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ResearchArticle

DEVELOPMENT of HAZARDOUS WASTE MANAGEMENT SYSTEM and ZERO WASTE STRATEGY at MERSİN UNIVERSITY, TURKEY

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ABSTRACT

In this study, the amount of hazardous wastes generated from the education and research activities of Mersin University between 2017 and 2019 years were investigated. Within the scope of zero waste strategy, actions were planned and waste management commission was established as a first step to supervise and coordinate. Considering the types and quantities of hazardous waste collected within three years, a hazardous waste management system was developed for the university, included identification, classification, transportation, storage and disposal of wastes. In addition, the results of the works implemented with the developed hazardous waste management road map were discussed.

Keywords: *Waste Management System, Waste Management in Universities, Hazardous Wastes, Hazardous Waste Management Trainings, Zero Waste*

1. INTRODUCTION

In recent years, it is observed that the consumption amount of water, energy and many other substances increased as a result of various activities of people in trade, production, education and industrial areas. This situation also cause the various wastes produced as a result of this consumption and adversely affect our environment and natural life. Therefore, waste generation should be prevented in many areas, waste production amount should be reduced where it cannot be prevented, recycling should be provided if possible, and disposed without harming the environment and living organisms. For this purpose, a waste management systems should be developed to cover all these processes.

Compared to European countries, it is observed that the rate of prevention, reduction, separation, reuse and recycling activities in waste management is low and the disposal rate is high in Turkey. This situation not only prevents the sustainable use of natural resources, but also increases the volume of landfill areas (Coutoa et al., 2013; Ferronato N. and Torretta V. 2019). However, the importance of waste management activities such as prevention, reduction, separation, temporary storage and disposal is increasing due to the fact that energy generation is not a preferred way in the management of hazardous wastes produced as a result of various activities in all sectors. Hazardous waste generation has become a problem in today's conditions as well as in universities that have laboratories in which R&D studies are carried out in many different areas besides education (Ghaffari and Talebbeydokhti, 2013; Adenirian et al., 2017; Salim et al., 2017; Lara et al. 2017).

All materials with explosive, oxidizing, corrosive, toxic, flammable and caustic properties due to their structural components are considered as hazardous wastes. Therefore, many industrial institutions and organizations operating in various fields using materials with these properties cause hazardous waste production. In universities, it is observed that hazardous wastes are generated in administrative unit offices, technical training workshops, R&D laboratories, technical services and maintenance-repair units as well as training and education activities.
As an example of hazardous wastes generated from universities;

- Chemical test residues, solutions, chemical contaminated beakers, and other contaminated laboratory equipment
- Print toner and cartridges from offices and administrative units,

- ❖ Hazardous chemical contaminated aprons, oily rags, gloves from vehicle maintenance and repair units
- ❖ Expired batteries,
- ❖ Organic solvents,
- ❖ Fluorescent lamps containing mercury,
- ❖ Remains of paint and varnish,
- ❖ Electronic wastes
- ❖ Packages contaminated with hazardous materials,
- ❖ Hardening salts containing cyanide
- ❖ Cable waste containing oil etc.

For the purpose of managing these wastes in universities, hazardous waste temporary storage areas (HWTSA) should be constructed in which hazardous wastes are stored safely according to their production amounts and then sent to recovery or disposal facilities appropriately. The process from the generation of hazardous wastes to disposal at universities should be controlled and the following works should be carried out in order to ensure waste management with an integrated system (Giles, 2010; Gallardo et al. 2016; Pourzamani et al., 2019):

- ✓ Establishment of the Waste Management Commission,
- ✓ Preparation of the Waste Management Directive, covering all the management principles of hazardous wastes generated from education, training and research activities at universities in accordance with legal regulations,
- ✓ Determination of hazardous waste generation points in universities and calculation of average monthly amounts of hazardous wastes generated,
- ✓ Identification, separation, classification and labeling of hazardous wastes in all units within the university,
- ✓ Identification responsibilities of the personnel for waste management in all units of universities within the scope of Hazardous Waste Management System and providing necessary trainings,
- ✓ Determination of the standards of transportation of hazardous wastes within the university,
- ✓ Determining the physical properties of the area where the hazardous wastes will be temporarily stored and establishing them in accordance with legal regulations,
- ✓ Preparation of the Waste Management Plan, which is mandatory under the legislation, for universities.

In this study Hazardous Waste Management System were established for Mersin University includes the identification, collection, classification, quantification and labeling of hazardous wastes produced as a result of education, training and research activities in all units of the university. This system aims to regulate all management principles of hazardous wastes generated from campus area and to raise awareness in all units of the University for minimizing waste generation within the scope of zero waste strategy.

2. MATERIAL AND METHODS

The study based on the steps of the zero waste strategy. Zero waste strategy is an understanding that includes the steps of preventing waste, reducing waste at source, preventing and minimizing waste generation (Gonen and Deveci, 2019). Fig. 1 shows the roadmap of the study for the implementation of the zero waste strategy in hazardous waste management at Mersin University.

Before the establishment of Mersin University hazardous waste management system, a university waste management commission was established to ensure the execution and coordination of the system. The Commission was formed with a structure consisting of faculty members from departments considered to have the highest waste generation.

The preliminary studies within the scope of Mersin University hazardous waste management system were initiated at the Department of Environmental Engineering. The types and quantities of hazardous wastes generated in this department on a 'unit' basis were determined. In the department, the collection, identification, separation, calculation of quantities and labeling of hazardous wastes, which are mainly produced in laboratories, were coordinated. It is also ensured that the wastes collected in the unit were safely transported to the Hazardous Waste Temporary Storage Area established within the campus.

In order to represent the units located in the university, the collection, identification, content determination, classification, labeling and weighing of hazardous wastes in environmental engineering department laboratories were carried out at certain time intervals. Weighing was done using Dikomsan DGC model electronic hand scale with 50 kg capacity and all data were recorded.

In order to comply with the zero waste strategy, hazardous waste training activities were also organized to reduce the amount of hazardous waste generated at Mersin University and to raise awareness of waste producers for this purpose.

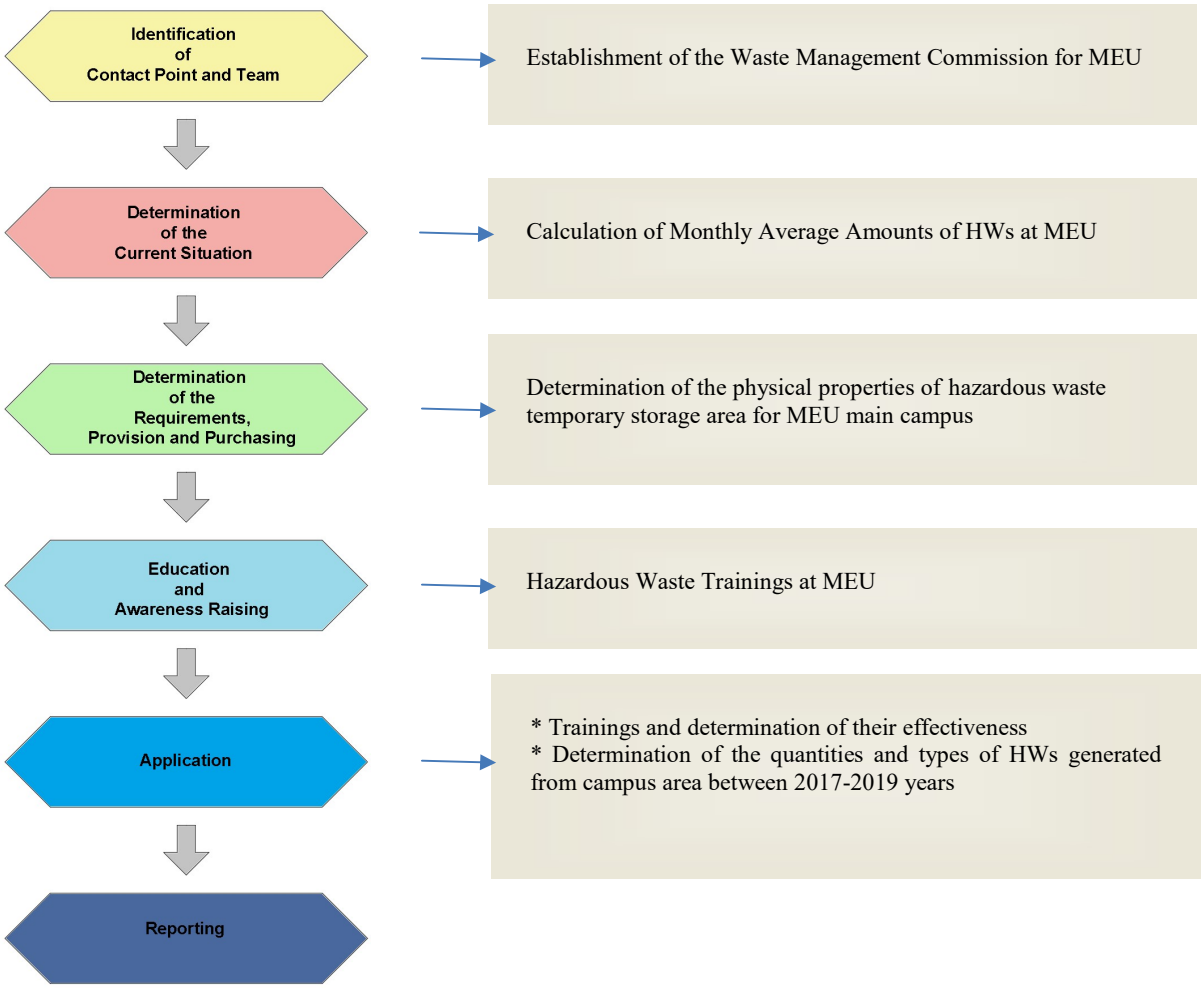

Figure 1. Zero waste strategy roadmap for hazardous waste management at Mersin University

3. RESULTS AND DISCUSSION

3.1. Quantities and Types of Hazardous Wastes Generated from Mersin University Environmental Engineering Department Between 2017-2019 Years

The quantities and types of hazardous wastes collected from the laboratories of the Department of Environmental Engineering between 2017- 2019 years are given in Table 1.

When the wastes collected from the laboratories of the environmental engineering department were examined in 2017, it was found that 94.66kg of waste was not labeled properly therefore their source was not correctly identified. After the hazardous waste trainings in 2018, it was determined that all wastes originating from laboratories were correctly labeled and thus classificated more easily.

Since the amount of waste varies according to the R&D studies carried out especially in the laboratories, no linear change can be detected according to years. In 2018, it was explained in the educational studies that microbial media can be disposed of as normal waste after autoclaving. Therefore, this waste was not encountered in the HWTSA for the following years. After the trainings, the total amount of waste was increased in 2019 compared to 2018, but decreased compared to 2017. This is due both to the correct identification of waste types and to the proper storage of hazardous waste and non-hazardous waste.

Table 1. The quantities and types of hazardous wastes collected from the laboratories of the Department of Environmental Engineering between 2017- 2019 years

2017 Waste Type / Quantitiy (kg)		2018 Waste Type / Quantitiy (kg)		2019 Waste Type / Quantitiy (kg)	
Chromium solution	8.82	Sulfuric Acid	0.78	Waste chromium solution	5.8
Waste Acid	3.65	Waste Acid	1.04	Waste Acid	5.5
Waste Talium (Tl)	0.25	Rodium (Rh)	2.34	Rodium (Rh)	0.98
Industrial Effluent	13.88	Industrial Effluent	7.92	Industrial Effluent	4.38
Industrial Influent	2.48	Industrial Influent	1.22	Contaminated Solid Waste	0.15
Wastewater from Bar Screen unit of Industry	4.62	Wastewater from Pumping Station	13.22	Experimental residue-wastewater	19.37
COD Test Residue	39.56	COD Test Residue*	56.02	COD Test Residue	79.76
Wastewater (unclear content)	94.66	Microbial media	2.02	-	-
General Quantity	**167.92**		**84.56**		**115.94**

**COD: Chemical Oxygen Demand (Wastewater quality test)*

During the first six months of 2019, hazardous wastes generated in environmental engineering department laboratories were collected on a monthly basis, identified and quantified (Table 2).

Table 2. *Identification and quantification of hazardous wastes generated in environmental engineering department laboratories during the first six months of 2019.*

Months/Waste Classification	COD Test Residue	Rodium (Rh)	Contamin. Solid Waste	Waste Cr solution	Waste Acid	Experimental residue-wastewater	Industrial Effluent	Monthly Quantity
January	15.66	0.98	0.15	0.00	0.00	0.00	0.00	16.79
February	16.30	0.00	0.00	0.00	0.00	3.66	2.38	22.34
March	12.41	0.00	0.00	5.8	0.00	0.00	0.00	22.23
April	9.52	0.00	0.00	0.00	5.5	4.54	0.00	24.38
May	6.04	0.00	0.00	0.00	0.00	5.02	0.00	16.27
June	9.80	0.00	0.00	0.00	0.00	6.15	0.00	15.95
Total (Kg):	**69.73**	**0.98**	**0.15**	**5.8**	**5.5**	**19.37**	**2.38**	**117.96**

Table 2 shows that, it is determined that most of the hazardous wastes produced are liquid wastes formed after the experimental studies, while the lowest amount of wastes are solid wastes. Although the amount of hazardous waste production in the Environmental Engineering Department varies month by month according to the frequency of laboratory studies, the average value range of hazardous waste produced monthly was between 15.95 kg and 24.34 kg.

3.2. Preparation of Hazardous Waste Temporary Storage Area for MEU Main Campus

Hazardous Waste Temporary Storage Area has been built in Mersin University Çiftlikköy campus with the physical conditions and principles regarding the characteristics of hazardous waste temporary storage areas specified by the Ministry of Environment and Urbanization of Turkey.

The hazardous waste temporary storage area was designed to protect the wastes from all kinds of external factors. The floor is covered with grid drainage structure against leakage and spills. Total of 5 ventilation windows provide air flow to the front and back walls. The interior area was divided into sections according to the characteristics of the hazardous wastes to be stored. Security measures have been taken against any emergency situation like fire.

Signs of safe work instructions were hung, stating that entry to the Hazardous Waste Temporary Storage Area is prohibited, except for authorized personnel, and that it should be kept locked up and contains rules to be observed in the area.

At this stage of the studies, the transportation of all hazardous wastes generated form the activities at Çiftlikköy Campus to the "Hazardous Waste Temporary Storage Area" was carried out by licensed hazardous waste transportation vehicles. The wastes are separated according to their types in the area and stored to be sent to the recovery/disposal facility.

3.3. The Impact of Training and Awareness Raising Activities on System Efficiency

Environmental education is a lifelong process and it is known that these trainings should continue in business environments. Providing these trainings for employee constitutes one of the most important steps to develop an effective waste management system.

Therefore, all employee responsible for waste management at different departments have been trained on two main title 'MEU Hazardous Waste Management System and Hazardous Waste Management in Laboratories'. In the training activities, subjects were detailed as the identification of hazardous waste, classification, transportation, storage of them, control procedures, information on regulations, and precautions to be taken in case of emergency were included. In addition, the waste collection containers placed on the campus area of Mersin University for non-hazardous packaging waste were also introduced and the importance of recycling and the concept of zero waste was mentioned (Fig. 2) With this training activities, it is planned to increase environmental awareness, support zero waste studies and manage hazardous wastes on campus area at Mersin University.

Figure 2. Non-hazardous recyclable waste collection containers (metal, paper, plastic) placed on the campus area of Mersin University

In order to determine the effectiveness of the training, all participants were pre-tested and post-tested at the end of the training (Fig.3).

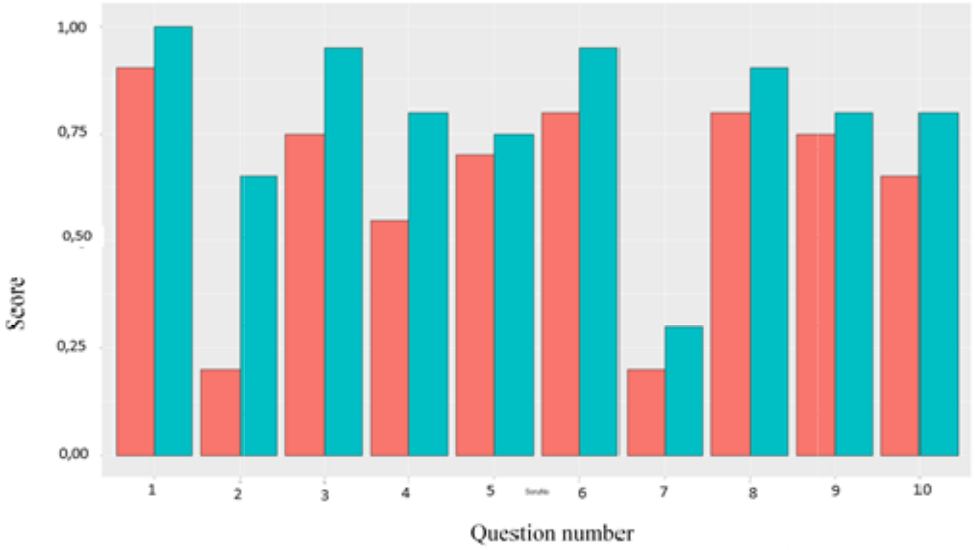

Figure 3. Scores of pre-test (red) and post-test (blue) for each question

As seen in the Fig 3, it was observed that the scores they received in the pre-test applied before participating in the training and information studies were low, and the scores they received in the post-test applied after the training increased. The participants showed that the majority of the answers to the second question, which about definition of hazardous waste, were wrong in the pre-training test. However, at the end of the training studies, the number of participants who answered the same question correctly increased significantly.

In the 7th question, the participants were asked about the definition of oxidizing substances among the subjects explained in the training. Although the number of participants who answered the question correctly and incorrectly is very close to each other, the fact that the correct answers given in the post-test are higher than the pre-test proves the effectiveness of the training.

4. CONCLUSION

This study contributed to the management of hazardous wastes resulting from education, training and research activities occurring at Mersin University main campus, to minimize the production of hazardous wastes and to develop programs related to administrative and technical procedures.

According to experimental results, research and development activities can create hazardous wastes more than education activities at Mersin University. Training evaluation results showed that, the amount of waste produced was reduced when appropriate awareness studies and trainings. In addition, legal obligations will be fulfilled as a result of collection and transportation of both non- hazardous and hazardous wastes within the system and working within the scope of the directive and waste management plan.

Hazardous waste management is a very important environmental issue in universities as well as industries. However, the waste management examples of universities are still limited, and scientific studies on this subject need to be increased.

REFERENCES

Adeniran, A.E., Nubi, A.T., Adelopo, A.O., (2017). "Solid waste generation and characterization in the University of Lagos for a sustainable waste management", *Waste Management*, 67,3-10.

Coutoa, N., Silvaa, V., Monteirob, E., Rouboa, A. (2013). "TerraGreen13 International Conference, Hazardous waste management in Portugal: An overview", *Energy Procedia*, 36, 607-611.

Ferronato N., Torretta V. (2019). "Waste Mismanagement in Developing Countries:A Review of Global Issues", *International Journal of Environmental Researchand Public Health*, 16, 1060; doi:10.3390/ijerph16061060

Gallardo, A., Edo-Alcón, N., Carlos, M., Renau, M. (2016). "The determination of waste generation and composition as an essential tool to improve the waste management plan of a University", *Waste Management*, 53, 3–11.

Ghaffari S., Talebbeydokhti, N., (2013). "Status of environmental engineering education in various countries in comparison with the situation in İran", *Procedia - Social and Behavioral Sciences*, 102, 591-600.

Giles, R.J.(2010). "The evolution of a campus chemical and laboratory equipment recycling program, University of Missouri". *J. Chem. Health Saf.*, 17,6,20-28.

Gonen, C., Deveci, E.U. (2019). "Application of Zero Waste Management System to Nigde Omer Halisdemir University", *1st International Conference on Environment, Technology and Management*, June 27-29 Nigde, Turkey.

Lara E.R., De La Rosa J.R., Castillo, A.I.R., Cerino-Córdova F.J., Chuken U.J.L., Delgadillo S.S.F., García P.R. (2017). "A comprehensive hazardous waste management program in a Chemistry School at a Mexican university", *Journal of Cleaner Production*, 142, 1486-1491.

Pourzamani H., Darvishmotevalli M., Akhyari S.H., Hadi S., Momeni F., Bakhtiyari, S.G., Fadaei, S. (2019). "Method for quantitative and qualitative evaluation of hazardous waste in laboratories of Isfahan University of Medical Sciences, Iran", *MethodsX*, 6, 377–382.

Salim, M., Bektas, N., Bayar, S., Engin, G., Çalıskan, Y., Salar L., Yetis, Ü. (2017). "Hazardous wastes and waste generation factors for plastic products manufacturing industries in Turkey", *Sustainable Environment Research*, 27,1 88-194.