RECYCLING OF MUNICIPAL SOLID WASTE IN THE STATE OF KUWAIT

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الخلاصـة :

تقع دولة الكويت في الطرف الشمالي الغربي للخليج العربي، وتبلغ مساحتها حوالي ١٨,٠٠٠ كيلومتر مربع وتعداد سكانها مليونان بمعدل زيادة سكانية حوالي ٤,٧٪ . وتقدر كمية النفايات الصلبة الكلية المتولّدة سنوياً بأربعة مليون طن ، منها مليون طن وهو ما يعادل ٢٥٪ بالوزن من تلك الكمية ناتج عن نفايات منزلية صلبة تتولد عن المناطق السكانية والتجارية، حيث يصل معدل تولد النفاية المنزلية الصلبة للفرد بـ ١,٧ كيلوجرام / اليوم، ونسب مكونات النفاية المنزلية بالوزن تبيّن أن بقايا الأطعمة حوالي ٥١,١٪، والورق والكرتون ١٨,٦٪، والأخشاب ٥٪، والبلاستيك ١٣,٤٪، والزجاج ٤,٥٪، والمعادن ٥٪، ومكوِّنات أخرى ٢,٤٪. وتبلغ نسبة الرطوبة بالنفاية ما بين ٤٠ - ٥٠٪ بالوزن، والكثافة لها ٥٩٠ كيلوجرام / المتر المكعب. وتُعتبر طريقة ردم النفاية هي الأكثر استخداماً للتخلص منها على الرغم من قلة المساحة والموارد . من هنا بدأ التفكير الجدِّي في إيجاد طرق بديلة منها تدوير نفايات الورق والزجاج والبلاستيك والمعادن..الخ.

ويبين البحث شرح مواصفات ومعدلات تولُّد النفاية المنزلية والتجارية وخبرة الكويت في مجال تدوير الورق، والزجاج، والبلاستيك، والمعادن، والسكراب، والبطاريات، والزيوت المستهلكة.

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ABSTRACT

The State of Kuwait is located at the northwestern (NW) corner of the Arabian Gulf and occupies an area of about 18 000 km^2 with a population of over 2 million and an annual growth rate of 4.7%. The amounts and composition of solid waste generated usually change from country to country and from one residential area to another. Currently, the total quantities of different solid wastes generated in the State of Kuwait are estimated at more than 4 million tons. About 1 million tons per year (representing 25% of the total) are household solid wastes (HHSW) generated in the residential areas, with a per capita rate of about 1.7 kg/day. The average of typical composition (% by weight) consisted of 51.1% food, 18.6% paper and cardboard, 5% wood, 13.4% plastics, 4.5% glass, 5% metals, and 2.4% others. Moisture content was estimated at about 40–45% by weight and the average density of such wastes is 590 kg/m^3. The main disposal system commonly practiced in Kuwait is dumping sites. Kuwait has limited land and resources; it needs to find more effective methods for disposing of its waste. The conventional method includes recycling of different ingredient, paper, metals, glasses, plastics, *etc*. This study aims at explaining the composition of generation rates of HHSW and commercial solid waste (CSW) in the State of Kuwait and information about the experience of Kuwait in the field of recycling of paper, glass, plastics, metals and scraps, used oil, and batteries, *etc*.

Keywords: Recycling; Recovery; Reclamation; Management; Segregation; Solid Waste.

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1. INTRODUCTION

The State of Kuwait is located at the northwestern (NW) corner of the Arabian Gulf and occupies an area of about 18 000 km^2 with a population of over 2 million and an annual growth rate of 4.7%. The amounts and composition of solid waste generated usually change from country to country and from one residential area to another. It depends on many factors, such as eating and cooking habits, and constantly rises as a result of the natural growth of the population and increasing living standards. Solid waste includes all types of waste produced by various domestic wastes, commercial waste, industrial, and agricultural wastes. Household solid waste (HHSW) is the remains of food basically from animal or plants such as grease, fats, bones, skin, meat, vegetables, fruits, grains, *etc.* It also includes papers, textiles, glass, and empty refreshment cans. HHSW also include restaurant and hotel wastes. The cities and the different population areas are the sources of this waste, where there are a lot of restaurants and hotels [1]. Commercial solid waste includes paper, cartons, wood, tires, used oils, used furniture, and electronic appliances such as refrigerators and heaters, *etc.* The sources of commercial wastes are stores, commercial malls, markets, and governmental and private organizations.

The total quantities of the solid waste generated in the State of Kuwait are estimated in the year 2000 at over 4 million tons. Currently, about 1 million tons per year (representing 25% of the total) are HHSW, generated in the residential areas, with a per capita rate of about 1.7 kg/day. The average typical composition (% by weight) consisted of 51.1% food, 18.6% paper and cardboard, 5% wood, 13.4% plastics, 4.5% glass, 5% metals, and 2.4% others [2]. Moisture content was estimated at about 40–45% by weight and the average density of such wastes is 590 kg/m^3. Inhabited areas in Kuwait were divided into six main collection districts. Each district is further subdivided into cleansing areas each with a cleansing center. Cleaning companies do the collection of wastes from different areas of the country without doing any preliminary sorting of the composition of the waste at the source. Plastic bags are widely used for handling HHSW [3]. The main disposal system commonly used in Kuwait is dumping sites. Kuwait currently has over 19 active and old closed solid waste landfills and dumpsites, which occupy many areas [3]. Kuwait has limited land and resources; it needs to find more effective system for disposing of its waste. Nowadays, the old magazines and newspapers are sorted out and put into special containers. Used oils and fats are being collected in special tanks located on each landfill for reprocessing. The Kuwait Municipality (KM) contracted with one of the national companies to establish and run a center for collecting and cutting metals and scrap cars. Also a factory for producing compost has been established.

2. OBJECTIVES

This study aims at explaining the composition and generation rates of HHSW and CSW and to highlight the experience of the State of Kuwait in the field of recovery and recycling of solid wastes.

3. RECYCLING

In the field of waste management, a great number of waste treatment processes and systems are available today. The conventional methods include recycling of different ingredient (metals, glasses, plastics, *etc.*), incineration, composting, and landfill. Landfill is the most widely used method for dumping disposal. It has a major impact on air, soil, and both surface and groundwater. Also, disposal of waste by incineration becomes feasible when land of landfills is not available and the environmental problem associated includes air pollution and the ashes residue. Composting is biological decomposition of solid organic materials by bacteria and other organisms into a fertilizer. Composting may fail due to economic and technical reasons [4].

Recycling and resource recoveries are a very important practice for the management of renewable and non-renewable resources and are simply of reusing waste in a beneficial manner [5]. Recycling, by definition, is the process of utilizing raw waste as a source of raw material and reusing them in industry, *e.g.* the paper industry, or to produce different products, *e.g.* slaughterhouse waste to produce proteins, leather, and fats, *etc.* [4]. The economic and environmental feasibility of the waste recycling process depends on the process of marketing products resulting from the recycling process, and also on the quantity generated annually of the various recyclable wastes, which depends mainly on the percentage of waste components and separation methods used.

In Kuwait, the recycling process depends on the private sector without any contribution or support from the governmental sector. Furthermore, collection or separation processes of the various types of wastes being recycled depends on the efforts of these companies. Some of these companies place special containers for the components desired to be obtained, such as newspapers, magazines, glass containers, or place compressors for carton paper near sources of their accumulation. The companies operating in the field of waste recycling obtain the required quantities of wastes by purchasing them from the individuals or companies operating in the field of waste collection and separation. We will highlight the companies operating in this field and illustrate the type and total quantities of solid and semi-solid wastes generated and recycled in the State of Kuwait.

3.1. Glass

The process of recycling this kind of waste or using it is considered as the best environmental method of disposal. Glass wastes can be collected un-separated or separated according to the different colors, which are green, brown, and clear. White glass wastes, which are considered the most important, can be used in many uses or products including: production of many types of bottles; windows; electric bulbs; fiberglass; reinforced glass; and production of sandpaper [6]. Crushed glass wastes can be used in the production of glass bricks and in the process of paving roads, after mixing them with asphalt [7].

The State of Kuwait has one company that is considered one of the biggest glass factories in the Gulf area. It was established in 1982 to produce various glass containers with a production capacity of 40 000 tons/year. The company can recycle a quantity of glass wastes estimated at 6000 tons/year. The company gathers glass wastes in containers posted at several public locations or buys the gathered quantities from several individuals or companies operating in the field of waste collection. The total quantities of waste glasses generated in Kuwait by the year 2000 are about 40 000 tons. The recyclable quantity is estimated at 5000 tons/year, *i.e.* with a recycling percentage of 13% of the total generated quantity.

3.2. Paper

There are various types of waste paper such as newspapers, magazines, computer papers, cardboard and corrugated cardboard, and wrapping papers, *etc.* The continuous increase of waste paper produced by the packaging industry makes it a very essential item on the recycled materials list [6]. Paper wastes are generally used in the production of various types of wrapping papers, types of insulating materials, and are used in some countries as fuel, *etc.* [7].

In Kuwait, there is a big company that was established in 1979 with a production capacity of 45 000 tons/year. The company can recycle a quantity of paper wastes estimated at 30 000 tons/year. Nevertheless, the company can collect this quantity from the local market. The quantity of paper wastes collected by the company from the local market, and recycled, is estimated at 20 000 tons/year. The company obtains paper wastes from the companies operating in the cleaning field. These companies place special containers and compressors to collect paper and cardboard from the areas and complexes considered as main sources. In the year 2000, the quantity of waste paper generated in Kuwait was estimated at 320 000 tons. The recycled quantity amounted to 50 000 tons/year, *i.e.* with an annual recycling percentage of 16%.

3.3. Plastic

Plastics are currently considered the basic material in the majority of industries due to their low prices and easy production compared to the various other metals. Plastic wastes are classified, with regard to the extent of recycling and reusing them, into various types including thermoplastics, which are characterized by the possibility of recycling and using them for more than one time, including polyethylene teraphthalate (PET), high-density polyethylene (HDPE), low-density polyethylene (LDPE), polypropylene (PP), and polyvinyl chloride (PVC).

Hard plastic waste, which is not reused more than once, includes reinforced plastic wastes and Melamine which is used in the production of electric appliances. Mixed plastics, which are mixtures of various kinds of plastic wastes, are difficult to separate into their original components [3]. It is possible to recycle them for production of types of wooden plastics, garbage boxes, water tanks, and some plastic parts of the cars *etc.* In addition to the previous uses, plastic wastes may be treated by distillation for production of some types of fuel oils [7].

In Kuwait the quantity of plastic wastes generated in the year 2000 is about 150 000 tons. Currently, there are no companies operating in the field of plastic recycling, except some companies operating in the field of plastic production. These companies are recycling a small quantity of their wastes inside the factory and other companies collect, separate, and export the waste, while plastic wastes in HHSW are not processed.

3.4. Textile

Various types of fibers are used in textile production, including natural fibers such as cotton and wool, and also including artificial fibers such as nylon, polyester, triline, and acrylic. Worn out clothes and textiles are separated as per type of fabrics used in their production. Cotton textiles, after cutting and re-weaving, can be made into material used in the production of wipers, car carpets, and covers, or reused as stuffing materials for some seats [7, 8].

In Kuwait the quantity of textile wastes generated in the year 2000 was about 65 000 tons. Some ready-made wares factories collect small quantities of their waste fabric pieces, which are not suitable for usage, and export them. Currently, there are no specialized companies operating in the field of recycling textile wastes, but there are some societies that collect suitable old clothes and send them outside Kuwait to other countries.

3.5. Wood

Wood wastes are considered among the large volume wastes, like used tires wastes, which occupy a much space in the municipal dumpsites. Wood wastes are generated from packaging, wooden boxes and bases, *etc.* Disposal of them by burial is considered as a loss of energy and natural resources. It is possible to use the wastes in the production of cardboard or compressed wood, as fuel, or in the production of certain kinds of gases for generating thermal energy [7, 9].

The quantity of wood generated in Kuwait in the year 2000 was about 70 000 tons. However, there is no company that operates in the field of wood waste recovery. Small quantities of wooden wastes are used, after being cut and crushed, as a cover material for the ground beds of birds and animals barns. Some quantities are reused and the rest are disposed of at municipal sites.

3.6. Organic Materials

The process of composting the organic materials in HHSW into organic compost is considered as one of the most significant methods of using these components. It is a process of biological decomposition of the organic material with complicated composition, through microbial enzymes under aerobic conditions and under comparatively high temperatures for the process of producing humus or compost [8]. The quality of organic fertilizer depends on the type and percentage of organic content in the waste.

Kuwait has had previous experiences in the production of organic fertilizers from the wastes since the 80s. KM built a factory for organic fertilizer at a production capacity 100 tons/day. Nevertheless, the experiment encountered many problems, which led to shut down of the factory. Another company is established at a recycling capacity 1000 tons/day of household wastes but that company also was closed at 1990. Currently KM prepared tenders for two composting plants to process wastes with total capacity at the beginning of 1500 tons/year.

3.7. Slaughterhouses

Slaughterhouse wastes may be used for many purposes including production of protein which can be used in poultry and animal fodder and production of animal fats used in the production of soap and some cosmetics [8]. Leather and wool wastes, after dyeing, may be used for production of various leather and wool products. Intestine wastes may be used in the production of foodstuff and medical threads, tennis rackets threads, and musical instrument strings, and in the preparation of organic fertilizer. Bone wastes serve in the production of glue and some dyes [3].

In Kuwait, the total quantity of wastes resulting from the slaughterhouses in the year 2000 were about 35 000 tons. There are some companies operating in the field of recycling and reclamation of slaughterhouse wastes in Kuwait. One of these companies recycles 5000 tons/year of slaughterhouse wastes and manufactures them into fodder concentrates, which are added to the animal fodder mixture. It also extracts animal fats for export. There is also another company for

leather dyeing, which recycles 8000 tons/year (2000 leather/year) for the production of leather and wool, which are all exported. There are some companies operating in the field of treating intestines by salting and exporting. The total quantity recycled is estimated at 15 000 tons/year.

3.8. Metals and Scraps

Iron wastes are considered the most recycled metal waste on the international scale. The largest percentage of remanufactured steel is generated from car scraps and household-consumer and industrial appliances such as stoves, refrigerators, dryers, and various electrical appliances, *etc.* [3]. In addition to the huge quantities of scrap car, small quantities of other metal wastes are generated, such as aluminum, copper, and zinc, *etc.* Aluminum is considered as the metal next in significance with regard to recycled metals, due to the diversity of its products, such as containers, decor materials, doors and windows, *etc.* [10]. The recycling process for the remaining metals such as lead, copper, and others are secondary in significance, due to their cheap price and the low usage of them.

In Kuwait there are some companies operating in the field of reclamation and recycling of metal wastes. One of these companies produces various cast iron products at a production capacity about 5000 tons/year. The company can recycle a quantity of wastes about 4000 tons/year. Other companies are operating in the field of cutting, compressing, and exporting metals. The total quantity of metals and scrap wastes generated in the year 2000 was estimated at 75 000 tons; about 7000 tons/year were recycled, *i.e.* an annual recycling percentage of 9%. White goods mean household and industrial appliances such as stoves, refrigerators, dryers, and various electric appliances [7]. This is a type of waste, which have big volumes and occupy much space in dumpsites. Therefore, serviceable parts may be used as spare parts and unserviceable parts are treated as metal wastes and cut down for recycling. In Kuwait, there is no annual estimation for the waste; a huge percentage reaches dumpsites and the small percentage still serviceable for use is resold in some used appliance shops.

3.9. Used Oils and Lubricants

The process of disposing of used oil involves environmental impacts, with its danger extending to public health, through its effects on the basic environmental elements, air, water, and soil [11]. Therefore, all countries are concerned to follow environmental methods for disposal of used oils by recycling and reusing them, to limit environmental pollution, reduce costs of importing crude oils, and to conserve natural resources and reduce energy consumption [12]. Automobile gearbox oils are considered the main percentage of used oils, followed by used oils generated from the various industrial activities. The reclamation process for oils, after clearing them of residues and suspended agents, *etc.*, is considered one of the best methods. The process of changing automobile oils is considered the main source for the used oils generated in Kuwait, representing about 80% of the total quantity generated annually.

Kuwait has a major company, established in 1985, with a production capacity of 15 000 tons/year of the various types of oils. The company collects used oil by putting special containers at the various consumption areas such as car wash stations and oil replacement shops, and at municipal dumpsites. The quantity of used oils generated in the year 2000 is estimated at 65 000 tons and the quantity recycled is estimated at 25 000 tons/year, *i.e.* an annual recycling percentage of 38%.

3.10. Used Batteries

There are two types of batteries, which may be recycled and used, lead–acid car batteries and household batteries such as alkaline, mercury, silver, and nickel batteries [3]. In industrial countries, car repair shops as well as shops selling and replacing batteries also collect used batteries in temporary collection sites. Batteries are transferred from these sites to the recycling factories to extract lead, sulfuric acid, and PVC. The process of recycling used batteries depends to a large extent on the price of lead metal in the local markets. A drop in its price will reduce the significance of the recycling process economically [7]. It is noted that the above batteries contain the majority of heavy metals such as mercury, silver, lead, cadmium, nickel, zinc, copper and antimony which are environmentally polluting elements if these batteries are disposed of at municipal dumpsites. Not all household batteries are fit for recycling, but elemental mercury and silver are extracted from the types of batteries containing them.

The quantity of used car batteries generated in Kuwait in the year 2000 is about 9000 tons (about 600 000 batteries). This number of batteries contains around 4000 tons of lead scrap. In Kuwait at present, there are no companies operating in the field of recycling used batteries, except some individuals working in the field of collecting and exporting them outside Kuwait according to the Basel Convention On The Control Of Transboundary Movements Of Hazardous Wastes And Their Disposal [13].

3.11. Tires

Used tires are wastes, which have a big volume and their physical characteristics make them difficult to store. Whole waste tires are bulky and rigid; consequently they cannot be easily compressed or packed together and require large volumes of space when stored or dumped in burial sites. Further, due to their elastic rubber nature, burial equipment used at the sites cannot compress them or reduce their volume, and it is preferred to cut them before dumping [3]. Many countries separate tires from the municipal wastes and collect them in a special pile, although this pile may be a source of fires, harmful insects, and rodents. Waste tires can be used as insulation material and in the series distillation process to extract types of fuel oils used as fuel [10]. In this method, in addition to extracting fuel oil, steel and carbon are extracted from used tires. Crushed tires may be used for production of a special type of rubber asphalt to the road surface, thus reducing the noise and the occurrence of fractures on the surface. Recycling of waste tire by retreating or recapping changes them into serviceable tires.

In Kuwait there are two companies operating in the field of tire retreating and recapping. The total quantity of waste tires generated in the year 2000 is estimated at 30 000 tons (about 2 million tires/year) of various sizes. A quantity of about 500 tons/year (12 000 tire/year) will be recycled, *i.e.* a recycling percentage of about 2%. Used tires may serve as windshields or as a protection means for some ports, boats, and small ships. Using tires after recapping on metal pipelines extending for long distances protects them.

4. CONCLUSIONS AND RECOMMENDATIONS

From this study, we find an absence of a clear and defined policy for encouraging and supporting companies already operating in the field of solid waste recycling or companies operating in the field of collecting and separating of waste components. This situation does not encourage the current companies to reinforce and expand their production capacity, nor does it attract the private sector to invest and expand the formation of new companies. We hope that a policy with clear and defined goals will be laid down, depending on:

- providing good support to encourage individuals and companies operating in the field of recycling;
- the government granting the companies operating in the field of waste collection, separation or recycling, first priority with regard to facilities, in addition to imposing customs protection and assisting them to market their products locally;
- giving those companies priority in purchasing products of these companies by government institutions;
- adopting a policy depending on using good separation systems for waste components, which will assist companies operating in the recycling field.

With this approach, the companies will support their abilities and expand their production capacity, or attract the private sector to invest and expand formation of new companies.

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Invited Paper Received 10 April 2001.