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Implementation of a sustainable protocol for the management of dental gypsum in an academic environment: an experience report

Jullyana Mayara P. Dezanetti Hermeling[1]
0000-0002-6912-1164

Yumi Vaz[1]
0009-0004-0500-8930

Leticia Gabriella Pereira Machado[1]
0009-0009-2847-6514

Luana Alegre de Lima Alves[1]
0009-0001-8384-3411

Ludimylla Menezes[1]
0009-0000-4460-2749

Ronaldo Carmona de Souza[1]
0009-0006-1819-6779

Giselle Emilãine da Silva Reis[2]
0000-0001-8405-4062

[1]Centro Universitário Autônomo do Brasil (UniBrasil). Curitiba, Paraná, Brasil.
[2]Universidade Federal do Paraná (UFPR), Curitiba, Paraná, Brasil.

Correspondence:
Jullyana Mayara Preizner Dezanetti Hermeling
E-mail: jullyanahermeling@gmail.com

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Abstract The production of dental waste represents an environmental and public health challenge, with dental gypsum standing out as one of the main materials, widely used in dental clinics, universities, and laboratories for the fabrication of study and working models. In view of the lack of standardized protocols for the disposal and recycling of this material, this study aimed to report on the experience of developing and implementing a protocol for the sustainable management of dental gypsum in an academic setting. The project was carried out at the Centro Universitário Autônomo do Brasil (UniBrasil), Curitiba through extension activities involving dental students. The actions included a literature review on the composition, environmental impact, and possibilities for reuse of gypsum, the creation of a visual identity, the development of suitable disposal containers, the production of educational folders, and the involvement of a specialized company responsible for presenting the technical stages of storage, transport, and reuse of this material. The protocol was implemented at the institution with wide dissemination among students and professors, encouraging environmentally responsible practices. The results showed broad student adherence, increased environmental awareness regarding improper disposal, and the feasibility of recycling with technical and logistical support. The experience reinforces the importance of integrating teaching, research, and extension in dental education, and highlights the need for public policies and regulations to standardize the management of dental gypsum. It is concluded that the developed protocol represents an effective, accessible, and replicable strategy, promoting sustainability in the academic environment and contributing to environmental preservation.
Descriptors: Calcium Sulfate. Dental Waste. Recycling. Sustainable Development Indicators. Education, Dental.

Implementación de un protocolo sostenbile para el manejo del yeso odontológico em el âmbito académico: um informe de experiencia

Resumen La producción de residuos dentales representa un desafío ambiental y de salud pública, destacando el yeso dental como uno de los principales materiales, ampliamente utilizado en clínicas, universidades y laboratorios para la elaboración de modelos de estudio y de trabajo. Ante la ausencia de protocolos estandarizados para la disposición y reciclaje de este material, este estudio tuvo como objetivo informar sobre la experiencia de desarrollo e implementación de un protocolo para la gestión sostenible del yeso dental en un entorno académico. El proyecto se llevó a cabo en Centro Universitário Autônomo do Brasil (UniBrasil). Curitiba, mediante actividades de extensión que involucraron a estudiantes de odontología. Las acciones incluyeron una revisión bibliográfica sobre la composición, el impacto ambiental y las posibilidades de reutilización del yeso, la creación de una identidad visual, el desarrollo de contenedores adecuados para su disposición, la producción de folletos educativos y la participación de una empresa especializada responsable de presentar las etapas técnicas de almacenamiento, transporte y reutilización de este material. El protocolo se implementó en la institución con amplia difusión entre estudiantes y profesores, fomentando prácticas ambientalmente responsables. Los resultados mostraron una amplia adhesión de los estudiantes, mayor concienciación ambiental respecto a la disposición inadecuada y la viabilidad del reciclaje con apoyo técnico y logístico. La experiencia refuerza la importancia de integrar la enseñanza, la investigación y la extensión en la educación odontológica, y destaca la necesidad de políticas públicas y normativas que estandaricen la gestión del yeso dental. Se concluye que el protocolo desarrollado representa una estrategia eficaz, accesible y replicable, promoviendo la sostenibilidad en el entorno académico y contribuyendo a la preservación ambiental.
Descriptores: Sulfato de Calcio. Residuos Dentales. Reciclaje. Indicadores de Desarrollo Sostenible. Educación en Odontología.

Implementação de um protocolo sustentável para o manejo do gesso odontológico em ambiente acadêmico: um relato de experiência

Resumo A produção de resíduos odontológicos representa um desafio ambiental e de saúde pública, destacando-se o gesso odontológico como um dos principais materiais, amplamente utilizado em clínicas, universidades e laboratórios para a confecção de modelos de estudo e de trabalho. Diante da ausência de protocolos padronizados para o descarte e reciclagem desse material, este estudo teve como objetivo relatar a experiência de desenvolvimento e implementação de um protocolo para o manejo sustentável do gesso odontológico em ambiente acadêmico. O projeto foi realizado na [texto ocultado], por meio de atividades de extensão envolvendo estudantes de odontologia. As ações incluíram revisão de literatura sobre a composição, impacto ambiental e possibilidades de reutilização do gesso, criação de uma identidade visual, desenvolvimento de recipientes adequados para descarte, produção de folders educativos e envolvimento de uma empresa especializada responsável por apresentar as etapas técnicas de armazenamento, transporte e reaproveitamento desse material. O protocolo foi implementado na instituição com ampla divulgação entre alunos e professores, incentivando práticas ambientalmente responsáveis. Os resultados demonstraram ampla adesão dos estudantes, maior conscientização ambiental quanto ao descarte inadequado e viabilidade da reciclagem com suporte técnico e logístico. A experiência reforça a importância da integração entre ensino, pesquisa e extensão na educação odontológica, e destaca a necessidade de políticas públicas e regulamentações que padronizem o manejo do gesso odontológico. Conclui-se que o protocolo desenvolvido representa uma estratégia eficaz, acessível e replicável, promovendo a sustentabilidade no ambiente acadêmico e contribuindo para a preservação ambiental.

Descritores: Sulfato de Cálcio. Resíduos Odontológicos. Reciclagem. Indicadores de Desenvolvimento Sustentável. Educação em Odontologia.

INTRODUCTION

The dental professional faces numerous daily risks of contamination in clinical practice, requiring specific precautions such as the use of personal protective equipment, proper preparation of the work environment and clinical instruments, as well as rigorous procedures of disinfection, sterilization, and correct disposal of contaminated waste[1]. The inadequate management of debris generated in dentistry has become a growing concern, as it contributes to environmental contamination and compromises the health of the professionals involved[2].

Among the various wastes produced in this environment is dental gypsum, which is widely used in private clinics, universities, and laboratories for the fabrication of study and working models to accurately reproduce the patient's dental arches, as well as for the construction of dental prostheses[3]. According to Resolution No. 431/2011, in force since 05/25/2011, issued by the National Environmental Council (CONAMA), gypsum received a new classification as a recyclable waste for other destinations and as a material for which no economically viable technologies or applications had been developed to allow its recycling or recovery[4].

The Health Service Waste Management Plan, regulated by ANVISA's RDC No. 222/2018, provides information on the classification of these wastes, from the management of the material and the collection frequency to the form of storage and its destination[5]. This resolution states that "gypsum waste from health care" must be packaged according to the guidelines of local authorities responsible for urban cleaning services, and when not sent for reuse, recovery, recycling, composting, reverse logistics, or energy recovery, it must be classified as refuse.

Likewise, NBR No. 10.004/2004, regulated by ABNT (Brazilian Association of Technical Standards), establishes criteria for the classification of solid waste according to its potential risks to the environment and public health, ensuring its proper handling and disposal[6]. This standard classifies waste into three main categories: Class I – Hazardous, which present characteristics such as flammability, corrosivity, reactivity, toxicity, or pathogenicity, posing risks to the environment and health; Class II A – Non-Hazardous and Non-Inert, which are not hazardous but may decompose, be biodegradable, combustible, or water-soluble; and Class II B – Inert, which neither decompose nor react with water, not releasing substances above the limits allowed for potability. The standard also states that when the characteristics of a waste cannot be determined under its terms, for technical or economic reasons, the classification of such waste will be the responsibility of state or federal pollution control and environmental preservation authorities, leaving the classification and disposal of the material subject to interpretation, as is the case with ANVISA's RDC No. 222/2018.

However, although general guidelines for the classification and disposal of waste are established, the standard does not objectively specify how the disposal of gypsum-based dental materials should be conducted. As with RDC No. 222/2018, the absence of clear technical guidelines directed at this specific type of waste ultimately generates different interpretations among institutions and regulatory bodies, resulting in heterogeneous and often environmentally inadequate practices.

Despite the existence of general standards for waste management in health services, there is still no specific protocol regulating the disposal and recycling of dental gypsum. This regulatory gap leads to divergent interpretations among educational institutions and professionals, resulting in inconsistent practices regarding the destination of this material. The lack of knowledge and clear guidelines directly impacts academic training, since many dental students do not fully understand their responsibility for the waste generated during clinical practice. In this context, the absence of specific regulations for gypsum contributes to its improper disposal, increasing environmental risks and hindering the implementation of sustainable actions in the university setting[7].

The improper disposal of this material negatively impacts the environment, potentially leading to obstruction of drainage systems, contamination of water resources, and degradation of water bodies, as observed in a study on irregular deposition of solid waste, which demonstrated that improperly discarded materials contribute to pollution and compromise local environmental quality[8]. Furthermore, gypsum waste has the potential to produce toxic substances, release flammable gases, and contaminate soil due to environmental humidity and the presence of sulfate-reducing bacteria, promoting the formation of carbon dioxide, hydrogen sulfide, and sulfur dioxide in the event of burning, the latter being considered a highly toxic gas[9].

Therefore, the recycling of dental gypsum waste is crucial both for environmental sustainability and economic efficiency, since recycled gypsum has properties like its original form, making it suitable for various applications, such as in agriculture[10], in civil construction[9], and even in the manufacturing of cement-based materials[11]. Although practical applications for the reuse and recycling of gypsum remain limited so far, awareness among professionals in the field and the creation of programs aimed at reintegrating gypsum waste into the productive process of sustainable construction are of great importance[11,12].

Considering the above, the present study aims to report the experience of undergraduate dental students from a private university in Curitiba, Paraná, in developing and implementing a protocol for the proper disposal of dental gypsum in an academic environment, with a view to its recycling and the strengthening of sustainable practices.

EXPERIENCE REPORT

This experience report was developed by faculty members and students from the Centro Universitário Autônomo do Brasil (UniBrasil). Curitiba, Paraná, Brasil, through the university extension project entitled "Protocol for the correct disposal of dental gypsum in dental schools." The project involved second-semester students enrolled in the course "Extension Program – PROEX II," totaling 34 participants. The central proposal was to encourage Dentistry students at UniBrasil, to develop a protocol for the proper disposal of dental gypsum, promoting an understanding of the importance of recycling this material. The objective was not limited to the creation of practical procedures but also included raising students' awareness regarding environmental impacts, sustainability, and professional responsibility in waste management, strengthening competencies that integrate clinical care with environmental preservation and the practice of a more conscious and sustainable dentistry.

The extension project was carried out throughout the first academic semester, with the participation of thirty-four students, distributed into five groups of seven members. Each group developed the activities listed in Figure 1, whose detailed description will be presented below.

Activities:

1. Literature review
2. Development of the project logo
3. Educational activity with a gypsum recycling company
4. Development of recyclable containers for the disposal of dental gypsum at UniBrasil
5. Preparation of an educational leaflet
6. Distribution of the leaflet at the university and development of the protocol
7. Final learning report

Figure 1. Activities developed by the student groups during the extension project.

Literature Review

With the aim of encouraging the search for scientific knowledge, each group of students initially conducted a literature review on the central topic of the study: dental gypsum. During this stage, the groups reviewed topics such as the composition and history of gypsum, its use in dentistry, types of dental gypsum, material disposal, environmental impacts of improper disposal, and future perspectives for its use and reuse. Among these topics, the disposal of dental gypsum generated the greatest number of questions due to the lack of standardization and specific protocols in literature. Each group prepared a structured review and submitted the material to the supervising professor, who provided corrections, suggestions, and detailed guidance, ensuring scientific consistency, clarity of information, and alignment of the content with the project objectives.

Development of the project logo

After completing the literature review, the second stage of the project consisted of creating a logo that would clearly and objectively represent the purpose of the initiative. The students presented their proposals in the classroom, promoting debate and exchange of ideas about the visual and conceptual elements that best reflected the project's objectives. Through voting, one logo was selected to guide the subsequent stages, consolidating the visual identity of the initiative. Figure 2 presents all the logos developed, highlighting not only the creativity of the groups but also the students' engagement and active participation — key factors in strengthening the sense of belonging and valuing collaborative work in the academic context.

Figure 2. Logos created by UniBrasil students for the extension project.

Educational activity with a gypsum recycling company

In the third stage of the project, UniBrasil received a visit from "HC Reciclagem Company", one of the few companies specialized in dental gypsum recycling in Curitiba-PR, for an educational lecture. During the activity, various aspects related to gypsum management were addressed, including its history and evolution, proper transportation of generated waste, recycling techniques and possibilities, as well as the destination of the material. The lecture provided students with a practical and in-depth understanding of the life cycle of dental gypsum, highlighting the importance of proper handling procedures to reduce environmental impacts and promote sustainability in academic and clinical settings.

The experience provided students with a comprehensive understanding of the dental gypsum management process, emphasizing the importance of each stage, which is described in the following topics:

Use and collection

In the use and collection phase, measures are adopted to ensure the proper management of gypsum waste from its initial disposal. This includes the use of appropriate equipment, such as containers and specialized trucks, capable of transporting the material safely and efficiently. In addition, the collected waste undergoes a careful sorting process, ensuring the correct separation of different materials and directly contributing to the success of the project and the feasibility of subsequent recycling stages.

Storage and transport

In the storage and transport stage, containers are used to properly store the gypsum throughout the entire process, ensuring the safety and integrity of the material. Waste handling also involves the necessary logistical organization for it to be sent to the warehouses intended for processing. Finally, the gypsum reaches the destination stage, where it is prepared for future use, ensuring that the following recycling and reuse stages are carried out efficiently and sustainably.

Sorting and destination

In the sorting and destination stage, gypsum is separated from other materials, such as metal and paper, ensuring the purity of the waste to be recycled. During this process, strict quality control is carried out to ensure that the material meets the standards required for reuse. In addition, gypsum waste is directed to sustainable facilities, promoting environmentally responsible practices and preventing negative impacts on the environment.

Recycling and sustainable use of gypsum

In the recycling and sustainable use phase, gypsum undergoes a reuse process, being combined with natural gypsum for use in various industries. Among its applications, agriculture for fertilizer production and civil construction stand out, demonstrating that the recycled material maintains properties like the original gypsum. This stage highlights the importance of recycling as a strategy to promote sustainability, reduce waste, and generate economic and environmental benefits.

Development of recyclable containers for the disposal of dental gypsum at UniBrasil

In the fourth stage of the project, students were challenged to develop containers for the disposal of dental gypsum using recyclable and disposable materials. This activity held great educational relevance, as it encouraged students to reflect on practical solutions for waste management in the academic environment, reinforcing sustainability concepts and professional responsibility acquired in previous stages. In addition to promoting hands-on learning, the creation of the containers allowed for an understanding of the importance of structuring proper gypsum disposal within the university, ensuring that the material is safely collected and appropriately directed for recycling. Figure 3 illustrates the containers produced by the groups, which were strategically placed throughout the institution, consolidating the project as a practical and educational initiative focused on sustainability in dentistry.

Figure 3. Containers created by the students for the disposal of dental gypsum waste at UniBrasil using recyclable materials.

Development of an educational folder

In the fifth stage of the project, students developed an educational folder with the purpose of clarifying the importance and benefits of recycling dental gypsum, promoting sustainable practices within the course. The material highlighted the main reasons for recycling, such as environmental protection and resource conservation, in addition to providing guidance on proper storage and disposal of gypsum. It also presented the consequences of improper disposal, such as soil and water contamination and the release of toxic gases during the material's decomposition or combustion. The folder emphasized that gypsum is a recyclable material and can be reused in industrial and agricultural applications, as

exemplified by the partnership with a specialized company. This educational material was distributed to all sectors of Dentistry in UniBrasil program that use gypsum, expanding environmental awareness and reinforcing the project's commitment to sustainability and social responsibility. Figure 4 illustrates the folder produced by the students, emphasizing the educational and socially engaging nature of the project.

Figure 4. Educational brochure produced by UniBrasil students for dissemination among the course undergraduates.

Dissemination of the folder and development of the protocol flowchart

After preparing the educational folder, the student groups presented the project results to all Dentistry students at UniBrasil, with the aim of disseminating best practices related to the proper disposal of dental gypsum. As a complementary stage, a protocol in flowchart format was developed, illustrated in Figure 5, which provides didactic and sequential guidance for the correct disposal process. The flowchart highlights the environmental risks associated with improper disposal, such as the release of toxic gases and soil and water contamination and directs users toward the proper destination of the material, emphasizing the importance of using clearly labeled bins for gypsum recycling. Additionally, the protocol provides information about the role of "HC Reciclagem Company", the company responsible for the collection and reuse of dental and civil gypsum and clarifies that both UniBrasil dental clinic and external clinics may carry out responsible disposal by contacting the company. This action consolidated the educational, practical, and sustainable character of the project, promoting environmental awareness among students and strengthening the institution's commitment to proper waste management.

Results achieved by the project

The implementation of the project was characterized by several positive aspects that significantly contributed to achieving its objectives. The initiative aimed not only at environmental education but also at promoting effective and sustainable changes in the disposal practices of dental gypsum. One of the main outcomes observed was the increased awareness among students and professors who use this material, emphasizing the need for its environmentally safe disposal. The project provided participants with both theoretical and practical insights into the processes of gypsum disposal and recycling, highlighting its potential for reuse in sectors such as agriculture and industry.

Furthermore, the activities developed critically addressed the consequences of improper gypsum disposal, emphasizing the environmental impacts resulting from the release of toxic substances and the contamination of soil and water. Through educational activities such as lectures, literature reviews, and the development of informational materials, students were sensitized to the importance of adopting environmentally responsible practices. A significant milestone of

the intervention was the installation of specific containers for gypsum disposal in different locations at UniBrasil, manufactured by the students themselves, which facilitated adherence and the proper routing of the material for recycling.

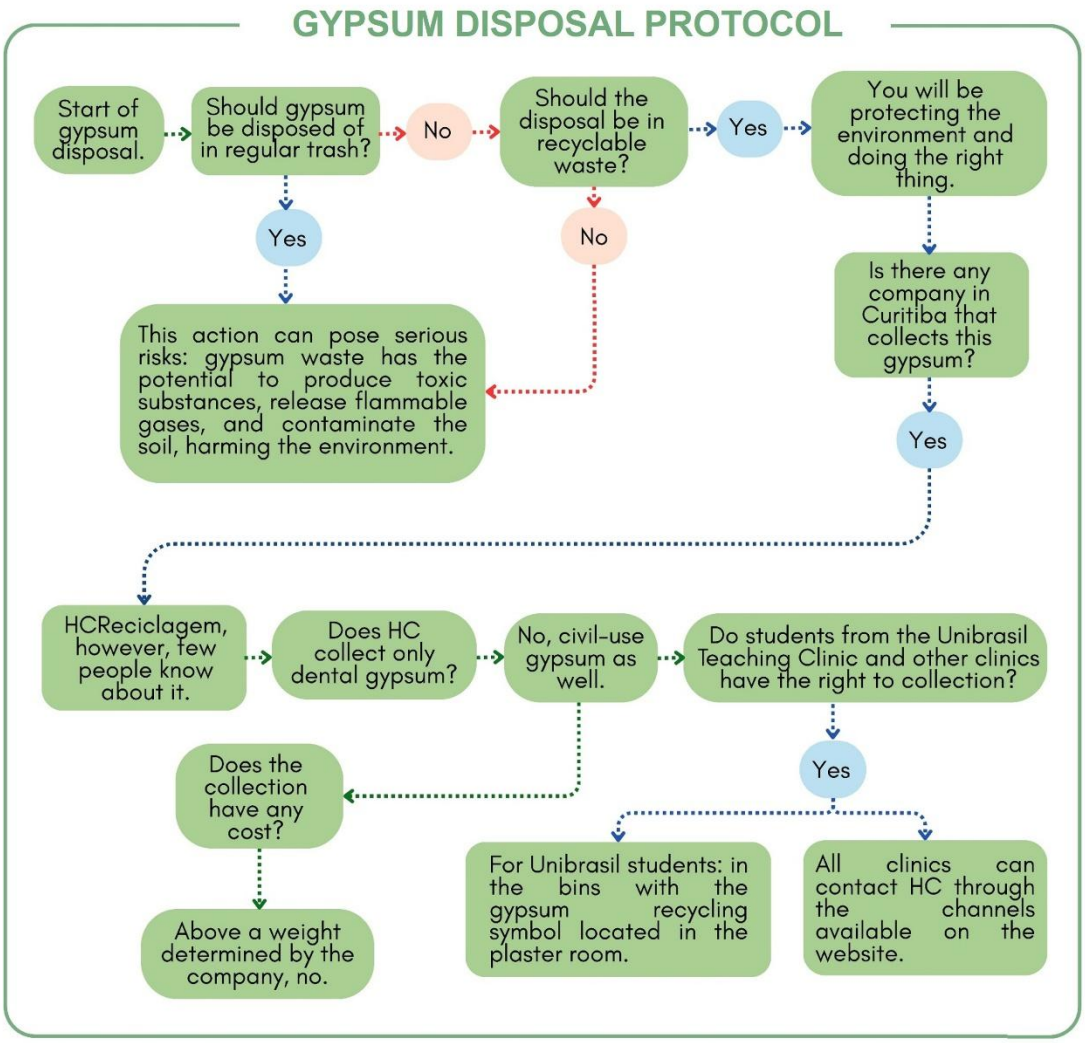

Figure 5. Flowchart of the dental gypsum disposal protocol at UniBrasil University, produced by the students of the extension project.

The analysis of the results demonstrated rapid acceptance and engagement of the students, reflecting a positive behavioral change in relation to the management of this waste. The project also fostered the exchange of knowledge among students and professionals in the field, as well as among incoming students, promoting the development of an institutional culture focused on sustainability. By incorporating the topic from the beginning of their academic journey, the aim is to ensure the continuity of proper disposal practices and to strengthen ethical-environmental commitment in the training of dental surgeons.

The main limitation observed during the implementation of the project was related to the scarcity of specific bibliographic references on the topic of recycling and sustainable disposal of dental gypsum. This lack of updated scientific literature hindered the establishment of a robust theoretical foundation and the contextualization of study within the broader framework of sustainability practices in Dentistry.

References are an essential element in any scientific investigation, as they provide conceptual and methodological support for the formulation of hypotheses, argumentation, and critical analysis of the results obtained[13,14]. The absence of consolidated sources on the topic therefore represented an obstacle to building a consistent theoretical framework, limiting the ability to establish connections with previous research and to position the present project within the existing body of knowledge.

Moreover, the lack of publications that address in detail the management and recycling of dental gypsum restricted the comparison of findings with other contexts and experiences. This limitation reinforces the need to expand scientific investigations on the topic, especially in the academic and clinical spheres, to promote environmentally sustainable and scientifically grounded practices in the disposal of dental waste. Thus, future research should prioritize the identification and systematization of scientific data on the reuse and recycling of dental gypsum, to expand theoretical support and establish evidence-based guidelines for this practice.

FINAL CONSIDERATIONS

The dental gypsum recycling project constitutes a relevant and innovative initiative aligned with sustainability principles. The proposal proved to be an effective strategy for reducing environmental impacts resulting from the improper disposal of waste, promoting the rational use of resources and encouraging more responsible practices within the academic environment. The results obtained demonstrated that the implementation of educational actions and the installation of specific containers for gypsum disposal facilitated student adherence and contributed to the development of an institutional culture focused on sustainability. In addition to mitigating the negative effects of incorrect disposal, the project provided environmental, economic, and social benefits, reinforcing the importance of collective commitment to the proper management of dental waste.

It can be concluded that the experience demonstrated that the integration between environmental education, clinical practice, and waste management can consolidate a more ethical, conscious, and environmentally responsible dentistry, strengthening the role of higher education institutions as agents that promote sustainable transformation.

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