HRÜ Uluslararası Diş Hekimliği ve Oral Araştırmalar Dergisi
HRU International Journal of Dentistry and Oral Research
Received date: 02 March 2025 / **Accept date:** 21 March 2025
DOI: 10.61139/ijdor.1649869

Sustainable Dental Approaches for The Environment And Human Health: A Traditional Literature Review

Meryem Dormen[12*], Pelin Özkan[2]

1. Ankara University, Institute of Health Sciences, Ankara, Türkiye.
2. Ankara University, Faculty of Dentistry, Prosthodontics Department, Ankara, Türkiye.

***Corresponding author**: Dormen M, Dentist, Ankara University, Institute of Health Sciences,, Faculty of Dentistry, Department of Prosthetic Dentistry, Ankara, Türkiye.
E-mail: meryemdormen@gmail.com.
Orcid: 0009-0004-6846-2495

Abstract

The world is on the brink of environmental crises, making the role of the healthcare sector increasingly critical. Dentistry is in a position to be a pioneer in this transformation with both its impact on the global environment and its potential to shape the future of sustainable healthcare. Efforts in the sector embody green dentistry, including eco-friendly practices.. In this context, green dentistry is an innovative approach that minimises environmental damage and prioritises patient safety by using resources in the most efficient way. Elements such as waste management, energy efficiency and digitalisation are key components of this approach. It is not only an environmental requirement, but also an opportunity that increases patient satisfaction, provides efficient clinical management and economic benefits in the long term. Starting from the historical development of green dentistry, this study comprehensively addresses the methods that can be applied for sustainability. It also emphasises the importance of training programs and international collaborations to raise the awareness of dentists and healthcare professionals. The dissemination of environmentally friendly practices can transform the entire healthcare system, not just the dental practices or polyclinics. Raising awareness of green transformation in the sector, developing sustainable policies and adopting feasible solutions at the individual level are critical to the success of the idea. Future studies should focus on innovative methods that will increase the applicability of this framework. In the future, thanks to innovation and conscious policies, more sustainable and effective dental practices with minimised environmental impact will be at the forefront.

Review (HRU Int J Dent Oral Res 2025; 5(2): 51-58)

Keywords: Public health dentistry, dental waste, carbon footprint, recycling, dental clinics.

Introduction

Our world and its inhabitants confront numerous challenges, such as climate change, biodiversity loss, air and water contamination, and the depletion of the ozone layer. The World Health Organization (WHO) declares that protecting public health through ecologically responsible actions is an ethical duty of every state(1). While one of the greatest challenges of the twenty-first century is the contamination of natural resources due to increased waste production, the global shift toward ecological sustainability has become imperative(2). Recently, rising environmental awareness, often termed “eco-consciousness”, has evolved into a gradual global movement aimed at reducing environmental harm, ultimately paving the way for “green” transformations(3). It is paradoxical that healthcare services, whose fundamental principle is to support and protect health and life, contribute to climate change through unsustainable practices, leading to increased mortality and diminished quality of life(4). Eco-friendly dentistry is a dental practice that simultaneously embraces sustainability, prevention, caution, minimally invasive patient-centered care, and a globally focused treatment philosophy. It is an emerging concept that benefits the environment, patients, clinical staff, and dentists alike(5). Not only does it help control waste pollution in dental clinics, but it also conserves water, energy, and other resources. Sustainability; one of the core principles of eco-friendly dentistry, refers to meeting the needs of the present

Received date: 02 March 2025 / Accept date: 21 March 2025
DOI: 10.61139/ijdor.1649869

without compromising the ability of future generations to meet their own(5) The field of dentistry is encouraged to integrate sustainable development goals into daily practice and promote the shift toward a green economy. Dental professionals have a duty to minimize their environmental footprint while advancing oral health for everyone and maintaining patient safety. (6). Advancements in eco-friendly dentistry may be achieved via two main avenues: developing and implementing customized policies, and leveraging the authority held by dentists themselves(7).

History of Green Dentistry

The concept of "green dentistry" was first discussed during the 5th European Dental Students' Association Congress in Belgrade, Serbia, in March 2003, when the delegation outlined the idea and proposed its acceptance by the assembly. The first international reference to eco-friendly dentistry was published on April 3, 2007, by Dr. Ali Farahani and Mittale Suchak(8). In 2008, Dr. Fred Pockrass and Ina Pockrass founded the Eco-Dentistry Association (EDA) to minimize waste and pollution, conserve energy, water, and financial resources, utilize cutting-edge technology, and integrate holistic approaches that emphasize healthy living(9). EDA provides education, standards, and networking for patients and dentists practicing green dentistry(7). On December 22, 2009, Dr. Steven Koos, Goran Kralj, and Mladen Kralj trademarked eco-friendly dentistry and officially defined it(8,9). In August 2017, the FDI World Dental Federation released a document titled "Sustainability in Dentistry," based on the United Nations report "Transforming Our World"(10).

The 5R Principle

Green dentistry is built upon the five-R model: Rethink, Reduce, Reuse, Recycle, and "Energy Recovery/Molecular Redesign"(11,12). When determining which materials are truly needed, healthcare teams can select suppliers that explicitly list raw materials and chemical contents, have a sustainable supply chain, and operate under eco-friendly, ethical working conditions. Reducing the purchase of packaged materials and maximizing the use of reusable products can help "reduce" waste(9). Single-use items should be replaced with reusable versions. Existing recycling programs—capable of recycling paper, metal, plastic, and gypsum—should be identified.(5,12) However, the large-scale reuse of retail packaging is limited by transport distances and conditions when returning empty cartons to suppliers. Some portion of the energy content in plastics can be recovered via incineration, achieving reasonable energy efficiency when co-firing in furnaces. Because part of the energy content is recovered, incineration is more advantageous than landfilling. Nonetheless, energy recovery does not reduce the demand for raw materials in plastic production and is thus considered less energy-efficient than recycling (12).

Concerns about emissions from incineration plants further reduce the appeal of this disposal method (13).

The 4A Management Protocol

Adapted from smoking cessation strategies, this protocol has been proposed as a method for achieving sustainability. "Ask"- Gather detailed information about all routine dental practices from the healthcare team. "Assess"- Evaluate which practices can be modified and encourage eco-friendly dentistry. "Advise"- Propose a guideline to follow. "Assist"- Help develop a framework suited to the conditions of the dental clinic or hospital (14).

Green Healthcare Approaches Worldwide and in Turkey

In 2022, Dentsply Sirona conducted a global survey involving more than 1,300 dentists from the USA, Europe, Asia, and Latin America to gain in-depth insights into sustainability in the dental sector, as part of their "BEYOND: Taking Action for a Brighter World" initiative (15). In collaboration with the FDI World Dental Federation, they also published a "Consensus Statement on Environmentally Responsible Oral Health," proposing strategies to reduce the environmental impact of the sector. They established a new online toolkit (MOOC) to provide global guidance and practical support to dentists on environmental issues, as part of the "Sustainability in Dentistry" initiative(16). In the United Kingdom, the National Health Service (NHS) uses carbon footprint analysis(17), and life cycle assessment (LCA), which examine broader environmental impacts, to understand the ecological impact of products and services(18). A carbon footprint is a measure that assesses how human activities affect the environment and demonstrates sustainable resource management(9). It comprises total emissions produced by supply chain participants, with its magnitude directly proportional to its impact on climate change(4,19). Global healthcare contributes significantly to national CO_2 emissions, accounting for around 5% on average(20). LCA, referred to as "cradle to grave," encompasses all aspects of a product's lifecycle, from raw materials to production,

use, transportation, and disposal. Alongside other healthcare organizations, NHS established the Coalition for Sustainable Pharmaceuticals and Medical Devices (CSPM), which recommends LCA for comparing services and aiding policymakers in making informed decisions. Another relevant measure is the human health burden, or DALY (Disability-Adjusted Life Years), reflecting the years of life lost due to both morbidity (disease and disability) and mortality
(premature death) within a population(18). DALYs can be calculated via LCA modeling based on the environmental impact of producing, using, and disposing of a product. The European Union recently adopted the Product Environmental Footprint (PEF) to standardize and compare environmental impacts(21). In Germany and Austria, there is a quality label called "DIE GRÜNE PRAXIS" (the green practice), which recognizes eco-friendly clinics(22). Currently, Turkey does not have organizations, projects, or associations capable of evaluating these criteria. However, dentists can individually refer to the "Sustainability in Dentistry" project established by the FDI World Dental Federation, use the Eco-Dentistry Association's GreenDOC Dental Office Certification Program for guidance, or utilize the University of Michigan's "Greening the Dental Clinic" assessment survey to form their own green teams(22).

Methods for Achieving Green Dentistry

- **Education**

For Dentists; Dental schools can integrate green dentistry into their curricula. The Sustainability in Dentistry Resource Kit, developed by Dentsply Sirona as part of the DS Academy Clinical Education Program, offers Continuing Education credits for completed courses taught by experienced dentists and sustainability experts, providing valuable insights into sustainable dental practices (16,23). ProDental CPD offers the "P300 Essentials of Sustainability in Dentistry" course, designed to educate dentists and support staff about dentistry's impact on climate change and ecological degradation(24).

For Patients; Posters can be displayed in waiting areas or shared electronically(25). Patients may be advised to use bamboo or, alternatively, recycled plastic-handled toothbrushes. Although some evidence suggests electric toothbrushes reduce plaque and gingivitis more than manual toothbrushes, no clinical data indicate that any particular toothbrush is more effective at preventing dental caries or periodontal disease(26). According to Lyne et al., the climate change impact of an electric toothbrush is 11 times higher and its effect on biodiversity and habitat loss is more than 36 times higher than that of a bamboo toothbrush(17). One study calculated the DALYs associated with manual plastic, manual bamboo, replaceable-head recycled plastic, and electric toothbrushes, finding that electric toothbrushes had the highest impact(27). Some companies have started labeling toothpaste tubes with #2 high-density polyethylene (HDPE) recycling codes. Patients can be informed about these codes and instructed on proper recycling procedures(28).

- **Recycling**

Healthcare waste is broadly categorized into general and hazardous waste(29). Traditional disposal methods (incineration or landfill), contribute to pollution and resource depletion. Recycling, by contrast, reduces the need for raw materials and minimizes waste(30). In a multi-stakeholder statement by Martin et al. regarding "Environmentally Sustainable Oral Health," the top (most preferred) tier of the waste pyramid is resource reduction, followed by repurposing, energy recovery, and, least preferred, disposal or direct release into the environment(31). According to EPA, the most effective way to manage waste is to avoid creating it in the first place. Reducing and reusing products are the best strategies for conserving natural resources, protecting the environment, and saving money(32).

Materials that can be recycled in dental clinic and laboratory;

Gypsum: Dental stone, plaster of Paris, investment plaster, and dental plaster can be recycled effectively without extensive chemical or physical modifications. Methods include using a 20% ammonium bicarbonate solution, semi-dry pressing, and calcination. Recycling one metric ton (1,000 kg) of gypsum can save 28 kWh of energy and 1.8 kg of aluminum (33).Recycled gypsum can be used as fertilizer, or in cement and specialized ready-mix concrete, as well as in plastics, adhesives, and insulation materials(30). Dental clinics should establish procedures for identifying and separating gypsum waste to facilitate proper disposal(34). They must also review and comply with national waste management policies; failure to do so may result in inspections by local authorities responsible for supervising various waste streams(30).

Broken or Unused Instruments: Dentists can recycle old hand instruments via Hu-Friedy's "Envirodent" program,

Received date: 02 March 2025 / Accept date: 21 March 2025
DOI: 10.61139/ijdor.1649869

initiated 31 years ago, which allows them to exchange these instruments for new ones free of charge (35).

Contaminated Waste: Infectious waste constitutes 10–25% of total healthcare facility waste, emphasizing the importance of proper waste management(36). Items such as IV tubing, catheters, syringes, and gloves are recyclable but must be placed in red bags. Specific solid wastes including anatomical waste (human or animal origin), body fluids, cotton swabs, expired medications, liquid waste, and laboratory waste go into yellow bags. General solid waste is disposed of in black bags. Infectious sharps (needles) go into white bags, while implants, glassware, vials, and ampoules go into blue bags, thus pre-sorting them for recycling(37). Artificial intelligence–based technologies (smart bins, sorting robots, wireless sensors) enable real-time monitoring of waste bins, predictive waste collection, and optimization of waste processing(38). Traditional bins simply collect waste, requiring manual checks by healthcare workers. This process is inefficient for routine waste management, and frequently filled bins can encourage the proliferation of pathogens and insects. Researchers are currently exploring methods to integrate waste-sorting robots into existing systems, enabling automated separation before it reaches landfills(39). To further enhance these robots, optical(40) and olfactory sensors(41), as well as microwaves(42), infrared, and gas sensors, are being investigated. Such robots could significantly boost efficiency, cut labor costs, and improve waste classification, making them highly relevant for the healthcare sector(38).

- **Green Building**

A green building emphasizes the use of locally available natural materials(43).

Flooring: Linoleum flooring is recommended for designing an eco-friendly dental clinic(7,44).

Paint: One of the most harmful chemicals in commonly used paints for clinic walls are volatile organic compounds (VOCs), which easily vaporize into the air and contain carbon. As paint dries, it releases these hazardous compounds(7). Recent technological advances in the paint industry have made it possible to reduce VOCs; therefore, ultra-low or zero-VOC paint is recommended(7,44–46).

Lighting: Compact fluorescent bulbs should be used, as they last 8–12 times longer than incandescent bulbs and cost only about one-quarter as much per hour(5).

Construction Materials: Concrete can replace brick to reduce heating and cooling demands and increase thermal efficiency. Double-glazed windows can maximize natural light while minimizing direct heat gain(47).

- **Electricity Consumption**

Nearly 90% of the energy consumed by washing machines is spent heating the water, so washing clinic gowns in cold water conserves energy. Set the washing temperature to cold or warm, with a cold rinse cycle(48). Additionally, “vampire power” refers to devices plugged in but not in active use; unplugging them after hours saves energy. Turn off unnecessary transformers, equipment, surge protectors, TVs, monitors, and computers when the clinic is closed(44).

- **Water Consumption**

Dental vacuum systems are essential in any practice, but their high water usage can lead to waste and water pollution(49). There are three types of dental vacuum pumps: water-consuming, water-recycling, and dry pumps. A “green” approach is the dry vacuum system, which can save approximately 1,400 liters of water daily compared to a wet vacuum in a typical clinic. This equates to around 12,000 half-liter bottles of drinkable water(47,48). Sensor-operated faucets, starting the autoclave only when fully loaded, and even rainwater harvesting can further reduce water consumption(50).

- **Hazardous Waste Management**

Amalgam and Composite Resins: Dental amalgam is an alloy containing elemental mercury. Mercury is a bioaccumulative toxicant, and evidence shows that dental amalgam is a primary source of mercury in the human brain and kidneys(51). The most toxic form of mercury is organic methylmercury, which, even at low concentrations, is highly damaging to water and soil quality(52,53). Elemental mercury can transform into methylmercury upon contact with aquatic organisms(37). Mercury in dental amalgam can contaminate the environment via spills or the extraction of amalgam-filled teeth. Amalgam waste, classified as mercury-contaminated, should be stored in designated containers with mercury-suppressing agents to prevent vapor exposure. Installing amalgam separators in units

facilitates the removal of amalgam particles from wastewater, ensuring that amalgam waste is properly collected and disposed of as hazardous(37). Likewise, microparticle pollutants that can contaminate the waste system are generated during placement and removal of resin-based composites(54). Commonly termed microplastics, these particles pose a significant environmental threat, potentially affecting aquatic life, soil, and food webs due to bioaccumulation(55). Microplastic pollution is defined as the release of synthetic plastic particles(56). In 2015, an estimated 800 million direct composite restorations were applied(57), and about 6% are expected to fail within 10 years, equating to 48 million restorations that must be removed or replaced, releasing composite resin particles into municipal landfills, incinerators, and wastewater(58). Assuming an average weight of 0.3 g per composite restoration, extrapolations suggest as much as 14.4 tons of particulate waste could enter wastewater annually. One meta-analysis indicates that 32 million posterior restorations placed in 2015 will require replacement or repair by 2025, underscoring the potential for resin microparticles in the waste stream(59). Still, composite resins are indispensable in restorative and esthetic dentistry(9).

- **Gloves and Rubber**

Incineration of chlorine-containing materials such as gloves and rubber can release dioxins, which have been linked to cancer and reproductive disorders(60). Non-chlorinated latex gloves are a viable alternative(32).

- **Integrating Quality of Life into Dentistry**

Aromatherapy and the use of greenery in the clinic can help patients relax naturally. A HEPA UV germicidal air purifier can remove airborne particles(61). Establishing a green area with native, insect-friendly plants, avoiding herbicides, and providing bird feeders and natural habitats (leaving branches, leaves) further supports local ecosystems. A green wall in the waiting area not only reduces patient anxiety but also promotes smoking cessation(25).

- **Digitalization**

Radiographic waste poses an environmental challenge. Popa D and colleagues found that dental clinics generate approximately 4.8 million lead foils and 28 million units of toxic radiographic material(62). Computer-Aided Design and Computer-Aided Manufacturing (CAD/CAM) systems eliminate the need for radiographic waste and the disposal of silicone or alginate impression materials.

- **Reducing the Greenhouse Effect**

Using nitrous oxide with oxygen as a dental anesthetic raises environmental concerns because nitrous oxide is estimated to contribute about 5% to the greenhouse effect(63,64). Consequently, sevoflurane has been recognized as a safe and effective alternative that can contribute to making dental procedures more environmentally friendly(65). Travel-related emissions can be minimized by utilizing technology for communication and professional interactions(66), scheduling appointments for multiple family members on the same date, or combining multiple treatments in one visit. Likewise, it is advisable to consolidate deliveries with technicians and suppliers to reduce shipping frequence(25).

- **Green Dentistry in Treatments**

Another sustainability concern is the pharmaceutical regimens that support dental care. Antibiotic overuse and the subsequent rise in antibiotic resistance exemplify this issue(67). Research on novel components like Camellia sinensis extract and ozonated natural olive oils in toothpaste and mouthwash arises from the understanding that the composition and balance of the oral microbiome play a crucial role in overall health. Probiotics have also been shown to benefit oral health(68,69).

Discussion

Studies investigating awareness of biomedical waste management among dentists report high levels of awareness. However, more education is needed to achieve comprehensive understanding, particularly regarding color-coded waste disposal(70). Inappropriate disposal of single-use items (syringes, gloves, masks) pollutes soil and groundwater, posing threats to terrestrial and aquatic ecosystems. Inadequate waste management systems and weak regulations exacerbate these environmental risks(2). Seven out of ten dentists want to adopt more sustainable practices but do not know how to begin, and six out of ten believe that creating a positive impact on the environment and society is the top priority for the dental sector. Nevertheless, in many markets, sustainability triggers positive emotions in fewer than half of dentists. Although most dentists wish to play a role in making dentistry more sustainable, 69% admit

they are unsure how to implement concrete actions or how these would affect everyday patient cared(71,72).

Conclusion

Awareness is vital for integrating sustainability into dentistry and developing eco-friendly behaviors in dental practices. A lack of professional and public awareness, knowledge and educational gaps, and factors related to the production and disposal of materials all hinder environmentally responsible practice(71,72). Individuals who are mindful of environmental considerations in their daily lives are more receptive to the same principles in dental settings. While sustainability is not yet a primary criterion for patients choosing a dental clinic,

its significance is expected to rise. Dentists must recognize the need to create eco-friendly clinical environments to be community-focused. Reducing one's carbon footprint is a frequently mentioned commitment to sustainability objectives. It is unfortunate that, this measure alone does not accurately reflect the full environmental impact, which also includes biodiversity loss, ecotoxicity, and air pollution, all linked to deteriorating human health(27). Such issues extend beyond the direct intervention and encompass every stakeholder in the healthcare supply chain(25). Measuring and reducing the ecological footprint of healthcare-related technologies is inevitable(19).

Author Contributions: The authors took an active role in all stages of this study. The conceptualisation and design of the study was carried out by M.D. Data collection, analysis and interpretation processes were carried out by M.D. and P.Ö. The writing, critical revision and finalisation of the manuscript were provided by M.D. and P.Ö. All authors reviewed and approved the final version of the manuscript and agreed to the accuracy of the content.

Conflict of Interest: The authors declare that there is no conflict of interest.

References

1. Toma A, Crişan O. Research on developing environmental ethics in pharmacists' activities. Environ Health. BioMed Central Ltd; 2021;20(1). PMID: 33952257
2. Saxena V, Datla A, Deheriya M. Green dentistry: a systematic review for objective and subjective research. Int J Res Med Sci. Medip Academy; 2023;11(9):3387–3395.
3. Mulimani P. Green dentistry: The art and science of sustainable practice. Br Dent J. Nature Publishing Group; 2017;222(12):954–961. PMID: 28642517
4. Martin N, Sheppard M, Gorasia GP, Arora P, Cooper M, Mulligan S. Awareness and barriers to sustainability in dentistry: A scoping review. Journal of Dentistry. Elsevier Ltd; 2021;112:103735. PMID: 34182058.
5. Arora S, Mittal S, Dogra V. Eco-friendly dentistry: Need of future. An overview. J Dent Allied Sci 2017;6(1):22.
6. Mazur M, Ndokaj A, Bietolini S, Nisii V, Duś-Ilnicka I, Ottolenghi L. Green dentistry: Organic toothpaste formulations. A literature review. Dent Med Probl. 2022;59(3):461-474. PMID: 36206496.
7. Chadha GM, Shenoy Panchmal G, Shenoy RP, Siddique S, Jodalli P. Establishing an Eco-friendly Dental Practice: A Review. IJSS Case Reports & Reviews 2015;1(11):78-81
8. Mittal R, Maheshwari R, Tripathi S, Pandey S. Eco-friendly dentistry: Preventing pollution to promoting sustainability. Indian Journal of Dental Sciences. Medknow; 2020;12(4):251.
9. Soğancı C. Green Dentistry: Sustainability In Dentistry. International Journal of Environmental Trends (IJENT). 2023;7(2):88–100.
10. World Dental Federation FDI. Sustainability in Dentistry: Adopted by the FDI General Assembly: August 2017, Madrid, Spain. Int Dent J. 2018;68(1):10-11. PMID: 29363120
11. Rastogi V, Sharma R, Yadav L, Satpute P, Sharma V. Green dentistry, a metamorphosis towards an eco-friendly dentistry: A short communication. Journal of Clinical and Diagnostic Research. Journal of Clinical and Diagnostic Research; 2014;8(7).
12. Thompson RC, Moore CJ, vom Saal FS, Swan SH. Plastics, the environment and human health: current consensus and future trends. Philosophical Transactions of the Royal Society B: Biological Sciences. 2009 Jul 27;364(1526):2153–2166.
13. Katami T, Yasuhara A, Okuda T, Shibamoto T. Formation of PCDDs, PCDFs, and Coplanar PCBs from Polyvinyl Chloride during Combustion in an Incinerator. Environ Sci Technol. 2002;36(6):1320–1324.
14. Vanka S, Wali O, Vanka A. Four A'S of eco-friendly dentistry. Brazilian Oral Research. Sociedade Brasileira de Hematologia e Hemoterapia; 2019. PMID: 30758404
15. Dentsply Sirona [Internet] Global Sustainability in Dentistry Study Excerpt. [Access Date:17.01. 2025] Acess Link: file:///Users/meryemdormen/Downloads/CORP-Global-Sustainability-in-Dentistry-Study-Outcomes-EN%20(2).pdf
16. Dentsply Sirona [Internet] Sürdürülebilirlik konusunda bilgi boşluklarını gösteren çalışma sonuçları [Access Date: 17.01.2025] Access Link: https://www.dentsplysirona.com/tr-tr/sirket/surdurulebilirligimiz/dis-hekimliginde-global-surdurulebilirlik-calismasi.html
17. Lyne A, Ashley P, Saget S, Porto Costa M, Underwood B, Duane B. Combining evidence-based healthcare with environmental sustainability: using the toothbrush as a model. Br Dent J. Springer Nature; 2020 Sep 1;229(5):303–309. PMID: 32918023
18. World Health Organization (WHO) [Internet] Global Health Estimates:Life Expectancy and and Leading Causes of Death and Mortality. Access Link: https://www.who.int/data/gho/data/themes/mortality-and-global-health-estimates
19. Hegedus T, Kreuter P, Kismarczi-Antalffy AA, Demeter T, Banyai D, Vegh A, Geczi Z, Hermann P, Payer M, Zsembery A, Al-Hassiny A, Mukaddam K, Herber V, Jakse N, Vegh D. User Experience and Sustainability of 3D Printing in Dentistry. Int J Environ Res Public Health. 2022 Feb 9;19(4):1921.
20. Pichler PP, Jaccard IS, Weisz U, Weisz H. International comparison of health care carbon footprints. Environmental Research Letters. 2019 Jun 1;14(6):064004.
21. European Commission [Internet] European Platform on LCA (EPLCA) European Footprint [Acess Date: 17.01. 2025] Acess Link: https://eplca.jrc.ec.europa.eu/EnvironmentalFootprint.html

22. W&H [Internet] Çevreci Diş hekimliği: Sürdürülebilir Diş Hekimliği içingirişimler ve kalite etiketleri [Acess Date: 17.01.2025] Acess Link: https://www.wh.com/tk_turkey/dental-haberpanosu/makale/1637856319146
23. Helping dental professionals develop more sustainable dental practices. BDJ Team. 2023 Jul 21;10(7):37–37.
24. ProDental CPD [Internet] P300 Sustainability in Dentistry Foundation Course [Acess Date: 17.01. 2025] Acess Link: https://www.prodentalcpd.com/module1725/p300-sustainability-in-dentistry-foundation-course
25. Veress S, Kerekes-Máthé B, Székely M. Environmentally friendly behavior in dentistry. Med Pharm Rep. Universitatea de Medicina si Farmacie Iuliu Hatieganu; 2023;96(2):199–205.
26. Yaacob M, Worthington HV, Deacon SA, Deery C, Walmsley AD, Robinson PG, Glenny AM. Powered versus manual toothbrushing for oral health. Cochrane Database Syst Rev. 2014(6):CD002281 PMID: 24934383
27. Duane B, Ashley P, Saget S, Richards D, Pasdeki-Clewer E, Lyne A. Incorporating sustainability into assessment of oral health interventions. Br Dent J. Springer Nature; 2020 Sep 1;229(5):310–314. PMID: 32918024
28. Earth 911 [Internet] Recycling Mystery: Toothbrushes and Toothpaste Tubes [Acess Date: 17.01. 2025]
29. Verma S, Jain A, Thakur R, Maran S, Kale A, Sagar K, Mishra S. Knowledge, Attitude and Practice of Green Dentistry among Dental Professionals of Bhopal City: A Cross-Sectional Survey. Journal of Clinical And Diagnostic Research. JCDR Research and Publications; 2020.
30. Tawade SU, Dhamande MM, Dubey SA, Sathe S, Selukar MS, Pathak A. Sustainable Dentistry: A Comprehensive Review of the Recycling Techniques for Gypsum Products in Prosthodontics. Cureus. 2024;16(3):e55997. PMID: 38606240
31. Martin N, Mulligan S, Shellard IJ, Hatton P V. [Internet] Consensus on Environmentally Sustainable Oral Healthcare A Joint Stakeholder Statement. Consensus on Environmentally Sustainable Oral Healthcare A Joint Stakeholder Statement. White Rose University Press; 2022. [Acess Date: 17.01.2025] Acess Link: https://www.fdiworlddental.org/sites/default/files/2022-12/consensus-on-environmentally-sustainable-oral-healthcare.pdf
32. Smart Practice [Internet] Earth Friendly Promotional Products from SmartPractice Makwe it Easy to Go Green Together [Acess Date: 17.01.2025] Acess Link: https://blog.smartpractice.com/earth-friendly-promotional-products-from-smartpractice-make-it-easy-to-go-green-together/
33. Zakiyuddin A, Indrani DJ, Khoirurrijal RA, Astutiningsih S. Recyclability of Dental Gypsum via Calcination. Materials Science Forum. 2020;1000:90–96.
34. Dental Review.News [Internet] Dental Gypsum Waste Disposal [Acess Date: 17.01.2025] Acess Link: https://www.dentalreview.news/practice-management/55-dental-law-and-regulation/716-dental-gypsum-waste-disposal.
35. Hu-Friedy Group.[Internet] Envirodent [Acess Date: 17.01.2025] Acess Link: https://www.hufriedygroup.com/en/environdent
36. Duane B, Stancliffe R, Miller FA, Sherman J, Pasdeki-Clewer E. Sustainability in Dentistry: A Multifaceted Approach Needed. J Dent Res. 2020;99(9):998–1003.
37. Alawad IA, Albawardi A, Alshalan AA, Alahedib KS, Daabash MD, Almutairi WM. Dental Office Waste and Its Risks on the Environment; a Narrative Review. Naturalista campano 2024;28(1):2601–2608.
38. Fang B, Yu J, Chen Z, Osman AI, Farghali M, Ihara I, Hamza EH, Rooney DW, Yap PS. Artificial intelligence for waste management in smart cities: a review. Environ Chem Lett. 2023:1-31
39. Leveziel M, Laurent GJ, Haouas W, Gauthier M, Dahmouche R. A 4-DoF Parallel Robot With a Built-in Gripper for Waste Sorting. IEEE Robot Autom Lett. 2022;7(4):9834–9841.
40. Mao WL, Chen WC, Fathurrahman HIK, Lin YH. Deep learning networks for real-time regional domestic waste detection. J Clean Prod. 2022;344:131096.
41. Burgués J, Esclapez MD, Doñate S, Marco S. RHINOS: A lightweight portable electronic nose for real-time odor quantification in wastewater treatment plants. iScience. 2021;24(12):103371.
42. Sivaprakasam BT, Sugilal G, Shah JG, Kaushik CP, Krishnamurthy CV, Arunachalam K. In situ process monitoring of nuclear waste glass melts using non-contact microwave sensor. 2020;160:107793.
43. Avinash B, Avinash BS, Shivalinga BM, Jyothikiran S, Padmini MN. Going green with Eco-friendly dentistry. Journal of Contemporary Dental Practice. Jaypee Brothers Medical Publishers (P) Ltd; 2013;14(4):766–769. PMID: 24309364
44. Fothedar Shailee. Green Dentistry: Eco-friendly Dentistry. Indian Journal of Dental Advancements. National Academy of Dentistry; 2015;06(04).
45. Chopra A, Gupta N, Rao N, Vashisth S. Eco-dentistry: The environment-friendly dentistry. Saudi J Health Sci. Medknow; 2014;3(2):61.
46. Goel V, Arora A, Nirola A, Awana M, Khurana P. 39 green dentistry "ways to go green at the dental office." Santosh University Journal of Health Sciences. 2015;1(1):39-40
47. Mohelay N, Deolia SG, Jagyasi D, Lakhwani R, Sen S, Chapekar J. Eco-Friendly Dentistry: A Green Business with Teeth 2016;3(2):66-70
48. Farahani DA, Suchak M. Eco-friendly dentistry the environmentally-responsible dental practice. University of Waterloo. 2007.
49. Hiltz M. The environmental impact of dentistry. J Can Dent Assoc. 2007;73(1):59–62. PMID: 17295946
50. Harford S, Duane B. Sustainable Dentistry: How-to Guide for Dental Practices Sustainable Dentistry. 2019
51. Musliu A, Beqa L, Kastrati G. The use of dental amalgam and amalgam waste management in Kosova: An environmental policy approach. Integr Environ Assess Manag. John Wiley and Sons Inc; 2021;17(5):1037–1044. PMID: 33710765
52. Harding G, Dalziel J, Vass P. Bioaccumulation of methylmercury within the marine food web of the outer Bay of Fundy, Gulf of Maine. PLoS One. 2018;13(7):e0197220.
53. Depew DC, Basu N, Burgess NM, Campbell LM, Devlin EW, Drevnick PE, Hammerschmidt CR, Murphy CA, Sandheinrich MB, Wiener JG. Toxicity of dietary methylmercury to fish: Derivation of ecologically meaningful threshold concentrations. Environ Toxicol Chem. 2012;31(7):1536–1547.
54. Mulligan S, Kakonyi G, Moharamzadeh K, Thornton SF, Martin N. The environmental impact of dental amalgam and resin-based composite materials. Br Dent J. 2018;224(7):542–548.
55. Mulligan S, Ojeda JJ, Kakonyi G, Thornton SF, Moharamzadeh K, Martin N. Characterisation of microparticle waste from dental resin-based composites. Materials. MDPI AG; 2021;14(16):4440.
56. Thompson RC, Olsen Y, Mitchell RP, Davis A, Rowland SJ, John AWG, McGonigle D, Russell AE. Lost at Sea: Where Is All the Plastic? Science (1979). 2004;304(5672):838–838.
57. Heintze SD, Ilie N, Hickel R, Reis A, Loguercio A, Rousson V. Laboratory mechanical parameters of composite resins and their relation to fractures and wear in clinical trials—A systematic review. Dental Materials. 2017;33(3):e101–e114.
58. Beck F, Lettner S, Graf A, Bitriol B, Dumitrescu N, Bauer P, Moritz A, Schedle A. Survival of direct resin restorations in posterior teeth within a 19-year period (1996–2015): A meta-analysis of prospective studies. Dental Materials. 2015;31(8):958–985.
59. Heintze SD, Rousson V. Clinical effectiveness of direct class II restorations - a meta-analysis. J Adhes Dent. 2012;14(5):407–31. PMID: 23082310
60. Subramanian AK, Thayalan D, Edwards AI, Almalki A, Venugopal A. Biomedical waste management in dental practice and its significant environmental impact: A perspective. Environ Technol Innov. 2021;24:101807.
61. Rahman H, Chandra R, Triphathi S, Singh S. "Green Dentistry-Clean Dentistry" Journal Of Dentistry 2021;112
62. Popa D, Constantiniuc M, Kui A, Alexandru B, Constantiniuc ** M, Burde A, Câmpian rs. Attitudes and behaviors in dental

Received date: 02 March 2025 / **Accept date:** 21 March 2025
DOI: 10.61139/ijdor.1649869

practice regarding human and environment protection attitudes and behaviors in dental practice regarding human and environment protection. Procedia Environmental Science, Engineering and Management. 2015;(2):107-112
63. McGain F. Why anaesthetists should no longer use nitrous oxide. Anaesth Intensive Care. 2007;35(5):808–9. PMID: 17933180
64. Levering NJ, Welie JVM. Current status of nitrous oxide as a behavior management practice routine in pediatric dentistry. J Dent Child (Chic). 2011;78(1):24–30. PMID: 22041005
65. Wang CY, Chiu CL, Har KO, Chan C, Rahman ZAA. A comparative study of sevoflurane sedation with nitrous oxide sedation for dental surgery. Int J Oral Maxillofac Surg. 2002;31(5):506–510.
66. Kotantoula G, Haisraeli-Shalish M, Jerrold L. Teleorthodontics. American Journal of Orthodontics and Dentofacial Orthopedics. 2017;151(1):219–221.
67. Machowska A, Stålsby Lundborg C. Drivers of Irrational Use of Antibiotics in Europe. Int J Environ Res Public Health. 2018;16(1):27.
68. Mazur M, Ndokaj A, Jedlinski M, Ardan R, Bietolini S, Ottolenghi L. Impact of Green Tea (Camellia Sinensis) on periodontitis and caries. Systematic review and meta-analysis. Jpn Dent Sci Rev. 2021;57:1-11. PMID: 33737989
69. Trybek G, Jedliński M, Jaroń A, Preuss O, Mazur M, Grzywacz A. Impact of lactoferrin on bone regenerative processes and its possible implementation in oral surgery - a systematic review of novel studies with metanalysis and metaregression. BMC Oral Health. 2020;20(1):232. PMID: 32843024
70. Belma Muhamedagic, Lejla Muhamedagic, Izet Masic. Dental Office Waste – Public Health and Ecological Risk. Materia sociomed. 2009;21:35–38.
71. Steinbach I, Stancliffe R, Duane B. Carbon modelling within dentistry Towards a sustainable future Carbon modelling within dentistry: towards a sustainable future. 2018.
72. Demeter T, Penzes M, Kovacs A, Karolyhazy K, Erdei C, Nimigean VR, et al. Smoking related major- And minor salivary gland flow rates, xerostomia and other sicca symptoms in Hungary. Revista de Chimie. 2020;71(4):373–83.