

SMART PLASTIC WASTE MANAGEMENT SYSTEM

¹Vaibhav Suresh Kamble,
¹Bachelor of Technology,
¹Mechanical Engineer,
¹Government College of Engineering, Karad, India,
 E-mail : vaibhavkamble2618@gmail.com

Guide : Mrs. Santhosh Lakshmi,
 Waste Management Project Co-ordinator, Bhumi, Chennai,
 Address: 3/2, Karpaga, Vinayagar kovil Street, Alandur.
 Chennai – 600016, Tamil Nadu, India.
 E-mail : santhosh.lakshmi@bhumi.ngo

Abstract : This paper contains an analysis of a ‘smart waste management system’, which can be an alternative or replacement solution for existing plastic waste management systems. It is a plan with a validation by comparing with existing new plastic managing products in market. This system brings down the starting of recycling process at the door steps of user having plastic waste. This will help to mobilize the un-mobilized 6000-8000 tons of accumulating plastic per year in major cities of India. Most of the waste products produced at domestic and industrial level contain both bio-degradable and non-biodegradable components. Biodegradable are naturally decomposed, but non-biodegradable components like plastic materials are need to be processed further and reused, but absence of an efficient methodology to manage plastic waste has made this problem as a global issue, because in India current system fails to collect 6000 tons of plastic per year. The prominence of plastic pollution is correlated with plastics being inexpensive and durable, which lends to high levels of plastics use by humans. However, it is slow to degrade. If not disposed properly, it will affect the living entities and its accumulation in environment affects wildlife, wildlife habitat, and humans. Plastic pollution can unfavorably affects lands, waterways and oceans. Human beings are also gets affected, through direct ingestion of plastic waste, or through exposure to chemicals within plastics that cause interruptions in biological functions like disruption of the thyroid hormone. This paper contains a solution of all the problems related to plastic waste and analysis of quantity of plastic waste managed, reduced cost of plastic recycling process by using ‘Smart plastic waste management system’. It handles all six types of plastic waste in an efficient manner by providing neat and clean, technologically enhanced way for disposal of plastic waste; by smart collection, separation, shredding of plastic waste. It also reduces accumulation of plastic waste in dumping yards, soil pollution, promotes public participation in waste management, easily available and accessible plastic raw materials for recycling industries, and eliminates three steps of plastic recycling process in recycling plant; which ultimately lead to reduce the cost of recycled plastic products. In the analysis of research it is assumed that the existing plastic waste management system has been replaced by ‘Smart waste management system’ and collects waste regularly. Existing plastic waste management system can be replaced by ‘Smart plastic waste management system’, which can handle 6000 tons of plastic waste per year which current system fails to collect. Analysis shows that cost of recycled plastic is reduced by 20-30% by using this system and a gain by selling 100kg of plastic waste is Rs.4001 / Machine / Day. It is also assumed that existing waste managing organizations e.g. municipal-corporations are using this system; and transportation of raw plastic from machine to recycling industry is done by them.

I. INTRODUCTION

Existing plastic waste management system fails to collect 6000-8000 tons of plastic waste per year which is a big threat for our ecosystem. Also, it needs to have a system which can collect and recycle the plastics in a smart way. This research is based on an analysis of a plastic waste shredding machine, which can be used in waste management by installing it at the place producing plastic waste. Machine indirectly purchases plastic waste, collected by user, and its purchase amount, based on type of plastic and quantity, is gets transferred to users account. Functions of this machine are collection, separation, shredding and providing a raw plastic to recycling industries. Machine allows its use for that person who has registered their unique ID to with ‘Smart waste management system’ like e.g. Aadhar number, user has to enter his ID before using shredding machine. When the plastic waste is provided by a particular user then its detection of type, separation, shredding, quantification, purchase money transfer and processed data saving is done by shredding machine; where plastic waste gets shredded to fine size with the help of shredders inside it. Based on quantity of waste provided by user, proportional purchasing amount will be paid to him through aadhar pay. Raw plastic shredded is then transported and sold to recycling industry; where it is further processed for recycling and reuse. Introducing this ‘smart waste management system’ in recycling process eliminates three steps of plastic recycling process in recycling industry i.e. collection, separation and shredding. This method causes to save a lot of time and money spend on these three steps, which reduces cost of recycling process and ultimately results in reduction of cost of recycled plastic. Saved money can be utilized to install Smart waste management machines at a large scale, which will act as a constant supplier of raw plastic for recycling industries. Pie chart: 1 explains a typical plastic waste collection by smart waste managing system per day according to their types, by estimation; a single machine can manage a region, producing plastic waste, of radius 1 km. Smart plastic waste managing system partially replaces the work of plastic collectors like kabadiwallahas, plastic retailers and intermediate agents between user with plastic waste and recycling industries by providing an efficient and technologically enhanced way for plastic recycling. This system gives a profit by eliminating intermediate processes which was causing to increase the price of plastic recycling process; and also by eliminating three steps of recycling.

II. OBJECTIVES :

The main objective of this research and analysis is to solve one of major problem i.e. accumulation of 6000-8000 tons of plastic waste in our society by giving a smart and technologically enhanced method for plastic disposal and recycling. Plastic waste accumulation is a very serious problem in our society and it badly affects the environment. 'Smart plastic waste management system' causes to eliminate the problems related to plastic like plastic disposal, accumulation, soil pollution, water pollution, its recycling, plastic waste in public places etc. and absence of any effective methodology has made this problem as a global issue. Installation of plastic shredder machine at various waste producing areas will cause to mobilize that accumulated plastic waste. To reduce the complexity of plastic waste management system and to establish a neat and clean technologically enhanced method for plastic waste disposal. Also, to introduce easy disposal of collected waste for its reuse and transportation than existing methods is one of the major objective of this system. Further, to start a recycling process at the door steps of plastic waste producing places; it brings steps of recycling process at lower level which causes easily accessible plastic disposal method. Purchasing of plastic waste through Shredding machine, results in elimination of intermediate agents between user having plastic waste and plastic recycling industries, which will cause reduction in price of raw plastic. Also, after purchasing of waste and paying the user digitally, shredding machine will shred that waste and converts it into fine sized plastic granules, which is easy to store and transport the raw plastic. 'Smart plastic waste management system' promotes public participation due to paying them by a more amount than existing purchase price depending upon the type of plastic and by analyzing the cost reduction of recycling process. Easy access of raw material for recycling industry with already sorted, shredded and stored separately according to its type. Selling the raw plastic to recycling industry at a lower price than existing will cause increased demand for already shredded plastic is the another advantage of this system. to obtain a higher profit by saving a time, money spent and eliminating the three steps of plastic recycling process by recycling industry. Saving the money spend on these steps and investing it to install more number of 'smart plastic waste shredding machines. To maintain cleanliness in metropolitan cities, tourist places, to establish a neat and clean waste management system. Also, it will acts as a continuous supplier of raw plastic to recycling industries.

This system provides an efficient collection, sorting and recycling of all types of plastic. Also, it Prevents saturation of plastic waste at dumping grounds and reduces the three steps of recycling process. Instead of dumping the waste into dumping yards and burning it the waste gets directly transported to recycling plant. Reduced size causes easy to transport and storage, results in neat and clean system. Requirement of low space for storage, replacement for the dustbin based systems. Installing at one time capital cost. Peoples get a motivated, to contribute in improved way of waste management. It is neat and clean, technologically enhanced way for disposal of Plastic waste. It has a potential to become an ideal replacement solution for the existing plastic waste management system. Also reduces plastic waste accumulation in dumping yards and soil pollution. Major impact can be made on public participation for regular management of plastic waste by paying them. As it eliminates three steps of plastic recycling process in recycling plant, which ultimately reduces cost of recycled plastic products, manages all the six types of plastic waste. Collection, Separation, Shredding of plastic waste by machine installed at public places. This machine can maintain cleanliness in metropolitan cities, tourist places etc. Smart plastic waste management machine is a business model for Startup by providing raw plastic to recycling industry. This machine can be installed at areas like metropolitan cities, public places, metro stations, hospitals railway stations, bus stands, various public residences.

III. PROPOSED SOLUTIONS : SMART PLASTIC WASTE MANAGEMENT SYSTEM

Function of this system is to collect, separate and shredding of plastics which come under the categories listed below which are further transported and sold to industry for recycling. 1. Polyethylene terephthalate (PET): Examples: Soda and water bottles; mouthwash bottles; peanut butter containers; salad dressing and vegetable oil containers; etc. 2. High density polyethylene (HDPE) : Examples: Milk jugs, juice bottles; bleach, detergent and household cleaner bottles; shampoo bottles; some trash and shopping bags; motor oil bottles; cereal box liners; etc. 3. Polyvinyl chloride (PVC) : Examples: Window cleaner and detergent bottles, shampoo bottles, clear food packaging, wire jacketing, medical equipment, siding, windows, piping; etc. 4. Low density polyethylene (LDPE) : Examples: Squeezable bottles; bread, dry cleaning and shopping bags; tote bags; carpet; etc. 5. Polypropylene (PP) : Examples: Syrup bottles, ketchup bottles, straws, medicine bottles; etc. 6. Polystyrene (PS) : Examples: Disposable plates and cups, meat trays, egg cartons, carry-out containers, aspirin bottles, compact disc cases; etc.

Instead of collection, separation and shredding in recycling plant smart plastic waste managing machine performs these steps at a lower level so that every user having plastic waste can dispose it, by easily accessible method, then raw plastic collected is sold and transported by recycling industry for recycling, further it can be directly processed.

IV. CONSTRUCTION : Shredding machine has two versions one is of a compact size with compact storage passages and other with bigger size having separate mechanical components for each type of plastic. The mechanical specifications of machine consists of following major components, 1. *Conical shaped hopper* : This is rectangular in shape and it is made of low carbon steel foil of thickness 3mm. It directs plastic waste from inlet port to primary shredder. 2. *Primary shredder* : Shredding is done at primary stage to reduce size of plastic waste, up to 10 mm. Size reduction helps in quantifying the amount of material put by the user into machine at the end of shredding process. Two rotating shafts with shredding cutter meshes with each other, is the primary shredder. 3. *Secondary Shredder* : It is placed below primary shredder which is similar in construction and function as primary shredder. It further reduce the size of plastic, to a fine granules; side stator shredder also helps to make resizing effective.

4. *Density Sensor* : Density sensor is necessary for the compact sized machine to detect type of plastic and to store them separately. Infrared density sensor detects the type of plastic put into the shredding machine according to its density; which is then stored separately in six storage passages, for six types of plastics. Based on the signals given by density sensor a mechanical arrangement directs the shredded plastic to a respective storage passage. 4. *Electric motor* : It act as the prime mover for the shafts of shredders. Primary and secondary shredders are driven by separate motor through gear box. 5. *Weighing System* : Weighing system made of piezo-electric sensors, determines the weight of the plastic waste stored in storage passage after every use. It transfers quantified data to the data processing unit, where it is stored on the registered account of user and user gets paid. 7. *Storage passage* : Storage passage with weighing system is placed at the bottom part of the machine. It has a capacity to store 20 kg of plastic for each type and its capacity can be varied as per the need. For both the versions of shredding machine storage passage has different construction. In case of compact version it has six compartments in a circular manner, and for larger size versions it has separate storage and other mechanical elements.

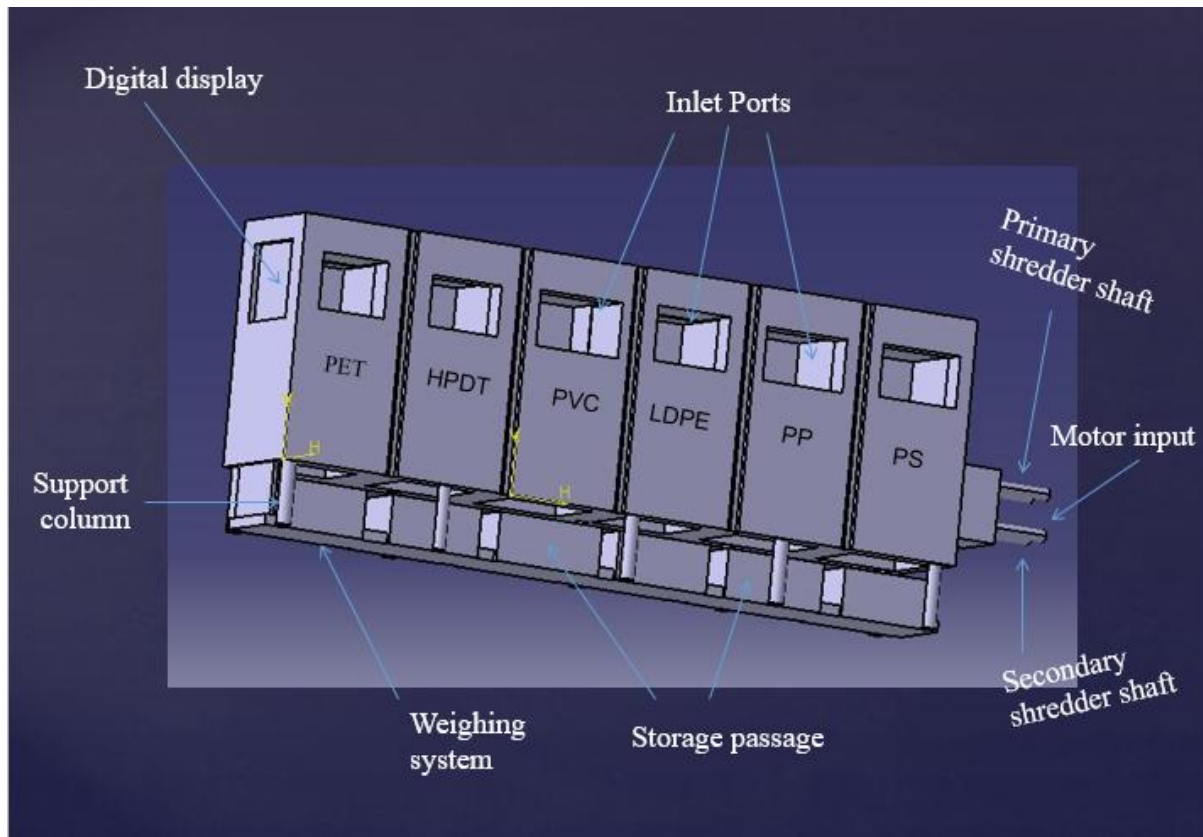


Fig-4: Version 2 : External parts of smart plastic waste management machine.

Source: Own study.

8. *Data Processing* : This unit stores the transferred data to the given ID. It sends a signal to the host processor, which forwards it to the networks for data saving and then digital fund transfer is done. A controlling room established to control this system will be installed with various electronics required. 9. *Casing* : It supports all the components of machine, acts as the external cover to all components. It consists of all six types of plastic storage passages connected with a combined weighing system. Supporting columns are provided at bottom of casing. Digital display is provided on the external casing.

This system will promote regular, neat and clean use of the waste management system with ties up with various recycling industries. Domestic, industrial and other types of plastics are the areas on which this model focuses. It can be installed at the places where the existing system works, and same organizations and its labors can operate this system. Technically enhanced model comprises, basically two parts Mechanical and digital processing of plastic waste. First, all plastic coming into plastic shredding machine will go under series of mechanical operations. At the final stage of this, plastic waste is resized to a convenient level, and then weighed by the weighing system to quantify the amount collected. Collected waste is then transported by the operators of existing system and sold it to the recycling plant for its reuse, and this cycle goes on. Quantified data output from weighing system goes under further processing which include data storage and paying purchase money to the waste provider. Regular use of this system will encourage the public and over a period of time it will be habitual for them. Also, it prevents saturation of plastic waste at dumping grounds and reduces the three steps of recycling process. Instead of dumping the waste into dumping yards and burning it the waste gets directly transported to recycling plant. Reduced size causes easy to transport and storage, results in neat and clean system. Requirement of low space for storage, replacement for the dustbin based systems. It has a potential to become an ideal replacement solution for the existing plastic waste management system.

Mechanical flow chart :

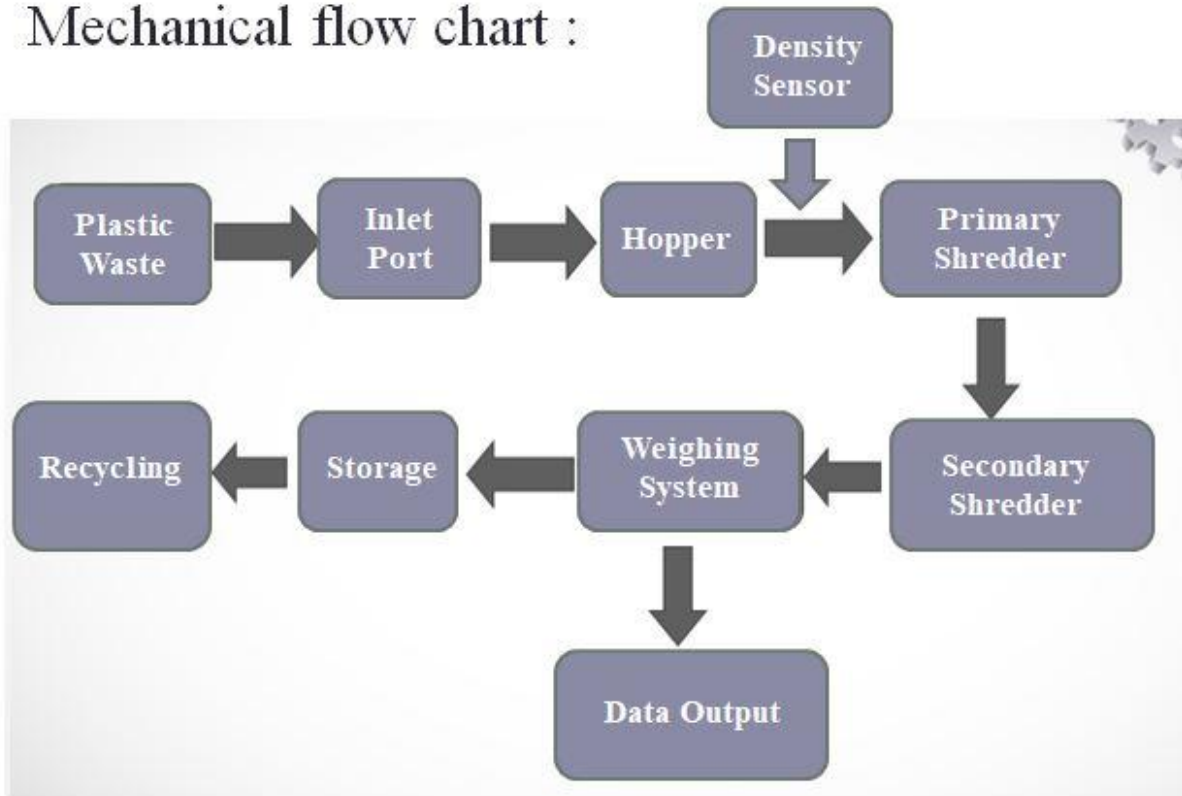


Fig-1: Mechanical working of smart plastic waste management machine.

Source: Own study.

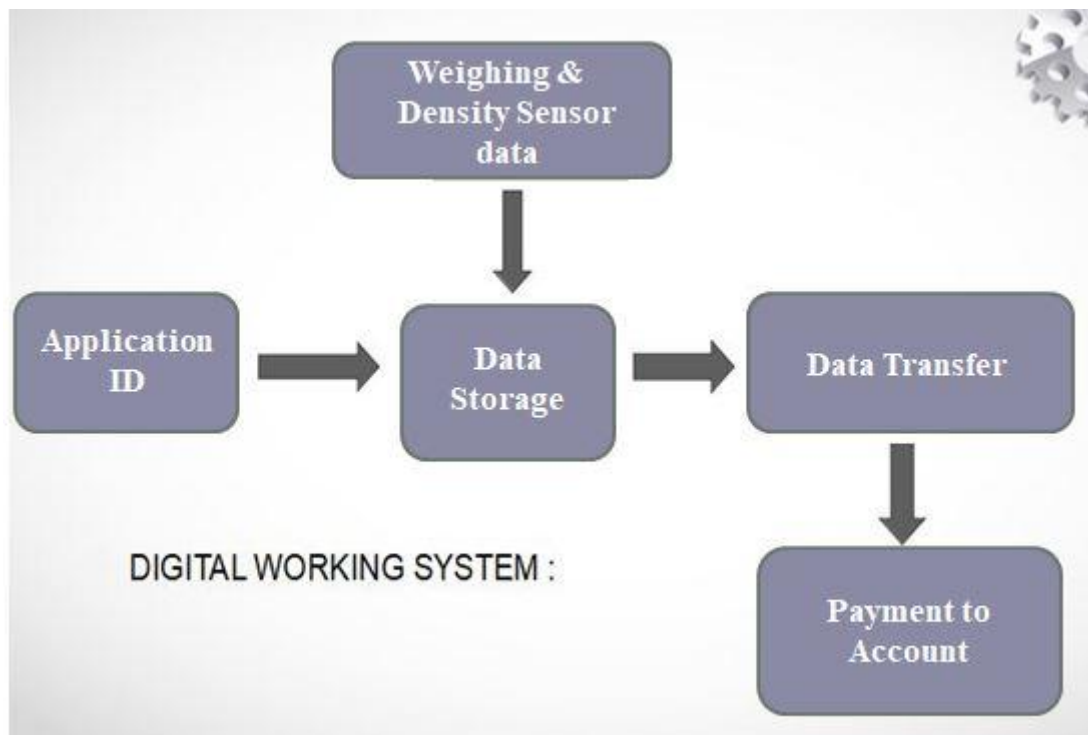


Fig-2: Digital working of smart plastic waste management machine.

Source: Own study.

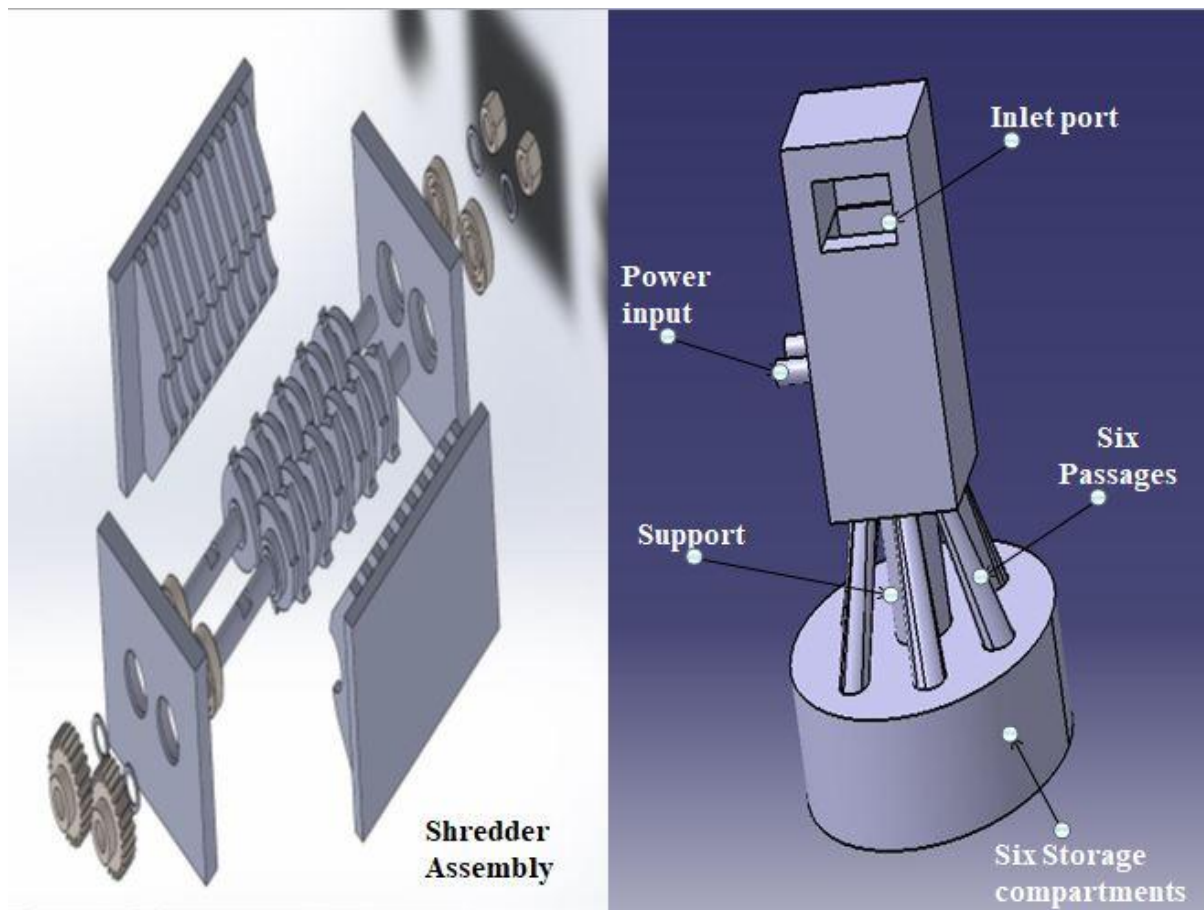


Fig-5: Version 1: Shredder assembly and compact design.

Source: Own study.

V. INSTALLATION COST OF SHREDDING MACHINE :

Sr. No.	Component	Quantity	Cost (Rs)
1.	Shredder	2	89,000
2.	Weighing System	1	27,000
3.	Electric Motor	2	40,000
4.	Density Sensor	1	17000
5.	Digital display	1	12,000
6.	Electronic System	1	65,000
7.	Frame / Structure	6	54,000
			Total : 2,95,000.

Chart-1 : Typical installation cost of plastic waste management machine.

Source: Own study.

VI. CURRENT PLASTIC WASTE MANAGEMENT :

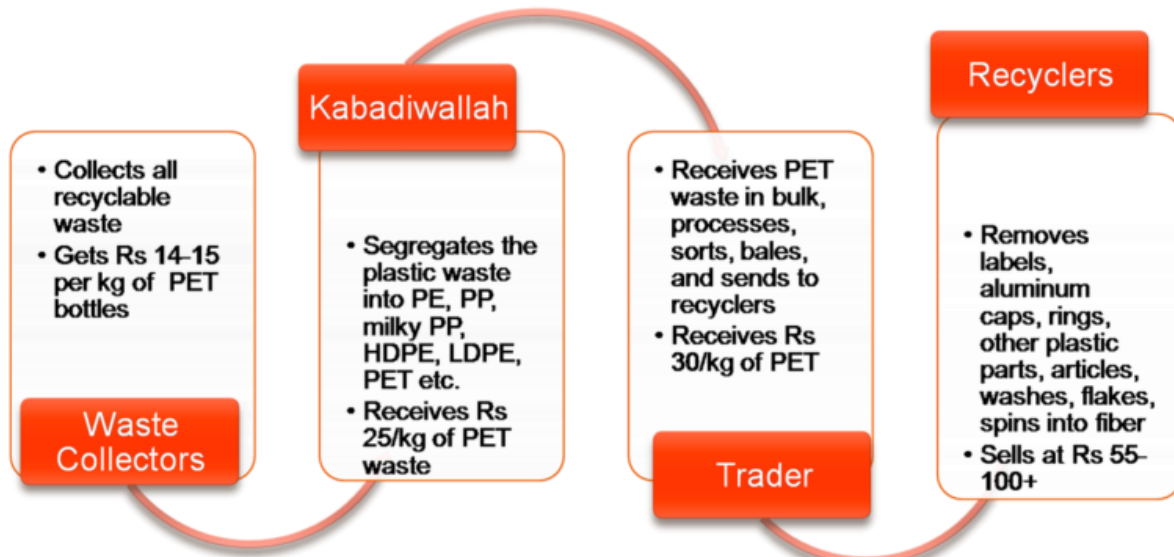


Fig-6: Current plastic waste cost flow chart.

Source: Internet.

Current system contains flow of plastic in various steps; more stages between plastic waste and recycling industry causes to increase cost of recycling process. A waste collector collects the waste from plastic provider; and purchases it. But the main disadvantage of this deal is that a collector purchases all types of plastic at same rate, and it is a fraud with the waste provider. In actual case collector should pay to provider according to type of plastic i.e. HDPE, LDPE, PET, PP etc. because these plastics have different rates based on its density. For example, in case of PET, price of these plastic becomes Rs.14-15/kg. At the second stage kabadiwallah does its sorting based on its kind and sells it at Rs.25/kg to traders, in case of PET. Traders' processes, separates, bales received plastic and sends it to recyclers at a price of Rs.30/kg in case of PET. Recyclers starts removing; labels on plastic wastes, aluminum caps, rings, other plastic parts, articles, washers, flakes, spins the plastic into fiber. After this finally raw plastic is converted into reusable plastic product by recycling industries at the price of Rs.55-100/kg in case of PET.

This intermediate flow of plastic waste increases time and cost of recycling processes. Smart plastic waste management system replaces these intermediate agents with shredding machine. Also, the intermediate agents can be the part of this system and they also can provide plastic waste; so that this will triggers plastic waste management system. Smart plastic waste management machine is a substitute for the current plastic waste collector, kabadiwallahs and traders. It also provides services to form a plastic raw to recycling industries. User is asked to provide his aadhar number before using machine so that its amount will be directly send to his account. User of this machine is given an amount about 17rs/kg rather than 14-15 Rs/kg in case of a PET bottle. Procedure of disposal of waste product will be shown on machine, e.g. to dispose a pet bottle user have to dispose its label and cap separately, So that same density materials will be stored and all types are disposed properly. Separation of plastic in 6 categories is done as per there density value of each plastic waste. After proper calculating density and weight, machine is actually purchasing that plastic and sorting it using IR density sensor and stores them separately by the mechanisms in machine. So, machine produces a plastic raw material which is ready to recycle, is sold at 60 Rs/kg. Overall profit made is 33Rs/kg by selling raw material to recycling industry. As described in figure:6 ; and save 10Rs/kg of recycle industries and give 2Rs/kg more to user of this machine. Peoples having any type of plastic waste have to put their plastic into this machine. Separation of plastics will be done by using IR density sensor. Before putting plastic waste user have to enter his unique ID like Aadhar number. This machine installed at various places will shred this plastic into small pieces. Quantity of Plastic collected can be calculated by weighing system, stored separately. User will be paid using Aadhar-pay, by an amount proportional to the quantity of waste collected in machine; this data will be stored to the users account, as per regular use. Plastic waste collected will be Transported and sold to plastic recycling industry. Comparison of cost of current and smart managing service is shown in figure -7.



Pie chart -1: plastic waste collection % of total plastic waste/day.

Source: Own survey.

Sr. No.	Type of raw plastic	Price per kg in Rs
1.	Polyethylene terephthalate (PET)	55
2.	High density polyethylene (HDPE)	90
3.	Polyvinyl chloride (PVC)	75
4.	Low density polyethylene (LDPE)	80
5.	Polypropylene (PP)	60
6.	Polystyrene (PS)	80

Note : These values may change from supplier to supplier.

Chart-2 : Raw plastic purchasing price by industry for plastic recycling process.

Source: Own study.

VII. CASE STUDY OF PET BY SMART PLASTIC MANAGEMENT SYSTEM :



Fig-7: PET waste cost flow chart after using Smart waste managing system.

Source: Own study.

It substitutes the procedure of plastic waste collector, kabadiwallahs and traders by shredding machine. In case pet bottle analysis as shown in fig-7, for every 1 kg of pet bottle plastic waste Smart plastic waste management system gains a profit of Rs.30 i.e. here profit is around 2/3rd of the previous selling price of raw plastic to recycling industry. In case of all other types of plastics profit will be 2/3rd of previous selling price. Smart selling price will be 0.87th of previous price; and as per the design of shredder machine it can manage plastic waste in an area of 1 km radius around it. Same analysis is done in case of other types of plastics with respect to their rates given in chart-2. By taking minimum collecting capacity of single version one machine shown in fig-5; is 100kg/day, smart waste management can make profit given in table-1. It gives an idea about the profit made by each shredding machine.

VIII. ANALYSIS RESULTS AND CONCLUSION :

The analysis done in table no. 1 and 2, gives overall profit by this system for a single shredder machine which is installed at a capital cost of around Rs.3,00,000. This installation amount can be recovered by total profit gain by single machine. It is assumed that shredder machine manages 100kg/day, and if this is less in actual case then it will only affect the recovery time of installation cost. Quantity shredded per day can be calculated from pie chart-1; out of 100kg collected per day. Example: in one day 100kg waste is shredded and managed, out of that 100kg contribution of PET will be 13kg same analogy for other. In analysis cost reduction by eliminating three steps of recycling process in recycling industries is not considered. This makes possible to give more amount to collector by collecting waste plastic at about 17rs/kg rather than 14-15 Rs/kg to satisfy plastic provider.

Table no. 1 and 2 gives the profit of plastic providers and recycling industries profit. Smart plastic waste management machine is a business model for Startup by providing raw plastic to recycling industry. This machine can be installed at areas like metropolitan cities, public places, metro stations, hospitals railway stations, bus stands, various public residences.

PLASTIC TYPE	CURRENT SELLING PRICE	SMART SELLING PRICE (0.87 OF PREVIOUS VALUE)	RECYCLERS PROFIT	PLASTIC PROVIDER GAIN	SYSTEM PROFIT
P.E.T.	55	48	7	18	48-18=30
H.D.P.E.	90	79	11	18	79-18=61
P.V.C.	75	65	10	15	65-15=50
L.D.P.E.	80	70	10	17	70-17=53
P.P.	60	52	8	12	52-12=40
P.S.	80	70	10	17	70-17=53

Table no.-1 : Selling price and profit analysis per kg / machine.

Source: Own study.

PLASTIC TYPE	QUANTITY SHREDED (kg.)	OVERALL PROFIT (Rs.)
P.E.T.	13	390
H.D.P.E.	18	1098
P.V.C.	5	250
L.D.P.E.	24	1272
P.P.	28	1120
P.S.	7	371
		Net profit = Total profit – Maintenance cost per day = 4501-500 = 4001 .

Table no.-1 : Overall profit analysis per day / machine.

Source: Own study.

From the analysis shown in table no.1 and 2, Smart waste management system can make a net profit of around Rs.4000 per day per machine. Single shredding machine can recover the capital cost of installation as per the following calculations.

CAPITAL INSTALLATION COST = Rs.3,00,000.

NET PROFIT PER DAY = Rs.4000.

RECOVERY DAYS = 75 DAYS; if 100kg waste collected per day.

= 150 DAYS; if 50kg waste collected per day.

New shredder machine can be installed after recovery of first machine and so on.

We can mobilize 6000-8000 tons un-mobilized plastic in 1.5-2 years by installing smart waste management system with 100 shredding machines at the major plastic waste producing areas in India.

IX. CONCLUSION :

Some existing models over this problem are there; but their usages are restricted for a specific application. Plastic recycling system has minimum limitations, as this serves its purpose without any dependencies. This field has a great potential of research and need further improvements. As it eliminates three steps of recycling industry and put them at lower level of process, so that user can access easy method of disposal of plastic. Plastic recycling system can be implemented in easy and effective manner. Installation of these systems will reduce the saturation of the plastic components at domestic level by 75%. Reduces cost of plastic recycled by 15-20%, it can be enhanced. It eliminates the two steps of recycling process hence ultimately reduces the cost of recycling in industry. We are confident that this idea will tack off and will be successful after implementation because of its simple usage and revenue generation. So we are willing to work with government to develop the product and implement it. Some existing models over this problem are there; but their usages are restricted for a specific application. Plastic recycling system has minimum limitations, as this serves its purpose without any dependencies. As proposed model is efficient than existing, it will work 2-3 times faster. Hence, increases the overall efficiency of plastic recycling process. It requires one time capital cost for its installation and regular maintenance so it will work for a long run. By selling plastic raw material to recycling industries, capital cost can be recovered after some period of time from the profit which coming from lowering the plastic raw materials cost. We can mobilize 6000-8000 tons un-mobilized plastic in 1.5-2 years by installing smart waste management system with 100 shredding machines at the major plastic waste producing areas in India. From the analysis shown in table no.1 and 2, Smart waste management system can make a net profit of around Rs.4000 per day per machine. As proposed model is efficient than existing, it will work 2-3 times faster. Hence increases the overall efficiency of plastic recycling process. It requires one time capital cost for its installation and regular maintenance so it will work for a long run. This will be a profitable business for the operating organizations.

X. ACKNOWLEDGMENT :

THANKFUL OF Guide :

Mrs. Santhosh Lakshmi, Waste Management Project Co-ordinator, Bhumi, Chennai,

Dr. Anirudh Garg, Institute Of Urban Farming & Sustainability, <ani.garg@yahoo.com>

Abhyudays' action plan competition, Indian institute of technology, Bombay,(IIT, BOMBAY).

XI. REFERENCES :

- [1] Plastic Waste Management, Pune : Current waste generation profile. <http://www.financialexpress.com/economy/indian-railways-innovative-green-move-installs-bottle-recycling-machine-at-mumbais-churchgate-station/278137/>
- [2] PLASTIC WASTE MANAGEMENT IN INDIA by Dr. Pawan Sikka Department of Science & Technology, Government of India New Delhi – 110 016 (India), <https://articles.mercola.com/sites/articles/archive/2013/04/11/plastic-use.aspx>
- [3] USEPA (2006) Municipal Solid Waste in the United States: 2005 Facts and Figures. Official Report, Municipal and Industrial Solid Waste Division, US Environmental Protection Agency, Washington, DC.
- [4] Report on Indian Plastic Industry 2012 - 2013, Plastindia Foundation, <https://www.vecoplanllc.com/plastics-shredders>
- [5] FICCI : A REPORT ON PLASTICS INDUSTRY.
- [6] Plastics: Issues Challenges and Remediation Vipin Koushal¹, Raman Sharma^{1*}, Meenakshi Sharma², Ratika Sharma³ and Vivek Sharma¹ ¹Department of Hospital Administration, Chandigarh, India, ²Senior Research fellow, School of Public health, PGIMER, Chandigarh, India, ³Department of Sociology, Panjab University, Chandigarh, India.
