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[1]Solid Waste Management: A Sustainable Waste Management for Human Health and Environment

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Abstract: The significant increase in robust waste management can be attributed to economic expansion, population growth, and shifts in waste disposal practices. This phenomenon can be attributed to the rapid urbanisation and increasing affluence of individuals, which directly impacts societal dynamics and national progress. Solid Waste is considered as an inevitable derivative of human activities. Economic improvement, urbanization, and improved residing standards in cities beautify the quantity and complexity of stable waste. The rapid increase of populace coupled with urbanization has positioned brilliant strain on Nagpur Municipal Corporation to fulfil the growing demands of its citizens The main objectives of sustainable waste management prioritize safeguarding both human health and the environment while conserving valuable resources. This study aims to engage the community actively in efficient solid waste management practices, fostering cooperation and participation. Ultimately, the goal is to ensure environmental sustainability through a thorough investigation and analysis of waste management practices within the city. This involves focusing on appropriate technologies tailored for waste processing. Thus researcher intends to know how garbage, can be used as a valuable resource the new methods of disposal will lead to a sustainable environment for future generations by this research.

Keywords: *Solid Waste Management, Sustainability, Waste Management, Human Health Environment, Sustainable development, Central India.*

Introduction

The improper and excessive disposal of garbage has led to significant environmental problems, such as the deterioration of water bodies, the loss of wildlife habitats, and the release of air pollutants, all of which reduce the visual appeal of the environment. This has a direct impact on the progress of nations and the structure of society. The development of more reliable waste management systems in emerging nations has been driven by urbanisation, population growth, and increasing residential demands. Therefore, it is imperative to construct an efficient waste management system, particularly in densely populated metropolitan and peri-urban areas, in order to ensure the nation's sustainable development. The management of solid waste is characterised

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by decentralisation, with the key driver being the financial condition of countries (Srivastava et al., 2014). The rapid development in the urban population, along with a strong economy and higher residential needs, has resulted in the production of significant amounts of municipal solid trash in different towns around India. This study evaluates the effectiveness of the current solid waste management (SWM) system in the city of Imphal in Northeast India, as well as the perception of the SWM system. It has been observed that the existing solid waste management (SWM) system is insufficient and surprisingly unsatisfactory in its reliance on solid waste. The Solid Waste Administration Rules (2016) provide a pragmatic framework for addressing the various difficulties related to the management of municipal solid waste in India. They signify a significant progress in comparison to the City Solid Waste Management Rules (2000), which were the first endeavour to delineate such directives as they were formerly suggested for urban regions in India. The Government of India has provided assistance for several public programmes, including JNNURM, AMRUT, smart city projects, and the Swachh Bharat Mission. However, despite these efforts, the issue still does not receive sufficient attention. Translating the objectives and goals stated in the Standards into a functioning and coordinated strategy to solid waste management is crucial.

Review of Literature

Al-Ghoutiet. Al. (2021) Waste decimation thru incineration needs comprehensively turned out should be a suitable Furthermore prominent decision comprehensively. Regardless of continuously viewed as an reasonable option, On not worked and figured out how well, it might make a standout amongst those at any rate as naturally wanted choices. It may be suitably that the waste from metropolitan solid waste (MSW) might be thought seriously about a renewable energy functional asset due to its limit of continuously converted from "waste" under valuable stock Also control. Yousafzaiet. Al. (2020) the acknowledgment of the services of invisible fingers that do pro-environmental work, notwithstanding residing in post-conflict trauma themselves, those "unintended sustain ecopreneurs" earn a residing even as assisting societies to grow to be extra sustainable. Their work for upstream manufacturers and downstream clients serves as a stepping stone in the direction of the introduction of cleaner manufacturing throughout waste fee chains in growing countries. They have superb consequences on more than one recycling sector. Iqbal et. Al. (2020) Municipal strong waste (MSW) management is a globally identified environmental difficulty. The standards of sustainability and the circular economic system have improved MSW control devices from simple disposal to recycling and resource restoration. Life cycle assessment (LCA) is the method that has been widely used to analyse MSW control systems. Mir et. Al. (2020) Assisting in political administration, promoting trash reduction, composting, and reuse methods, empowering individuals, offering financial incentives for recyclable things, formulating a stringent policy, and incorporating creative advancements. Moreover, an efficient waste management system in the city of Ludhiana, located in the state of Punjab.

. Abu Hajaret. Al. (2020) It has been argued these days that inexperienced increase is the most effective financial development pathway to comfortable a sustainable destiny. The Government of Jordan has released a National Green Growth Plan aiming to facilitate the transition in the direction of inexperienced growth in six precedence sectors; among the ones is the stable waste management area. Jordan Vision 2025 aims to achieve a 33% reduction in the volume of solid waste deposited in landfills or dumpsites by the year 2025.Luoet. Al. (2021) Selecting a sustainable municipal strong waste control (MSWM) situation can lessen greenhouse gas emissions and deal with the power disaster, successfully. However, traditional decision approaches simplest rank opportunity

eventualities but fail to manage them. Implementing effective management for alternative MSWM eventualities can store choice fees and enhance efficiency. Thus, this paper aims to assemble a novel multi-standards institution decision-making (MCGDM) method to manipulate and rank sustainable situations. Pujaraet. Al. (2019) Open disposal is an unavoidable outcome of transferring municipal solid waste (MSW) to most cities in India, not just limited to the stated metropolitan centres. This motion assumes a wide, organic position. Moreover, the release of greenhouse gases (GHGs) during the direct burning or decay of waste materials leads to health risks. Integrated solid waste management (ISWM) encompasses a range of procedures, such as incineration, decomposition, anaerobic digestion, gas recovery facilities, and material recovery facilities. Furthermore, the practice of sterile landfilling extends the longevity of tonsil well-being.. Das et. Al. (2019) Solid waste management, usually referred to as SWM, is a crucial element of an environmental management system. The use of the "reduce," "reuse," and "recycle" (3R) principles has significantly improved solid waste management (SWM) practices, making them a more viable and efficient solution for achieving sustainability. La da Silvaaet. Al. (2019) applicable set of sustainability signs to research municipal solid waste management (MSWM) in big and medium-sized global cities and to apply those findings in 3 municipalities located in the kingdom of Rio Grande do Sul, in southern Brazil.
W. Warunasingheet. Al (2016) The health and environmental conditions in the United States of America are enhanced when there is an efficiently managed and effective waste management strategy. This survey examines the perception of the Solid Waste Management facility in a peri-urban area (Kottawa in Colombo) in terms of the willingness of individuals to participate in an enhanced programme and their level of awareness regarding the health and environmental hazards associated with inadequate management of solid waste.
Nagpur, located in the state of Maharashtra, is the third most populous city with a population of 2.5 million according to the 2011 Census. The city serves as a prominent hub for education and is rapidly becoming as a major centre for healthcare in the country. The city is facing significant strain to accommodate the demands of its expanding population, resulting from both urban migration and intercity mobility.

Research Methodology

The researcher engaged in extensive interviews with a diverse range of individuals residing in Nagpur city in order to obtain a comprehensive and pertinent understanding of the situation. The researcher obtained the data from individuals residing in various regions and households in Nagpur, as well as from waste collectors across the entire city, officials from the Nagpur Municipal Corporation (NMC), and subject matter experts. Questionnaires and structured interviews were employed to gather comprehensive data that would enhance individuals' comprehension of the project topic. Data collection involved the utilisation of judgmental sampling and the simple random sample approach to ensure the absence of bias.

The Sample was drawn for the study from Nagpur region only and the ratio of the respondents are 1500- Household respondents, 200-Garbage collectors, 20-NMC officials: and, information collected from 5 Subject experts through scheduled interview

Objectives

•To analyse the various methods for creating better understanding of disposal of solid waste management
•To examine the opinions to ensure the sustainability of the environment through effective solid waste management
•To explore all the aspects of concerned stakeholders of the proposed study

Research Hypothesis
For Household

H0:- There is no significant relationship between Awareness Level of people with proper solid waste management system

H1:- There is a significant relationship between Awareness Level of people with proper solid waste management system

For Garbage collectors

H0: The practice of waste separation by individuals has no significant impact on the solid waste management system.

Development of Understanding of Solid Waste Management:

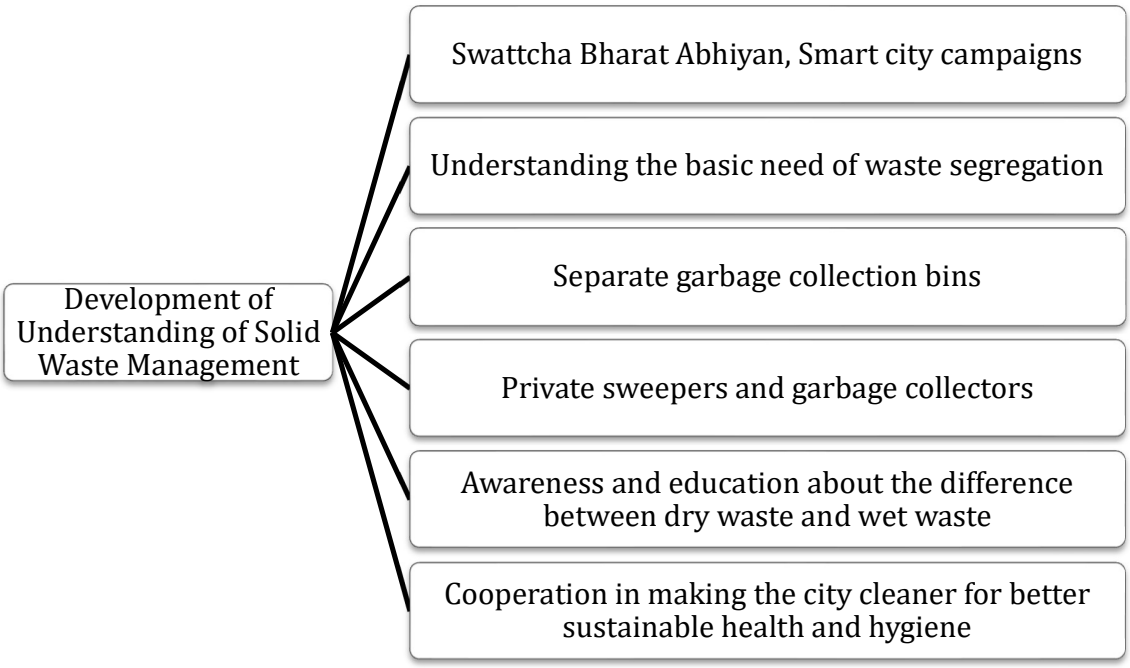


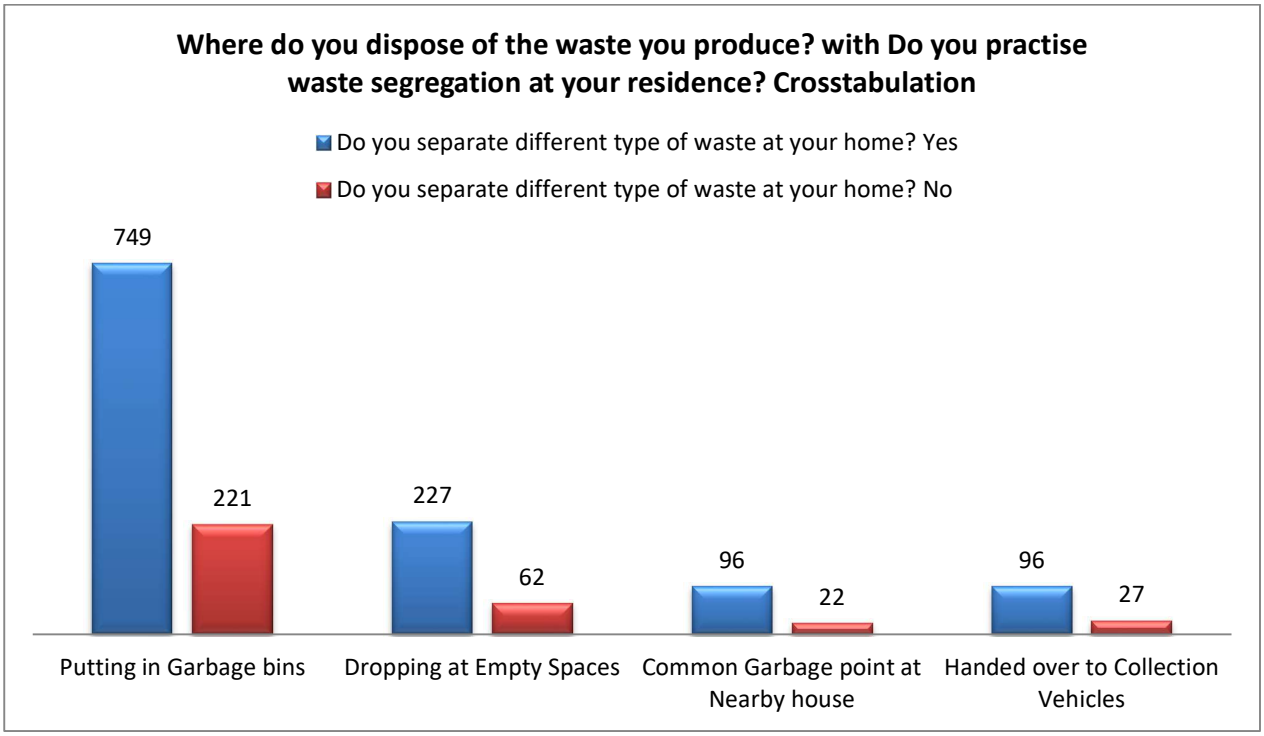
Fig1: Development of Understanding of Solid Waste Management

While interacting people also said that they were willing to use a more sustainable way of buying that is properly disposing of packaging waste or using recyclable material more if it does not hamper their monthly budget in any way. This simply highlights the fact that given proper information and options people will try and contribute towards sustainable solid waste management if they feel that they will be benefitted from the outcome. Most of the respondents felt that they would abide by the law and follow all the rules and regulations if they were completely aware of changes in rules. They also felt that cooperation was indeed needed on the part of civic bodies and the general public as well to get the desired result which was already intended. The respondents were quite ready to act out their roles and responsibilities in making the city cleaner for better sustainable health and hygiene.

Data Analysis and Data Interpretation

Table 1: -Waste products

Where do you dispose of the waste you produce? Do you practise waste segregation at your residence? Cross-tabulation				
Count				
		Do you separate different type of waste at your home?		Total
		Yes	No	
Where do you dispose of the waste you produce? Do you practice waste segregation at your residence?	Putting in Garbage bins	749	221	970
	Dropping at Empty Spaces	227	62	289
	Common Garbage point at Nearby house	96	22	118
	Handed over to Collection Vehicles	96	27	123
Total		1168	332	1500

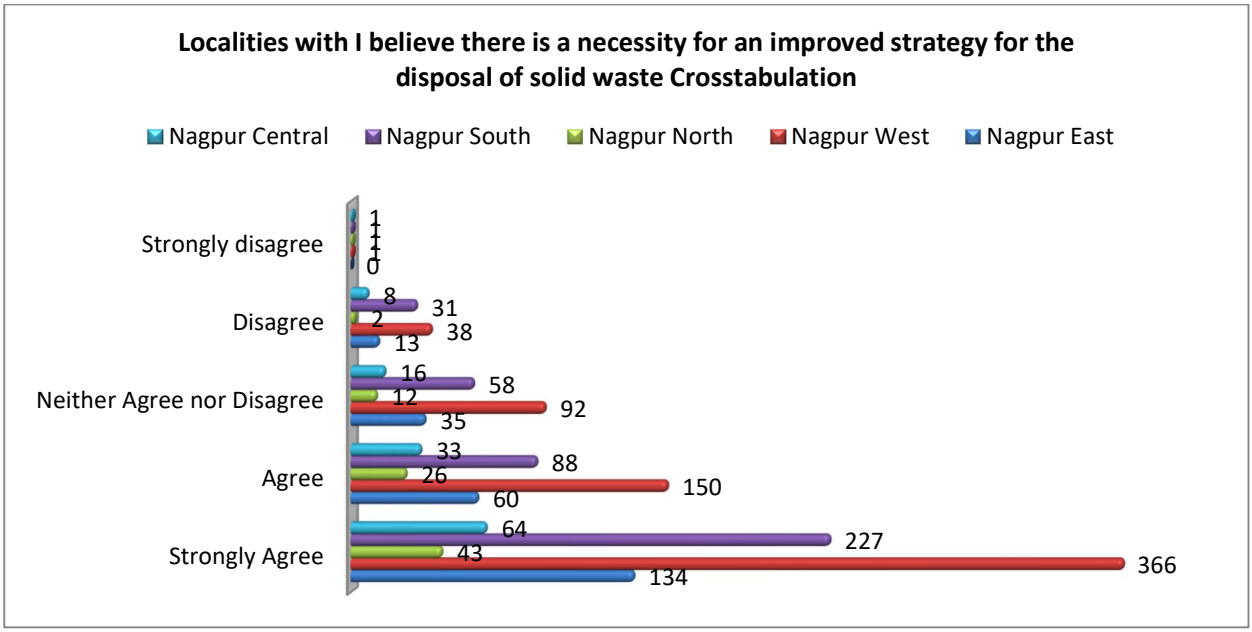


The question was used to understand the disposal habits of the waste generated at home. It can be observed the respondents who were aware about separation of waste at household tend to dispose of garbage more responsibly as compared to the respondents who were unaware about it. The responsible disposal waste includes disposing the garbage in designated bins or disposing it at common garbage collection places. The analysis in the above case processing summary was intended to on showing completeness of the data obtained. The researcher ensured that only complete and valid questionnaire was considered to analyse the data in order to ensure the completeness of the project data analysis.

Analysis 10:

Table 2: - Managing and disposing of solid waste.

Localities with I think there's a crucial need for an enhanced approach to managing and disposing of solid waste.							
Count							
		I think there's a crucial need for an enhanced approach to managing and disposing of solid waste.					Total
		Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly disagree	
Localities	East	134	60	35	13	0	242
	West	366	150	92	38	1	647
	North	43	26	12	2	1	84
	South	227	88	58	31	1	405
	Central	64	33	16	8	1	122
Total		834	357	213	92	4	1500



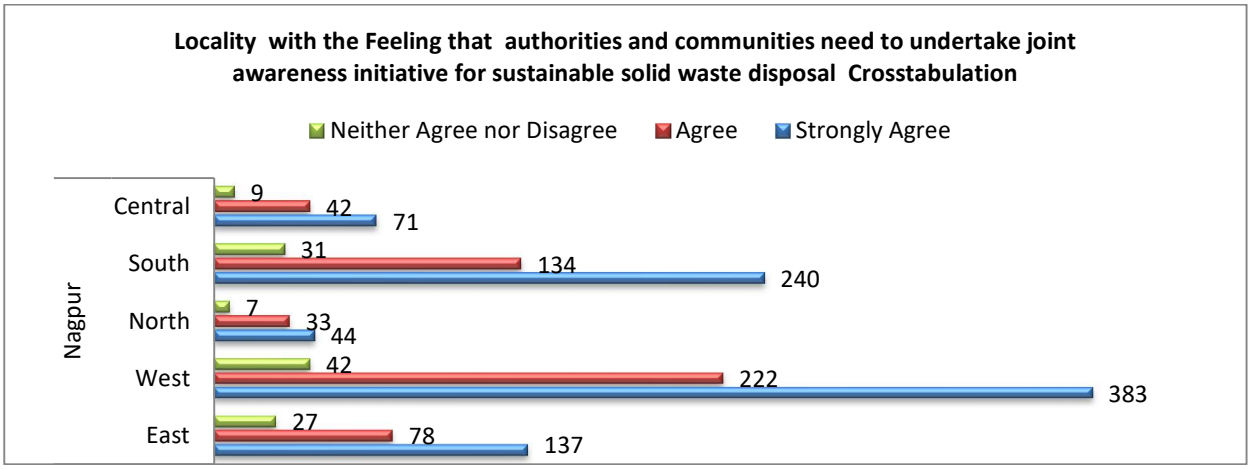
The above analysis was carried out for better understanding of implementation of government's plan of action for Swattcha Bharat Abhiyan and smart city initiative. The above analysis showcases show that respondents want to up the ante and feel there is a need of a more sustainable and actionable plan which is implemented across similar tier 2 cities in India that would result into much better fulfilment of anticipated outcomes.

Analysis 11

Table 3: - Sustainable solid waste disposal

Locality * I feel authorities and communities need to undertake joint awareness initiative for sustainable solid waste disposal Crosstabulation					
Count					
		I feel authorities and communities need to undertake joint awareness initiative for sustainable solid waste disposal			Total
		Strongly Agree	Agree	Neither Agree nor Disagree	
Locality	East	137	78	27	242
	West	383	222	42	647
	North	44	33	7	84
	South	240	134	31	405
	Central	71	42	9	122

Total	875	509	116	1500



Respondents in commonly opined that rather than testing and applying a common method and awareness level campaigns it would be much better if the awareness campaigns are structured more keeping in mind more sensibilities. Carrying out common and joint initiatives can result in much better results as the joint responsibility campaigns would make people feel more involved and responsible for execution at the task in hand

Table 4: - Solid Waste Disposal System

Locality * I feel my role in better solid waste disposal system is well defined and I am aware of it Crosstabulation

Count

		I feel my role in better solid waste disposal system is well defined and I am aware of it				Total
		Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	
Locality	East	146	58	28	10	242
	West	346	175	90	36	647
	North	52	18	11	3	84
	South	220	110	55	20	405
	Central	70	29	19	4	122
Total		834	390	203	73	1500

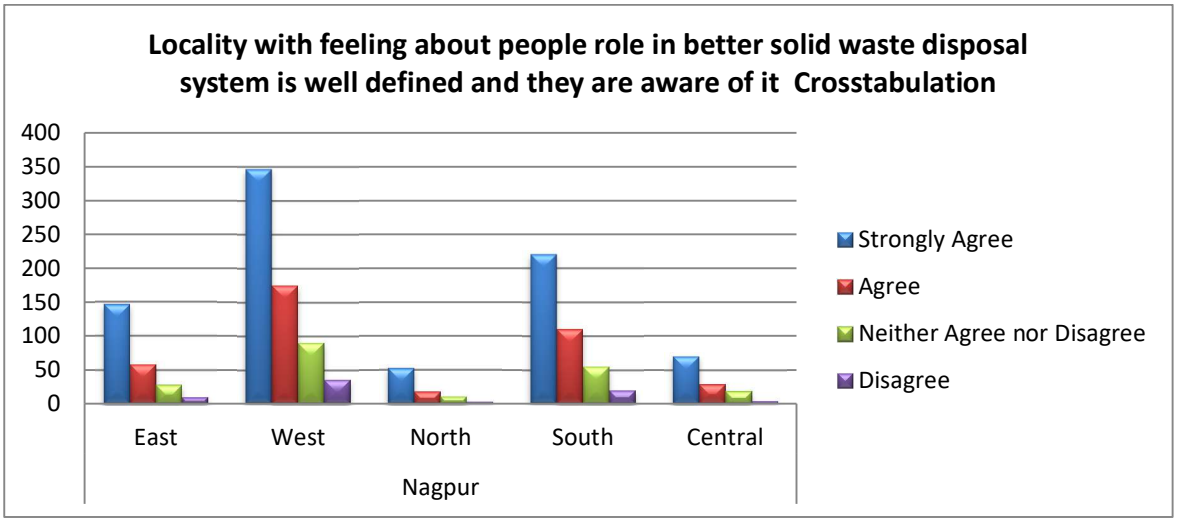
The awareness in terms of individual role or part an individual can play was checked to find out the respondent's perspective about separation of solid waste and proper solid waste disposal methods. During the survey many respondents opined that though they feel that they have a clear idea of what they can do to contribute by not throwing away garbage in open their knowledge

about the sustainable solid waste disposal was not very high and was construed only with workable or no knowledge at al many also felt that during the survey they got quite an information which they were not aware about.

Analysis-12

Table 5: - Solid Waste Management

Locality * I feel a better solid waste management is a part of environment conservation Crosstabulation							
Count							
		I feel a better solid waste management is a part of environment conservation					Total
		Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly disagree	
Locality	East	137	57	37	11	0	242
	West	375	178	74	20	0	647
	North	47	26	11	0	0	84
	South	220	106	59	18	2	405
	Central	69	32	15	6	0	122
Total		848	399	196	55	2	1500

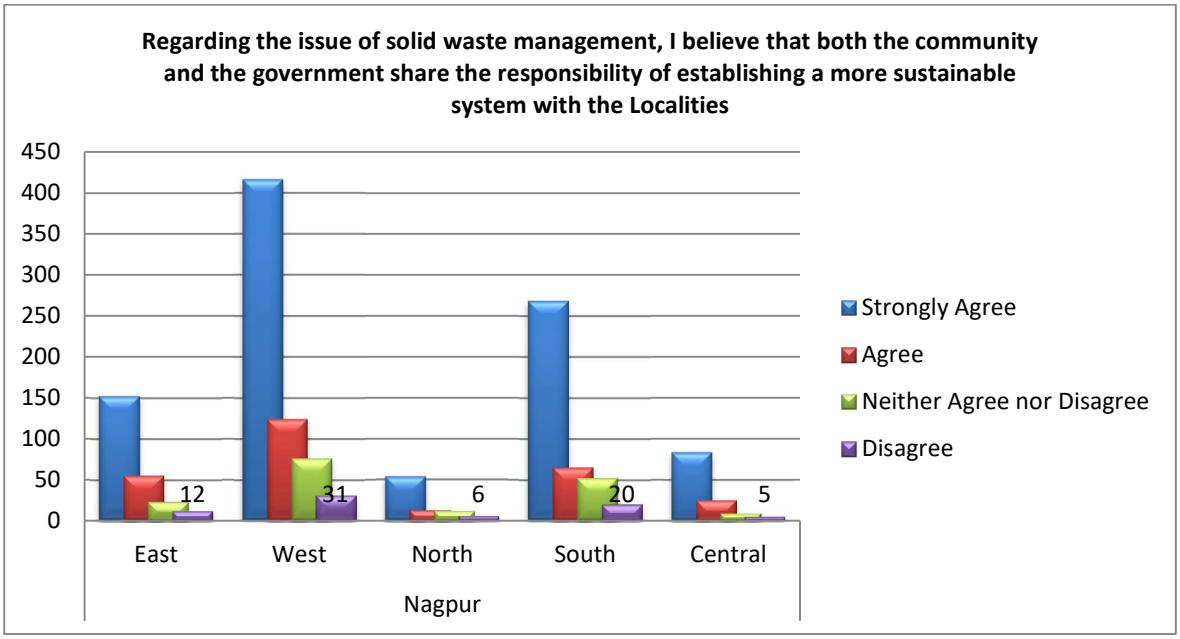


Respondents answered affirmatively that a better solid waste disposal can lead to a better environmental sustainability or conservation. Many respondents said that they believed a cleaner and better solid waste management plan can lead to better environmental sustenance.

Analysis 15:

Table 6: Issue of solid waste management

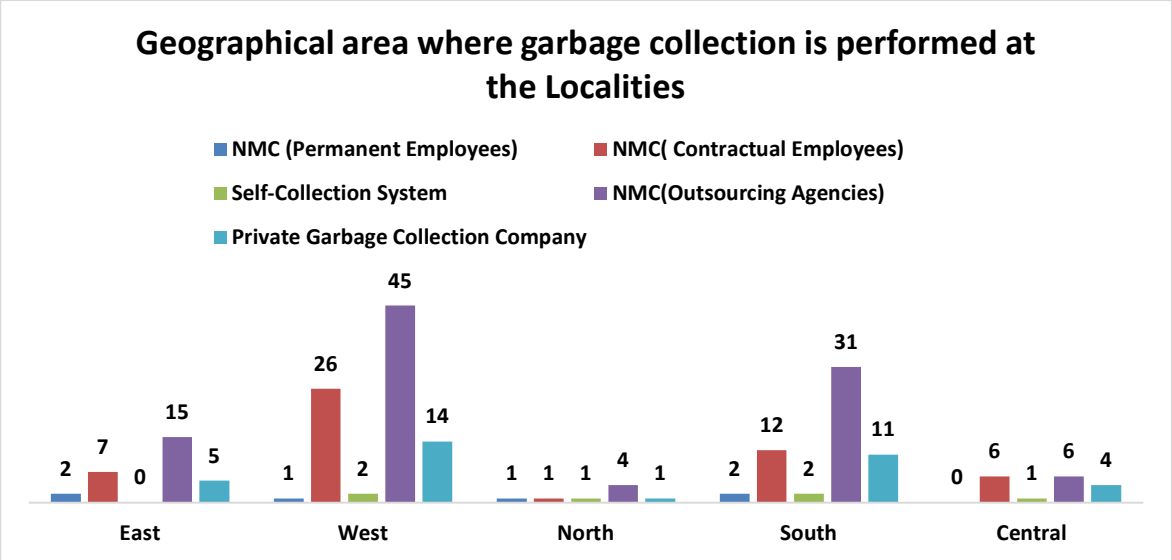
Regarding the issue of solid waste management, I believe that both the community and the government share the responsibility of establishing a more sustainable system with the Localities Crosstabulation						
Count						
		I believe that both the community and the government share the responsibility of establishing a more sustainable system with the Localities				Total
		Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	
Localities	East	152	55	23	12	242
	West	416	124	76	31	647
	North	53	13	12	6	84
	South	268	65	52	20	405
	Central	83	25	9	5	122
Total		972	282	172	74	1500



The aforementioned analysis aimed to gather the respondents' opinions regarding the expectations of various localities regarding the combined coordinated efforts to enhance the sustainability and execution of the solid waste management project. None of the respondents explicitly challenged the notion that collaborative coordination is a more feasible and sustainable approach for improving solid waste management.

Table 7: Localities

Geographical area where garbage collection is performed at the Localities Crosstabulation							
Count							
		Where garbage collection is performed at the Localities?					Total
		NMC (Permanent Employees)	NMC(Contractual Employees)	Self-Collection System	NMC(Outsourcing Agencies)	Private Garbage Collection Company	
Locality	East	2	7	0	15	5	29
	West	1	26	2	45	14	88
	North	1	1	1	4	1	8
	South	2	12	2	31	11	58
	Central	0	6	1	6	4	17
Total		6	52	6	101	35	200

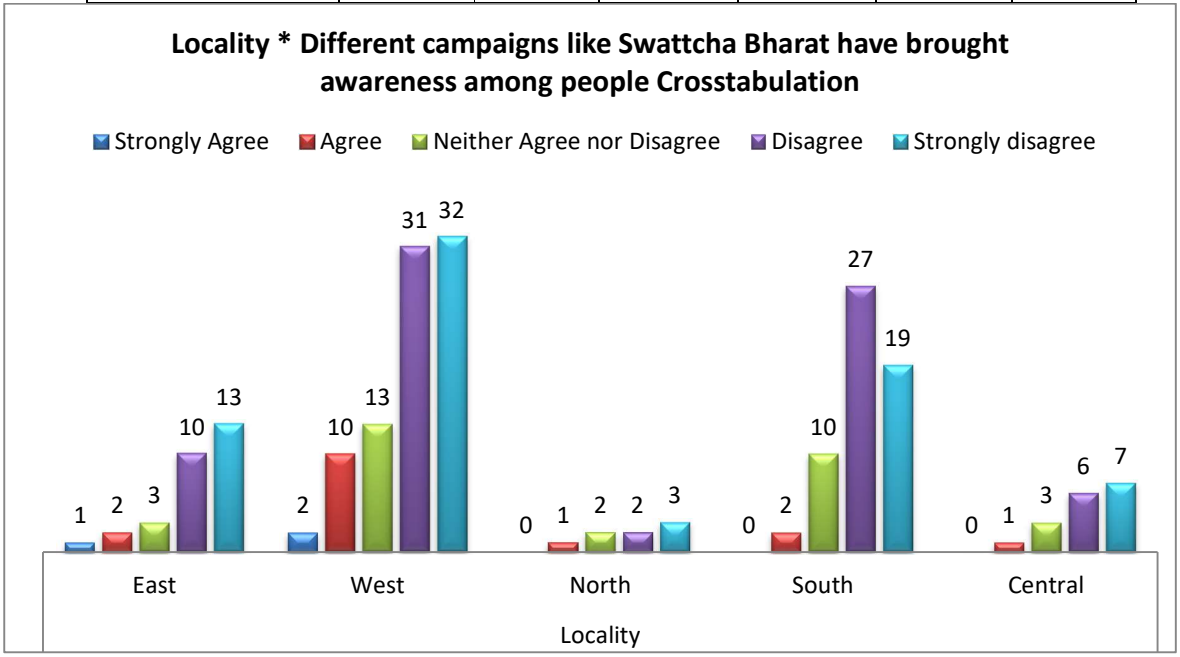


The analysis gave a clear idea of the place of working of the respondents. Carrying out the survey in different strata gave a varied output in order to have a whole sum picture and varied perspective of the system can be obtained.

Analysis: -3

Table 8: Awareness among people

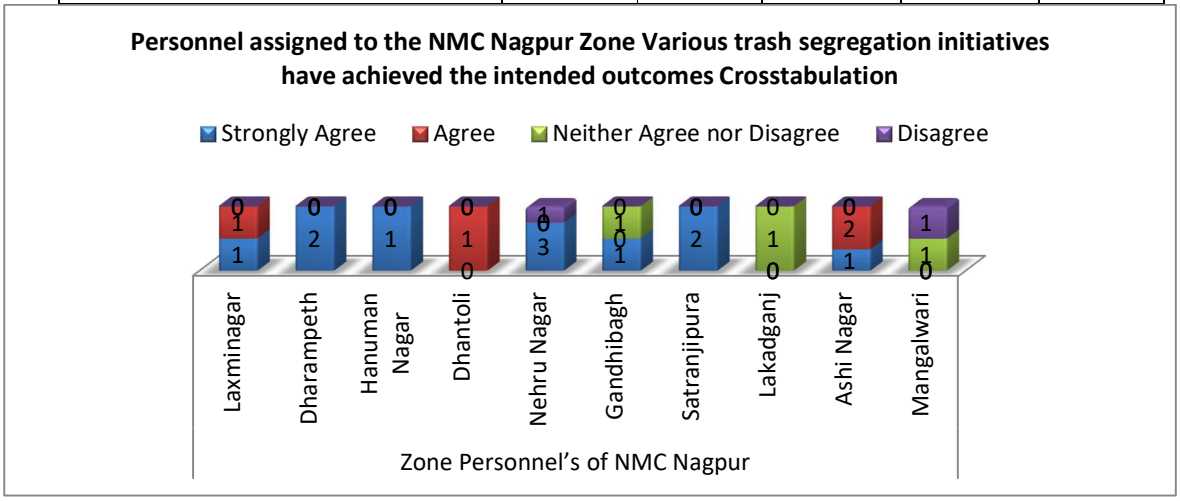
Locality * Different campaigns like Swattcha Bharat have brought awareness among people Crosstabulation							
Count							
		Different campaigns like Swattcha Bharat have brought awareness among people					Total
		Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	Strongly disagree	
Locality	East	1	2	3	10	13	29
	West	2	10	13	31	32	88
	North	0	1	2	2	3	8
	South	0	2	10	27	19	58
	Central	0	1	3	6	7	17
Total		3	16	31	76	74	200



The analysis for this question was done to check the garbage collectors perspective about the effectiveness of campaigns like Swattcha Bharat Abhiyan in creating awareness among the respondents in the targeted areas. The effectiveness of campaigns was checked by asking about changes in waste disposal behaviour.

Table 9: Outcomes

Personnel assigned to the NMC Nagpur Zone Various trash segregation initiatives have achieved the intended outcomes. Crosstabulation						
Count						
		Different waste segregation exercises have yielded the desired results				Total
		Strongly Agree	Agree	Neither Agree nor Disagree	Disagree	
Personnel assigned to the NMC Nagpur Zone Various trash segregation initiatives have achieved the intended outcomes.	Laxminagar	1	1	0	0	2
	Dharampeth	2	0	0	0	2
	Hanuman Nagar	1	0	0	0	1
	Dhantoli	0	1	0	0	1
	Nehru Nagar	3	0	0	1	4
	Gandhibagh	1	0	1	0	2
	Satranjipura	2	0	0	0	2
	Lakadganj	0	0	1	0	1
	Ashi Nagar	1	2	0	0	3
	Mangalwari	0	0	1	1	2
Total		11	4	3	2	20

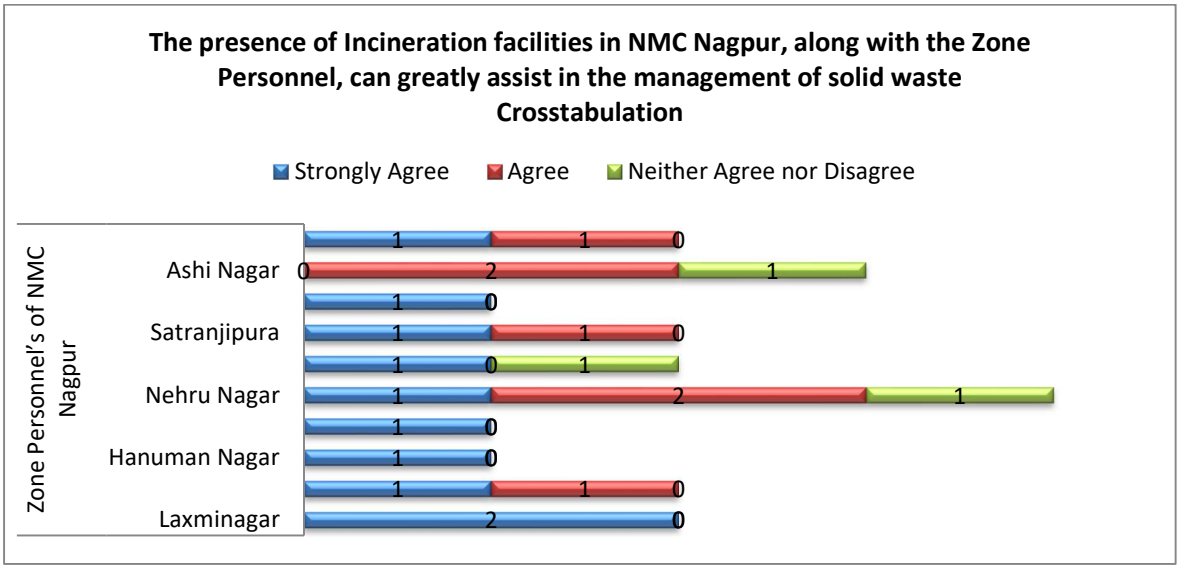


Although the trash segregation exercise has been proven to have a favourable impact on solid waste management, it has also been observed to alleviate some of the strain during rubbish

collection. However, they believed that further progress might be made, as not all households in all zones were fully complying with the laws and properly segregating their garbage. Therefore, more efforts were needed to attain the desired outcomes.

Table 10: Incineration facilities

The presence of Incineration facilities in NMC Nagpur, along with the Zone Personnel, can greatly assist in the management of solid waste. Crosstabulation					
Count					
		The presence of Incineration facilities in NMC Nagpur, along with the Zone Personnel, can greatly assist in the management of solid waste.			Total
		Strongly Agree	Agree	Neither Agree nor Disagree	
Zone Personnel's Area	Laxminagar	2	0	0	2
	Dharampeth	1	1	0	2
	Hanuman Nagar	1	0	0	1
	Dhantoli	1	0	0	1
	Nehru Nagar	1	2	1	4
	Gandhibagh	1	0	1	2
	Satranjipura	1	1	0	2
	Lakadganj	1	0	0	1
	Ashi Nagar	0	2	1	3
	Mangalwari	1	1	0	2
Total		10	7	3	20



Based on the collected viewpoints from various stakeholders, it is evident that incineration plants can really serve as a solution for improving solid waste disposal strategies. However, there is uncertainty regarding their operational mechanisms and potential effects on related factors. They also expressed their opinion that while they possess a rudimentary understanding of the process, they do not have a comprehensive idea or knowledge of it.

Hypothesis Testing Analysis 1)

H0. There is no significant relationship between Awareness Level of people with proper solid waste management system

H1. There is a significant relationship between Awareness Level of people with proper solid waste management system

Table 11: Analysis

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	I possess comprehensive knowledge of solid waste management techniques.	1.00	1500	0.000	0.000
	I possess a clear understanding of my responsibilities in improving the solid waste disposal system.	1.68	1500	0.884	0.023

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	I possess comprehensive knowledge of solid waste management techniques. -I possess a clear understanding of my responsibilities in improving the solid waste disposal system.	.677	.884	.023	.721	.632	29.636	1499	**0.000**

Analysis and Interpretation of Test:

From above analysis it can be observed from the analysis of Paired Sample T-Test it can easily be gauged that the obtained value 0.000 is less than the required acceptable level of 0.05 where researcher can safely say that null hypothesis can be rejected and alternate hypothesis is accepted i.e. There is a significant relationship between Awareness Level of people with proper solid waste management system.

Hypothesis Testing Analysis 2)

H0. The status of Separation of Waste by people has an insignificant effect on solid waste management system.

H1. The status of Separation of Waste by people has a significant effect on solid waste management system.

Table 12: Analysis

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.219[a]	.048	.043	1.243
a. Predictors: (Constant), I feel separating different type of waste at home is a key to better solid waste management				

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	15.484	1	15.484	10.019	**.002[b]**
	Residual	306.016	198	1.546		
	Total	321.500	199			
a. Dependent Variable: People are aware of the concept of wet waste/dry waste						
b. Predictors: (Constant), I feel separating different type of waste at home is a key to better solid waste management						

Coefficients[a]						
Model		Un-standardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.477	.230		10.772	**.000**
	I feel separating different type of waste at home is a key to better solid waste management	.451	.143	.219	3.165	**.002**
a. Dependent Variable: People are aware of the concept of wet waste/dry waste						

Analysis and Interpretation of Test

According to the results of the regression analysis test, it is clear that the values that were obtained, which were 0.000 and 0.002, are lower than the threshold of 0.05 that is considered acceptable. Consequently, it is possible to confidently reject the null hypothesis, and the alternative hypothesis is accepted.. **The status of Separation of Waste by people has a significant effect on solid waste management system.**

H0. There is an insignificant effect of incineration of waste with the on the on the improvement of solid waste management system

H1. There is a significant effect of incineration of waste on the improvement of solid waste management system

Hypothesis Testing Analysis 3)

Table 13: Paired Samples Statistics

Paired Samples Statistics					
		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Incineration facilities can be quite beneficial in the management of solid waste.	1.65	20	.745	.167
	The state of solid waste management in Nagpur has witnessed significant improvement during the past five years.	2.55	20	.999	.223

Paired Samples Correlations				
		N	Correlation	Sig.
Pair 1	Incineration facilities can be quite beneficial in the management of solid waste. & The state of solid waste management in Nagpur has witnessed significant improvement during the past five years.	20	.202	.0394

Paired Samples Test									
		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Incineration facilities can be quite beneficial in the management of solid waste. & The state of solid waste management in Nagpur has witnessed significant improvement during the past five years.	.900	1.119	.250	1.424	0.376	3.596	19	**0.002**

Analysis and Interpretation of Test:

The results of the Paired Sample T-Test clearly show that the obtained value of 0.002 is less than the permissible level of 0.05. As a result, we may confidently reject the null hypothesis and accept the alternative one. i.e. **There is a significant effect of incineration of waste on the improvement of solid waste management system**

Conclusion

The campaigns and initiatives have helped in forming a knowledge base for the population. Initiatives like Swattcha Bharat Abhiyan, Smart city campaigns have helped in creating awareness among the respondents. The respondents opined that having clarity of thought and campaign messages helped them in understanding the basic need of waste segregation. Newer instructions by local civic bodies of having separate garbage collection bins in large societies have also shown admirable effects in terms of garbage waste disposal. Large societies have also included the cost of private sweepers and garbage collectors in their maintenance fees which have made the coordination between appointed garbage collection vehicles/collectors and societies much easier to manage. The garbage collection vehicle drivers they said that the strategy/gimmick of using a song like "Gadi Wala Aaya Ghar se kachra nikal" turned out to help call out the public to dispose of the garbage in the moving vehicle and turned out to be effective as compared to the old practice of honking, as it gathered instant attention and instigated the people to dispose of the garbage in the vehicle. They also opined that many of the general public also said that they were happy with garbage collection vehicles coming down in their lane/doorstep to collect the garbage as it saved them efforts of going down to garbage disposal bins and also saved time. The effort yielded better results in many areas wherein frequenting of small garbage collection vehicles was a regular feature. The change in perception of locals due to different awareness campaigns such as Swattcha Bharat Abhiyan, smart city initiatives, and whether there was any change in waste disposal habits of locals due to an increase in awareness. The officials felt that though there was a change in attitude and behavior of locals the changes in approach were more or less restricted to only certain areas with a higher density of educated population or with the people who had access to media and information. Areas wherein there was a high density of Jhuggis or the population lacked in education haven't shown much of a change in waste disposal habits. And hence there was a need for more localized and customized campaigns with more local dialect and touch to spread the awareness. Having a local face, the local theme can also be really helpful in achieving the desired results.

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