A New Dynamic Mathematical Modeling Approach of Zero Waste Management System

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AbstractDr. Paul Palmer coined the phrase "zero waste" in 1973 to describe the complete removal of municipal solid waste (MSW) from landfills. Through a literature study and an interactive survey method, the conceptual basis and procedures employed in 25 cities throughout the world. The Battle Environment Evaluation System was used to study and analyse certain essential key issues involved in the present zero waste management system (BEES). The Delphi Technique was commonly utilised in this study to evaluate the present municipal solid waste management system (MSWMS) of the study area. The value of Environmental Quality (EQ) determined for the area under study's existing MSWM system was found to be 238; however, the ideal value for a good rating of an existing MSWM system should be 521. Various conclusions were drawn based on the facts and findings, including the development of innovative product design, a focus on the Solid Liquid Resource Management Centre (SLRMC), the Domestic Composting System (DCS), the design of optimal collection and transportation routes, the development of transfer stations, the implementation of the 3R principles, and the monitoring of the MSWM system at various stages. A model for zero-waste management has also been created and presented.

Keywords: Zero waste Technique and Management system, environmental quality (EQ) & Environmental Impact Unit (EIU), Parameter Important Unit (PIU), Delphi Technique (DT), Solid Liquid Resource Management Centre (SLRMC), Domestic Composting System (DCS), Battlle Environmental Evaluation System (BEES).

1. Introduction

Zero waste is a euphemism for "zero waste." It is not an absolute concept. It's a philosophical notion that encourages rethinking the resourced life cycle so that all products can be reused. Zero waste focuses on systematically designing and managing goods and processes to avoid and eliminate wastes and materials, as well as conserving and recovering all resources from the waste stream. [2]

Because waste is a societal problem that we have created, we will have to use social engineering as well as modern technology to eliminate it. In reality, zero waste management (ZWM) emphasises society's desire to reduce resource usage or consumption by maximising the [8] Rs: repurposing, recycling, repairing, redesigning, regenerating, reducing, remanufacturing, and reselling of things. [3, 4]

1.1 Objectives

The basic aim of this study is to:

- ✓ Identify the most important concerns related to achieving minimum zero waste.
- ✓ Raise consumer awareness and expand consumer and product-maker obligations.
- ✓ SLRMC, residential composting system, and Ray bicking services will be prioritised.
- ✓ Create zero-waste bike-sharing systems.

1.2 Status of zero waste cities in the world

On the basis of facts and finds through literature review following Table 1.2.1 shows status of zero waste achieved by cities, target years and mechanism used to achieve the target have been summarized in it.

Table 1.2.1: Summary of zero waste cities

S. No.	Name of city	Mechanism	Status of zero waste	Target Year
1.	Austin[6]	Food donation (i.e., reuse), composting.	90%	2041
2.	Ambikapur, Chhattisgarh, India[7]	Segregation involved in segregation centre, composting and use of biodigesters recycling.	No dumping ground	2019-20
3.	Argentia (Bueroaires)[8]	Banned on recycling and empowered waste pickers.	100%	2021
4.	Auckland (Newzeland)[9]	Emphasis on waste incineration.	100%	2041
5.	Belgium[10]	Focus on waste reduction at source.	100%	2021
6.	Cappanori (Italy)[11]	Reduction at source.	100%	2020
7.	Casual (Ireland)[12]	Emphasis on Waste preventation, composting and education.	75%	2030
8.	ChhotaNarena, Rajasthan, India[13]	Reduction at source.	80%	2021
9.	California[14]	Composting.	95%	2021
10.	Durg, India[15]	Reduction at source, develop domestic composting service and SLRM centre.	90%	2030
11.	Fort collians (Colombo)[16]	Expanded reuse recycle and composting.	100%	2030

S. No.	Name of city	Mechanism	Status of zero waste	Target Year
12.	Gipuzkoa shain[17]	Focus on waste reduction.	70%	2020
13.	Kamikatasu (Japan)[18]	Reduction at source.	100%	2040
14.	Lapus (Rumania)[19]	Focus on composting and recycling.	80%	2020
15.	Medimurje[20]	Avoidance of incineration and implementation of 3R principle.	70%	2020
16.	Mumbai, India[21]	Focus on waste segregation using waste pickers composting.	70%	2032
17.	Nova Scotia[22]	Reduction at source.	90%	2020
18.	New York[23]	Reduction at source, composting.	70%	2020
19.	Pune, India[24]	Focus a waste pickers, reduction at source.	75%	2025
20.	SantMovika, U.S.[25]	Reduction at source.	95%	2032
21.	Slovenia[26]	Door to Door collection of waste, reduction at source	100%	2025
22.	Swedan[27]	Protect burning rubbish, 50% incinerated and converted into energy.	50%	2020
23.	Sun Diego[28]	Reduction at source.	100%	2040
24.	Taiwan[29]	Focus on zero waste policies, banned as disposable – utensils from restaurant.	50%	2020
25.	Wales[30]	Focus on 3R principles.	70%	2025

Source reduction was prioritised by 44 percent of respondents, whereas composting was prioritised by 28 percent. The value of garbage recycling was discovered to be 12 percent, compared to 8% for waste collection systems and just 8% for reuse. The statistics above clearly demonstrate that a zero-waste management system will be realised by 2040, or two decades later.

1.2 Identification of key issues related to existing waste management system

Using an interactive survey method and a literature review strategy, some common major concerns were found and described in this study and summarized in Table 1.2.1.

Table 1.2.1: Summary of common issues pertaining to existing waste management

S. No.	Issues
1.	Old infrastructures i.e., collection vehicles, tricycles, community bins were

	located haphazardly
2.	Old like and conventional consumption practice
3.	Open burning of MSW
4.	Open dumping of MSW
5.	Unwillingness to change behavior
6.	Lack of environment of community and other public private participate (PPP)
7.	Poor awareness and education policy of MSW
8.	Improper implementation of incentive services viz. levy, taxes, penalty.
9.	Engineered landfill
10.	Provision of finance in budget regarding MSW is unadequate and demoralized service
11.	No provision of Ray backings service in MSWM system
12.	No provision of transfer station
13.	Poor monitoring of MSWM system

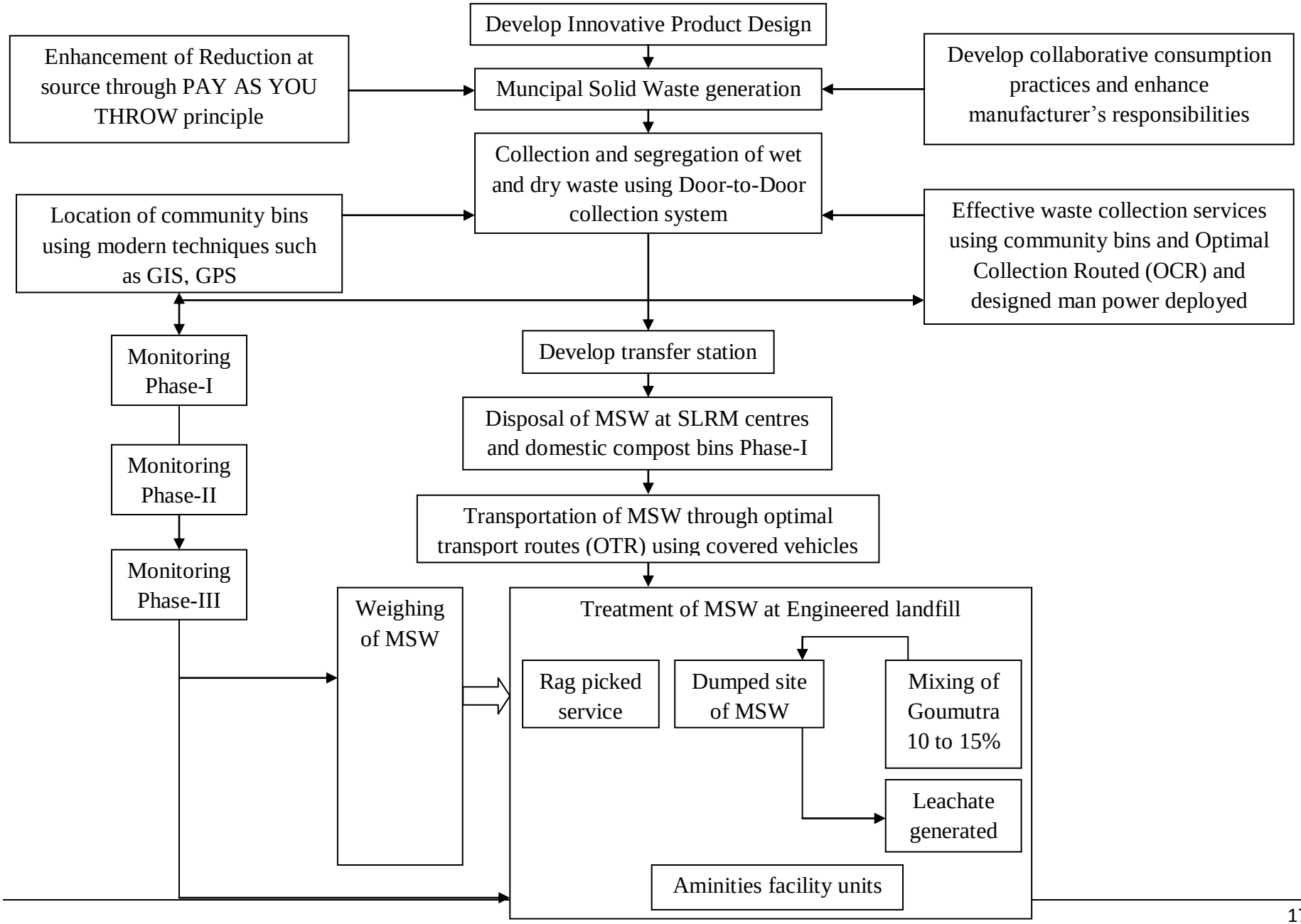
To achieve zero waste, a zero waste management model has been developed involving all those key issues which may likely to influence the ZWM system.

2. Material and Method

A survey was conducted to investigate various key issues relating to the zero waste management system in use in the study area, and all pertinent information was gathered via questionnaire. A comprehensive check list was then developed, with each parameter assigned a rating of Good (G), Fair (F), Satisfactory (S), Poor (P), and Nil (N). The criteria were evaluated according to the EIU, as stated in Table 2.1.

Table 2.1: Assessment of criteria according to EIU

S. No.	Criteria	Rank	EIU
1.	Effective modern techniques being used for collection transportation and disposal of MSW in existing MSWM system.	G	100
2.	Monitoring and controlling on MSWM system is not effective.	F	75
3.	Strategies used in existing MSW management system need to be improve.	S	50
4.	Implementation of MSW Rules and Regulation.	P	25
5.	Open burning and dumping of MSW is in common practice.	N	0


Develop Innovative Product Design
Enhancement of Reduction at source through PAY AS YOU THROW principle
Muncipal Solid Waste generation
Develop collaborative consumption practices and enhance manufacturer's responsibilities
Collection and segregation of wet and dry waste using Door-to-Door collection system
Location of community bins using modern techniques such as GIS, GPS
Effective waste collection services using community bins and Optimal Collection Routed (OCR) and designed man power deployed
Monitoring Phase-I
Develop transfer station
Disposal of MSW at SLRM centres and domestic compost bins Phase-I
Monitoring Phase-II
Transportation of MSW through optimal transport routes (OTR) using covered vehicles
Monitoring Phase-III
Weighing of MSW
Treatment of MSW at Engineered landfill
Rag picked service
Dumped site of MSW
Mixing of Goumutra 10 to 15%
Leachate generated
Aminities facility units

Now evaluation the existing MSWM system of area under study has been done with the application of Delphi Technique[31] which focused on the following relations of EQ, PIU, EIU.

viz., $EQ = PIU \times EIU$

Where EQ stands for Environmental Quality (EQ)

PIU means Parameter Important Unit and

EIU is nothing but Environmental Impact Unit.

The advantage of Delphi Technique (DT) is the anonymity. The result has been summarized in Table 2.2.

Table 2.2: Evaluation of existing MSWM system of area under study with the application of Delphi Technique (DT)

S. No.	Attributes	PIU	Rating	EIU	EQ = PIU x EIU
1.	Development of innovative product design	0.9	N	0	0
2.	Application of source reduction pattern through PAY AS YOU THROW (PAYT) Principle	0.1	P	25	2.5
3.	Enhancement of manufacturers responsibilities and develop collaborative consumption practices	0	N	0	0
4.	Segregation at source (Door to Door collection of waste with result to dry and wet house hold waste separately	0.8	G	100	80
5.	Status of Domestic Composting Service (DCS)	0.75	F	75	56.25
6.	Location of community bins using modern techniques viz. GPS, GIS	0	N	0	0
7.	Design and development of optimal collection routes	0	N	0	0
8.	Provision of transfer station.	0	N	0	0
9.	Deployment of man power to MSWM system without following MSWM Rules and Regulation 2005	0	N	0	0
10.	Develop SLRM centers	0.5	5	50	25
11.	Design and identification of optimal transfer routes	0	N	0	0
12.	Treatment of MSW at landfill using with modern techniques	0.6	P	25	15
13.	Status of composting system at landfill	0.75	S	50	37.5
14.	Application of rag bicking services at landfill	0.8	P	25	20

15.	Preventive measure of leachate generated from landfill.	0	N	0	0

Total PIU = 0 + 0.1 + 0 + 0.8 + 0.75 + 0 + 0 + 0 + 0 + 0.5
+ 0 + 0.6 + 0.8 + 0.75 + 0 = 5.2

Total EQ = 0 + 2.5 + 0 + 80 + 56.25 + 0 + 0 + 0 + 0 + 25
+ 0 + 15 + 25 + 20 + 37.5 = 236.25

$\simeq 236.0$

Based on the above result, an ideal MSWM system with uniformly good rating (= 100) should have an EQ of 5.2 x 100 = 520.
In this study the value of EQ was found to be 236 on the basis of facts and found following conclusions were drawn.

1. No new product design concepts have been produced and deployed in the MSWM system.
2. The use of the 3R concept and PAY AS YOU THROW (PAYT) was shown to be ineffective.
3. The municipal government successfully adopted a source separation system.
4. The use of floral waste gathered from numerous holy locations was substantially curtailed with the launch of the Domestic Composting System (DCS).
5. The placement of communal bins was done at random and without rationale.
6. The most efficient collection and transportation routes were not identified or planned.
7. The MSWMS Rules were not adhered to.
8. Inadequate manpower deployment leads to financial embezzlement.
9. No transfer stations, landfill conversion to engineered landfills, or rag collection services are provided.
10. Three SLRM centres, located in different parts of the study region, were used to reduce the amount of MSW.Condition of composting system being done at landfill was found to be very poor and irregular.
11. Monitoring services are not available at any level of the MSWM system.
12. There were no safeguards in place to prevent landfill leachate from contaminating the environment.

3. Conclusions

Using a literature review and an interactive survey method, many major challenges related to zero waste strategy were discovered and analysed in this study. The Battlle Environmental Evaluation System (BEES), the Environmental Impact Unit (EIU), and the Dolphi Technique were used to assess certain common criteria involved in the existing MSWM system of the research area (DT). The value of Environmental Quality (EQ) was discovered to be 236 based on facts and findings. A good rating value of 520, on the other hand, is perfect. It indicates that some characteristics, such as the enhancement of product manufacturing duties and the right location of

community dumpsters with valid rationale, will require adjustment and improvement. Similarly, innovative techniques should be employed to establish optimal collection and transit routes. Special attention should be paid to the development of SLRM centres and transfer stations. Rag Picking Services should be incorporated into the MSWM system, with proper manpower deployment and usage. Preventive measures for leachate created by landfills should be implemented. Monitoring services for each stage of the MSWM system should be given special attention. For the area under investigation, a model of a modified MSWM system approach has been built.

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