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Survey of Solid Waste Management Status in Academic Centers: Case Study in a Military University

Research Article

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Abstract

Background: Planning and optimum waste management as the first step has need to waste characterization studies including the existing status, quantity and quality (physical composition) of generated solid waste at University. The aim of this study was evaluation of the existing situation, identification of the quantity and quality of solid waste in one of Iranian military universities. Materials and methods: This cross-sectional research was done in one of the Iranian military universities. The status of waste management was determined using self-made checklist (valid and reliable) and site visits and documents analysis. Quantity, quality, and physical analysis of waste was determined by weighting via trained personnel. The collected data were analyzed using SPSS 18 software and descriptive statistical methods. Results: Existing situation of waste management which has 58 score was weak in comparison with desirable situation as 112 score. The average weight, capitation and density of the waste were 419 kg/d, 288 gpc/d and 105.3 kg/m^3 respectively. Putrescible waste 40.15%, paper and cardboard 13.99%, soft plastics 13.10%, dried plastics 6.35%, wood and plant waste 6.14%, glass 5.64% and ferrous metals 0.82% were the predominant components. Conclusion: Despite separation of valuable dry wastes, waste management status in this university is not desirable. . 40% of total wastes were valuable and recyclable. Recycle is a best-recommended procedure, which can lead to volume and capitation reduction and decreasing of collection, transport and disposal costs nearly 50%.

Keywords: Solid waste management, Solid waste composition, Waste per capita per day, Waste generation, Military University , Case study.

Introduction

In recent years, optimal solid waste management (SWM) has become as one of the most important environmental challenges in Iran (1). In addition to imposing high costs, complication of quality and quantity of solid wastes, lifestyles change, and improvement of social and economic status, unsanitary disposal of solid wastes had led to several environmental pollution (2-4).

Nowadays, development of human activities, lifestyle changes, and consumer patterns led to elevation of solid wastes production (5-7). These problems overcome need to proper planning to scientific management of solid wastes in which public health, economic aspects and environmental damages should be considered simultaneously (8-11).

Proper management and sanitary disposal of solid wastes can play a significant role in enhancing the social health (12, 13).

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Solid wastes can be categorized as household, commercial, industrial, construction, medical, and agricultural wastes that each of them has a particular importance in waste management planning (14). Quantity and quality of the produced solid wastes and their components including corruptible materials, paper and carton, plastics, fabrics, textiles, metals, glass, wood, and especially leachate depend on different factors (15, 16).

Awareness of the amount of produced solid waste and its physical components in the every community, adopting systematic and implementation of appropriate policies for control of the amount solid waste, control and economizing on consumption of materials, and planning to improve the SWM are very important process, and failure to adhere to them lead to an increase in costs from waste production to disposal and all of stage of SWM (17-20).

Teaching and increasing societies knowledge about optimal and desirable SWM, reduction of solid waste production, source separating and recycling are very important and essential. (21, 22). Food and garden solid wastes account for more than 50% of municipal solid wastes in developing countries (23) while the weight and percent of paper and plastics is predominant in developed countries (24). Per capita solid waste production in different cities and countries in the world ranges from 0.25 to 2.13 kg/day that depends on the

conditions of areas (23-26). Recycling is one of the best economical options in SWM, which has remarkable environmental advantages (27-31). Since 1995, numerous studies have focused on "Integrated solid waste management (ISWM)" in different cities of Iran (32). According to the results of studies that conducted in Mazandaran Province the corruptible solid waste with 66.7% accounted as the largest component of solid wastes, followed by paper and carton with 19.8% and plastics with 10.8% (33). Several studies, which conducted in Kashan (18), Kerman (34), Sistan and Baluchistan (27), Urmia (35), Ardabil (36), and Tabriz (37), implied that corruptible solid waste was the predominant component of the municipal solid waste.

Due to development of societies toward sustainable development and green management, scientific and academic centers have also started important activities to achieve green management. One of the most important indices of green management is implementation of ISWM. After the adoption of the Waste Management Law in Iran in 2004, the ISWM was considered seriously and 41 projects in 22 provinces were implemented among which the 12 projects were finalized.

The first necessary phase of ISWM is to identification and determines the current status of solid waste management, quantity, production per capita, density, and physical properties of the wastes that produced in the centers under study. Although the ISWM has been carried out in many cities of Iran however, SWM investigation was not considered completely in universities. Research in Iranian universities and academic centers showed that Gilan University carried out a study on ISWM in 2015. The results showed that the per capita waste production was 114 gr, and corruptible organic waste accounted for 57% of the whole wastes, followed by plastics and paper with respectively 19% and 13% (38).

Around the world, numerous studies have also been conducted in academic centers. For example, the study of waste management at the University of Mexico in 2010, during a period of 16 months focused on the separation and recycling of valuable waste materials. The study was done in the academic center of California and Mexico City and proposed the separation of paper and cardboard as the title of the most recyclable part of waste was welcomed by staff at the start of the implementation of the ISWM (39). Literature review showed that although several researches were performed on military hospital SWM, but, no study available on the management of SWM in Iranian military academic centers (40-44).

Proper management of waste produced in military centers, is depending to identifying of the current status, production sources identification, quality and quantity of solid waste evaluation.

Since the scientific institutions and academic centers are one of the solid waste generation operand need for appropriate handling in which health and economic aspects should be considered, this study was done with aim of determining of SWM status in a military academic centers as case study in Iran in 2014.

Materials and methods

Determination of the SWM status

This cross-sectional descriptive study was conducted in 2014. This university was selected by a convenience purposive and non-randomized sampling method. Valid and reliable researcher-designed checklists were used data gathering. Different sources of solid waste production were identified, and the status of SWM including storage, collection, transport, and disposal were specified through field observation of the current status, analysis of documents and completion of checklists.

The prepared checklist consisted of two sections: general information and information related to SWM. The score of each question was between zero and two. The value, importance, and weight of each question ranged from one to three and were determined based on the experts' viewpoint, and separately calculated for the whole checklist. Afterwards, the total status of SWM were evaluated based on the obtained scores at four levels as desirable (80% and above), average (60-79%), poor (50-59%), and undesirable (below 50%), (Table 1).

Table 1: Scoring method of different sectors of waste management

	Topics studied in the process of waste management	Scoring status			
		Undesirable	Weak	Average	Desirable
1	Total status of waste management	>56	56-68	68-90	90-112
2	Generalities of waste management	>17	17-20	20-27	27-34
3	Production and maintenance	>28	28-34	34-45	45-56
4	Collection and transportation	>8	8-10	10-13	13-16
5	Final disposal	>3	3-4	4-5	5-6

Determining the quantity, per capita, and density of solid wastes

Before the start of the executive, first, necessary subjects instructed in the form of face-to-face training. All of executive services staff trained about the hazards and threats of the various types of waste and the necessary preventive measures that must followed during collecting, transporting, weighing, separating and analyzing the waste samples. Necessary instruments and equipment such as working clothes, boots, special gloves, masks, goggles and helmets, balance, containers, large garbage bags were provided for analyzed and weighing. Weighing and separating the wastes were carried out by service staff and under direct supervision of the research conductor. This operation was carried out as follows:

- Weighing all of the solid waste produced in the university were carried out one week per month from Saturday

to Friday during three months. It was conducted in the first week of the first month, the middle week of the second month, and the last week of the third month.

- For weighing and determination of the density of the solid wastes, used from containers with a 240 l volume. Density was determined by calculating the proportion of weight to volume of the wastes. After weighing of the total amount of the daily wastes produced and determined the population of the university, the per capita of the waste, was determined based on gr per day.

C. Determining the physical analysis of solid wastes

In order to determine the quality of the produced waste, physical analysis of the all solid waste produced during 2 days per week and a total of 6 days over 3 months was conducted. Analysis was carried out on the solid wastes such as corruptible waste, paper and carton, plastics, soft plastics and rubber, glass, ferrous metals, non-ferrous metals, dried bread, cloth, yarn, old clothing, kitchen burned oil, garden waste, solid construction debris, street dirt, and leachate. After the collected data were fed into the computer, they were analyzed using descriptive statistics and calculating central indices (mean) and distribution (variance) through SPSS 16.0 and Excel, and the results were statistically analyzed and presented in the form of tables and diagrams.

Results

SWM status

According to the obtained scores and by comparing them with Table 1, the total status of SWM was evaluated to be at a poor level. SWM was in an unfavorable status compared to other different issues (See Table 2).

Table 2: The status of waste management axes and earned Score

	Topics studied	Number of questions	Before the project	
			Score	Health condition
1	Generalities of waste management	11	9	Undesirable
2	production and maintenance of Wastes	17	29	Weak
3	collection and transportation of Waste	6	14	Desirable
4	Final disposal of wastes	1	6	Desirable
5	Total	35	58	Weak

The collection was semi-mechanized and traditional. In this system, the waste were collected by the workers and disposed into the special car and then transferred to the terminal of the municipal waste.

Quantity, per capita, and density of solid waste

The mean weight of the waste produced in this university was 419 kg per day. Over the 3 months of the study, 8,800 kg waste was weighed and an average of 467 kg waste per day was analyzed. The mean per capita and density of the disposed waste were respectively 288 gpc/d and 105.30 kg/m^3.

Physical analysis of solid wastes

The mean of the data obtained from the physical analysis of the solid wastes is presented in Table 3 in terms of weight and weigh percentage. Physical analysis and weighing 2,802 kg of the sampled solid wastes showed that corruptible wastes with 40.15%, paper and carton with 13.99%, types of soft plastics with 13.10%, types of dry plastics with 6.35%, wood and plant wastes with 6.14%, types of glass with 5.64%, and ferrous metals with 4.82% respectively accounted for the most abundant components of the produced solid wastes.

Table 3: Average and percent of each of the separated waste

Row	Waste Type	Average weight and percentage of waste Separation per month						Total average (kg)	Total weight percentage
		first month		Second month		Third month			
		Average (kg)	Weight percentage	Average (kg)	Weight percentage	Average (kg)	Weight percentage		
1	Types of Fabrics, Yarns, Clothing and etc	2	0.33	22	6.18	25	5.82	16.34	3.5
2	Putrescible Wastes	328.5	53.37	146	41.01	88	20.49	187.5	40.15
3	Paper and Carton	101.5	16.49	44	12.36	50.5	11.76	65.34	13.99
4	Glass Types	10	1.63	22.5	6.32	46.5	10.83	26.33	5.64
5	Types of ferrous metals	28	4.55	18	5.06	21.5	5	22.5	4.82
6	Non-ferrous metals	1.5	0.24	2	0.56	0	0	1.17	0.25

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Row	Waste Type	Average weight and percentage of waste Separation per month						Total average (kg)	Total weight percentage
		first month		Second month		Third month			
		Average (kg)	Weight percentage	Average (kg)	Weight percentage	Average (kg)	Weight percentage		
7	Soft plastic	80.5	13.08	43	12.08	60	13.97	61.16	13.1
8	Dry plastic	31	5.04	34.5	9.69	23.5	5.47	29.67	6.35
9	Wood and plant waste	18.5	3	7.5	2.11	60	13.97	28.66	6.14
10	Street trash	0	0	0	0	44	10.24	14.66	3.14
11	Dry bread	14	2.27	16.5	4.63	10.5	2.45	13.67	2.92
Total		615.5	100	356	100	429.5	100	467	100

Discussion

Desirable SWM in order to protect the environment is always one of the main indicators of green management, green engineering and sustainable development in assessing the health of each community, and Considering Article 50 of the Constitution of the Islamic Republic of Iran and the importance of protecting the environment, Desirable SWM is one of the most necessary areas of healthy life in sustainable development. For this reason, always troops commit themselves to protecting the environment and natural resources, and in various forms and designs focusing on environmental issues, on environmental health and the prevention of pollution of water and soil and air Emphasize.

The health is a part of human essence and nature and one of his basic rights. The military's force work environment should be attractive, joyful and lively, refreshing and relaxing. The work environment as their second home must have the attraction to work with employee motivation. Because health is an individual and collective effort in an organization.

According to the Draft Standard for Defense Management of the Armed Forces, paragraph 6-6, about waste management requirements, on the existence of a strategic and operational management plan for waste management from production to final disposal in all the Armed Forces, has been emphasized.

Research and identification of the current status, especially for the ISWM model, is an introduction to the development of such a program. Because the first phase of an ISWM plan is to identify the current status of SWM, quality and quantity of waste produced. Therefore, in this research the current status of SWM and quantitative and physical analysis of waste production at a military university was studied.

Solid waste management

A Part of the desirability of SWM foreseen in the 1404 vision document is the full implementation of the SWM law, the separation and recycling of all conventional wastes, which indicates the importance of SWM status in upstream documentation. Management of solid waste types as one of the main environmental pollutants is highly regarded by health and environmental authorities and the state, and its laws and regulations are becoming increasingly rigorous. These laws and regulations that have been developed according to the best health, economic, social, environmental, and technical laws and regulations first lead to an increase in high costs of SWM, and due to numerous problems associated with supplying the necessary budgets and credits, it is necessary that the attitude and approach of commanders and authorities towards more and accurate control on the production and quantity and quality and the source of the production of wastes.

Production many amounts of solid waste are not in the dignity of an advanced and civilized community, especially military centers that should be appropriate models for the whole society. Particularly, given restrictions on supplying and having access to resources, production of large amounts of waste is just caused by mismanagement, and this problem should be strictly controlled so that SWM can be facilitated and the costs can be decreased.

The United Nations Conference on the Environment and Development (UNCED), held in 1992, in resolution 21, recommended a measures necessary to optimize waste management. In summary, the recommendations include the prevention and minimization of the wastes production, even the reuse and recycling of wastes, the treatment of wastes with reliable and environmentally valid methods, and the disposal of the final residual waste through sanitary landfill (49). In that treaty, it is also emphasized that every producer is responsible for treatment and disposing of the wastes produced (50). Similar issues have been taken into account in Iran's law of SWM. Proper SWMs of a military university and success like in other non military centers are mostly dependent on the method of executive management, the managers' awareness, availability of proper laws, regulations, and instructions along with specialized supervision on their execution, enough budgets, and attraction of active participation of the employees and informing them. The undesirable current status indicates the necessity of paying more attention to SWM in this military university and providing necessary facilities and the exact monitoring of responsible device systems.

In the present study in which SWM status in different stages of management elements was examined,

the mean score of total waste management status was earn of 58 score from 112, which showed a poor status. Because there was a special vehicle for transfer the solid wastes and municipal services were used for end disposal of solid wastes, in these two sections of collection, transportation and waste disposal, the evaluation results by checklist indicated the desirable status. The results of examining the current status of SWM showed that the wastes produced in the clinic was also collected in the form of mixed with other wastes and disposed by a non-standard method.

One of the positive points regarding solid waste collection in this university was availability of an appropriate vehicle and high speed of collection operations and in the appropriate time. However, there is no doubt that the amount of the produced solid wastes due to unplanned recycling by some sections is more than the solid waste amount of collected and weighed.

The result of weighing 8801 kg solid wastes in the university under investigation showed that the per capita and density of the wastes were respectively 288 gpc/d and 105.3 kg/m3. Physical analysis of the solid wastes showed that construction wastes, street wastes, and waste oil of kitchen were separately managed, a part of the valuable dry wastes such as papers, cartons, plastics, and non-ferrous metals were separated and sold by the contractor, and they did not exist in the mixture of the analyzed wastes.

In spite of access to necessary laws, regulations, and guidelines to manage the produced solid wastes, the SWM current status in practically was not desirable. This status has been caused by the lack of a certain and coordinated plan, the lack of enforcement, failure to supply sufficient resources, the lack of coordination among the interfering parts without separate duties in SWM, and the lack of monitoring and control. The results of the present study showed that the current status did not comply with the current laws and regulations especially SWM law, executive guidelines, and health instructions in many aspects.

Regulations and rules include issues such as emphasis on producing less waste by executing the adopted regulations, providing necessary facilities to produce and consume goods that are easier to recycle, restricting the production and consumption of goods that are harder to recycle and dispose, developing the consumption of recyclable raw materials in producing products by adopting necessary policies, and giving the responsibility of supplying and pay for a part of the recycling costs to the goods producers. Lack of recycling, failure to implement separation programs and necessary policies at the production of types of normal and semi-household wastes, and collection and disposal of the wastes in the form of a heterogeneous mixture lead to production of large amounts of waste and failure to follow Articles 4, 5, 7, 13, and 15 of SWM Law.

According to SWM Law, a preventive approach to reduce the production of wastes from the source, and reusing and cycling have been paid special attention, which is a necessary solution to resolve this problem. Final success; however, depends on creating the culture of public participation in implementing new methods and patterns along with providing necessary trainings, such that necessary attitude and preparation can be created to implement the new methods.

The status of SWM in many urban areas has been studied in Iran and other countries, which were referred to in the background section above. Physical analysis of 2,800 kg of the collected solid wastes in the target university showed that corruptible wastes with an average amount of 40.5%, paper and carton with an average amount of 14%, types of dry plastics and soft plastic bottles and objects with an average amount of 19.45%, and ferrous metals and non-ferrous metals with an average amount of 4.82% respectively accounted for the most abundant components of the produced solid wastes. Comparing the per capita production of solid waste in Guilan University (38) with the university studied in the present investigation showed that the per capita production of solid wastes in the latter was two times more that the former; however, the percentage of corruptible wastes in the latter was 17% less than the former, and their paper, carton, and soft and dry plastics were equal. The results of the present study showed that over 40% of the solid wastes produced in the military university was recyclable and sellable, and if the separation plan is executed from the source of the waste production, the produced and recycled wastes will drop by 40%, and the per capita volume of the waste will decrease by more than 50% in the first year. Since dry solid wastes are bulky and have a low density, separating them leads to a decrease in their density and the collection and transportation costs. The conducted calculations showed that the gained revenues could easily compensate for waste management costs. A study carried out in Mexico City University reported similar results (39).

Literature Review the background of such studies in military centers showed that Masumbeigi et al carried out seven study, in which study of SWM in military centers was the main or a remarkable part. The first study carried out in 2006 focused on management of the solid wastes produced in a military hospital with an emphasis on reduction and separating the wastes. In that study, the current status of SWM was identified, and for resolve the problems, the model of separating and recycling different types of solid wastes from the production source was proposed and implemented and it is still ongoing process (41-42).

The second study focused on sharp wastes in the same center (43). The third investigation examined the status of SWM and physical analysis of the produced solid wastes in two selected military clinics, which was not reported to be at a desirable level (44). In the fourth research was studied the environmental health status and SWM in some selected military centers in 2013. The results of this study indicated that the status of SWM in those centers was unfavorable (45). The fifth study focused on examining the environmental health status of public places in a number of military bases in Ilam Province, and the results showed that collecting the solid wastes was carried out in a mixed form and without adhering to necessary standards, and the status was undesirable (46). The sixth study was research

about the Study of environmental health status of food storages and fridges in one of Tehran province military forces in 2012. In this research, survey of the status of SWM was a part of study, which was evaluated and reported to be intermediate (47). The seventh study was ISWM Plan in one of the armed forces, that their results were published and implemented in all bases of military.

Conclusion

The purpose of the current study was to determination of SWM status in academic centers as case study in a military university. Mismanagement and dispossession of wastes is one of the most important problems in many societies, including military centers. The results of this research showed that successful management of this university solid waste, in accordance with the rules and regulations, and within the framework of the designated health regulations, along with accessible and clear targets, is depend on an ISWM. Thus, today more than ever, the existence of an ISWM plan at the whole levels of this military university is necessary. Re-engineering and a fundamental review the existing status of waste management is required the support and special attention of the authorities.

Competing Interest

The authors have no conflicts of interest to declare.

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