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Introduction to the Wasteology and the Evaluation of Municipal Solid Waste Management System in Fayoum Governorate

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Abstract

In this section, we will discuss how the creation of a waste science, it will be including the classification of waste clarification some of important Definitions. The scientific basis for waste management plus the current situation of waste management in Fayoum governance (infrastructure, equipment, workers) As an example of Egypt's existing waste management problem and try to find solutions. In addition, it sheds light on some Important applications to benefit from plastic waste to produce fuel.

In recent years the burdens that waste puts on the environment have been widely publicised. To address the earth's dwindling resources and the growing mountains of waste many countries have introduced statutory waste minimization and recovery targets. The general public is generally more concerned with the effects that waste has on the environment. Whereas waste managers and planners need to consider the financial costs of collection, processing, and disposal.

Keywords: Waste management, waste science, Wasteology, solid waste, Municipal Solid Waste Management.

1. Introduction

Solid waste is one of the most natural issues at present time everywhere throughout the world. It's created by different human activities, with the expanding populace, rising way of life, and industrial advance. It is unsafe for the general wellbeing as well as for social and financial angles. Proper disposal is the principal issue we are confronting. Municipal solid waste (MSW) relies on the level of earnings of the consumer, attributes, and conditions of the group, and human conduct. The higher pay produces waste more than those with lower levels of wages, all of this led to an urgent need to establish a science for the waste not only mechanisms for waste management. This science will include (waste definition, characterization, classification, concepts, applications, and management.

In this research, waste management in Fayoum government as a model was suggested for waste management in Egypt. The conversion of plastic waste to fuel was proposed as a part solution of the problem.

2. Wasteology

Wasteology or Waste science is based on waste classification and characterization, management, and technology.

2.1 Waste Classification

The waste may be classified according to the physical state of matter (solid, liquid, gaseous), the degree of risk (hazardous, non-hazardous), in accordance with recyclability (recyclable, non-recyclable) and according to the source of the waste (industrial, agricultural, domestic, hospitals, commercial, educational, surveying and contracting, office, mining).

Table (1): Waste classification

Main Category	Subcategories	Definition and examples
Physical state	**Solid**	The particles of matter that cannot move freely, which means that they have a clear and stable size, although they may be broken. Examples: concrete waste, metals, paper, plastic, wood, electronic waste, electrical appliances, general waste, etc.
	Liquid	Liquid matter has a classical monolith structure and has a clear size if the temperature and pressure are constant, its density is much closer to the density of the solid, and larger than the gaseous substances. Examples: oil waste, chemicals, sewage, industrial wastewater, etc.
	Gaseous	The gas molecules are large in size, characterized by their ease and speed of movement, especially in the open space, which are compressible materials. Examples: Gaseous wastes are mostly caused by factories, some agricultural activities, incinerators, bakeries, etc.
Degree of risk	**Hazardous**	The waste resulting from the remains and ashes of various activities and processes that are the characteristics of hazardous substances or are substances to be disposed of in accordance with the regulations and national laws that require special methods and techniques to deal with it and treat it and cannot be disposed of in regular waste sites of municipal because of the hazard characterization and negative effects on the environment and public safety. Also, it can be defined as any material that cannot be produced or reused from any other material. Examples: General, medical and chemical waste, etc.

	Non-hazardous	It is the solid waste that does not contain materials and components that have characteristics of hazardous materials and also vary in chemical and physical characteristics and include inorganic and organic materials. Examples: Garbage, construction, demolition waste, agricultural waste, etc. concrete, metals, securities, plastic, wood, etc.
Recyclability	**Recyclable**	Any material that can be recycled and produced from its substance similar to the original material or other material that can be used. Examples: Concrete or cement waste, oil, metals, paper and cardboard, plastics, wood, glass, etc.
	Non-recyclable	Material that cannot be produced from any other material reused. Examples: General, medical and chemical waste, constriction waste, etc.).
The waste source	**Industrial**	The types of waste generated by manufacturing depend on the type of product. Examples: • Organic waste as the main waste of the food industry. • Cement, metal waste, etc. as the main waste of precast factory. • Chemical waste as the main waste of the painting industry. • Others like waste oil, metals, plastic, wood, glass, gas, wastewater, electronic waste, general, food waste, paper, plastics, etc.)
	Agricultural	Waste generated from agricultural activities. Examples: Garden waste, backyard waste, organic waste, dung, etc.
	Domestic	Waste generated from homes. Examples: Organic, food, metals, plastics, wood, glass, gases, waste water, electronic, etc.
	Hospitals	Waste generated from healthcare activities. Examples: Chemical, medical, pathological waste, etc.
	Commercial	Intended for establishments operating in the field of trade. The quality of waste resulting from packaging materials, or the residues of the materials being traded is most likely to be. Examples: Paper, plastics, wood, glass, waste, food, electronic, etc.
	Educational	Waste generated from educational activities. Examples: General waste, paper, plastics, wood waste, glass, waste, food waste, electronic waste, etc.
	Construction	Waste generated from construction activities. Examples: Cement, constriction waste, wood, metal, oil, glass, etc.)
	Office	Waste generated from administrative activities. Examples: Paper, plastics, wood, glass, food, electronic, etc.
	Mining	Waste generated from mining (petroleum or minerals) activities. Examples: Oil waste in all forms of crude oil and oil products, any kind of liquid hydrocarbons, lubricants, fuel oils, refined oils, bitumen, and other materials extracted from oil or petroleum products or its wastes

Notes:

Should be considered when classification waste by source, A division of labor that contains waste produced by the individual in his normal life such as (general waste, paper, plastic, food waste, etc.).

The second division is waste resulting from the activity practiced by the establishment (construction, health, education, industry, etc.). This section represents the bulk of the waste generated by the establishments. [REF .6]

2.2 Concepts of Integrated Waste Management

Waste management is an integrated process dealing with proper waste collection, transfer, and proper disposal. Generally, aims to approach the ideal case which is to investigate public health protection and contamination of the surrounding environment and all of its elements for the preservation of natural resources.

Components of the integrated system for waste management:

1. Reduced waste from source: programs are designed mainly to reduce the amount of waste left by the individual from home to work and his whereabouts. Thus reduce the amount of waste that comes to the site waste treatment.
2. Re- use: the reuse of waste to be disposed of within the organization for the same purpose or for another purpose.
3. Recycling: one of the methods used commonly in many developing and developed countries. The waste is recycled in front of the production of the same recycled product or a new product such as the production of plastics from plastic waste or the production of fuel from plastic waste.
4. Heat treatment: the art of burning waste, to reduce the volume of waste and reduce the quantity, in addition to the production of energy, used to generate electricity, heating, and water desalination.

5. Healthy waste backfill: Adopted all over the world for a long period of time. The art of Healthy waste backfillis a way to get rid of waste because of the expansion of urbanization and growth population. It depends on the space available for reclamation, which made them think that the treatment of such waste could give good economic returns.It is the operations which do not lead to the extraction or reuse of substances such as landfill in the ground or deep drilling or (biological, physical , chemical) treatment or permanent storage or destruction or any method approved by the competent authorities. [REF (3-4-6)]

2.2.1 Waste Management Hierarchy

The waste hierarchy varies in its exact form but usually ranks waste management options in a preferred order: waste minimization, reuse, materials recycling, biological treatment, incineration with energy recovery, incineration without energy recovery, and landfilling.

The hierarchy intuitively ‘feels right’ and as such has greatly influenced waste management decisions and strategy at the local, national, and international levels during the past 25 years. Although such a hierarchy is widespread and often suggested, the value of this approach has limitations:

- The hierarchy has little scientific or technical basis. There is no scientific reason, for example, why materials recycling should always be preferred to thermal treatment with energy recovery.
- The hierarchy is of little use when a combination of options is used, as in an integrated waste management (IWM) system. In an IWM system, the hierarchy cannot predict, for example, whether composting combined with incineration of the residues would be preferable to materials recycling plus landfilling of

residues. What is needed is an overall assessment of the whole system, which the hierarchy cannot provide.

- The hierarchy does not address costs. Therefore, it cannot help assess the economic affordability of waste systems.

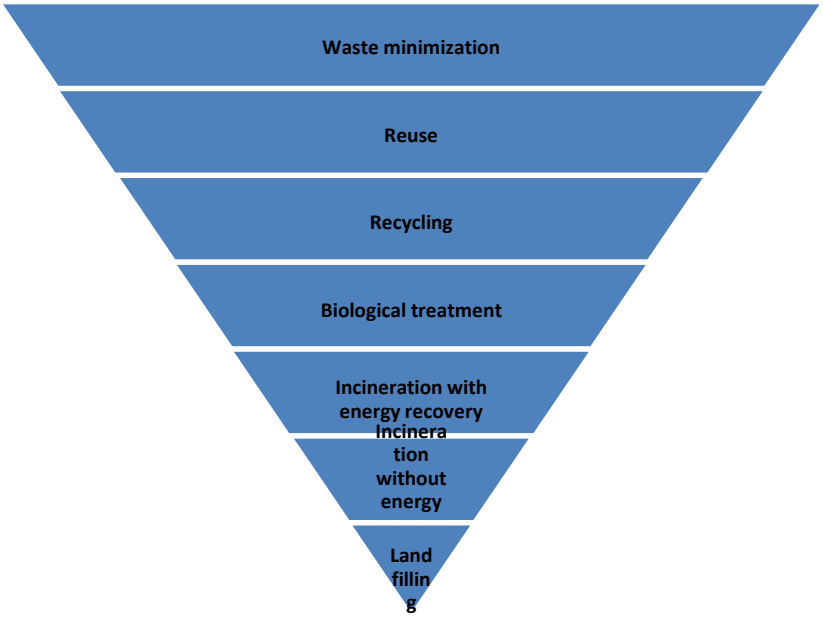

Fig. (1): Waste management hierarchy.

The hierarchy should now be used as a simple menu of possible waste management options. It is also useful as a simple presentational tool to be used when discussing waste management with the public, although it should not be presented as a rigid set of preferences.

2.2.2 Waste Handling

All processes that start from the time of generating the waste until the safe disposal, including collection, storage, transport, treatment, recycling, and disposal of waste. [REF (3-4)]

2.2.3 Municipal Solid Waste Management in Fayoum Government: A Case Study

It is important to note the differences between the amount of solid waste generated and that reaching final disposal sites. In developed countries, the two figures are usually much the same, Fayoum is considered as one of the cities which is suffering from the problem of SWM. Improper disposal of solid waste increases the production of resulting waste. The lack of dumpsites or location for waste is another major problem in the city. Solid waste pilings are locating in the streets, which become a place for insects, rodents, and other animals. Burning of waste on the roads, canals, and drains added to the environmental pollution rate. Fayoum governorate was chosen as a case of waste management in Egypt. Some suggestions for solving the problem will be discussed. [REF. (7-10-4-1-12)]

2.2.3.1 Objectives of the Study

We aim contributing to sustainable development and encourage waste producers to minimize them or re-use. Work on the establishment of regulations and legislation on the control of waste. Reduce the final placement of waste in landfills. Suggest an integrated system to regulate the process of collecting and transporting waste and disposal. Encourage enterprises producing various types of waste to adopt policies and technologies aimed at reducing waste. Finally, creating opportunities and investing in the field of waste management.

2.2.3.2 Display of the status quo

Fig. (2): Administrative division of the governorate.

Table (2): Amount of waste generated from Fayoum Governorate.

Year	Municipal waste (ton)
2002	403,000
2005	621,000
2015	2,500,000

2.2.3.4 Population

Table (3): Distribution of population size and the number of families in Fayoum during the period (2006- 2027). [REF 13]

No.	Statement	Total number
1	Population in 2006	312,000
2	Families no. in 2006	79,604
3	Population in 2027	444,780
4	Families no. in 2027	113,638
5	Population added for 2027	128,670
6	Families no. added for 2027	34,034

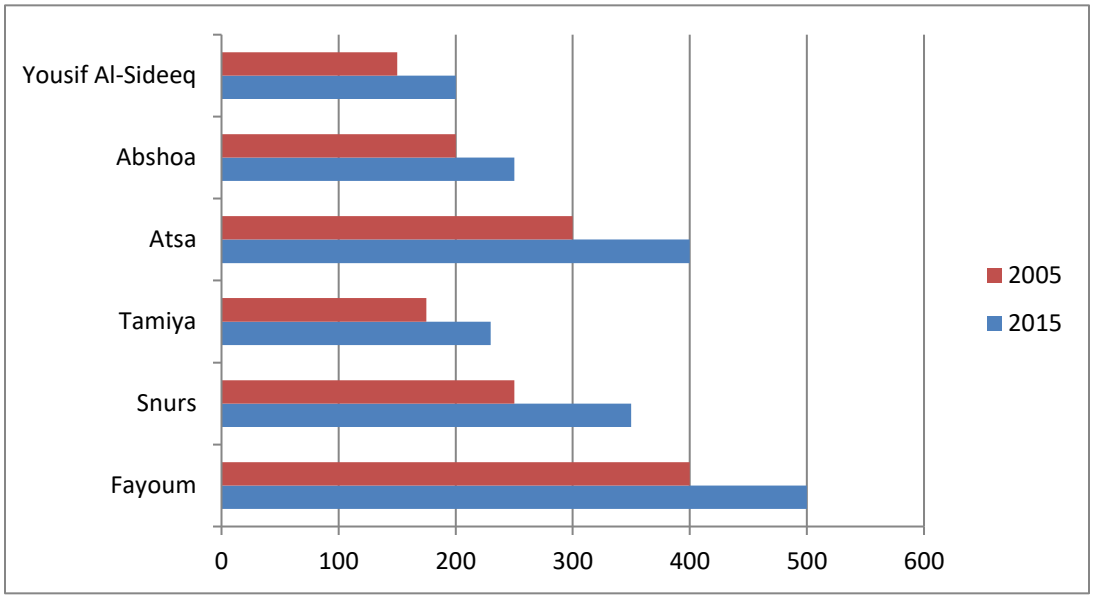

Fig. (3): Comparison of the amounts of waste generated from Fayoum Governorate in 2005 and 2015.

As shown in Tables (3) and Figure (3) there are significant increase in the rate of waste generation.

2.2.3 .5 Statement of Equipment and Workers

Table (4): Number and distribution of workers in all sectors.

Unit Name	Permanent Laborers	Temp. laborers	Drivers	Supervisors	total	Characterization of the collecting system and disposal
Fayoum city	525	500	75	13	1113	The city is divided into four sectors for cleanliness. - dustbin Number 244/ container 446, 140 liters - Street sweeper daily. - Estimated amount of accumulated buildings waste is about 120 m. -Number of participants: 66,000 housing units 20000 Shops.
Fayoum center	22	20	27	11	80	Irregular sweeper for the main roads.
Tamiya	32	----	17	18	66	Cemetery health Places outside the village assembly Cemetery healthy Places outside the village assembly
Sonores	18	36	11	18	77	The daily It is Used Bridge Ponds and swamps Randomly
Atsa	16	2	13	2	22	General garbage collection
Ibshway	21	14	12	5	56	General garbage collection
Siddiq Joseph	27	15	7	16	65	Garbage collection transfer to landfill

Table (5): About 8 thousand of garbage collectors in the Fayoum government in 2000.

Unit Name	Number	Brand and Model	Validity	Load (ton)
Fayoum city	5	Nasr Solar- Tipper	70%	8
	1	Efco	70%	8
	1	Ford compressor Solar	50%	4
	1	Chevrolet NBR Solar	50%	4
	2	Tata compressor Solar	50%	4
	1	Compressor Solar	50%	4
	1	Romanian tractor - Solar	65%	4
	4	Russian tractor Solar	70%	4
	7	Nasr Solar Tipper	65%	8
	2	Chevrolet NBR Solar	70%	4
Tamiya	4	Chevrolet 93 Solar	70%	6
	1	Mitsubishi Canter 2002 diesel	70%	6
	1	Tata piston 94 Solar	50%	6
	1	Isuzu 82 Solar	50%	5
	2	Nasr 125 Model 85 Solar	50%	5
	1	Belarus Tractor 93 Solar	50%	----
	1	Tractor Loader 94 Solar	60%	-----
	1	Tractor Loader 2001 Sula	65%	-----
	1	Tractor Loader 94 Solar	70%	-----
	1	Romanian tractor trailer 2002 Solar	70%	-----
	1	Bulldozer Jweser 79 Solar	65%	-----
	1	Backhoe loader 65 j op 1	65%	-----
	1	2003 Mitsubishi ride	70%	----
	1	Greider Katrppler 79 Solar	50%	------
	1	87 Solar Tractor victory	70%	------
	1	Belarus Tractor 94 Solar	70%	-------
Sonores	3	Bedford tipper 93	70%	3
	1	Tata tipper 97	70%	3
	1	Bedford tipper 93	80%	3
	2	Mitsubishi inverter 2000	80%	3
	1	Belarus tractor 99 afforestation	75%	-----

	1	Tractor Belarus 94	60%	------
	2	Trailer Nzalh developer	Valid	-----
	1	Romanian tractor 2001	80%	-----
	1	GreiderKatrppler 89	60%	-----
	1	Backhoe Caterpillar	95%	-----
Atsa	2	Russian tractor	Valid	-------
	3	Romanian tractor	Valid	-------
	1	Nsser tractor	Valid	------
	1	Romanian tractor	Broken	--------
	1	Belarus tractor	Valid	-------
	5	Katrppler 120 J Greider	Valid	------
	4	Chevrolet Solar	Valid	2.5
Ibshway	4	Chevrolet (1/2) Transfer flip-flop	Broken	5
	1	Tata equipped with a flip-flop	Broken	5
	1	Ford equipped with Hydraulic	Valid	10
	1	Nasr flip-flop	Broken	10
	1	Ford Ventas to spray	Broken	10
	1	Greider Katrppler	Broken	----------
	1	Backhoe loader	Broken	---------
	5	tractor	Broken	6
	1	Flip Flop Anturnash	Broken	10
Siddiq Joseph	1	Chevrolet 99 Solar	Valid	3
	1	Greider Solar	Valid	-------
	1	Sweeping tractor Solar	Valid	----------
	1	Sweeping trailer	Valid	----------
	1	Fontas Nasr Solar	Broken	3-5
	1	Tractor trailer	Broken	2
	1	Romanian tractor	Broken	----------

2.2.3 .6 The current situation in Fayoum governorate

The table below shows the Summary of Waste Management System in Fayoum Governorate and the weaknesses in the current system.

Table (6): The current situation in Fayoum Governorate.

Statement	The current situation	Weakness points
Insufficient capacity of the collection system	Accumulation of garbage in front of Houses and dumping Streets and configure Dumps open in center Urbanism	Lack of financial resources needed for safe disposal.
No separation at the origin	• Large accumulation of trash in the front of homes, streets, and open dumps. • Lack of cooperation of citizens	• Lack of governmental support. • Lack of funding needed for equipment maintenance. • Lack of separation facilities.
Not sufficient recycling plants	No full advantage of the solid waste. Speed fullness to Litter bins and waste landfill.	• Lack of funding sources for the establishment of recycling plants. • No participation of the private sector.

The SWM in Fayoum appears to be inadequate and there is urgent need to upgrade. The solid waste has to be disposed off scientifically through a sanitary landfill and a recyclable portion of the waste should be salvaged. Segregation of recyclable material would also lead to a reduction in the quantity of solid waste for final disposal. [REF (1-2-5)]

2.2.3 .7 The proposed methodology to improve municipal SWM in Fayoum Governorate

Tables (7): Targets and how to achieve them.

Targets	How to achieve them?
Establishment of centralized SWM plants.	• Issue laws and supporting decisions for the SWM system. • Provide the funding for the new plants. • Establishment of the infrastructure.
Participation of the private sector in waste investment.	• Bidding in that regard.
Expansion of recycling plants.	• Modernization of the existing recycling plants. • Establishment of new plants.
Expansion of landfills.	• Rehabilitation and expansion of the existing landfill area. • Create new landfills sites.
Developing all the equipment used in the collection transportation, sorting, and treatment systems.	• Direct foreign grants to equipment maintenance.

2.3 Production of fuel from plastic waste

Without a doubt, untreated solid wastes frequently contain components that have the potential to cause infectious diseases. Greater efforts need to be made to segregate wastes at source, to sort them, and in particular, to establish and expand newly treatment and recovery facilities.

The most common option for waste recycling is the production of the same original material, for example, the production of papers from the waste paper that has been separated and the plastic products from the plastic waste that has been separated. However, the facts that cannot be denied are the resulting products that are of lower quality than the original materials. A different option is the production of fuel from plastic waste and the production of biogas from food oil. Energy recovery from plastic waste does not only mean to save natural resources but to replace petroleum materials. Plastic waste represents 6% of the total waste produced annually (2005-

2006), only 30% is recycled and 5% is reused and the remaining is buried. [REF. (11-8)]

2.3.1 Obstacles of plastic recycling in Egypt [REF .8]

1. The difficulty of extracting licenses to set up a recycling plant.
2. Washing and sorting technology needed to produce high-quality products is not available.
3. Lack of standard specifications for judging the recycling process.

Table (8): Polymers and Their Application and Life Span

Polymer	Applications used	Life span (Year)
High Density Polyethylene (HDPE)	Packaging films, bottles, tubs, cups, lids	2
	Reservoirs, soda water boxes, cables insulation, pipes, gasoline tanks, shipping containers, seats	30
Low Density polyethylene (LDPE)	Packaging film, installation ribbons, bags, sacks, lids, games	2
	Lining, flexible containers, tubes	5
	Irrigation pipes	20
Polyester (PET)	Flamme food packaging, cassette tapes, water bottling, mineral oils	5
	Fiber, ropes, vehicle tires, carpets	10
Polypropylene (PP)	Yogurt and jam cans, confectionery wrappers, packaging films, bottles and lids	5
	Car battery	+15
	Electrical components, carpet	5
Polystyrene (PS)	Packaging applications, containers of dairy products, dishes and doors	5
	Electrical applications, cassette tapes	10
Polyvinyl chloride (PVC)	Doors and window frames, water pipes and fittings	50
	Construction components and facades of buildings	50
	Flooring, wires and cables	50
	Medical tubes, bags, shoes, adhesive tapes	5

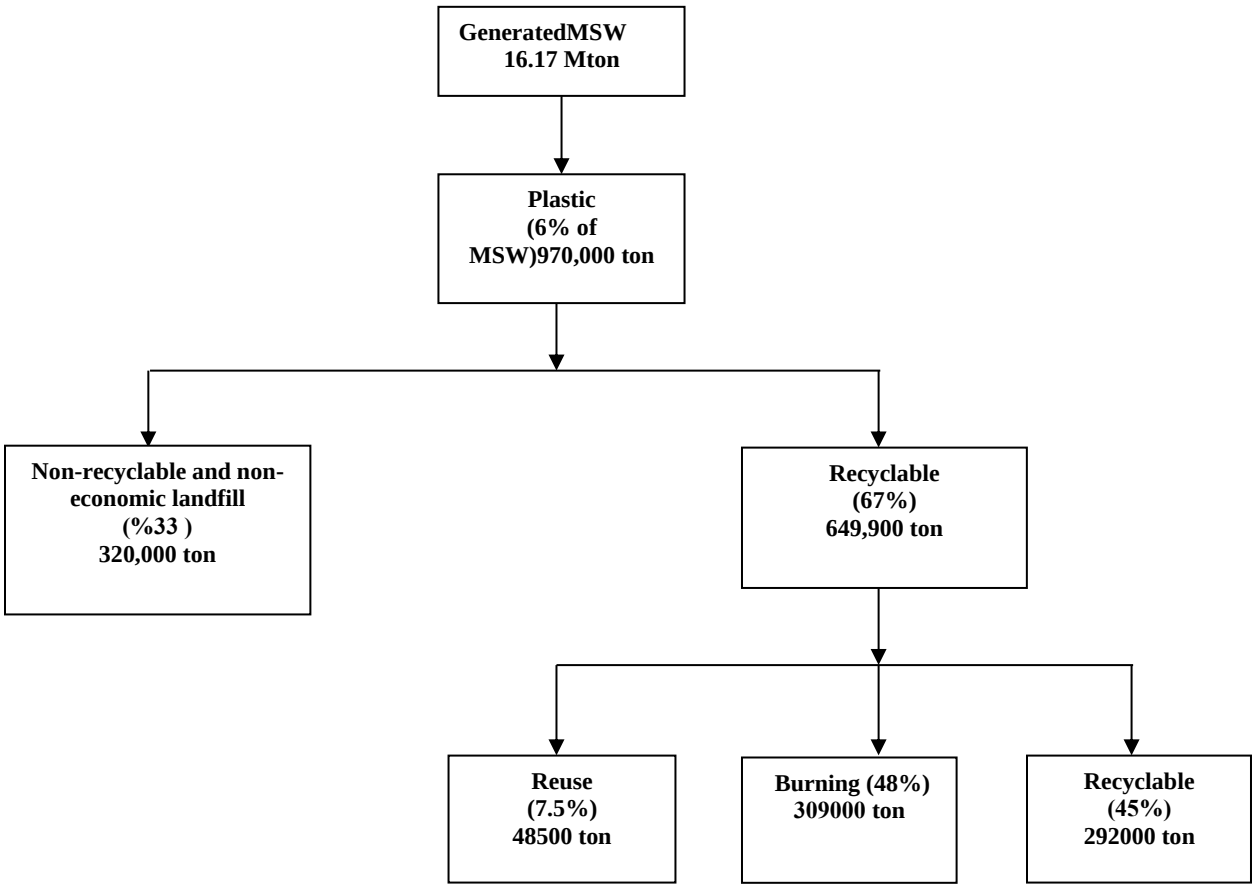

Fig. (4): Plastic waste cycle in Egypt. [REF. 8]

2.3.2 Economic Analysis of The Plastic Recycling Sector

Table (9): Plastic waste market prices (pounds/ kg) during various processing stages in Egypt (2006).

Polymer type	Scavengers	Retailer	Hacking	washing	Formation	Article price rate Initial	Price compared to Article Initial
Polyethylene poly Tervthalat	1500	1800	2400	3200	--	1400	22.9%
Polypropylene	1700	1900	2500	3300	4000	10500	38%
High-poly ethylene Density injection	1500	1700	2300	2700	3600	8000	45%
High-poly ethylene Density inflatable	1600	1800	2400	2800	3800	8000	47.5%
Poly Styrene	1500	1700	2200	2500	3200	8000	40|%
PVC	1800	2000	2200	2500	3200	7500	42.6%
Polyethylene low Density films	1800	2200	2600	3200	4000	9500	42.1%

Factors affecting prices of recycled plastic:

1. Prices of raw materials which are determined by the price of oil.
2. Seasonal demand on the final product.
3. Relative strength of the local economy.
4. Government policies relating to trade, including import restrictions.

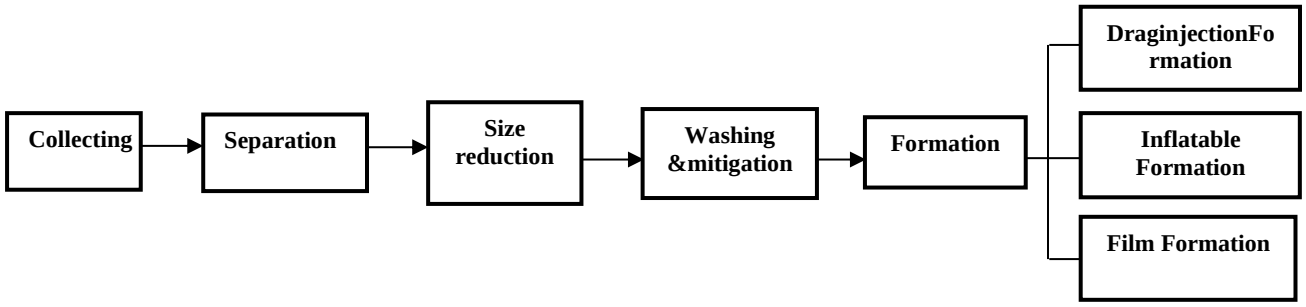

Fig. (5): Schematic flow diagram of plastic recycling in Egypt

The quality of final recycled products depends on removing all impurities from plastic waste, accessing to the slightest degree of moisture for plastic waste, and separating of different types of plastic as much as possible.

There are three methods used to plastics recycling globally: mechanical recycling, recycling feedstock polymerization, and recycling to access energy.

2.3.3 Mechanical recycling [REF.8]

Most polymers are affected by many factors that affect their properties, during use such as temperature, UV, oxygen, and ozone, this leads to a gradual deterioration in the length of the polymer chain and also leads to molecular oxidation of the polymer chains. Therefore, recycled polymers have fewer properties than raw materials.

Plastic recycling contains a number of processing stages:

1. Separation of plastics by type of material.
2. Washing to remove dirt and contaminants.
3. Crackling and cutting of plastics to reduce the waste volume.
4. Recapitalization of new products.

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2.3.3.1 Recycling feedstock polymerization.

1. **Polymeric recovery of polymers**

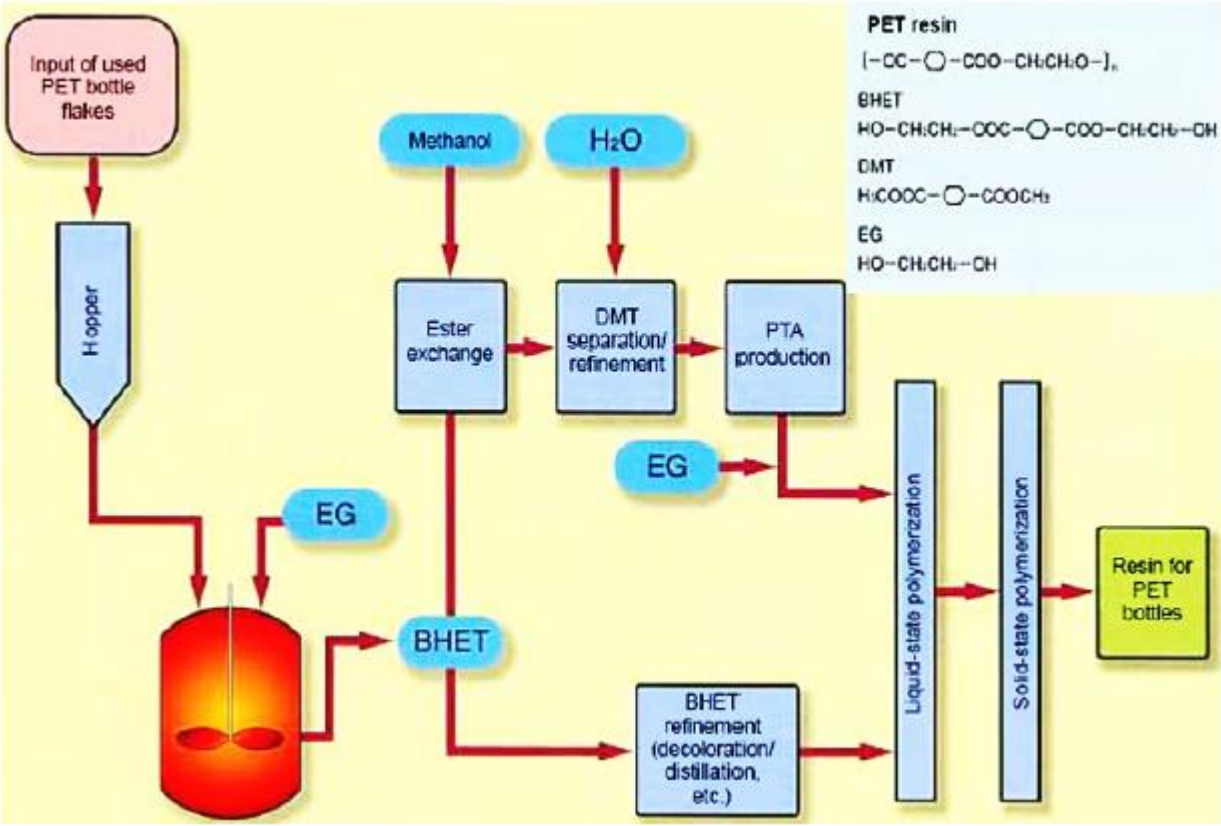

Fig. (6): Converting polyethylene phthalate to monomers [REF .8]

2. Recycling in the steel industry

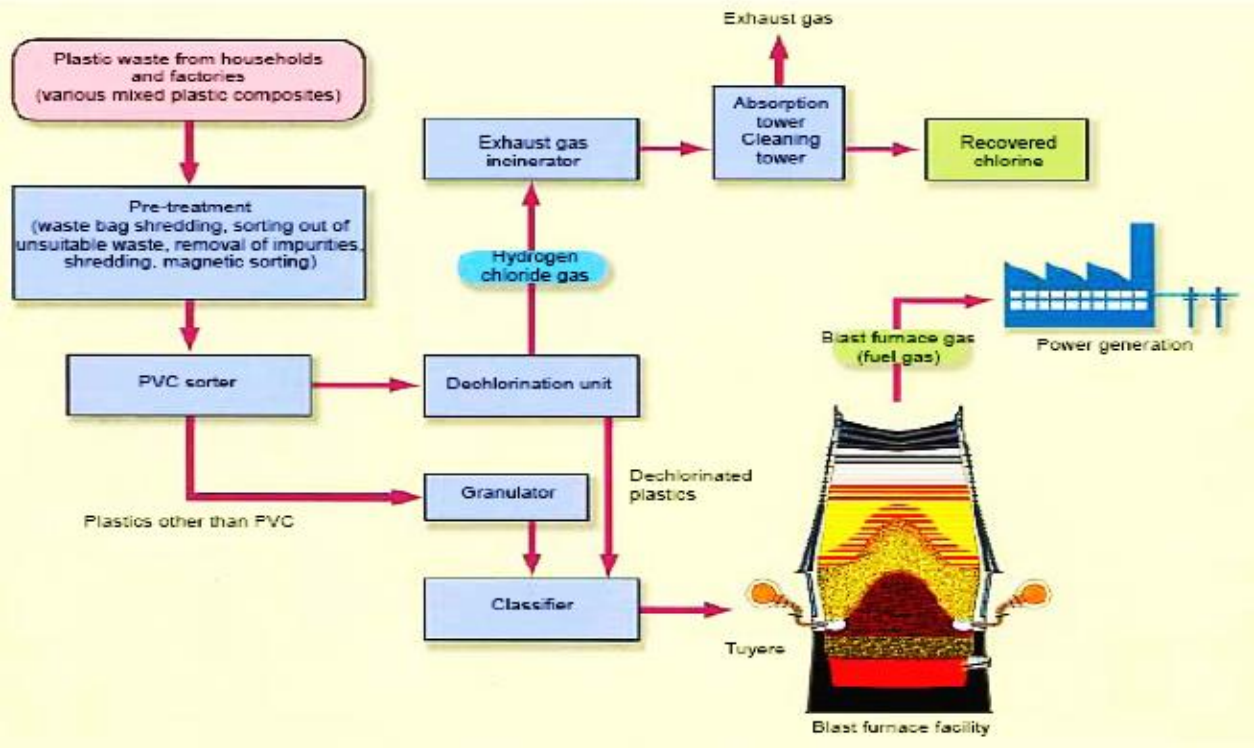

Fig. (7): Using of plastic waste as a reducing agent in the steel mills [REF .8]

3. Recycling in coke oven

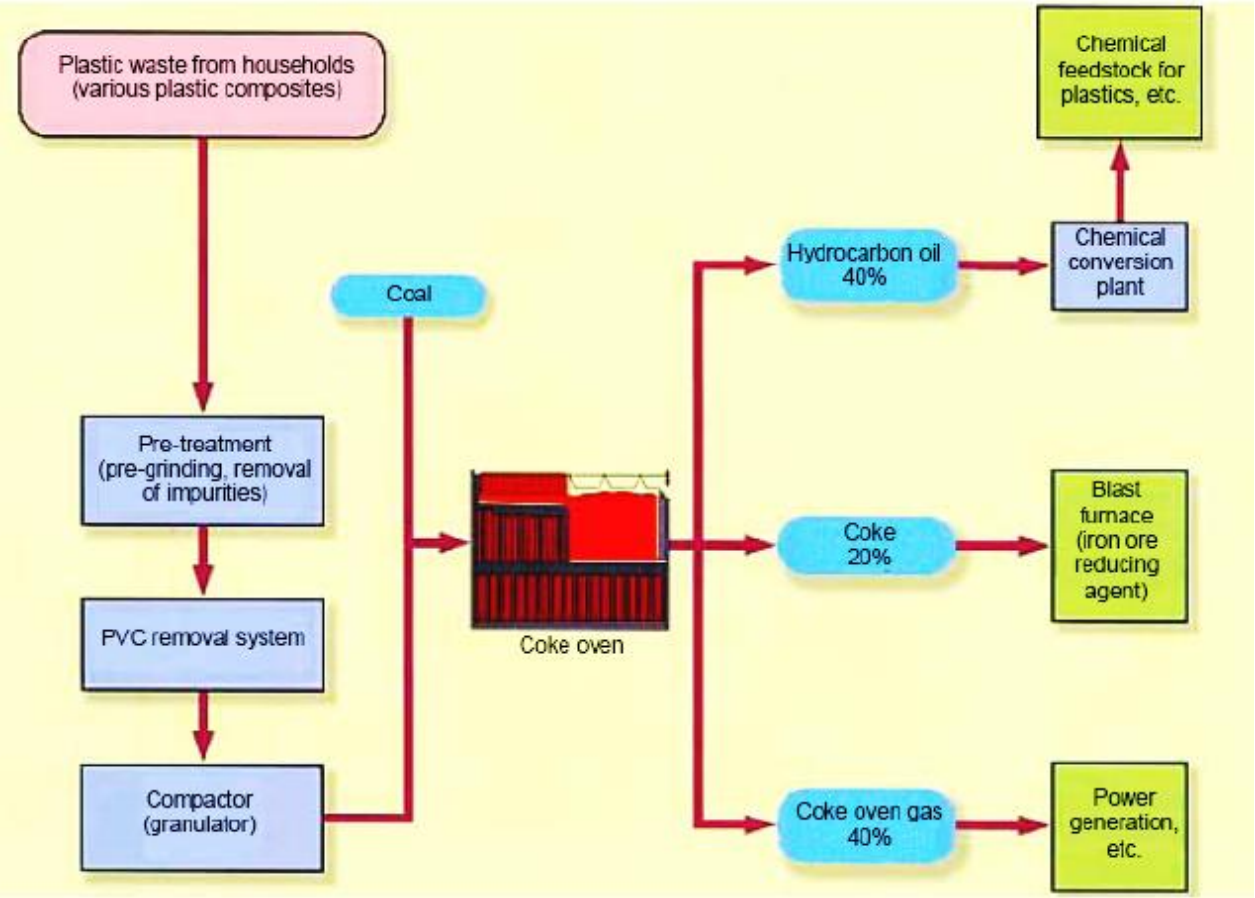

Figure (8): Using of plastic waste as a reducing agent in coke industry [REF. 8].

4. Conversion to gas

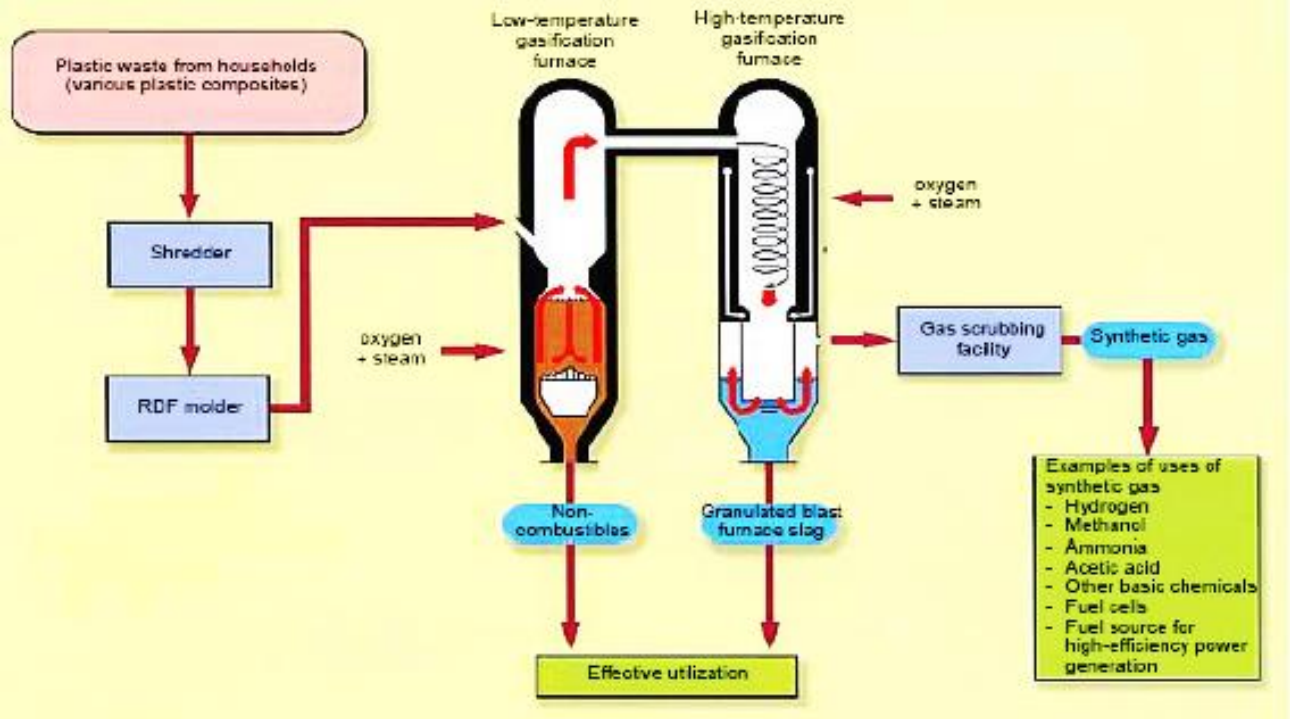

Fig. (9): Conversion to gas [REF.8]

5. Energy Recovery

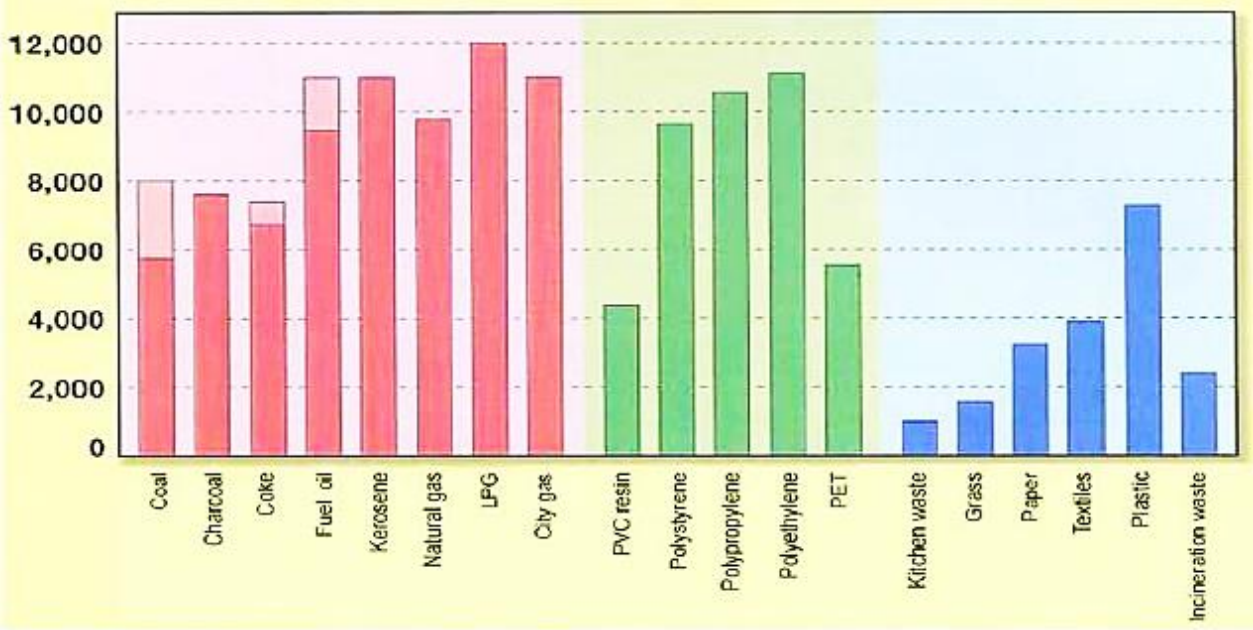

Fig. (10): Amount of energy generated in (Megawatt) by the combustion of various materials [REF.8]

Plastic of high calorific value can be used as fuel; it has twice the thermal value of paper waste. Polyethylene is the most plastic type that has a thermal value equal to that of oil. Plastic is made from oil, however, it is possible to reverse the process using a thermal decomposition and a catalyst to reduce the heat used.

3. Conclusion

At present, attention should be paid to the waste issue because it is considered one of the most serious environmental issues. Until now, the maximum waste utilization and the integrated management are not achieved; this may be due to the lack of knowledge of the waste specifications. Therefore, a waste science must be

establishment to achieve maximum benefit. The science will include clarification of the scientific concepts of wastes and their classification, and the implementation of the integrated waste management system will be proper.

Solid waste management system in Fayoum governorate was studied as a case study. Conversion of plastic waste to valuable products also was proposed.

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