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Artículo Original

Prototyping of biodigesters to raise awareness and disseminate the 2030 Agenda in an educational environment

Prototipos de biodigestores para concienciar y difundir la Agenda 2030 en un entorno educativo

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Abstract

With the huge problems presented in communities, the biodigester has become a viable solution for many of these problems, mainly for the generation of clean and renewable energies. The biodigester, in addition to energy, contributes to the sanitation of homes, preservation of the water system, reduction of disease contamination among living beings. The present work aims to show the development of low cost biodigester prototypes with the proposal of scientific dissemination, sensitizing students about renewable energies, allowing inserting the study of environmental education. In addition, it aims to contextualize and promote Sustainable Development Goals (SDGs) 4, 7 and 11 in school environments. This work was carried out based on an extensive research on the topics addressed in this work, which highlighted the methods and materials used in the assembly and monitoring of a prototype of biodigester for data collection and the application of awareness about renewable energies with students. The proposal presented by the research was concluded, showing the benefits that addressing important issues for society in a simpler and more accessible way, scientifically disseminating how the research and its respective results were carried out. With the context and promotion of the 2030 Agenda, it was observed that, in order to reach the SDGs, the collective engagement of the whole community and education is necessary, it is the starting point of sustainable learning.

Keywords: Biodigester, Sustainable Development Goals, Environmental Education, Renewable Energies, Sustainability

Resumen

Con los grandes problemas que se presentan en las comunidades rurales, el biodigestor se ha convertido en una solución viable para muchos de estos problemas, principalmente para la generación de energías limpias y renovables. El biodigestor, además de energía, contribuye al saneamiento de los hogares, preservación del sistema de agua, reducción de la contaminación por enfermedades entre los seres vivos. El presente trabajo tiene como objetivo mostrar el desarrollo de prototipos de biodigestores de bajo costo con la propuesta de divulgación científica, sensibilizando a

los estudiantes sobre las energías renovables, permitiendo insertar el estudio de la educación ambiental. Además, tiene como objetivo contextualizar y promover los Objetivos de Desarrollo Sostenible (ODS) 4, 7 y 11 en los entornos escolares. Este trabajo se llevó a cabo a partir de una extensa investigación sobre los temas abordados en este trabajo, en la que se destacaron los métodos y materiales utilizados en el montaje y seguimiento de un prototipo de biodigestor para la recogida de datos y la aplicación de la concienciación sobre energías renovables con los estudiantes. Se concluyó la propuesta presentada por la investigación, mostrando los beneficios que reporta abordar temas importantes para la sociedad de una manera más sencilla y accesible, difundiendo científicamente cómo se llevó a cabo la investigación y sus respectivos resultados. Con el contexto y promoción de la Agenda 2030, se observó que, para alcanzar los ODS, es necesario el compromiso colectivo de toda la comunidad y la educación, es el punto de partida del aprendizaje sostenible.

Palabras clave: Biodigestor, Objetivos de Desarrollo Sostenible, Educación Ambiental, Energías Renovables, Sostenibilidad

1. Introduction

From the oil crisis of the 1970s, research and development of new alternative sources of energy for nations, dependent on this energy resource, which underwent profound changes in the search for the replacement of that product, was promoted. Brazil has concentrated its efforts to replace oil through research on some alternative sources, such as alcohol, shale and methanol. One of the options for low-cost energy production that has been showing favorable results and is already widespread in several countries is biogas, which despite being known for a long time, only since 1976 have studies been intensified regarding its use aiming at its energy use in Brazil [1].

Until December 1979, China, with 7.2 million biodigesters installed, produced an energy value equivalent to five times the energy generated by the Itaipu plant. This represents an equivalent to 48 million tons of coal. Brazil has favorable climatic conditions to exploit the immense energy produced by biodigesters. With that, it could stop using bottled gas and liquid fuels, such as kerosene, gasoline and diesel for rural and urban areas. This would reduce a significant portion of imports of oil products [2].

The biodigester, in addition to energy, contributes to: the sanitation of homes, eliminating odors and sources of contamination from organic waste; pollution control, contributing to the preservation of the water system and soil fertility and reduces contamination and the spread of diseases among living beings. The maintenance cost is low, since it is fed with material collected from the property, providing yet other savings with the biofertilizer, which substitutes chemical fertilizers with advantages. Anaerobic biodigestion represents alternatives for solving environmental problems and the demand for sustainable energy production [3,4]. The biodigester is a piece of equipment that consists of a closed chamber where the biomass is inserted in an aqueous form which, from its anaerobic decomposition, generates biogas and biofertilizer [1].

The main component of biogas is methane, representing about 60 to 80% in the composition of the total mixture. Methane is a colorless, highly combustible gas, burned with a lilac blue flame, which leaves no soot and with a minimum of pollution. This gas is not dangerous and can be used indoors. Natural and anthropogenic sources produce methane, and a significant portion of the presence of this gas in the atmosphere comes from organic waste deposited in the environment. Therefore, through the appropriate treatment of these residues, it is possible to use methane for energy purposes and the biofertilizer as a fertilizer [1].

Biomass is any material capable of being decomposed by biological action. It is a renewable resource that originates from the total mass of organic matter that accumulates in a space, referring to it all plants, animals and waste. Biomass can be found in different ways, where the best known are, firewood, the residues generated by agricultural crops, energy forests, municipal solid residues, agro-industries and animal husbandry [5].

Considered a source of biomass, solid urban waste (MSW) is recognized as an energy source, but its participation in the matrix is still relatively small (less than 0.07%), considering the high amount of waste produced daily in the country. country, about 176.4 thousand tons/day [6]. The Energy Research Company estimated that the potential for power generation from MSW using landfill gas exploitation technologies is 311 MW, accelerated anaerobic digestion is 868 MW and incineration is 3,176 MW [7].

According to data from a study carried out by Urbanizadora Municipal S.A., the municipality of São José dos Campos collects 14,472 tons / month of common collection and 1230 tons / month of selective collection [8]. Today, solid and liquid waste is a major challenge for the community and especially for generating institutions, which have the task of minimizing and properly managing "waste", in order to avoid contamination and impacts on the environment. Among the sources of environmental degradation, the waste generated in industries, schools and homes has an important peculiarity: when improperly managed, they offer potential risk to human beings and the environment [9].

As a viable solution, the use of biodigester technology has been shown to be efficient in solving problems encountered in society. In this context, we can see that it can help achieve the Sustainable Development Goals (SDGs). In 2015, with 193 member countries, the United Nations (UN) unanimously approved a 15-year action plan to eradicate poverty and hunger, protect the planet from environmental degradation, ensure prosperous and fulfilling life for all people and promote peaceful, just and inclusive societies, the so-called Agenda 2030 [10].

To achieve sustainable development, it will require a profound transformation in the way we think and act. To create a more sustainable world and engage with issues related to sustainability, as described in the SDGs, individuals must become agents of change aimed at sustainability. They need knowledge, skills, values and attitudes that allow them to contribute to sustainable development. Education, therefore, is crucial for achieving sustainable development. The well-established approach to education for sustainable development enables learners to make informed decisions and take responsible actions to ensure environmental integrity, economic viability and a fair society for present and future generations [11].

When reflecting on the role that education has in promoting a more sustainable development, it is understood that schools and educational institutions are essential actors in the necessary change for sustainable development. Thus, educational institutions need to be models of sustainability not only when passing on knowledge and tools to their students and communities so that they have the capacity to make more conscious decisions, but they also need to be models of sustainability in sustainable management and in how they transmit knowledge and relate to their students and to the communities they are part of [12].

In times when information plays an increasingly important role, citizenship education is plausible to motivate and sensitize people to transform the various forms of participation in the defense of quality of life, highlighting that environmental education increasingly assumes yet another transformative function, in which the co-responsibility of individuals becomes an essential objective to promote

sustainable development. Thinking about environmental complexity opens a favorable opportunity to understand the gestation of new social actors who are mobilized for the appropriation of nature, for an educational process articulated and committed to sustainability and participation, supported by a logic that privileges dialogue and interdependence from different areas of knowledge [13].

The present work aims to show the development of low cost biodigester prototypes with the proposal of scientific dissemination, sensitizing students about renewable energies, awakening knowledge and generating curiosities, allowing inserting the study of environmental education. In addition, it aims to contextualize and promote Sustainable Development Goals (SDGs) 4, 7 and 11 in school environments.

2. Materials and Methods

This work is part of the research line of the Senac Science Club of São José dos Campos, which investigates the use of Biomass Energy, which uses the Biodigester as one of its means of production.

The Science Club aims to awaken in young people an interest in Science and scientific research and make them more apt to learn science and related subjects familiarize the student with projects, bibliographic, laboratory and field research works. In addition, it aims to stimulate the development of technology-based entrepreneurship through Senac's Formative Brands, putting into practice the Pedagogical Proposal of Senac SP.

The Clube de Ciências members engage young people from state schools by promoting partnerships that produce rich exchanges of knowledge, bringing quality of life to city residents, based on the projects created in the unit's laboratories and study environments.

Following the purpose of the Science Club and the pedagogical proposal of Senac SP, this work was carried out through research in articles, books, documents and public bodies on the topics addressed in this work for its elaboration.

The following will show the methods and materials used in the assembly and monitoring of a biodigester prototype for data collection and the application of awareness about renewable energies with students, contextualizing and promoting Sustainable Development Goals (SDGs) 4, 7 and 11 in school environments.

Prototype of the biodigester

Initially, extensive bibliographic research was carried out on academic bases on the subject. After the research, a batch biodigester prototype was developed based on the knowledge generated during the research, which included the assembly and daily monitoring of the prototype, in order to study the technical and environmental characteristics of the biogas production process, with the ability to measure the amount of gas produced and the hydraulic retention time. The prototype was assembled at the home of one of the authors to facilitate daily monitoring for data collection that lasted 60 days. The monitoring took place in a visual and tactile way.

The materials used were a 2-liter PET bottle painted with black paint, a 2-liter PET bottle (cut in half), 200 mL of crushed food scraps, 300 mL of bovine manure and 500 mL of water. Bovine manure serves to accelerate the process of decomposition of food and helps to produce biogas, as it is one of the residues with good energy potential.

The assembly of the prototype started with the mixing of the residues: food scraps, bovine manure and water. The residues were inserted in a 2-liter PET claw painted black so that sunlight would not stimulate the production of algae (which impair the process of anaerobic bacteria) and to increase the temperature inside the biodigester. The bottle was sealed with a cap that contained a hose attached to transport the generated biogas to a 510 mL bottle marked every 50 mL filled with water that will be upside down in another container (2 liter PET bottle cut) with water, causing the gas to be stored in the bottle, similar to the Torricelli Barometer experiment.

Fig.1 Biodigester prototype

Awareness workshop

To disseminate the knowledge generated during the research and the data obtained in the biodigester prototype, an awareness-raising workshop was held with a group from the Senac Apprenticeship Program at the São José dos Campos unit on October 29, 2019.

The Senac Professional Learning Program in São Paulo, aims to comply with Law no. 10.097/2000, its decrees and ordinances, providing initial professional education for young people hired as apprentices by companies. At the end of the program, the young person will be able to participate in actions of organization and general operation of the administrative services of companies, including the operating processes of the areas and departments. It will adopt a negotiating, sustainable, ethical and citizenship attitude, in order to facilitate the flow of company processes in which it is inserted and have more basis to define choices related to staying in it or identification and search for new perspectives [14].

The importance of renewable energies was exposed to students, with a focus on biomass energy and the biodigester processes. The awareness-raising workshop took place in the classroom, using slides and videos on the theme, and ended in the external space of the school, where the batch biodigester was set up, applying the concepts covered in the presentation made in the classroom.

During the workshop, details of renewable energies (hydro, biomass, geothermal, wind, solar and wave and tidal) were detailed, how they work and their relevance to the problems faced by Brazil. With a focus on biomass energy, the waste that can be placed in the biodigester was highlighted, as is the anaerobic decomposition process, variables, biogas composition and the efficiency of each type of waste.

The assembly of the demonstrative biodigester took place with a volunteer from the participating class, where the step by step of how to assemble a prototype biodigester was shown. This prototype featured a 5-liter bottle painted black, in which the mixture of residues was placed (the same as in the previous prototype with an amount proportional to the bottle size). This bottle was connected to another bottle with water by a hose, where the biogas passed to remove a percentage of the moisture contained in the gas. Finally, the biogas followed by another hose, in which it had a bladder at its end that retained the gas produced. This prototype assembled by the students, unlike the test prototype, was only intended to observe the production of biogas, with no data collection.

Fig.2 Prototype of the Biodigestor developed at the Awareness Workshop

3. Results and Discussions

The prototype that was carried out at the home of one of the authors initially stayed in a place with great exposure to the sun throughout the day, but after a tactile measurement on the bottle, it was identified that the residues were at a very high temperature, which could cause the death of the anaerobic bacteria present in the process. To solve this problem, the prototype was relocated to a location with controlled exposure to the sun. The prototype was manually shaken once a week to homogenize the waste. Due to the daily monitoring of the prototype, it was also possible to identify that on mild days with cloudy and rainy weather, the temperature of the waste decreased, affecting the production of biogas, which declined during this period.

The time for observation and analysis of the prototype was 60 days. During that period between 650 ml to 700 mL of biogas was produced. It was observed that, after 45 days the biogas production was insignificant, concluding that the hydraulic retention time is 45 days.

The biofertilizer produced by the biodigester was tested in flowers and vegetables, obtaining a significant result in the plants.

In order to disseminate the knowledge generated during the research, the awareness workshop with the Senac Apprenticeship Program class at the São José dos Campos unit took place as planned, exceeding expectations for the class's interest in the subject and the commitment to participate in the assembly of the prototype, in which doubts and curiosities were explained and resolved.

Fig.3 Vegetables and flowers used for the biofertilizer test

Fig.4 Awareness workshop

Fig.5 Assembly of the biodigester prototype

The prototype of a biodigester was assembled only to visualize the production of biogas, with the filling of the bladder, with no data being collected. For better visibility of the prototype, the biodigester was installed in Senac's green area, with easy access to students.

The initial idea of this research arose from the interest in developing the low cost biodigester prototype, to be applied as didactic material in the classroom. A view was gained of the importance of discussing relevant topics today, which helped to build a better environment, with a more sustainable and committed community, showing how Sustainable Development Goals 4, 7 and 11 in school environments can be contextualized and promoted to from the biodigester technology.

Taking into account that SDG 4 is about quality education, being a very important way to reach all other SDGs, it was observed that schools are the starting point in the pursuit of achieving the SDGs, and low cost biodigesters developed with students will enable the development of scientific, cultural, environmental and historical knowledge for schools, in addition to allowing the development of environmental education in a practical way.

SDG 7 aims to achieve clean energy that is accessible to everyone. Applying this concept in what was developed with the students in theory and in practice, one of the actions carried out was the awareness of the students, showing the importance of clean and renewable energies and how the different alternative sources work, after all, one should encourage consumption and practices to ensure a sustainable future for all.

SDG 11 has goals and indicators to make cities and communities sustainable, and the activities described in this paper show how school environments are a place for addressing relevant topics, helping students understand the importance of creating viable solutions and the developing a vision of a sustainable future for the community in which they live, showing that renewable energies can be a solution to the problems encountered in cities.

The research sensitized the students of the Senac Apprenticeship Program to important issues, as they are students who are entering the job market and will be able to use their knowledge and experience in favor of evaluating, participating and influencing decision-making on management strategies local, national and international companies related to environmental and social issues addressed in this work.

The Senac São José do Campos Science Club develops its lines of research with students from different areas and levels of education, encouraging interest in science. The biodigester prototype brought them closer to scientific concepts, in addition to stimulating both students participating in the Club, as well as students participating in raising awareness to adopt a sustainable and citizen attitude, thinking about seeking improvements for society.

4. Conclusions

The present work aimed to show the development of low cost biodigester prototypes with the proposal of scientific dissemination, sensitizing students about renewable energies, awakening knowledge and generating curiosities, allowing inserting the study of environmental education. In addition, it aims to contextualize and promote Sustainable Development Goals (SDGs) 4, 7 and 11 in school environments. It is concluded that the objective of the present work was reached. The proposal presented by the research was concluded, showing the benefits that addressing important issues for society in a simpler and more accessible way, scientifically disseminating how the research and its respective results were carried out. With the context and promotion of the 2030 Agenda, it

was observed that, in order to reach the SDGs, the collective engagement of the whole community and education, which is the starting point of sustainable learning, are necessary. Thus, the research helped raise people's awareness of the topic of renewable energy, contributing to the construction of smarter communities. It is suggested as future research, the analysis of the knowledge generated by the students and suggestions for improvements in the approach to the theme, after raising awareness with surveys or questionnaires. It is also suggested to develop awareness of renewable energies with students from state schools in partnerships, with the aim of providing knowledge exchanges. With this, promote quality of life for city residents, based on the projects created in laboratories and study environments of the unit by the Senac São José dos Campos Science Club, being able to address other SDGs that were not addressed in this work.

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Conflict of interest

The authors declare no conflict of interest.

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