ORIGINAL ARTICLE

Quantity and Quality of Construction and Demolition Waste Materials in Kermanshah City, Iran

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Received: 06 January 2023
Revised: 09 February 2023
Accepted: 27 March 2023

Abstract

Background: The aim of this study was determination of the quantity and quality of construction and demolition waste materials in Kermanshah city, Iran.

Methods: This descriptive cross-sectional research was carried out on eight urban areas in Kermanshah city from April to December in 2018. Due to the fact that in winter season, the C&D rate in Kermanshah is very low, data were not included in the study. Parameters of weight, volume, and density were calculated and presented in a seasonal average. The descriptive statistics were used to analyze the data in SPSS and Excel software.

Results: More than 372.62 ton of waste materials were generated during the study, and the amount of concrete, bricks, soil, plaster, stone, ceramic, asphalt, and glass were approximately 31.49, 26.09, 23.45, 10.7, 3.37, 2.79, 2.07, and 0.0003%, respectively. According to the results, ferrous and non-ferrous metals, wood, plastic, paper, and cardboard have been recycled and sold due to their high economic value. Therefore, they were not in the C&D waste or were very little.

Conclusion: With regards to the high volume of C&D waste generated, setting laws and regulations to reduce C&D waste should be considered to control optimally and efficiently the processes of production, collection, transportation, disposal, and recycling of waste.

Please cite this article as: Biglari J, Kazemi S, Shokri R, Jalilian K, Mohammadi M. Quantity and Quality of Construction and Demolition Waste Materials in Kermanshah City, Iran. J Health Sci Surveillance Sys. 2023;11(2):365-370.

Keywords: Construction and demolition waste, Generation, Classification

Introduction

Construction and demolition (C&D) waste consists of materials produced during construction operations. These wastes include building materials such as insulation (bitumen and all kinds of foam used as heat and cold insulation as well as sound in the building), nails, wires, rebar, ruby layer materials, stumps, and rubble. These wastes may contain lead, asbestos, or other hazardous substances.[1] The increasing volume of C&D waste has caused many problems in large cities. Available statistics on the composition of construction waste in large cities in Iran show that brick and concrete are the two main constituents of construction waste.[2]

One of the problems of the municipal solid waste management system is the production of large volumes of C&D waste, which in addition to the huge economic costs, cause environmental pollution.[3] These wastes include solid waste that results from altering, repairing, and rebuilding structures such as roads and residential, commercial, official areas, etc. Natural disasters such as floods, earthquakes, storms, etc.are the cause of such debris. Due to the growing population and the increasing need for new spaces and buildings to be built, this process will lead to mass production of C&D waste.[4, 5] In Iran, C&D waste accounts for a large portion of the generated waste; for example, the amount of this waste produced in Tehran is 5.2 kg per capita per day, and 81% of them are

landfilled.[3] In the city of Gorgan, an average of 264 tons daily and 96861 tons of construction waste are disposed of at disposal sites during the year.[6] In Italy, the amount of special waste produced is about 143 million tons, 40% of which is C&D waste.[7] According to previous studies, the amount of C&D waste in developed and developing countries is about 35% and 50% of municipal solid waste, respectively.[8]

These statistics show that if a proper approach to C&D waste management is not implemented quickly, we will see a new urban environmental problem in the near future, such as the current problems such as air pollution, water shortage, and so on.[9] The most important and the first requirement for proper management of construction and demolition waste in any city is the awareness of its quantity and quality, as a result of which quantification in the field of construction waste has recently received much attention.

One of the risks that can be C&D waste in the environment is asbestos. It is a major threat to human health because these fibers can enter the lungs and cause cancer and other lung diseases. Also, the release of heavy metals from this waste and their entrance to the surface and groundwater; subsequently, it endangers the human health. The environment is another problem that leads to improper disposal of construction waste.[10]

In many cities of our country, there is no accurate data on the amount of C&D waste produced. For example, Kermanshah, as one of the major cities in the country, has not yet developed a plan for the quantitative and qualitative study of construction waste and its management. Due to the increasing urban population of Kermanshah and consequently the increase of construction and C&D waste production and the environmental problems caused, it is necessary to conduct detailed studies in this area. The significance of the data includes:

1) this research illustrates a detailed description of the C&D waste generated in the largest city in the west of Iran with over one million populations, 2) the first step in the C&D waste management system is to have information about the type, source of waste, composition, and amount of waste production. In order to achieve a proper management plan, create a system, achieve sustainable development, and improve management and planning, it is necessary to determine the quantity and quality of waste of the city, and 3) in order to implement a successful reduction, recycling and reuse plan for waste disposal, it is important to have information about the quantity and quality of wastes. The objective of the present study was determination of the quantity and quality of construction and demolition waste materials in Kermanshah city.

Methods

The city of Kermanshah is the capital of Kermanshah Province, located in the western part of Iran. Kermanshah is the largest and central city in the west with a population about one million people and a total area of approximately 93389956 m^2 (Figure 1).[11]

Figure 1: Kermanshah Province[11]

In this descriptive cross-sectional study, the samples were collected from Kermanshah official site for C&D waste. The containers from each area of the municipality that entered the site were identified and analyzed in quantitative and qualitative terms, separately. The study was conducted from April to December 2018, and the results were presented on an average for the season and metropolitan area. Due to the fact that in winter season, the C&D rate in Kermanshah is very low, data were not included in the study. Parameters of weight (kg) and density (kg/m^3) were calculated and presented in a seasonal average. The checklist was classified into 12 items: concrete, bricks, ceramic, ferrous metals, non-ferrous metals, glass, wood, plaster, asphalt, soil and stone, paper, and paperboard. In this checklist, components percentage of C&D waste, season, metropolitan area, density and weight was provided.

After weighing the debris, their density was calculated. To calculate the density of the samples, the study of Ansari et al. (2018) was used.[12] At first, each class of C&D waste was entered into a cylindrical container filled with water, and by calculating the amount of water extracted from the container, which was the same volume of waste materials, the density was calculated (waste weight was divided by volume and reported in kg/m^3). After physical analysis, the quantity and quality of the waste were compared according to urban areas and season. In general, Specifications of the data are shown in Table 1. The descriptive statistics was applied using in $SPSS_{20}$ and Excel software. All collected data were coded. In the first step, the normality tests were used to check

Table 1: Specifications table[12]

Subject area	Environmental science
More specific subject area	Construction and demolition waste
Type of data Tables	Tables, Figures
Data format	Raw/Analyzed
Data collection method	1. Determine the eight metropolitan areas of Kermanshah city 2. Weighing the construction and demolition waste of each region as follows: a. Weighing machines for collecting the construction and demolition waste in each area, b. In order to increase the accuracy of the study, weighing of the construction and demolition waste was carried out in the middle of each month for one week and the average was reported. c Sampling was carried out in three seasons: spring, summer and autumn in 2018. d. To estimate the density, special containers with a volume of 0.5 m^3 were used. 3. Physical analysis: the construction and demolition waste materials were separated into 12 items based on a researcher-made checklist. The weight, volume and the density waste were calculated.
Surveyed elements	Weight, volume and the density based on metropolitan areas and season
Experimental features	The construction and demolition waste materials were categorized based on the composition.
Data source location	Kermanshah, Kermanshah province, Iran.
Data availability	The data are presented in this article.

whether the data were consistent with the Gaussian distribution. Then, analysis of variance (ANOVA) test with Tukey method was used for comparisons between different seasons and type of wastes. All tests were performed at a significance level of less than 0.05.

Results

Based on the obtained data, Figure 2 presents the percentage of soil, concrete, bricks, ceramic, glass, stone, plaster, and asphalt generated in Kermanshah. Ferrous and non-ferrous metals and plastic were not found in the debris, and the amount of wood, paper, and cardboard (0.000007%) was very low. In contrast, the amount of concrete (31.49%), bricks (26.09), and soil (23.45%) was higher than other waste. According to the results, the total amount of C&D waste generated in Kermanshah was more than 372.62 ton per year, approximately. Figures 3-6 show the annual generation, generation rate in different season, different metropolitan areas, and density of the construction and demolition waste in Kermanshah, respectively.

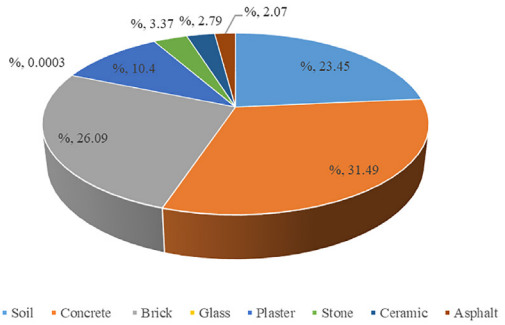

Figure 2: The components percentage of the construction and demolition waste in Kermanshah (by authors)

Discussion

Construction activities require significant quantities of inert material (sand and grit), which is actually provided by direct extraction of alluvial samplings. This matter changes the balance of the environment and reduces the natural resources. On the other hand, the annual production of C&D waste has increased with increasing

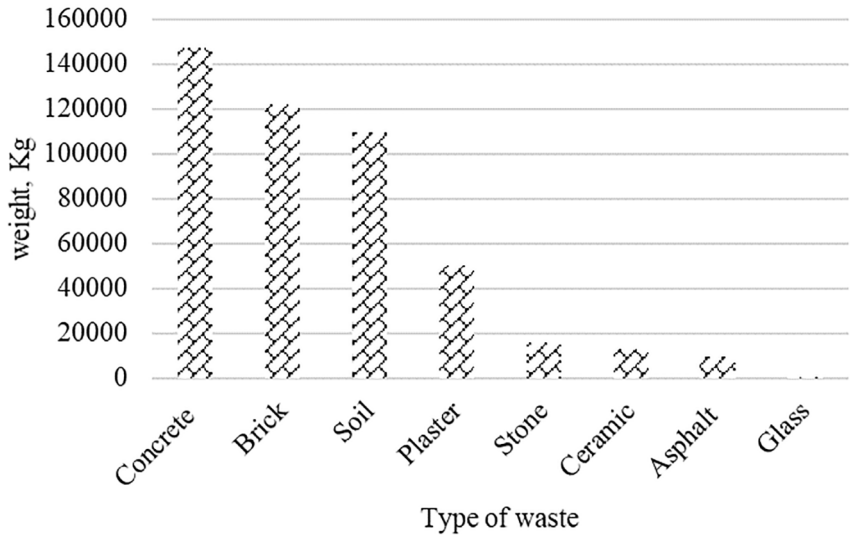

Figure 3: The total generation of the construction and demolition waste in Kermanshah (by authors)

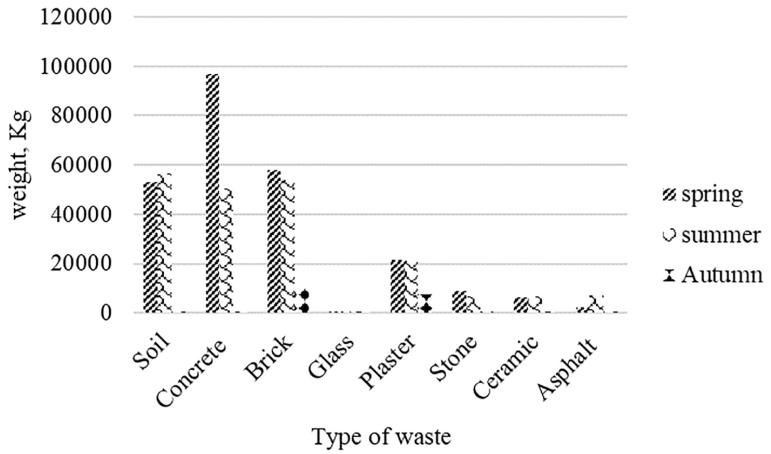

Figure 4: The generation of the construction and demolition waste in Kermanshah based on season (by authors)

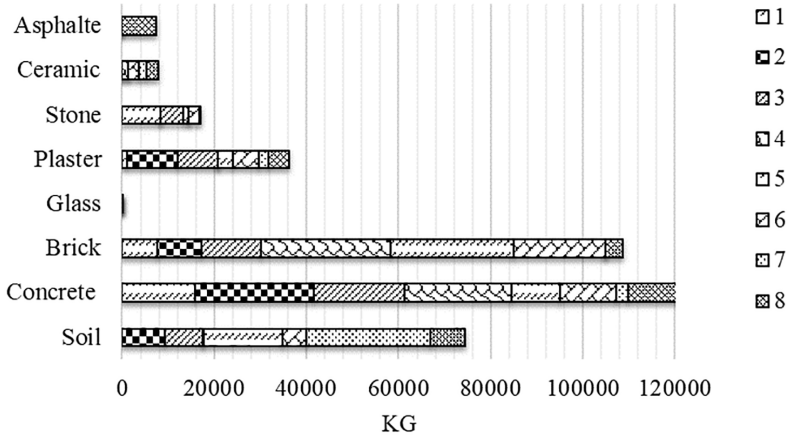

Figure 5: The generation of the construction and demolition waste in Kermanshah based on metropolitan area (by authors)

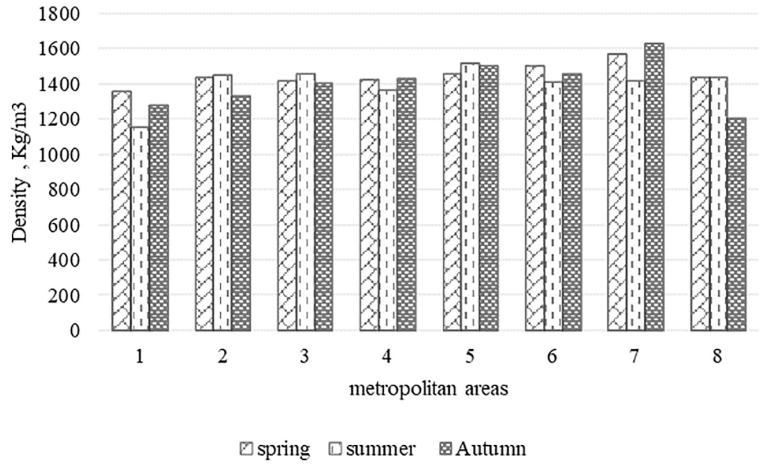

Figure 6: The density of the construction and demolition waste in Kermanshah (by authors)

population and urbanization.[13] Today, the most important challenge with which the management of C&D waste in Kermanshah is faced is the lack of information on the amount and composition of production waste. Therefore, in this study, an attempt was made to survey the amount and composition of construction and demolition wastes produced in examining the existing documents and field visits. The majority of the C&D waste in Kermanshah city were concrete, bricks and soil, respectively. On the other hand, the minimum level of the noted component waste was wood, paper, and cardboard. The ferrous and non-ferrous metals and plastic have been recycled

and sold due to their high economic value. According to a similar study conducted in Tehran, $14\times10^6 m^3$ of C&D waste is produced per years, which is a very low recycling rate (0.19%). However, in our study, values were lower than in Tehran.[3] The reasons for this are the size of Tehran, and the volume of C&D in Tehran is more than Kermanshah. On the other hand, given the volume of illegally dumped garbage around the city, this amount is even higher in Kermanshah. The city of Kermanshah, due to the large area of dilapidated building and the weakness of urban infrastructure, has always faced extensive efforts by city managers to develop the city and improve the roads, streets, and so on. Mortazavi's study in 2015 showed that the largest volume of C&D waste in Fooladshahr was composed of a mixture of sand and cement, brick, concrete, soil, and asphalt.[14] Also, the study of Martus et al. in Europe showed that concrete was the most important and abundant weight and volume percentage of C&D waste, so that the rate of concrete production in the process of demolition of buildings and facilities was estimated at 840 kg per square meter. Even this amount is about 300 kg per square meter for wooden buildings.[15] During a study in 2010, Rimoldi believed that concrete, depending on the type of the structure being demolished, contained 40 to 85 percent by weight of the rubbish produced in Europe. On the other hand, the proportion of construction waste components is different in developed and developing countries. In the United States, for example, construction waste accounts for 26 percent of the total weight of the waste disposed. The figure is 20 to 29 percent in Germany, 19 percent in the Netherlands, 13 to 15 percent in Finland, about 65 percent in Hong Kong, about 35 percent in Canada, and more than 50 percent in the United Kingdom.[16] In Iran, the need for weight percentage of construction waste in landfills is estimated at more than 52%.[17] A study by Lauritzen showed that in the developed world, 500-1000 kg per capita per year of C&D waste was produced, and this large volume of waste was a valuable and recoverable resource.[18] Jafari's study in Kerman also revealed that 2400 tons of C&D waste was produced daily. From 2400 tons of C&D waste, 120 tons was recycled and 2280 tons was disposed. Most of the recovered C&D waste was iron (3%), soil (2%), brick (1%), wood (0.5%), and asphalt (0.5%).[19] In developed countries, including Australia, Malaysia, Greece, Hong Kong, etc., there has been a great deal of research on C&D waste.[20]

Some of the hazardous waste materials are also classified as C&D waste including asbestos.[21] In order to control this hazardous contaminant during the recovery of the construction waste, it is necessary to design a solidification process by mixing asbestos with glass and trapping it in glass matrix. These glass blocks can be used as a substrate for road construction. If other parts of the C&D waste are exposed to or mixed with such hazardous substances, they will also be at risk.[22] The results of this study show that no measure is taken to control these hazardous waste in Kermanshah city during the collection, recycling, and disposal of C&D waste. Unfortunately, the management of construction waste in Kermanshah has become a problem due to the lack of national and regional laws and regulations. At present, the system of collection, transportation, recycling, and disposal of C&D waste in Kermanshah city, like other Iranian cities, has the following problems:

- Illegal recovery by beneficiaries
- Storage in forbidden areas without regard to the principles of collection and disposal of this type of waste by some citizens
- Lack of proper technology in collection, transportation, and disposal (It should be noted that two lines of C&D waste recycling site have recently been launched (2019) in Kermanshah, which is capable of recycling two thousand tons of noted waste, daily)
- Lack of qualitative and quantitative evaluation
- Failure to perform separation
- Lack of investment facilities for the recycling of these wastes

Conclusion

Kermanshah was the first city in Iran to own a construction and demolition waste recycling site, but it has been shut down for five years after re-launching twice. The closure had several reasons, most notably the site's lack of a permanent location and the lack of funding needed to continue the project. There are now about 40 million tons of C&D waste depots around Kermanshah city that need more than 10 years to be recovered. The following measures are recommended for sustainable development:

- Forming a construction and demolition waste committee
- Establishing laws and regulations to reduce C&D waste, determining rewards for encouraging the builders to comply with regulations, and efficient and effective control over the process of production, collection, transportation, and disposal of building waste
- Public education of C&D waste management and sustainable urban development through provincial and municipal media holding relevant workshops,
- Encouraging new methods in the demolition and construction process, especially in the field of optimum design and structural engineering
- Providing special facilities for employers, contractors and designers, as well as providing effective training for executives and workers in the field of construction, providing native specialized solutions for the use of durable materials, and familiarizing them with the newest technologies and technologies
- Supporting local and national authorities to launch Kermanshah C&D waste recycling site

Acknowledgment

The authors of the article thank Kermanshah University of Medical Sciences, Kermanshah, Iran.

Conflict of Interest: None declared.

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