

**JOINT ENVIRONMENTAL EDUCATION ACTIONS FOR THE DEVELOPMENT,  
AWARENESS, AND INNOVATION IN THE FIELD OF GEOTECHNICAL  
ENGINEERING**

**AÇÕES CONJUNTAS DE EDUCAÇÃO AMBIENTAL PARA O DESENVOLVIMENTO,  
CONSCIENTIZAÇÃO E INOVAÇÃO NO ÂMBITO DA ENGENHARIA GEOTÉCNICA**

**ACCIONES CONJUNTAS DE EDUCACIÓN AMBIENTAL PARA EL DESARROLLO,  
SENSIBILIZACIÓN E INNOVACIÓN EN EL ÁMBITO DE LA INGENIERÍA  
GEOTÉCNICA**



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**ABSTRACT:** Teaching, research, and extension projects in the areas of Geotechnical and Environmental Engineering include laboratory and field experiments, in addition to theoretical and practical studies, aiming at environmental education and the social, economic and technological development of the community. In this sense, this article aims to report the actions of a university extension project developed at the Federal University of Santa Maria/RS in collaboration with companies and society. Within the project, environmental awareness actions were carried out in early childhood education, dissemination of knowledge to university students, in addition to continued training for professionals, aiming to raise awareness regarding the conscious disposal of waste, the correct disposal and operation of landfills, including assessments geotechnical risk and environmental contamination.

**KEYWORDS:** Sustainability. Environment. Solid waste reduction. Extension projects.

**RESUMO:** *Projetos de ensino, pesquisa e extensão nas áreas da Engenharia Geotecnia e Ambiental incluem experimentos de laboratório e campo, além de estudos teóricos e práticos, objetivando a educação ambiental, o desenvolvimento social, econômico e tecnológico da comunidade em geral. Neste sentido, o presente artigo tem como objetivo relatar as ações de um projeto de extensão universitária desenvolvido na Universidade Federal de Santa Maria/RS em conjunto com empresas e a sociedade. Dentro do projeto, foram realizadas ações de conscientização ambiental na educação infantil, disseminação do conhecimento para discente da universidade, além de cursos para capacitação de profissionais, visando a conscientização quanto a destinação consciente de resíduos, a correta disposição e operação de aterros sanitários, incluindo avaliações de risco geotécnico e a contaminação do meio ambiente.*

**PALAVRAS-CHAVE:** *Sustentabilidade. Meio Ambiente. Redução de resíduos sólidos. Projeto de extensão.*

**RESUMEN:** *Proyectos de enseñanza, investigación y extensión en las áreas de Ingeniería Geotécnica y Ambiental incluyen experimentos de laboratorio y campo, así como estudios teóricos y prácticos, con el objetivo de la educación ambiental y el desarrollo social, económico y tecnológico de la comunidad. En este sentido, el presente artículo tiene como objetivo informar sobre las acciones de un proyecto de extensión universitaria desarrollado en la Universidad Federal de Santa Maria/RS en colaboración con empresas y la sociedad. Dentro del proyecto, se realizaron acciones de concientización ambiental en la educación infantil, la difusión del conocimiento para los estudiantes universitarios, así como la formación continua para profesionales, con el objetivo de concientizar sobre la disposición consciente de residuos, la correcta disposición y operación de vertederos sanitarios, incluyendo evaluaciones de riesgo geotécnico y la contaminación del medio ambiente.*

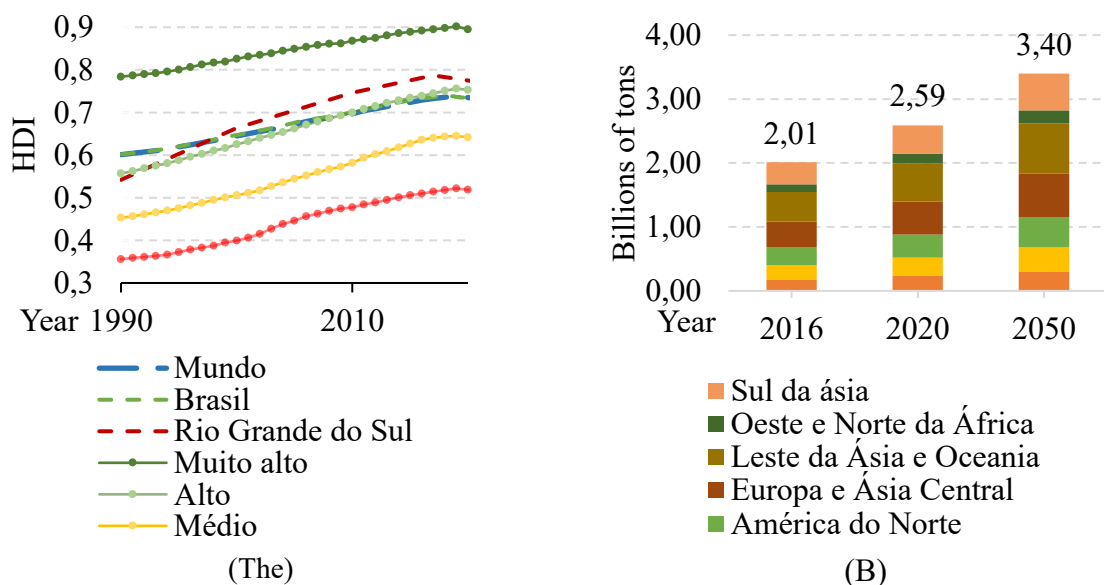
**PALABRAS CLAVE:** *Sostenibilidad. Medio ambiente. Reducción de residuos sólidos. Proyecto de extensión.*

## Introduction

Improving the quality of life of the population as a whole is always welcome, linked mainly to health, longevity, education, and income of individuals, and can be analyzed quantitatively through the Human Development Index (HDI). The Human Development report (Human Development Index, 2022) from the United Nations Development Program (*United Nations Development Program – UNDP*) points out, in Figure 1 (a), the global average Human Development Index (HDI) between 1990 and 2021 and its division into levels, from low to very high, highlighting the proximity and slight superiority of the HDI values of Brazil and the state of Rio Grande do Sul to world levels considered high.

A development in the HDI is observed at all levels over time, which, even though it is positive, raises an alarm on other issues, such as the production of urban solid waste (RSU, *Resíduo Sólido Urbano*, in Portuguese) being proportional to the increase in the per capita income of individuals (Chen *et al.*, 2020; Wilson; Velis, 2015). In this sense, Kaza *et al.* (2018) they made a forecast for the generation of RSU for the next 30 years, shown in Figure 1 (b), in which it is estimated that 3.40 billion tons of RSU will be produced worldwide, with Latin America being responsible for around 11%, totaling approximately 374 million tons of RSU in the year 2050 alone.

**Figure 1** – (a) HDI timeline in the world; (b) Estimate of RSU generation in the world, per year



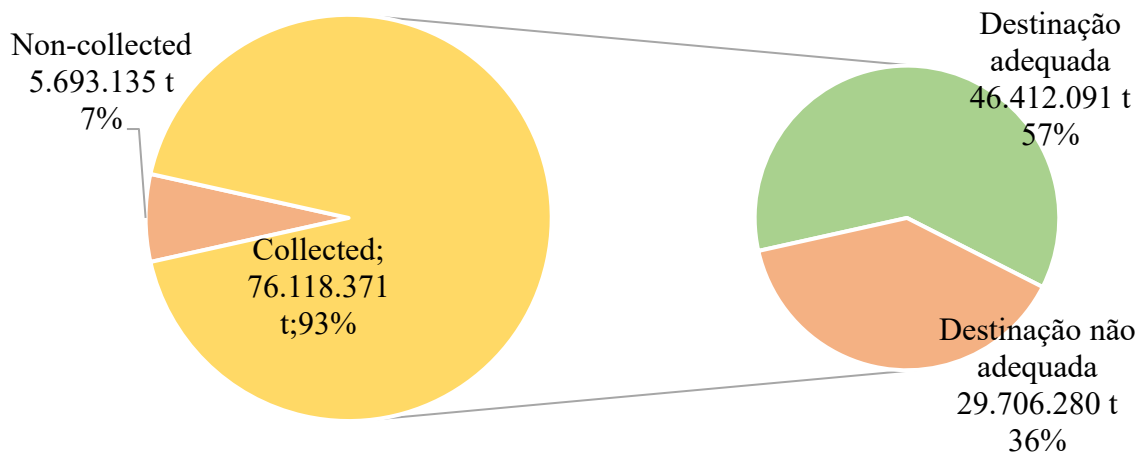
Source: Adapted from Roser (2019) and Human Development Index (2022).

Source: Adapted from Kaza *et al.* (2018).

Therefore, it is essential to strictly follow the National Solid Waste Policy (PNRS), governed by Law No. 12,305, of August 2, 2010, which, together with NBR 10004 (ABNT, 2004) defining RSU as any discarded product solid and semi-solid state, resulting from human activities in households, urban cleaning and commercial establishments and service providers; and brings together the guidelines for the correct integrated management and adequate management of RSU.

Even though the PNRS, which is found in Brazil (2010), defines that the appropriate final disposal of RSU must be carried out in an appropriate and standardized location, where the waste is confined in such a way that it does not pollute the environment, in accordance with the Panorama of Solid Waste in Brazil (ABRELPE, 2022), the final disposal of RSU in Brazil is far from ideal, as shown in Figure 2.

**Figure 2 – Final disposition of RSU in Brazil**



Source: Adapted from ABRELPE (2022).

Compared to the total RSU generated in Brazil in 2022, 81.8 million tons (about 381 kg/inhabitant/year), 76.1 million tons were collected (93%), however, of these, 36% they did not have an adequate final destination, being deposited in controlled dumps and landfills. Inadequate disposal causes direct environmental impacts on the environment, such as pollution of surface and underground waters, contamination of local fauna and flora and high emission of gases contributing to the greenhouse effect, these being the main responsible for global climate change, as pointed out by Machado *et al.* (2019), Mannheim *et al.* (2021), Abubakar *et al.* (2022).

As for the RSU that had an adequate final destination, they were directed to sanitary landfills (SA), which, according to NBR 8419 (ABNT, 1992), are a technique for the disposal of urban solid waste that aims at the maximum reduction of environmental impacts in the short and long term to the deposition environment. According to Lange *et al.* (2008) and Boscov (2008), the AS are designed thinking both about their operation during the waste disposal operation and in the post-operation period, being described as a work of Civil and Sanitary Engineering and acting correctly from a complex operating system, which has several levels of geotechnical and environmental protection. Added to the fact of the increase in the generation of RSU with the need for its correct disposal, techniques and materials have been developed to execute AS with greater capacity, quality and safety in relation to both environmental and geotechnical aspects and aiming for a sustainable future. For example, predicting the behavior of these structures in the short and long term (Teixeira, 2015; Chiarello, 2022) and the energy use of biogas (CRVR, 2023), studies that may allow the subsequent use of the operation area of the AS and minimizing its environmental impact, respectively.

In parallel, as pointed out by Toro and Vaz (2022), environmental education policies help to encourage the learning of current and future generations on the topic. In line with what the authors said, the distance of the academy in relation to the problems and challenges of this area of activity results in the training of professionals who are unfamiliar and/or qualified, which can lead to deficient or incomplete training of Engineers who, soon, will have active participation in private or public companies, responsible for the operational and environmental management of RSU.

Even with the correct management of urban solid waste, as regulated in NBR 10004 (ABNT, 2004) and Brazil (2010), there are negative effects on the deposition of RSU, even in landfills. Tabata *et al.* (2011) point out that the deposition of RSU in AS is costly, since there are high costs related to its final destination, in addition to polluting products from its degradation, such as leachate and gases that cannot yet be completely absorbed by the environment or by anthropogenic treatments. In this sense, Verma and Borogan (2022) demonstrate the significant reduction in the generation of by-products when studying the deposition of RSU with and without prior treatment, in which, with simple actions such as recycling and composting, there can be a significant reduction in the emission of gases that contribute to climate change.

Given the urgency in minimizing the negative effects of increasing the population's quality of life in the face of RSU production, Amaro and Bernardes (2018) emphasize that

environmental education is one of the ways to achieve this, since the knowledge transmitted is capable of providing attitudinal changes on individuals, such as the normalization of the aforementioned actions: separation of household waste for recycling or composting. To achieve this, it is necessary to move away from just the theoretical field, and unite this medium with practice, through actions aimed at all individuals and areas of knowledge. The 3 R's policy – Reduce, Reuse and Recycle, which emerged 30 years ago, are actions that must be part of citizens' daily lives, aiming for tomorrow. Faced with this problem, the initiatives of this extension project aimed to answer the question of how to bring this issue to the academic and social sphere and also how to resolve it.

In view of the above, this article presents actions that integrate teaching, research and extension led by the Federal de Santa Maria (UFSM) and which aim to bring to the study and discussion the problem and also the benefits of the construction and operation of AS combined with the practices of environmental education. The actions developed promote the exchange and gain of knowledge between professionals, technicians, students and teachers, in activities related to the different disciplines offered in undergraduate and postgraduate courses in Civil Engineering and Sanitary and Environmental Engineering at UFSM. With the interaction between the UFSM academic community and society in general, everyone involved is benefiting, as it enables the discussion of different aspects that allow for the expansion and dissemination of knowledge, promoting interdisciplinarity, relationships with other educational institutions, with the external community and with companies.

### **Action methodology**

Landfills play a fundamental role in the proper management of waste, that is, minimizing environmental impacts and promoting public health. As a result, in order to guarantee the effectiveness of the waste disposal system, it is essential to adopt policies based on population education, characterization of materials and use of data in teaching, research and extension projects. Given the technical knowledge on the topic, a broad working group was assembled, composed of students, technicians and teachers from the undergraduate course in Civil Engineering and the Postgraduate Program in Civil Engineering at UFSM, also involving the Materials and Civil Construction at UFSM, and professionals from different units of the Companhia Riograndense de Valorização de Resíduos (CRVR), a company that manages six landfills in the state of Rio Grande do Sul, which receives around 73% of municipal Solid Waste

collection from the state of Rio Grande do Sul. The project is registered with the UFSM Technology Center, in the extension category, under no. 057370, entitled: Joint Actions for the Development of Innovation, Sustainability and Safety in Large Sanitary Landfills.

The extension project consists of a variety of actions by the technical staff and the community in general, since extension is any and all transformative interactions, between UFSM and external communities, related to serving the external public, in which students and teachers are involved. Therefore, the project's main objectives are :

- a) Promote the group's partnerships with institutions, companies, class entities and groups of people outside UFSM;
- b) Hold meetings, presentations, lectures, mini-courses and *workshops*, between project participants and the academic community, the community in general (residential and business), and school communities;
- c) Disseminate knowledge with publications in newspapers, scientific magazines and conferences, to publicize and demonstrate the project's activities and results.

Due to its wide scope, different work fronts were defined to reach the broad target audience, being research and teaching fronts, and an extension front. Within one of them, research activities have been developed in landfills in the state of Rio Grande do Sul, such as: assessment of technical conditions, characterization of landfills and geosynthetics, holding courses, training employees and carrying out field tests and laboratory by the aforementioned team. The data provided from tests and monitoring are used in academic research.

On another front of work, a link was sought between the university and the local community. The university's action with the external community is part of institutional policy, making the knowledge acquired through teaching and research available to the general public. From extension actions, new knowledge is produced; In this way, some activities have been developed and others are ongoing. In this article, the actions carried out and their respective particularities will be reported. In this way, each activity followed its own methodology for the development of the action, being divided into: environmental awareness actions in early childhood education, dissemination of knowledge to the technical environment, actions developed for students, and, finally, continued training of members of the group. Basically, it is research with a basic nature, with qualitative and quantitative approaches, involving bibliographical, experimental procedures, participatory research and field research.

## **Environmental awareness actions in early childhood education**

In one of his works, educator and philosopher Paulo Freire defined awareness as the process by which people become aware of the social, political and economic realities that surround them, seeking to understand their positions and roles within these structures (Freire, 2018). The phenomenon of raising awareness is associated with the act of educating. In view of this, Barros and Recena (2024) infer that environmental education is much more than raising awareness about waste, recycling and pollution.

Due to the fact that the environmental education is a process that needs to be collective and continuous, it is seen as a tool to be used by educators in schools in relation to the discussion about solid waste production and its control (Silva; Almeida, 2018). Early childhood education provides learning and discoveries, so this is the right time to start these experiences in the classroom (Barros; Recena, 2024). In short, extension activities, which seek to disseminate knowledge and raise awareness among young citizens, are carried out in this project in early childhood education schools.

The objective of these actions is to promote the implementation of educational policies with an environmental bias, since, according to Verderio (2021), it is in this age group that concepts and values for life are constructed. In this way, there is the opportunity to develop in children's values and behaviors aimed at conserving the environment, making them aware of the importance of the topic in question. Thus, concepts of sustainability are inserted into the environment, since sustainability consists of the ability to satisfy the needs of the present, without compromising future generations (ONU, 1983).

Verderio (2021) also states that it is important that environmental education is included in all levels and modalities of formal and non-formal education, starting in early childhood education, as it is the first stage of basic education, continuing throughout the individuals' school lives.

In this way, the methodological path constituted a didactic proposal composed of activities developed in the month of June 2023, with the 1st year class of Escola Infantil e Fundamental Heroica, located in Santa Maria, Rio Grande do Sul. The class is composed by 21 students aged between six and seven years old. The pilot project developed was composed of theoretical and practical activities, which addressed the issue of waste generation, demonstrating that a large part of the activities we carry out daily generate waste of different types, in addition to emphasizing the importance of selective collection, having considering



that, according to the National Circular Reference for Early Childhood Education (RCNEI), the child needs to “observe and explore the environment with an attitude of curiosity, increasingly perceiving themselves as a member, dependent and transformative agent of the environment and valuing attitudes that contribute for its conservation” (Brasil, 1998, p. 63, our translation). The experience at the Heroica school was divided into five stages:

- a) First stage: presentation from the Federal University of Santa Maria, with contextualization about the role of the Civil and Sanitary Engineer in relation to the environment;
- b) Second stage: demonstration of the types of waste generated within the school environment and students' homes, to encourage correct separation, in addition to presenting the colors used in selective collection;
- c) Third stage: explanation about waste generation, exploring, in a playful way, issues related to environmental preservation, the 3Rs policy (reduce, reuse, recycling) and the ideal destination for waste;
- d) Fourth stage: to apply the previous stages, waste hunting was proposed. The activity consisted of collecting different images of waste that were inserted inside a surprise balloon that, after bursting, were spread around the school yard. After finding them, the students needed to identify the type and which bin they should be allocated to;
- e) Fifth stage: to finalize and with the aim of establishing the knowledge acquired, as well as sharing it, a homework activity was proposed for students to carry out with their families.

### **Dissemination of knowledge to the technical environment of the state of Rio Grande do Sul**

According to Luis (2011), the dissemination of scientific works is one of the greatest challenges for researchers, requiring the search for publications in different environments and languages, in addition to dissemination in the media, scientific academic events, among others. In this way, it is understood that scientific congresses are essential for disseminating and propagating knowledge, in addition to providing dialogue between researchers from different scientific communities and fostering new academic relationships.

Therefore, every two years, the Rio Grande do Sul Geotechnical Engineering Seminar (GEORS) is held to encourage discussions about Geotechnical Engineering, one of the thematic areas being Environmental Geotechnics. The event, which welcomes professors and students from different universities in the state of Rio Grande do Sul, self-employed professionals, professional associations, companies and the general public, is organized by the Brazilian Soil Mechanics Association (ABMS), a nucleus in RS, in together with the university that is hosting the event. Professor Magnos Baroni was the president of GEORS in 2019 and 2022. In 2019, the aforementioned seminar was held at the Federal University of Santa Maria and received around 500 participants (UFSM, 2019).

In 2022, the XI GEORS, again held by UFSM and chaired by professor Magnos Baroni, was organized by the project work team together with ABMS Núcleo RS and with financial support from entities and private companies. A space was provided for researchers to publicize their work through the event annals and the presentation of work in plenary sessions. Six leading professionals in Brazil were invited to present their research and ideas on the event's themes, with Environmental Geotechnics highlighted by the participation of Professor Dr. Maria Eugenia Gimenez Boscov, head of the USP Polytechnic School, CNPq research productivity scholarship – Level 2, which actively works in the area of Environmental Geotechnics, contributing to the development of Brazilian technical standards, dissemination of knowledge and activities in the scientific world.

In order to ensure the continuity of the event in the future and the target audience's approval of the general GEORS schedule, a questionnaire was administered to participants with the aim of evaluating the event, understanding the participants' motivation and level of education, and what the level of satisfaction with the technical lectures and thematic sections. The following questions were asked:

- a) What is your graduation? Is this your first participation in a GEORS?
- b) What motivated you to participate in the event?
- c) What area within Geotechnics are you most interested in?
- d) What is the level of satisfaction with the technical lectures? And what about the thematic sections?

In this way, it was possible to understand the opinion and level of satisfaction of those present, pointing out which aspects future events need to work on to maintain the interest of the target audience.

### **Actions developed for university students**

Through complementary activities to undergraduate and postgraduate courses, students have the opportunity to improve their knowledge, expand their curriculum and complement their knowledge on various topics. As it is a technical area with different possibilities for action and broad knowledge, activities parallel to the Civil Engineering course allow students to develop activities at their own convenience, aiming to improve their training.

In summary, the group proposed extracurricular activities for the student body of undergraduate courses in Civil Engineering and Sanitary and Environmental Engineering, as well as students of the Postgraduate program in Civil Engineering, both at UFSM. The initiatives carried out are listed below:

- a) Technical lecture as Inaugural Class for undergraduate and postgraduate courses, with professor Dr. Nilo Cesar Consoli, from the Federal University of Rio Grande do Sul, entitled “Innovation in Geotechnics and Environmental Geotechnology” (UFSM, 2023). The speaker presented to the students the various possibilities of study in the area of geotechnics and environmental geotechnics, in addition to working with urban solid waste, but also with mining waste, which are materials that present geotechnical behaviors different from traditional soils, and studies are currently in demand to advance mining waste disposal techniques.
- b) Civil Engineering Sustainability Marathon, entitled “A Brief Overview of the Applicability of Sustainable Materials in Geotechnical Projects”, given by project member Engineer Ma. Paula Taiane Pascoal. This lecture aimed to present to students of the Civil Engineering and Sanitary and Environmental Engineering courses at UFSM about the work carried out in the area by the research group, disseminating knowledge in the academic world.
- c) Short courses for Introduction to the Dimensioning and Stability of Earth Slopes and Landfills, taught by project member Engineer Ma. Patricia Rodrigues Falcão. In the short courses, the technical and practical state of the art related to slope stability was presented

to students of the Civil Engineering and Sanitary and Environmental Engineering courses at UFSM, elucidating practical examples in the application of theory in conjunction with *software*, preparing them for post- formed.

- d) Technical visits guided by CRVR professionals to the landfills of Minas do Leão and Santa Maria, both in Rio Grande do Sul, based on the CRVR open doors program. Field visits aim to present to students the general functioning of the structure of an AS, including the monitoring, operation, implementation and management stages.

### **Continuing training of group members**

The training of the group's members occurs at undergraduate and postgraduate levels, with the development of research - both articles for the annals of regional, national and international congresses as well as the development of Undergraduate Course Completion Works, Master's Dissertations and Theses. Doctorate degrees focused on various areas, as well as environmental geotechnics – and participation in technical events in the area – which provide, in addition to knowledge, opportunities to expand the students' contact network, and to present their productions, acquiring a legacy in the area. In short, these play a key role in professional training, as they provide opportunities for learning, exchanging ideas and constructive debates.

Like Undergraduate Course Completion Works, Master's Dissertations and/or Doctoral Theses, the use of landfill monitoring data and design and implementation needs of works generate study topics addressed within the group in these types of research.

The study, execution, publication and presentation/dissemination of work in the area provide a space for awareness and discussion about the risks associated with landfills and the valuation of RSU, thus contributing to the dissemination of information about environmental protection. In this way, group participants are encouraged to carry out scientific research and participate in events to disseminate knowledge, in addition to acquiring experience in the area in question, which is a differentiator when they are full-fledged engineers working in the job market or, also, if they move on to the academic and scientific field.

## Results and discussions

From the application of the aforementioned methodology – in which the applied educational and professional actions were reported –, the fruits of these works are presented, which were developed within the scope of early childhood, technical and higher education, and also within the extension project with an emphasis on awareness, innovation and sustainability, aiming at environmental education. It should be noted that the people who appear in the photographs included in the Figures authorized the use of the images and are in compliance with ethical and legal guidelines.

### Actions in Early Childhood Education

The pilot extension project with an emphasis on early childhood education was developed at the Heroica school, located in the municipality of Santa Maria/RS, with the teaching theme focused on environmental awareness and the climate crisis. The development of activities was considered productive for both educators and small citizens.

The main focus of the activities developed was to disseminate at school the importance of reducing, reusing and recycling waste, cultivating the values of sustainability and attention to the environment. As can be seen in Figure 3 (a), the topic was initially introduced by professor Magnos Baroni and the scientific initiation students of the Civil Engineering course at UFSM. After explanations on environmental issues, landfills and the climate crisis, an educational video was presented, followed by a new presentation consisting of photos and discussions on the aforementioned topics. Interaction with elementary school students began during the presentation, as many of them already knew how to dispose of waste and the ideal destination for each type. Afterwards, in the school yard, the waste hunting activity was carried out, in which after popping the surprise balloon, the children collected images of different types of waste, to identify them and later deposit them in the respective bins, as shown in Figure 3 (b).

The educators at the institution where the activity was carried out evaluated the approach as attractive and striking, as it involved a relevant theme in a light and relaxed way, attracting the children's attention. It was suggested that this activity be carried out in other classes and periodically, as repetition is combined with the consolidation of learning.

By carrying out this action in a school environment, it was realized that there are countless possibilities for approaching environmental issues in early childhood education.

Almeida *et al.* (2020) and Cunha *et al.* (2020) discussed global warming and environmental awareness in a playful way, and were also successful in their approaches, concluding that children have a great capacity to understand environmental education. Similar to Verderio (2021), we believe that, although there are different ways of approaching the topic in early childhood education, it is still necessary to develop more research in the area and promote adequate training for teachers and educators, so that it is possible to further consolidate about what is discussed. By raising awareness and educating the adults of tomorrow, we will have a balanced society and the search for environmentally ideal solutions will be closer to success.

**Figure 3** – Action in early childhood education with the introduction to the topic in (a) and the playful activity in (b)



(A)



(B)

Source: Own collection (2023).

### **Actions in Higher Education**

The XI Edition of GEORS was the first major in-person event held on the theme of Geotechnical and Environmental Engineering, for the public in southern Brazil, after the COVID-19 pandemic. It was possible to bring together more than 350 students from 15 different universities, several companies and professional associations, as well as teachers and professionals in the field (ABMS, 2022a), as shown in Figure 4 (a). The congress was extremely important from an educational and professional perspective, as it provided a space for the exchange of knowledge, debates and experience, contributing to the advancement of scientific knowledge, with more than 60 articles being published in the proceedings of the event (GEORS, 2022). The presence of Professor Dr. Maria Eugenia Gimenez Boscov, a renowned researcher

on the subject of Environmental Geotechnics, who spoke on *the Use of Waste in Geotechnical Works*, stands out. The professor is the author of the book *Environmental Geotechnics* (Bosco, 2008), widely used in Brazilian academia. In addition, other researchers disseminated their knowledge through the presentation of technical lectures and selected articles, as stated in ABMS (2022b).

For the undergraduate students participating in the extension project, it was their first experience related to organizing a major technical event. In addition to all the planning and organization that lasted for months, the opportunity to be close to renowned researchers, great examples of professionals, was something remarkable for everyone. Figure 4 (b) presents the XI GEORS organizing team.

**Figure 4** – GEORS 2022 (a) event participants (b) event organization team



(A)

(B)

Source: Own collection (2022).

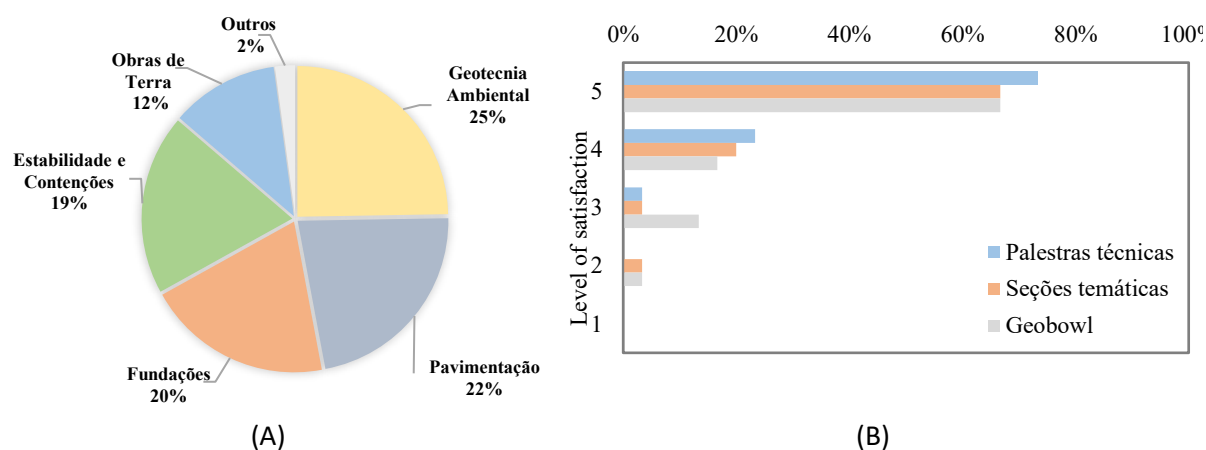
When applying the proposed evaluation questionnaire, 59% of the participating public was reached. Of this participating public, 64% were pursuing an undergraduate degree, 19% have degrees in areas related to the event, 8% of participants have a master's degree and 9% have a doctorate in related areas. For 75% of the public who responded to the questionnaire, it was their first participation in a scientific event, so it was satisfying to know that the event had a positive impact and really reached the desired audience.

When questioning the motivation for participating in XI GEORS, the most recurrent answers were: Interaction with renowned professionals in the area, Update of knowledge, Interest in the area of geotechnics, Opportunity to publish and present the research carried out. Within the possible areas of activity in geotechnics, the areas of greatest interest are shown in Figure 5 (a). It is noted that the thematic area of Environmental Geotechnics presented greater

interest in action. This is possibly occurring due to the awareness of the technical community regarding environmental issues, in addition to the possibilities and opportunities to work in the area, such as in projects and administration of landfills, in works to decharacterize tailings dams, mining works following, in companies and paving works that consider the reuse of coating material, among others.

Another question asked of event participants was related to their level of satisfaction with the technical lectures and the thematic sections, considering responses on a scale of 0 to 5, as shown in Figure 5 (b). It is noted that the level of satisfaction was high for all activities, demonstrating that the approach and theme choices were adequate to what was expected by the academic public, companies and professional entities participating.

**Figure 5** – (a) areas of activity of participants (b) level of satisfaction of participants with the event



Source: Own preparation (2023).

For actions developed exclusively for UFSM students, the inaugural class of the first academic semester of the year 2023 is highlighted, for Undergraduate and Postgraduate courses in Civil Engineering and Sanitary and Environmental Engineering. This master class was taught by Dr. Nilo Cesar Consoli, who is on the list of the most cited scientists in the field of Engineering and Technology and is currently the sixth most influential researcher in the world (Research, 2023). The lecture entitled Innovation in Geotechnics and Environmental Geotechnology: new materials and solutions for new and old geotechnical problems was attended by more than 200 students. In addition to the lessons shared and professional aspirations, the lecture encouraged the development of new studies and research in the



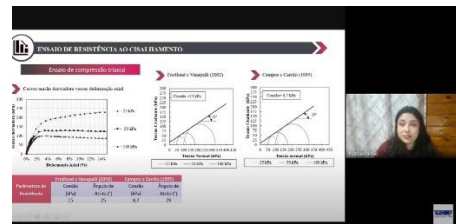
environmental area, including the reuse and valuation of waste and the development of new technologies with energy matrices.

In addition to the inaugural class mentioned above, other technical lectures and short courses were held by the project team in conjunction with the Tutorial Education Program (PET) of the Civil Engineering course, seeking integration between other sectors of the university in favor of teaching. An example of the fruit of this recurring partnership, the lecture A Brief Overview of the Applicability of Sustainable Materials in Geotechnical Projects, was given by project member Engineer Ma. Paula Taiane Pascoal, at the 1st Sustainability Marathon in Civil Engineering, given to more than 60 students at the 2nd semester of 2022 - Figure 6 (a). In addition, two short courses in the thematic area were offered to UFSM students, they were taught during the COVID-19 Pandemic, by Engineer Ma. Patricia Rodrigues Falcão, entitled Introduction to Earth Slope Dimensioning and Percolation and Slope Stability Problems, as shown in Figure 6 (b). Both the speaker on the topic of sustainability and the mini-course minister evaluated the opportunity granted as beneficial, as expectations regarding student participation were considered satisfactory. Regarding the content covered, they considered it to be extremely necessary in civil engineering, as it is a multidisciplinary topic.

**Figure 6** – Actions in higher education: (a) lecture given by a member of the project; (b) mini-course taught by a member of the group



(A)



(B)

Source: Own collection (2023).

The actions carried out for UFSM students are very important to train students on the technical aspects related to environmental geotechnics, its problems, and solutions, focusing on ensuring environmental preservation and safety and encouraging the carrying out of new research in area.

The ability to combine theoretical and practical knowledge is an important differentiator in an educator. This is how professionals can captivate and encourage their students to seek solutions to different problems, develop new technologies, and design safely and sustainably. Given this, one of the activities developed within the extension project for UFSM students is the technical visit to Landfills. In view of the partnership between the group and CRVR, visits were carried out at AS de Minas do Leão and AS de Santa Maria - Figure 7 (a) -, both in Rio Grande do Sul. In addition to technical visits, teachers guide the CRVR technical team, with courses to improve the quality of operation, maintenance and safety of landfills. Figure 7 (b) exemplifies a course taught by professors Magno Baroni and Rinaldo Pinheiro, in the year 2022, at the Minas do Leão/RS unit.

**Figure 7** – (a) Aerial photograph of the technical visit carried out at the Santa Maria Landfill – RS; (b) Training course for the work team at the Minas do Leão unit



(A)



(B)

Source: Own collection (2023).

### Continuing training of engineers

The continuous training of members at undergraduate and postgraduate levels occurs in parallel with all the activities being carried out. In this way, members of this project are encouraged to carry out research in the area of environmental geotechnics and to participate in lectures, courses and conferences in the area. Currently, due to the search for solutions to the needs of the practical environment, the group develops research related to landfills, waste recovery and sustainability. Therefore, members are strongly encouraged to write technical articles to disseminate research and share knowledge, examples being the articles by Nascimento *et al.* (2022), Nascimento *et al.* (2023) and Ben *et al.* (2023) published and presented in proceedings of recognized Brazilian environmental geotechnical congresses.

Nascimento *et al.* (2022) received an Honorable Mention for best scientific article in the thematic section of Environmental Geotechnics at the XI Geotechnical Engineering Seminar of Rio Grande do Sul.

The environmental theme is also addressed by professors Magnos Baroni and Rinaldo José Barbosa Pinheiro, in the supervision of course completion, master's and doctoral studies. Examples include doctoral theses by Salamoni (2019), Scapin (2021) and Klamt (2025, in press), master's theses by Rauber (2008), Salamoni (2008), Delongui (2012), Denardin (2013), Reis (2013), Teixeira (2015), Chiarello (2022) and Nascimento (2024, in press), in addition to undergraduate course completion work by Nascimento (2022), Marques (2021) and Arruda (2022).

The constant improvement of professionals who work in the area of Environmental Geotechnics is relevant, as new methods and technologies are frequently introduced into the environment, and the high demand for environmentally correct solutions makes professionals seek continued training. In view of this, it is emphasized that the aforementioned activities, developed by postgraduate engineers and future engineers who are undergraduate students, in addition to contributing to their training, bring positive responses to society as a whole.

### **Final remarks**

The construction of social values, knowledge, attitudes and skills focused on the environment are essential for human beings, as the population's quality of life is linked to this. Therefore, environmental education must be present at all levels and modalities of the educational process, whether formal or non-formal. Knowledge regarding the attitudes and activities we develop today is extremely important due to the consequences of our actions, since the waste we generate today will certainly be the problem for tomorrow.

The 3R's policy has been part of society's education process for years, however, a lot of waste is still generated and the fate of each type is different. In the case of landfills, the complexity of carrying out activities and managing the necessary demands is challenging for the professionals responsible, making continued training necessary.

In view of this, it is understood that environmental education should be an issue at all levels, whether in school environments or not. The sooner training begins, the more success you can achieve. Thus, this university extension project developed and continues to work on comprehensive environmental education demands, in addition to the search for innovation and

development of solutions for landfills and waste, with a sustainable bias in its activities and research.

Through the link formed between the university and the local community, a playful experience was carried out in an early childhood education class. The activities showed positive results, concluded from the interaction and knowledge acquired by small citizens. On the other hand, in higher education, the offer of a quality event to transmit knowledge from great researchers in the area of environmental geotechnics, was one of the activities carried out at XI GEORS, an event held by the team that makes up the extension project. Through the activities carried out, confirmed with the application of a questionnaire, it can be concluded that future engineers are aware that caring for the environment must be part of their days, and that they will have a fundamental role in solving environmental problems.

Still in higher education, through lectures, short courses and technical visits, the aim is to qualify undergraduate and postgraduate students in civil and environmental engineering, providing quality education, with good technical training and character building, so that the society can count on conscientious and qualified professionals.

Proximity to companies, such as CRVR, provides evolution for both sides. An example of this were the training offered by UFSM professors to the company's employees. On the other hand, having access to monitoring data and characterization of landfills provides research for the group, which is able to contribute with solutions to new and constant challenges.

Finally, it is understood that this broad extension project is not carried out only by the authors of this article, being a constant work carried out by many hands. Many results have already been obtained, however, the main result is the consolidation of a broad work team and the carrying out of activities for different groups, making it possible to affirm that the actions already carried out and future actions will have an important impact on the preservation of our planet and improving the population's quality of life, pointing out that the results obtained and to be achieved are and will be positive, as well as other studies that are being initiated on the topic.

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### ***CRediT Author Statement***

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**Availability of data and material:** The works mentioned in the text are available in the event annals and in the repository of the Federal University of Santa Maria (UFSM).

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