



Original Article



Qualitative and Quantitative Analysis of Dental Clinics Waste in Karaj City, Iran

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Abstract

Background: In light of 21st-century environmental challenges and growing concerns over waste management, certain medical disciplines, particularly dentistry, exert a considerable environmental impact due to carbon emissions and waste generation. This study aimed to evaluate and analyze the types and quantities of waste produced by dental clinics in Karaj city.

Methods: Sampling was conducted three times across 58 dental centers in Karaj, yielding a total of 174 samples. Waste materials were manually separated into 64 distinct components and subsequently categorized into four main groups based on their potential hazard. A digital scale with 0.01-gram precision was used to weigh each component. The average daily weights of each waste type were calculated, and the data were analyzed using Excel 2016.

Results: The total annual dental waste generated in Karaj was estimated at 4,522.995 kg. Of this, infectious waste accounted for 38%, household-type waste for 36%, chemical and pharmaceutical waste for 16%, and toxic waste for 10%. The largest proportion of waste was attributable to infectious and household-like waste.

Conclusion: Educating dentists on proper waste segregation, reduction, and recycling in accordance with health and environmental guidelines can prevent hazardous dental waste from being mixed with municipal solid waste. Such practices not only mitigate environmental pollution but also enhance the effectiveness of municipal waste management policies.

Keywords: Dental center, Infectious wastes, Waste management

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Introduction

Dentistry plays a critical role in individual and public health; however, oral care and dental procedures inevitably generate significant amounts of biomedical wastes.¹ Dental clinics produce clinical service waste similar to medical waste, primarily due to exposure to biological fluids such as blood and saliva, as well as various chemicals.² Also, dental procedures often involve the use of highly toxic materials, including heavy metals and chemical compounds, which pose serious risks to both human health and the environment.³ Although the volume of contaminated materials and dental waste may be relatively small, improper handling and management can lead to cross-contamination and environmental pollution.⁴ In many dental clinics, it is common for dental

surgeons, staff, and even patients to dispose of items such as cotton, paper products, and blood-contaminated materials in general waste bins. However, these materials must be properly classified and disposed of in containers appropriate for each type of waste, in accordance with established guidelines.⁵ Proper segregation of healthcare waste, including that from dental practices, is a fundamental component for effective waste management.⁶ The observance of regulations regarding the separation of healthcare waste at the source can noticeably reduce the volume of hazardous wastes, lower the risk of occupational injuries, and contribute to improved public health and environmental protection.⁷ The negative impacts caused by the incorrect handling of these wastes affect everyone, requiring attention from health authorities and



policymakers.⁸

Dental healthcare service units generate a variety of wastes that can be classified as hazardous, non-hazardous, biohazardous, pharmaceutical, and sharps waste.⁹ These wastes may include bloody bandages and tissues, sharp objects, heavy metals, paper, cardboard, glass, gloves, needles, X-ray films, dental amalgams, garbage, infectious materials, and instruments.¹⁰ Several studies have attempted to quantify dental waste generation. For instance, a study in Greece reported an average of 53.3 g of dental waste per patient per day across 20 clinics.¹¹ Similarly, research conducted in Brazilian cities in 2022 found that although collection procedures were consistent, general waste such as paper, cardboard, and plastic film posed the greatest challenge due to inadequate recycling infrastructure and the absence of selective collection in many municipalities.¹² An important step to implementing proper medical waste management is to increase awareness about quantity and quality in all cities.¹³ The 2030 Agenda for Sustainable Development, adopted in 2015, outlines 17 goals in social, economic, and environmental categories, and specifically identifies the issue of waste accumulation and disposal.^{14,15} Moreover, in 2017, the FDI World Dental Federation issued a statement emphasizing the sustainability of dental care. According to the statement, dental practices should limit as much as possible the consumption of energy, water, and paper, emissions into the air and water, as well as improper disposal of substances harmful to the environment.¹⁶

Therefore, the aim of this study was to determine the quality and quantity of the various types of dental waste in dental clinics through sampling, physical analysis, and weighing the separated waste generated in the dental clinics, as well as decides the status of the dental solid wastes (DSWs) management in Karaj a popular city close to the capital of Iran.

Material and Methods

Area of Study

Karaj, the capital of Alborz province (Figure 1), is located between latitudes 35°31' and 36°12'N and longitudes 50°11' and 51°29'E, with an average elevation of approximately 1300 m above sea level.¹⁷ The climate is classified as cold and semi-arid, with an average annual rainfall of 261 mm. The city has an area of 858 km² and a population of 1.97 million people.¹⁸

Sampling and Analytical Method

In this descriptive cross-sectional study, out of all dental offices in Karaj (including both general and specialized clinics), 88 were initially identified, of which 58 agreed to participate. Waste sampling was conducted by environmental health experts over three consecutive working days (Monday, Tuesday, and Wednesday) during February, March, April, and September 2023. To minimize the influence of clinic closures on waste volume, sampling was scheduled during weeks without



Figure 1. Location of the city of Karaj in Iran¹⁹

official holidays.

Three samples were collected from each participating dental office, resulting in a total of 174 samples. All the samples were transferred to the laboratory within 10 hours of collection. They were physically analyzed and weighed using an EK120A precision scale. First, the waste was sorted into 64 subcategories based on hazard potential and environmental relevance. These were then consolidated into five major categories (Table 1), namely: household, infectious, chemical and pharmaceutical, sharps and cutting waste, and toxic waste.²⁰

Meanwhile, to ensure operator safety during waste separation and analysis, appropriate gloves, lab coats, and face masks were used throughout the process.²² Each component was weighed three times, and the average weight was recorded for each category using a laboratory scale with 0.01 g accuracy.²³ Finally, the average daily weight of each waste category was calculated, and all data were analyzed using Excel 2016.

Results and Discussion

Dental waste management is a relatively new, a cross-sectional study conducted over a 5-month period in 2007 found that most dental waste was thrown in the trash.²⁴ In this study, the total annual dental waste generated in Karaj was calculated to be 4,522.995 kg/year. The production rates of the different waste categories were as follows: infectious waste (38%), household waste (36%), chemical and pharmaceutical waste (16%), and toxic waste (10%). The majority of waste generated in dental facilities in Karaj was attributed to household-like waste. To estimate average waste generation, the data collected over three sampling days were averaged to calculate the daily production rate of each waste component per dental office. To project the annual waste output, it was necessary to determine the number of working days for dental centers. According to the 2023 calendar, there were 288 active working days. The annual production of each waste type was then calculated by multiplying the average daily waste generation by 288. Besides, to scale the results to represent all dental units in the city, a scaling factor of 1.517 was derived by dividing the total number of dental

units in Karaj by the number of sampled offices (Table 2).

By multiplying this number by the annual production of various waste components in sampled dental centers, the total annual generation of waste in the dentists of the city of Karaj was achieved (Figure 2).

Another study conducted in Lebanon clearly showed that only 28% of participants properly separated sharps waste into appropriate containers, and only 70% of dentists reported treating infectious waste before disposal. Furthermore, approximately two-thirds of the surveyed dentists did not follow local guidelines, and half did not take proper precautions when managing dental wastes. The majority of the participants (90%) also admitted to lacking written procedures for waste management.²⁵ Similarly, findings from a study in Bangkok indicated that only a small proportion of dentists complied with all recommended waste disposal practices. A noticeable amount of dental waste was discharged into the household waste stream, emphasizing the need for behavioral change interventions.^{26,27} The widespread mismanagement of dental waste reported in various countries underscores

the urgent need for training programs at all levels of dental units—from dentists and assistants to waste handlers, maintenance personnel, and cleaning staff.¹¹

In Saudi Arabia, Sabbahi et al performed a descriptive cross-sectional study involving 314 dental healthcare providers from four dental colleges and 20 private dental clinics in Jeddah. The study found that knowledge among oral healthcare providers regarding proper procedures for isolating, collecting, transporting, and treating dental waste was poor and non-standardized. These observations point to an urgent need to establish clear policies and regulations for dental waste management in Saudi Arabia.²⁸ Similarly, Ali et al reported that dental waste management practices in Karachi, Pakistan, were inadequate and inappropriate. The study emphasized the need for government supervision of all dental practices and the enforcement of regulatory guidelines.²⁹ To calculate per capita waste generation, the number of patients visiting each clinic per day was divided by the total number of working days, based on clinic patient registries. After weighing the waste, data were analyzed

Table 1. Types of Wastes in the Dental Offices²¹

Segmentation	Components
Household waste	Dry paper towels, dry gas, dry cotton, dry dental rolls, nylon coated paper, syringe and needle packaging coating, sandpaper, paper and cardboard, sterile carbon, fabric, radiographic film coating paper, plastic radiographic film coating, amalgam empty capsule, rubber, molding plaster, adhesive tape, glass adhesive tape, wound glue, matchstick, food, food packaging coating, tea pulp, cigarette filter, soil and plaster mixture, ampoule packaging coating, nylon and plastic, carbon paper, mask, gas and plaster mixture
Infectious waste	Paper towels covered in blood and saliva, gas covered in blood and saliva, cotton covered in blood and saliva, dental rolls covered in blood and saliva, nylon gloves, latex gloves, surf action, tooth extraction, strip tape, bracket, mouth stick, Gotha Percha, airtight coating, dental coating, Matrix tape
Toxic waste	Amalgam-coated paper towels, amalgam-coated gas, amalgam-coated dental roll, amalgam-coated cotton, radiographic film, amalgam particles, lead foil radiographic film coating
Chemical and pharmaceutical waste	Ampoules used, wax, molding paste, acrylic, calcium hydroxide
Sharp and winning waste	Needles and sharp objects, dental mirrors, surgical blades, needle stitches, dental spatula, plastic syringe

Table 2. Weight of Various Components of Dental Wastes in Dental Offices in the City of Karaj

Row	Type of weighed wastes	Average (kg)	Number of kg/year*
1	Paper towels contaminated with saliva (infectious)	0.952	274.176
2	Blood-contaminated paper towels	0.644	185.472
3	Gas contaminated with saliva (infectious)	0.658	189.504
4	Gas contaminated with blood (infectious)	0.480	138.240
5	Nylon (household)	2.490	717.12
6	Disposable gloves (infectious)	0.354	101.952
7	Plastic gloves (infectious)	1.571	452.448
8	Chalk and molding paste (chemical- pharmaceutical waste)	0.669	192.672
9	Plastic (household)	1.025	295.2
10	Paper and cardboard.	2.093	602.784
11	(Sharp and winning waste)	1.045	300.96
12	Needles and Sharp Objects.	0.506	145.728
13	Stick mouth (infectious)	0.607	174.816
14	Pharmaceutical	1.922	553.536
15	Dental gas contaminated with saliva (infectious)	0.343	98.784
16	Dental gas contaminated with blood (infectious)	0.345	99.36
17	Total sum	15.704	4522.752

* Daily average of various waste components × number of working days in 2023.

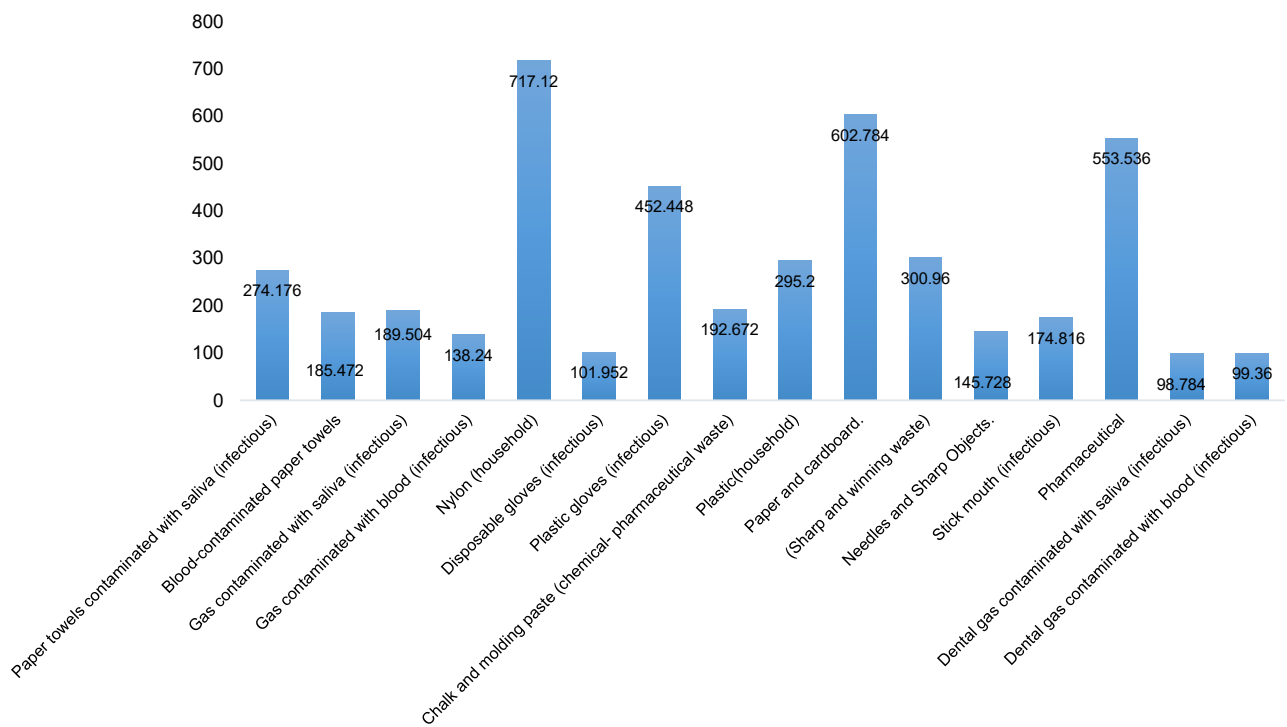


Figure 2. Annual generation of dental wastes in Karaj

using Excel 2016.³⁰ Table 3 shows the annual quantities of different dental waste components in dental offices in Karaj.

Based on Figure 3, infectious waste accounts for 38% of the total dental waste, followed closely by household and semi-household waste at 36%. Chemical and pharmaceutical waste makes up 16%, while sharps and cutting waste constitutes the remaining 10%.

In Iran, a study by Danaei conducted in dental offices in Bojnord city reported a total of 6,162 kg of dental waste generated annually, of which 49.99% was attributed to general (household-like) waste and 1.69% to hazardous waste. A cross-sectional study involving 595 private and public dental clinics at Shiraz University found that approximately 90% of dental offices segregated infectious waste from general waste, but only 60% used standard systems for managing sharps.³¹ Research by Amouei et al in Babol city revealed that the highest proportion of waste was related to semi-household waste (52.5%), while toxic waste had the lowest share (0.3%).³²

Similarly, Nabizadeh et al reported that dental clinics in Hamedan produced an average of 8,677.56 kg/year of waste, with 91.4% being household waste and only 0.02% classified as toxic.³³ At Zabol Dental Clinic, annual waste generation was reported as 5,457 kg, with the following composition: infectious and potentially infectious waste (48.08%), household waste (43.75%), chemical and pharmaceutical waste (7.82%), and toxic waste (0.35%).³⁰

In Urmia, studies also revealed that household waste constituted the largest portion of dental waste.³⁴ The results of a study by Lakbala performed in Bandar Abbas found that dentists generally do not have much awareness about

dental waste disposal in Bandar Abbas. In addition, most of the waste management services were substandard.³⁵ In addition, most of the waste management services were substandard. Enforcement of waste management laws requires continuous monitoring and timely training. Therefore, like other developed countries, there is a need to build a comprehensive medical waste management system in Iran.³⁶ A related study in Shahrekord also found that domestic and infectious waste comprised the largest proportions of dental waste. However, measures for segregation, minimization, and recycling were largely absent.³⁷ In line with previous findings, the present study also emphasizes the importance of waste classification, particularly for household and infectious waste. The results indicate that among all waste components, nylon materials had the highest annual weight at 717.231 kg, followed by paper and cardboard (e.g., packaging, tissues, prescription forms) at 602.712 kg/year, and rubber gloves at 452.561 kg/year. Effective medical waste management heavily depends on the proper identification and classification of waste.³⁸ Dental waste can and should be managed through environmentally sustainable strategies following the 3R principle: reduce, reuse, and recycle.³⁹ Given the high volume of nylon and plastic waste in Karaj, reducing disposable materials and increasing the use of reusable tools and equipment can significantly lower total waste output. Implementing waste sorting programs at the source is essential for reducing overall waste production and promoting the recycling of semi-household waste such as paper and plastic. Thus, training dental staff and developing sustainable strategies for the collection, transportation, treatment, and recycling

Table 3. Different Components of Dental Wastes in Dental Offices in Karaj

Volume (kg/year)	Components
1714.929	Infectious
1615.256	Household
746.206	Chemical-Pharmaceutical
446.564	Sharp and winning

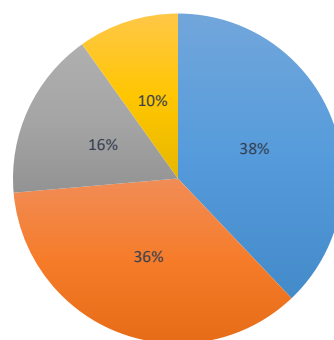
of biomedical waste is critical. Clear regulations and enforcement mechanisms are also necessary to address current challenges and reduce the environmental burden of poor recycling practices.⁴⁰ The innovation of this study lies in the comprehensive access to detailed data from all dental centers in the city. This information, including clinic names and addresses, was obtained from the Municipal Waste Management Organization, which maintains accurate records as dental centers are required by regulation to contract with this body and provide documentation to the provincial University of Medical Sciences. Unlike previous studies that provided only general recommendations, this research offers specific data on waste components and quantities, making it directly applicable for municipal planning such as budget allocation, waste policy development, and project implementation in dental waste management.

Conclusion

Given that infectious and household waste constitute the largest portions of dental waste, selecting appropriate methods for the safe handling, disposal, and recycling of such waste is crucial. Effective recycling of household-type waste can significantly reduce the volume of waste buried in landfills and lower associated environmental health risks. The collection and disposal of all categories of dental waste—including toxic, chemical-pharmaceutical, potentially infectious, and semi-household waste—must be carried out separately and strictly in accordance with national regulations and guidelines. It is essential to raise awareness among dental professionals, staff, and even patients about the importance of sustainable waste management practices in dentistry. Furthermore, stakeholders must be educated on the environmental impacts of dental waste and encouraged to adopt eco-friendly alternatives and responsible disposal practices. An integrated waste management approach, which includes source reduction, recycling, and material recovery, should be prioritized to both protect public health and preserve the environment. To achieve this, it is necessary to implement a nationwide program for the systematic management of dental waste, supported by training, monitoring, and enforcement mechanisms at local and national levels.

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■ Infectious ■ Household waste ■ Chemical-pharmaceutical ■ Sharp and winning.

Figure 3. Percentage of Dental Waste Components in the City of Karaj

Authors' Contribution

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Supervision: Fariba Jalali, Mohammad Mosayyebi, Nahid Ghobadi.

Validation: Fariba Jalali, Mohammad Mosayyebi, Zeinab Atashzaban, Fariba Fatehi, Marzieh Moradi.

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Writing—review & editing: Fariba Jalali, Mohammad Mosayyebi, Nahid Ghobadi, Zeinab Atashzaban, Fariba Fatehi, Marzieh Moradi.

Competing Interests

The authors declare no conflicts of interest.

Ethical Approval

This study was done without receiving ethical code.

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