



ESTIMATION OF POLYVINYLCHLORIDE (PVC) IN HOUSEHOLD SOLID WASTE AT TRIPOLI-LIBYA: A CASE STUDY

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ABSTRACT

Population and economic growth usually lead to the increase of solid household waste volume in addition to great changes in quality and specifications of materials, and tremendous increase in some contents particularly plastic waste. Polyvinyl chloride (PVC) is one of the most widely used plastic materials, which accumulate in landfill after end-life uses. Solid waste management has drawn special attention to this material because it contains varied types and quantities of additives. PVC and its additives display potential detrimental impact on the environment and human health as moved gradually from production and service life to disposal (buried and incinerated). PVC waste is expected to rise due to increased application in several areas such as construction, demolition waste and household waste. In this work, field work survey and statistical study were carried out to estimate the percentage of total plastic and PVC in particular, in solid household waste in the city of Tripoli-Libya. To determine the main sample size, a random sample contained 34 portions was taken in one day from studied area. The main samples were collected for successive 6 days (85 portions). Sorting of plastic and PVC waste were performed on the bases of the information collected from plastic factories and by using fourier-transform infrared spectroscopic analysis. The results concluded that the weight percentages of plastic waste and PVC were about 10.52% and 1.36%, respectively. The percentage of PVC from plastic waste only was 12.94%. The calculated weight of plastic waste from the study area was 36.78 ton/day containing 4.70 ton/day PVC. The overall quantity of household solid waste in Tripoli was 550 ton/day collected in two sites, which generates 57.80 tons plastic waste that include 7.48 ton PVC.

Key words: Plastic waste, Polyvinylchloride, PVC, Municipal solid waste.

INTRODUCTION

Waste in general, is an inevitable byproduct of all human development and culture activities, and is directly proportional to the consumption of resources. The root of waste problem is the culture of consumption and is directly proportional to the affluence of human societies. The waste finally finds the way to final disposal and/or accumulated in landfills.

Municipal solid waste (MSW) landfills receive a large variety of materials generated by industry, household, agriculture and other streams^{1,2}. Cities have become major centers of consumption and waste generation all over the world. Cities use some 755 of the world resources and release a similar proportion of waste. Waste generated by the traditional societies was little and simple, mostly containing natural and organic matter, while those generated by the modern technological societies are large and complex. Industrial products were composed of relatively limited number of material from natural resources. Technological advancement has created a new category of synthetic materials. Increasing complexities have occurred in the composition of solid waste ever since the technological revolution of the 20th century. Waste components that have an important influence on the composition of MSW are plastics waste². Percentage of plastics in MSW has increased tremendously during the last 50 years. The use of plastic has increased from almost non-measurable quantities in the 1940s to about 8 and 10% per year, by weight^{3,4}. The plastic waste produced from different waste streams such as solid household waste.

Population and economic growth not only lead to increase in volume of solid household waste but also to great changes in its specification and contents. There is tremendous increase in some nonbiodegradable contents, particularly plastic waste, which contain toxic additives. That has attracted great concern because most plastic materials cannot be easily decomposed in nature and hence, their safe disposal is creating extraordinary technical, health, environmental, economic, political and social problems². PVC is one of the most widely accumulated plastic materials in landfill after end-life uses. Solid waste management draw special attention to this material because it contains different types and quantities of chemical additives⁵. PVC and its additives display potential detrimental impact on the environment and human health as moved gradually from production and service life to disposal (burial and incineration)^{6,7}.

Data on PVC waste in different waste streams are of great importance for annual waste analysis. Several studies were carried out to estimate the percentage of this polymer in different waste streams⁸. Accordingly, the most important increase in future PVC waste arising can be expected in construction and demolition waste and in household waste. The amount is based on several parameters such as industrial prosperities, consumption, life span and education. In general, data on PVC accumulation in landfills in Libya are very limited and information on PVC waste arising and amounts of PVC waste being landfill is unavailable. This work has focused on the estimation of the weight percentage of PVC in household solid waste.

EXPERIMENTAL

General background on the studied society

For sampling purposes, each study area was classified on the bases of the degree of urban or rural nature. They vary from being moderately urban to high rural areas. According to daily life style, Tripoli city was selected to be the subject of this study. Tripoli is the capital of Libya and is located in the Northwest of Libya on the Mediterranean Sea. According to the official statistical survey carried in 2006, the population is 1,083,000. It is the center of small industries and trading activities.

Collection of samples

Statistical study was carried out to estimate the percentage of PVC in household solid waste at Tripoli city. The most difficult part of the study was collecting a representative sample of the study society. To perform the study, primary sources of information for the survey included the solid waste streams management and interview with personnel associated with household solid waste collection and disposal was collected. This information was essential in planning the characterization study. Basic questioner was proposed and implemented. This information involved collection points and areas, applied

facilities, daily weight of household solid waste and other relevant data. This data is utilized for collecting random sample for one day. Full details of the statistical study were reported elsewhere⁹. Field sampling at Al-Swani Factory for organic fertilizer production as a disposal site involves selecting unbiased representative loads of waste to be sampled, taking a sample weighting about 200 Kg from each load, and sorting the sample into different material categories. Each material category was then weighted and disposed or recycled.

Collection of random sample

Random sample was selected to identify several parameters such as number of real size and number of samples, which determine the study society, degree of confidence and standard deviation of results. The sample was collected in one day, weighted and the plastic materials were sorted manually. The plastic waste was then weighted and characterized.

Collection of main samples

Main samples from solid waste at Tripoli city were taken for permanent 6 days from studying area (Tripoli city). The sampling date was carefully selected. The quantity of plastic of plastic waste from each sample was determined and the contents were identified as described previously. The collected data were statistically analyzed using SPSS software version 11.0.

Characterization of the plastic waste

Solid waste should be measured by weight because its density can vary significantly by types of waste materials. The sorted plastic from household solid waste at Tripoli was weighted initially. The plastic waste content (types of plastic) were identified on the bases of information collected from manufacturers and chemically by using Fourier-Transform Infrared Spectroscopy (FTIR Bruker Tensor 37).

RESULTS AND DISCUSSION

Solid waste from Tripoli city, in general constitute a large portion of the waste stream and this study is considered the household solid waste only. This waste stream is collected by Government and private company. The waste composition is food remains, paper plastic, metal cans and others. The major components of the waste were food and different plastic materials. The organic matters in the waste were disposed by recycling into organic fertilizer for agriculture purposes.

FTIR is a very effective technique for the analysis of different plastic materials and its additives¹⁰. It has been a classical method for identification of plastic analysis for many years. Different samples from the collected plastic were analyzed by FTIR to identify the chemical nature and then the sorting process is completed. Fig. 1 represents the FTIR spectra as an example of PVC waste and reference PVC material. It is clear that both spectra are similar and the absorption bands characterizes the present the PVC material.

According to data collection from the landfill, the total household waste collected in Tripoli city was 550 tons/day. Only 350 tons was received at the organic fertilizer plant (Al-Swani-Libya) and the rest was sent to other factory. Number of portions in the random sample taken was determined to be 34. The average weight of the portion was 200 Kg. The collected data for the random sample was analyzed statistically. The arithmetic mean of total plastic and PVC material from total solid waste are given in Table 1. It can be seen from the table that the calculated mean of total plastic is 0.112128 with standard deviation of 0.0458692 while the presence of PVC in solid waste is 0.010300 with standard deviation of 0.0071217. Furthermore,

the weight percentage of total plastic and PVC in the household solid waste were 11.21% and 1.03%, respectively.

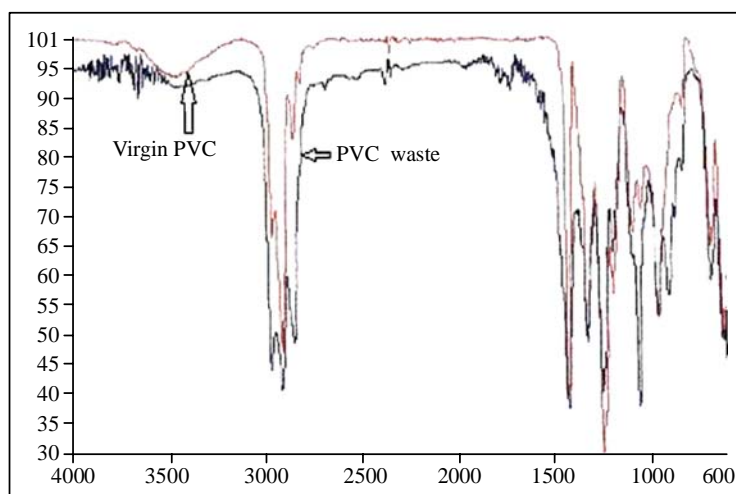


Fig. 1: Sample of the FTIR spectra of PVC waste and virgin PVC material

Table 1: The arithmetic mean and standard deviation of total plastics and PVC random samples in household solid waste at Tripoli city

Waste material	Number of portions	Arithmetic mean	Standard deviation
Total plastic	34	0.112128	0.0458692
PVC	34	0.010300	0.0071217
Other plastics	34	0.101828	0.0409415

The analyzed data obtained for the random sample showed that the number of portions needed to be taken for 6 days are between 81 and 100 at 95% accuracy. For practical reasons, the number of portions has been taken, was 85, which located between targeted number of portions and agreed with the mentioned accuracy. The calculated arithmetic mean of plastic waste, PVC and other plastic materials in household solid waste at Tripoli city, are presented in Table 2. This data elaborated that the percentage of total plastic and PVC waste were about 10.52% and 1.36%, respectively. Furthermore, the percentage of PVC waste in total plastic waste in Tripoli was 12.94%. According to National Environmental Report⁴, the percentage of total plastic in household solid waste was 7.80% in the year 2000. This indicates that the percentage has increased. The increase in the amount of plastic disposal was not because recycling dropped, but probably was due to increased generation of plastic waste, leading to greater tonnage being disposed. The polyvinylchloride waste from household includes pipes, toys, cables, furniture, agriculture, electric/electronic items and many others.

Table 2: The arithmetic, mean, and standard deviation of total plastic PVC in household solid waste at Tripoli city in the main samples

Waste material	Number of portions	Arithmetic mean	Standard deviation
Total plastic	85	0.1051857	0.03437023
PVC	85	0.0136007	0.00841520
Other plastics	85	0.0915850	0.02750468

Based on the statistical results obtained, the amount of total plastic and PVC in the collected household solid waste at Tripoli was calculated to be 57.80% ton/day and 7.84 ton/day, respectively. These huge generated quantities are accumulated in landfill and eventually lettering and harming the environment. The plastic waste needed to be collected and stored prior to disposal and recycling. Sorting of plastic waste is relatively costly process and elimination of the cost can be achieved by the inclusion of the population. The residents are responsible for sorting and collecting the plastic waste from the source. The public also has needs to be educated on how to use the environmentally friendly products when ever possible. In 2006, Maldonado¹¹ established a program for the minimization and recycling of organic matter in an academic organization in Southeast Mexico. He showed that the amount of waste sent to the final disposal site could be reduced by thirds of the quantity and at the same time created environmental awareness among the institution's members. The cost benefit was also analyzed and showed that, after a while, the program may even become profitable.

CONCLUSION

This study was carried out to estimate the percentage of polyvinylchloride in household solid waste at Tripoli-Libya. To achieve this aim, a systematic statistical study was implemented at 95% accuracy. Random sample was taken and number of representative sample portion was identified to be between 81 and 100. The general conclusions of the present work are:

- (i) The weight percent of plastic waste in the household solid waste at Tripoli was higher than that obtained in the other study.
- (ii) Total plastic in the solid waste was estimated to be 10.52% and PVC was 1.36.
- (iii) The rate of total plastic waste generated was 57.80 ton/day and PVC was 7.84 ton/day in the studied society.
- (iv) Data base needs to be established to provide information on waste generation and can be utilized in recycling of plastic materials and others.

REFERENCES

1. N. H. Mutha, M. Patel and V. Premnath, Plastic Materials Flow Analysis for India, Resources Conser. Recycl., **47**, 222-244 (2006).
2. V. Misra and S. D Pandey, Hazardous Waste, Impact on Health and Environment for Development of Better Waste Management Strategies in Future in India, Environ. Int., **31**, 417-431 (2005).
3. Environmental Protection Agency, National Waste Data Base, Municipal Waste Composition, Ireland (2001).
4. Solid Waste Management, National Environmental Report, Libya (2000).
5. K. A. Brown, M. R. Holland, R. A. Boyd, S. Thresh, H. Jones and S. M. Ogilvie, Economic Evaluation of PVC Waste Management, AEA Technol. (2000).
6. E. Plinke, N. Wenk, G. Wolff, D. Castiglione and M. Palmark, Mechanical Recycling of PVC Wastes, Study for DG XI of the European Commission, Brussels (2000).
7. I. Mersiowsky, Long-term Fate of PVC Products and their Additives in Landfills, Prog. Polym. Sci., **27**, 2227, 2277 (2002).
8. D. Braun, Recycling of PVC, Prog. Polym. Sci., **27**, 2171-2195 (2002).

9. F. M. Ghania, Masters Thesis, Department of Environmental Science and Engineering, Libya Academy of Higher Studies, Tripoli-Libya (2006).
10. D. Braun, Simple Methods for Identification of Plastics, Fourth Edition, Alden Press, Oxford, England, Chapter 7.
11. L. Maldonal, The Economics of Urban Solid Waste Reduction in Educational Institutions in Mexico: A 3-Year Experience, *Resour. Conserv. Recyc.*, **48**, 41-55 (2006).