vast population and the substantial volume of waste producedaround 1.3 billion tons annually, accounting for one-third of the global total. Enhancing the recycling sector is essential, as only 5% of recyclable materials are currently processed for reuse. Addressing these issues is vital for ensuring a sustainable future and safeguarding the environment. It is imperative for India to develop long-term waste management strategies that can adapt to evolving lifestyles. Effective recycling requires the separation of household and institutional waste at the source.The aim is to reduce landfill waste, which needs the community to get involved. Large-scale recycling of e-waste is essential to address the e-waste disposal issue. India needs to tackle these problems because they are not only local but also global, impacting everyone.

Sustainable waste management is a critical concern in India, and the nation has made significant progress in enhancing its waste management framework in recent years. Although there are still some challenges that need to be addressed, the overall approach has proven to be an effective model for waste management. The primary benefits of a sustainable waste management system include a reduction in waste generation, conservation of natural resources, and job creation. However, there are also drawbacks, such as the high costs associated with establishing and maintaining these systems, the longer timeframes required to see results compared to traditional methods, and the increased labour demands. Despite these challenges, Indian authorities have acknowledged the significance of sustainable waste management and are actively working towards implementing more efficient systems nationwide.Waste management plays a crucial role in our society for numerous reasons. It not only ensures the proper disposal and recycling of waste but also aids in environmental conservation, resource preservation, and the promotion of sustainable development. By managing waste effectively, we can decrease pollution, mitigate health risks, and create a cleaner, healthier environment for future generations.

The concept of sustainable waste management establishes a holistic decisionmaking framework that engages all community stakeholders. This framework delineates the processes involved in the development, evaluation, and execution of a waste management strategy. A hierarchical approach, where different levels function independently, can compromise the overall effectiveness of the system. Each level within the hierarchy is interrelated through shared preferences and benefits, underscoring the importance of perceiving the entire framework as a cohesive model aimed at improving resource efficiency and reducing the adverse effects of consumption.

Public participation in waste management faces significant challenges, and there is often a noticeable lack of accountability within communities regarding waste disposal. To address this, it is crucial to foster community awareness and shift public attitudes towards waste, as these changes are essential for establishing effective and sustainable waste management systems. A sustainable approach to waste management should focus on maximizing resource recovery while ensuring the safe disposal of residual waste through engineered landfills and waste-to-energy facilities. India is grappling with issues related to waste policy, the selection of appropriate waste technologies, and the shortage of adequately trained professionals in the waste management field. Without addressing these foundational issues, India will continue to experience inadequate waste management, leading to adverse effects on public health and the environment.When all stakeholders actively participate in waste management, it can lead to improvements not only in economic, social, and environmental conditions but also in tackling the growing problem of solid waste through the implementation of advanced technologies in sustainable waste management.

Most household waste in rural areas is organic, with little inorganic material, and is non-toxic. Because of its environment - friendliness, composting is a highly suitable method of waste management in rural areas.

Wastewater is water that has been used for various purposes, such as domestic, industrial, or agricultural activities and contains pollutants and contaminants. Wastewater management is the process of collecting, treating, and disposing of wastewater safely and sustainably. Wastewater management is crucial for reducing water pollution, conserving water resources, and improving public health and environmental quality. However, wastewater management faces many challenges, such as: Lack of adequate infrastructure and technology, Lack of proper regulation and enforcement, Lack of awareness and participation.

To overcome these challenges, India needs to adopt a holistic and integrated approach to wastewater management, which involves, investing in infrastructure and technology, Strengthening regulation and enforcement, Increasing awareness and participation.

India's Potential to Lead the Way in Wastewater Management, India has a huge potential to become a leader in wastewater management, as it has several advantages, such as: A large and diverse market, A vibrant ecosystem, A global and regional role, By harnessing its potential and overcoming its challenges, India can not only solve its water crisis but also set an example and inspire the world to adopt sustainable and inclusive wastewater management practices.

At the national policy level, the ministry of environment and forests has legislated the Municipal Waste Management and Handling Rules 2000. This law details the practices to be followed by the various municipalities for managing urban waste.Public participation help in waste management to improper waste disposal in urban areas can only be handled with the contribution and attention of citizens. Namely, waste is appropriately managed when municipalities and waste management companies integrate systems digitally and cooperate with citizens.

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