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Reduction in Cycle Time, Implementation of 5s & Value Stream Mapping for A Plastic Recycling Plant

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Abstract -Bengaluru generates 5000 tonnes of waste every day, out of which 21.9% is dry waste. Almost 2000 tonnes per day comes from Household Waste and Small Commercial Establishments, and the rest comes from Industries. The Household waste is collected by the BBMP daily, via contractors. The waste is collected and then segregated by the Pourakarmikas and the wet waste is collected in the compactors.

The Dry Waste that is collected by the Contractors is then sent to the DWCCs present in the respective Wards. The aim of establishing these Dry Waste Collection Centers was to affect the Decentralization of Dry Waste from the Landfills.

The Landfills at Mandur have been shut down due to their adverse environmental effects such as contamination of the water table. This lead to lack of space to dispose off the Dry Waste. The Decentralization of Waste within the ward itself has been suggested for this purpose.

While the High Value Wastes such as Tins, Bottles, Newspaper are already taken care of by the informal economy consisting of Rag Pickers and Kabadiwallahs, the Low Value Wastes and Reject Wastes consisting of Low Density Plastics, Thermocol and other such materials have no market.

The DWCCs were established to take care of this Waste and they are sent to Dry Waste Processing centres. Currently there are only two such centres in Bengaluru, with each having limited capacity to store and process. Due to the ever-growing population, these processing centres are not able to handle the excess waste that is being generated. The input of Low Value dry waste is much higher than the output.

Hence the efforts have been made to try to increase the production capacity of one such Dry Waste processing centre, Swachha Eco Solutions.

Keywords– Pourakarmikas ; Decentralization ; Kabadiwallahs ; Dry Waste ; Low Value Wastes ; High Value Wastes.

I. INTRODUCTION TO SOLID WASTE MANAGEMENT

Solid waste refers to the range of garbage arising from animal and human activities that are discarded as unwanted and useless. Solid waste is generated from industrial, residential and commercial activities in a given area, and may be handled in a variety of ways.As such, landfills are typically classified as sanitary, municipal, construction & demolition or industrial waste sites. Waste can be categorized based on material, such as plastic, paper, glass, metal, and organic waste. Categorization may also be based on hazard potential, including radioactive, flammable, infectious, toxic, or non-toxic. Categories may also pertain to the origin of waste, such as industrial, domestic, commercial, institutional or construction & demolition.

Solid Waste Management is defined as the discipline associated with control of generation, storage, collection, transport or transfer, processing and disposal of solid waste materials in a way that best addresses the range of public health, conservation, economics, aesthetic, engineering and other environmental considerations.In its scope, solid waste management includes planning, administrative, financial, engineering and legal functions. Solutions might include complex inter-disciplinary relations among fields such as public health, city and regional planning, political science, geography, sociology, economics, communication and conservation, demography, engineering and material sciences Waste treatment techniques seek to transform the waste into a form that is more manageable, reduce the volume or reduce the toxicity of the waste thus making the waste easier to dispose of. Treatment methods are selected based on the composition, quantity, and form of the waste material. Some waste treatment methods being used today include subjecting the waste to extremely high temperatures, dumping on land or land filling and use of biological processes to treat the waste.

II. CURRENT SCENARIO IN BANGALORE

An uneasy status-quo was disrupted in Bangalore about a year ago. Till July 2012 like most other Indian cities, the IT town transported its unsegregated waste to its landfills outside the city. The Bruhat Bengaluru Mahanagara Palike was left with

no options to dump the 3000 to 4000 tons of waste the city produces every day when the Karnataka State Pollution Control Board closed the Mavillipura landfill citing environmental and public health hazards.

The Karnataka High Court, hearing a PIL asking the court to enforce the Municipal Solid Waste Management Rules 2001 in Bangalore, instructed the BBMP to mandate segregation of waste at source, decentralise waste processing and increase citizen involvement through the formation of ward committees.

A number of false starts, frustrations, BBMP's inability to implement court orders in total apart, the Bangalore story could hold important lessons for other cities like Chennai.

The most important is the recognition that the landfilling of waste is not an environmentally sustainable or socially just method of waste disposal. The High Court, the BBMP and a number of community groups acknowledge that people living next to landfills have a right to clean air and water and should not have to bear the environmental ill-effects produced by the city's garbage.

The current policy discourse in Bangalore seeks to move the city away from using landfills as the main option for waste disposal. Source reduction, decentralized waste management are the new watch words.

III. INTRODUCTION TO SWACHA ECO SOLUTIONS

A. About Swacha Eco Solutions

Founded in 2008 initially as Indus Waste Management, a privately-owned Recycling Consulting firm, an urgent need to set up an organization capable of working hand-in-hand with the Government and the community, albeit at a larger scale, in Bangalore was identified. The current governmental setup`s inadequacies and the enormity of the waste management situation in Bangalore left a glaring void that needed to be filled by private organizations capable of showcasing sustainable and environmentally-friendly waste disposal practices. With constant innovation, advanced management systems, and the highest standards of customer service, an "Integrated Solid Waste Management System Approach" capable of managing Bangalore`s current situation was formed called "Swachha" a Non-Government Organization in the year 2012.We are duly registered Organization adhering to all Law/Rules in force from time to time and maintain all statutory records, as per the various, Govt. organizations and departments.

Swachha Eco Solutions is an Integrated Waste Management Company, partnered with Government working towards "Swacha Bharath Mission".

B. The Current Process

The following steps are involved in processing of plastics

- ***Segregation***

Fig. 1

- ***Grinding***

Fig. 2

- ***Extrusion***

Fig. 3

- ***Cooling***

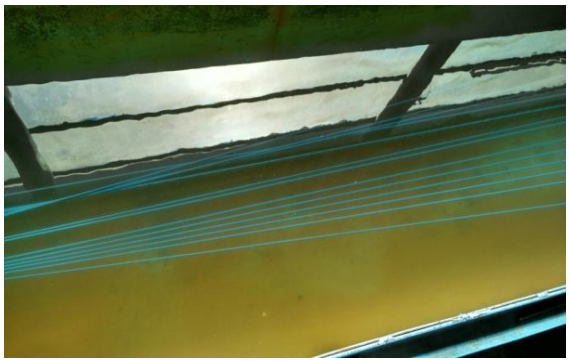

Fig. 4

- ***Cutting***

Fig. 5

Collection of Pellets

Fig. 6

IV. PROBLEMS FACED AT SWACHA

A. Observations

Some of the observations made at Swachha Eco Solutions that are were found to be critical in establishing the project objectives are given below.

- New Industry with absence of Standard Operating Procedures
- Process is not streamlined due to presence of bottlenecks (segregation process)
- Unscientific techniques used for sorting
- Excess Inventory
- Irregular production schedules
- Unaccounted Worker Productivity

B. Areas of Study

- How much waste to buy and how often should it be bought from each company such that the optimum value is achieved between sales revenue earned and cost of buying the waste?
- Sorting mechanism. Is manual sorting preferable or should any equipment be used? What are the best practices involved in sorting?
- Do any changes must be made in the layout of the Processing Plant?
- Are safety standards and quality standards met in the plant?
- Do all the processes add value to the product? Can there be changes or improvements made?

V. OBJECTIVES

- To reduce the Cycle time of the process.
- To develop a better, more ergonomic and efficient method for manual segregation of waste
- To determine worker productivity
- To implement 5s in the workplace
- To determine areas of continuous improvement.

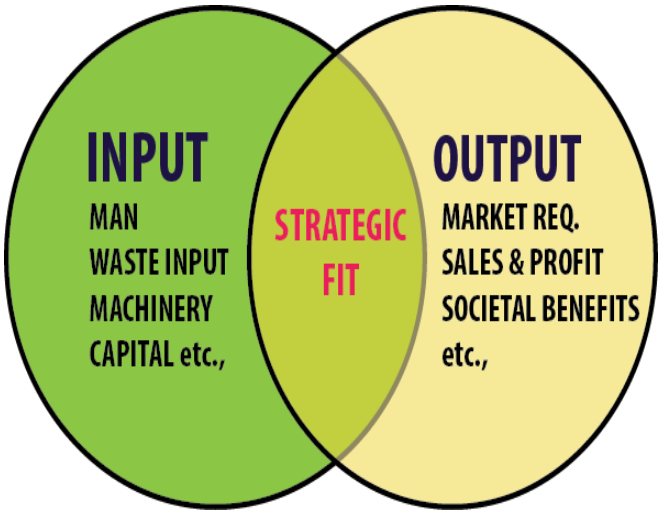

Fig. 7 Balance Between Input and Output

VI. PROJECT METHODOLOGY

The method used is directly absorbed from the Six Sigma process called DMAIC which is:

- **Define:** the problem, improvement activity, opportunity for improvement, the project goals, and customer (internal and external) requirements.
- **Measure:** process performance.
- **Analyze:** the process to determine root causes of variation, poor performance (defects).
- **Improve:** process performance by addressing and eliminating the root causes.
- **Control:** the improved process and future process performance

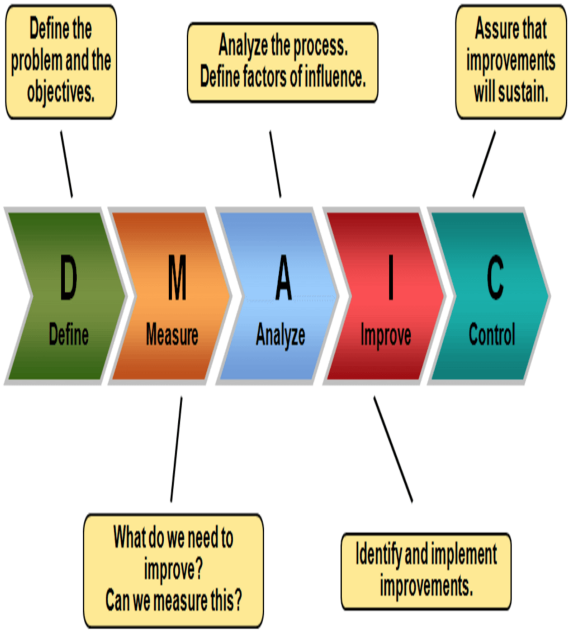

Fig.8 DMAIC Methodology

The tools and techniques used are:

- Ishikava Diagram/ Fish Bone Analysis
- Column and Line Graphs
- Process Charts
- Value Stream Map
- 5S

VII. DATA COLLECTION AND ANALYSIS

A. Fish Bone Analysis (Ishikava Diagram)

A Fish Bone Diagram was developed and causes for increased cycle time were found out. Segregation was found to be one of the most important factors in delaying the process.

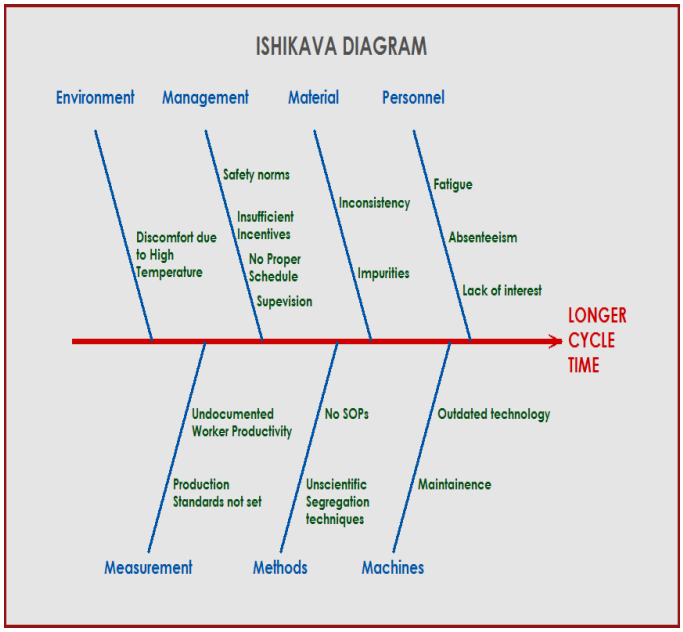

Fig. 9 Fish Bone Diagram

B. SEGREGATION -Analysis of the data collected for segregation of Wipro waste (Present Method)

Workers sit in a circle and the waste is dumped in the middle. They then start segregating the waste. They remove the impurities such as stickers and keep it in a small basket near them and throw the segregated material behind them.
Number of Trials: 5 Weight of waste to be segregated per trial: 100 Kg

Fig. 10 Present method of segregation

WEIGHT (in Kg)					AVERAGE
TRIAL 1	TRIAL 2	TRIAL 3	TRIAL 4	TRIAL 5	
16.1	16.23	15.87	17.22	17.09	16.502
15.55	14.49	16.87	15.89	14.68	15.496
13.19	14.82	12.32	12.75	14.11	13.438
16.24	15.61	16.45	14.33	15.86	15.698
12.89	11.32	12.7	12.62	12.61	12.428
10.9	9.45	10.31	11.71	8.72	10.218
12.7	13.62	11.21	12.47	12.38	12.476
97.57	95.54	95.73	96.99	95.45	96.256
55 min 28sec	51 min 36sec	49 min 13sec	57 min 53sec	53 min 46sec	53 min 58sec

Table 1: for Segregation Data for Wipro Waste (Existing method)

WORKER	WASTE SEGREGATED (in KG)					AVERAGE
	TRIAL 1	TRIAL 2	TRIAL 3	TRIAL 4	TRIAL 5	
1	14.13	15.17	15.16	15.18	15.19	15.166
2	13.83	14.95	14.97	14.89	14.78	15.094
3	14.12	15	15.16	15.05	15.08	15.082
4	14	15.17	15.05	15.13	15.1	15.09
5	14.23	15.12	15.07	15.18	15.09	15.138
6	13.62	14.54	14.61	14.51	14.52	14.56
7	14.81	15.8	15.91	15.87	16.08	15.894
SUM	98.74	105.54	105.81	105.67	105.84	105.72
TIME	35 min 23sec	34 min 12sec	36 min 43sec	35min 52sec	34 min 31sec	36 min 41 sec

Table 2: For Data Collected for Segregation of Wipro Waste (Proposed Method)

Note: Workers do not segregate equal amount of material; the amount of waste they segregate is based on their speed of segregation.

C. Time taken for Segregation of Waste from WIPRO (Proposed Method)

7 workers sit along a straight line and segregate the waste in a scientific way. The waste is placed before them, impurities are removed and segregated plastic is placed on the right. All the workers equal amount of waste to be segregated. 5 trails were made for calculating the time taken for segregation in the proposed method, each trial done for 100 kgs of Waste from WIPRO.

Fig. 11

Note: It is observed that the amount of waste segregated per person is almost equal as the bags of waste are weighed before it is distributed to each person.

D. Calculations for Profit And Reduction In Cycle Time

a). Current Method of Segregation:
Segregation Time for 100 kgs= 55 min
Working Hours in a day = 7 hour = 420 min
Amount of material segregated daily = 763.63 kgs

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b). Proposed Method Of Segregation:
Segregation time for 100 kgs = 35 min + allowances = 40 min
Working Hours in a day = 7 hour = 420 min
Estimate of Amount of material segregated daily = 1050 kgs

c). Segregation Time:
Existing Method Segregation Time = 55 min
Future Method Segregation Time = 40 min
Percentage Reduction in Segregation Time = ((55-40)/55) *100 = 27.27%
d). Savings Made:
Extra waste segregated per day = 237 kgs per day
= 1422 kgs per week
Selling price per kg = 44 rupees

Profits made = 62,568 rupees per week = 2.50 lakhs per month

e). Cycle Time:
Cycle time for Existing Method = 3048.40 min
Cycle time for Proposed Method =2733.40 min
Percentage Reduction in Cycle Time = ((3048.40-2733.40)/3048.40) *100
= 10.33%

VIII. VALUE STREAM MAPPING

Value stream mapping is a lean-management method for analyzing the current state and designing a future state for the series of events that take a product or service from its beginning through to the customer. At Toyota, it is known as "material and information flow mapping". It can be applied to nearly any value chain.

1. Planning and preparation. Identify the target product family or service. Create a charter, define the problem, set the goals and objectives, and select the mapping team. Socialize the charter with the leadership team.
2. Draw while on the shop floor a current state value stream map, which shows the current steps, delays, and information flows required to deliver the target product or service. This may be a production flow (raw materials to consumer) or a design flow (concept to launch). There are 'standard 'symbols for representing supply chain entities.
3. Assess the current state value stream map in terms of creating flow by eliminating waste.
4. Draw a future state value stream map.
5. Work toward the future state condition.

Value stream mapping has supporting methods that are often used in Lean environments to analyze and design flows at the system level (across multiple processes).

Although value stream mapping is often associated with manufacturing, it is also used in logistics, supply chain, service related industries, healthcare, softwareproduct development, and administrative and office processes.

Thus, the activities become easily separated into the value stream, which is the focus of one type of attention, and the 'waste' steps, another type. He calls the value stream the process and the non-value streams the operations. The thinking here is that the non-value-adding steps are often preparatory or tidying up to the value-adding step and are closely associated with the person or machine/workstation that executes that value-adding step. Therefore, each vertical line is the 'story' of a person or workstation whilst the horizontal line represents the 'story' of the product being created.

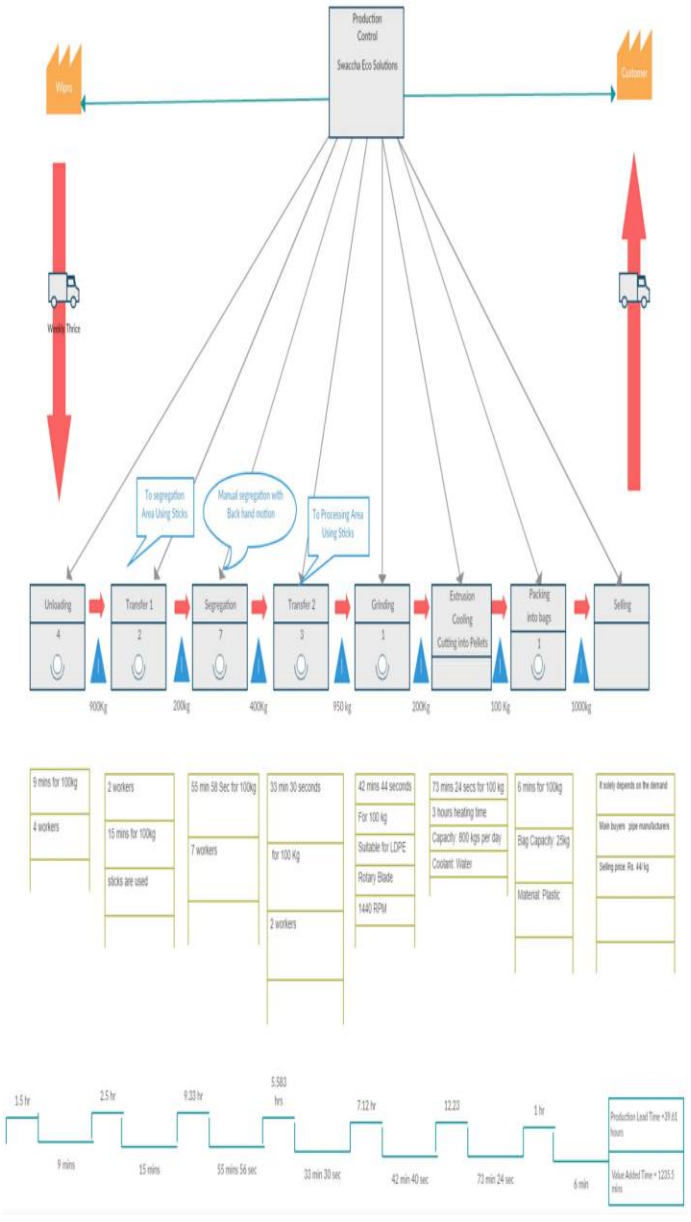

Fig. 12 The Value Stream Map that was Developed

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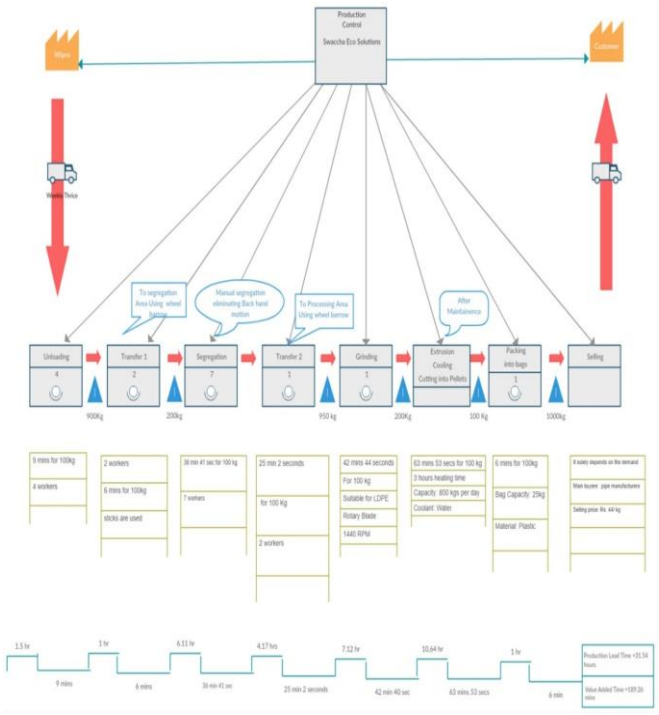

Fig. 13

IX. IMPLEMENTATION OF 5S AND PRODUCTIVITY IMPROVEMENT

Fig. 14 Problem Areas Observed Before Visual Management and 5S

A 5S (Five S) program is typically a piece of, and the key segment of setting up a Visual Workplace and are both a piece of Kaizen - an arrangement of constant change which is a segment of lean assembling.

5S is the name of a working environment association strategy that uses a rundown of five Japanese words: seiri, seiton, seiso, seiketsu, and shitsuke. Transliterated or converted into English, they all begin with the letter "S". The rundown portrays how to arrange a function space for productivity and viability by distinguishing and putting away the things utilized, keeping up the territory and things, and supporting the new request. The basic leadership process as a rule originates from an exchange about institutionalization, which constructs understanding among representatives of how they ought to take the necessary steps.There are five primary 5S phases:

They can be translated from the Japanese as "sort", "straighten", "shine", "standardize", and "sustain". Other translations are possible.

In order to implement 5S at the plant, observations were made in the model room. Some of the results of these observations were the development of a 5S Diagnostic Check sheet.

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5S DIAGNOSTIC CHECKLIST FOR SWACCHA DRY WASTE PROCESSING CENTRE

# of Problems	0	1	2	3 to 4	>5
Rating Level	Level I 4	Level I 3	Level I 2	Level I 1	Level I 0

Sl. No.	Category	Description	# of Problems	Rating Level
1	**Sort** (Organization)	Distinguish between what is needed and not needed		
		Unneeded equipment, tools, furniture, etc. are present		
		Unneeded items are on walls, bulletin boards, etc.		
		Items are present in aisleways, corners, etc.		
		Unneeded inventory, supplies, parts, or materials are present		
		Safety hazards (water, oil, chemical, machines) exist		
2	**Set in Order** (Orderliness)	A place for everything and everything in its place		
		Correct places for items are not obvious		
		Items are not in their correct places		
		Aisleways, workstations, equipment locations are not indicated		
		Items are not put away immediately after use		
		Insufficient labelling of various parts. Eg. Machine parts,pipelines		
		Height and quantity limits are not obvious		
3	**Shine** (Cleanliness)	Cleaning, and looking for ways to keep it clean and Organized		
		Floors, walls,and surfaces are not free of dirt, oil, and grease and unwanted waste		
		Equipment is not kept clean and free of dirt, oil,grease etc		
		Cleaning materials are not easily accessible		
		Lines, labels, signs, etc. are not clean and unbroken		
		Other cleaning problems (of any kind) are present		
		Air is not free of dust and other particulate matter		
4	**Standardize** (Adherence)	Maintain and monitor the first three categories		
		Necessary information is not visible		
		All standards are not known and visible		
		Checklists don't exist for all cleaning and maintenance jobs		
		All quantities and limits are not easily recognizable		
		How many items can't be located in 30 seconds?		
5	**Sustain** (Organization)	Stick to the rules		
		How many workers have not had 5S training?		
		How many times, last week, was daily 5S not performed?		
		Number of times that personal belongings are not neatly stored		
		Number of times job aids are not available or up to date		
		Number of times, last week, daily 5S inspections were not performed		

Table 3: 5s Diagnostic Checklist for Swaccha Dry Waste Processing Center

X. CONCLUSIONS

This project was a great experience in learning how a waste management plant actually works. It helped in understanding the importance of applying Industrial Engineering Principles in an industry.

Principles of Motion Economy were used to develop a better segregation technique through which employee fatigue was reduced.A new segregation technique was developed and the cycle time was reduced by 11%. Improvements were made for carrying the waste from segregation area to the processing area using a wheel barrow which can carry the unit load from the segregation area to processing area.

By preparing a Current and Future State Value Stream Map, the waste activities were removed and the segregation time was reduced by 27%. By implementing the proposed method, the facility will be able to achieve profits of upto 2.5 lakhs per month. Time taken for segregation of 100 kgs was reduced from 55 min to 40 min with the proposed method of segregation.

The Project helped to see the implementation of 5S and also the importance of Visual Management in a Waste Processing facility.5S has helped in decreasing potential time wasted looking for items, getting rid of unnecessary items from production facility and freeing up space which can otherwise be used effectively. It also helped in developing better safety standards for the workers. This practice helps to implement proper procedures and discipline on a routine basis.

Hence the project helped the facility to reduce the waste activities, decrease the total cycle time and also help in implementation of better practices in the facility.

XI. SCOPE FOR FUTURE WORK

Implementation of automated methods of segregation was not possible due to the restriction on capital investment. Educating workers about the importance of safety norms and equipment was a challenge and by doing so it will help in making the facility more efficient.

Use of machines to segregate the incoming waste was difficult and hence by designing a new machine with appropriate specifications the segregation process may be simplified.

Belt drives may have been used to carry the segregated waste from segregation area to the processing area which will in turn help in reducing cycle time.

XII. ACKNOWLEDGEMENT

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