Environmental sustainability practices in the metal mechanical industry: challenges and opportunities for small and medium enterprises in the city of Cartagena de Indias

Prácticas de Sostenibilidad Ambiental en la Industria Metalmecánica: Retos y Oportunidades para las Pequeñas y Medianas Empresas de la Ciudad de Cartagena de Indias

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Cómo citar/ How to cite: Cardona, D., Alarios, A. & Rojano, Y. (2024). Environmental sustainability practices in the metal mechanical industry: challenges and opportunities for small and medium enterprises in the city of Cartagena de Indias. *Revista Saber, Ciencia y Libertad*, 19(1), 321 – 339. https://doi.org/10.18041/2382-3240/saber.2024v19n2.12202

Abstract

The purpose of this research is to analyze the environmental sustainability practices implemented by small and medium-sized companies also called SMEs in the metal-mechanical sector in the city of Cartagena, to contrast them with the good environmental practices that should be developed by companies that work in favor of sustainable development.

Fecha de recepción: 16 de marzo de 2024
Fecha de evaluación: 16 de mayo de 2024
Fecha de aceptación: 3 de junio de 2024

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The methodology used for this study is quantitative and was transversal and field-based; the sample was non-probabilistic by convenience; it was made up of 120 companies out of a population of 662 SMEs according to the data of the Chamber of Commerce of Cartagena. The results indicate that a representative group of the companies analyzed has undergone a positive change towards environmental care, which has resulted in water-saving programs in their production processes; However, regarding energy consumption, although some SMEs have adopted energy-saving measures, a significant number of companies have not yet implemented them, which shows a lack of energy-saving culture; concerning gas emissions, there is evidence of the absence of measurement systems, which leads to a lack of knowledge of how they are impacting the environment. In conclusion, although some SMEs in the metal-mechanical sector in Cartagena have adopted environmental practices in their production processes, challenges remain regarding the lack of ecological awareness and the implementation of programs to reduce the environmental impact of their production processes, which are barriers to the strengthening of an organizational culture oriented to sustainable development.

Keywords

Environmental practices, SMEs, metal mechanical, sustainable development.

Resumen

El propósito de la presente investigación es analizar las prácticas de sostenibilidad ambiental implementadas por las pequeñas y medianas empresas también llamadas PyMES del sector metalmecánico en la ciudad de Cartagena, con el fin de contrastarlas con las buenas prácticas ambientales que deben desarrollar las empresas que trabajan a favor del desarrollo sostenible. La metodología empleada para este estudio es de carácter cuantitativo y fue transversal y de campo; la muestra fue de orden no probabilístico por conveniencia, estuvo conformada por 120 empresas, sobre una población de 662 PyMES de acuerdo con los datos de la Cámara de Comercio de Cartagena. Los resultados señalan que un grupo representativo de las empresas analizadas, han experimentado un cambio positivo hacia el cuidado del medio ambiente, que

se ha traducido en programas de ahorro del agua en sus procesos productivos; sin embargo, en cuanto al consumo de energía, a pesar de que algunas PyMES han adoptado medidas de ahorro, se observa que existe un número importante de empresas que aún no las implementa, lo que muestra una falta de cultura de ahorro energético; en lo que tiene que ver el con la emisión de gases, se evidenció la ausencia de sistemas de medición, lo que conlleva al desconocimiento de qué manera están impactando sobre el medio ambiente dicho aspecto señalado. En conclusión, aunque algunas PyMES del sector metalmecánico en Cartagena han adoptado prácticas ambientales en sus procesos productivos, siguen permaneciendo desafíos alrededor de la falta de conciencia ambiental y la puesta en marcha de programas que permitan la reducción del impacto ambiental en sus procesos productivos, que son barreras para el fortalecimiento de una cultura organizacional orientada al desarrollo sostenible.

Palabras clave

Prácticas ambientales, Pymes, Metalmecánico, desarrollo sostenible.

Introducción

In today's business environment, the adoption of sustainable environmental practices is no longer a voluntary option but a strategic necessity. Society's demands and concerns about climate change, the scarcity of natural resources, and warnings about environmental deterioration from the scientific and academic communities have inspired companies in all sectors to rethink their production processes and business models. In this regard, small and medium-sized enterprises (SMEs), particularly those in industrial sectors such as metal mechanical, face major challenges in reducing their environmental impact while at the same time achieving their business objectives.

According to the report presented by the Caldas Chamber of Commerce (2023) on the metal-mechanic industry, this sector is considered strategic for national economic growth, due to industrial linkages, the generation of added value and the absorption of skilled labor. For this reason, the report explains that the metal-mechanic industry plays an important role as a supplier of materials and inputs to the mining, construction, agricultural, automotive and manufacturing industries

and that these characteristics and dynamics serve as a thermometer to evaluate the country's economic performance.

The development of programs and/or actions aimed at good sustainable practices not only responds to the demands of society but also to consumers and business partners who demand more environmentally responsible products and services; this can contribute to the reputation of the brand, better positioning in the minds of consumers and reduce costs through activities aimed at saving water and energy consumption in their production processes, which translates into improved competitiveness of companies. Likewise, sustainable environmental practices can allow companies access to new markets and the possibility of obtaining environmental certifications that can lead to new business opportunities, strengthening the company's reputation and its ability to compete in an increasingly globalized market (Mejía, et al., 2012) (Páez, et al., 2016) (Valle & Niebles.,2017) (Sánchez, et al., 2024).

Likewise, companies that adopt sustainable practices are more resilient to environmental and economic risks, allowing them to better adapt to emerging environmental regulations and market fluctuations. In a world where sustainability has become a key value for consumers, investors, and regulators, those companies that integrate sustainability into their business strategy will not only protect the environment, but also improve their profitability and reach their business and financial goals. (2021) and González et al., (2022) developed in Mexico, confirm that companies that adopt good environmental practices develop better capabilities to respond better to the environment and therefore improve their organizational performance. In the same way, Roffe et al. (2024), in their work, determine that environmentally responsible companies improve their financial performance.

The metal-mechanical sector in Cartagena, the subject of this research, is predominantly composed of small and medium-sized enterprises (SMEs), which contribute significantly to the local economy, providing employment and supporting industrial development. However, this sector faces the challenge of adopting practices that promote environmental sustainability. Although there is growing global awareness of the importance of the 2030 agenda, particularly its social and environmental goals, many SMEs in Cartagena continue to use traditional production methods that cause high levels of pollution, excessive use of natural resources, and the generation of hazardous waste. These practices not only harm the environment but also pose risks to public health and safety. In addition, the lack of

sustainable approaches can diminish the competitiveness of these companies in the global marketplace, where both consumers and business partners increasingly value responsible business practices.

For this reason, the purpose of this research is to analyze the sustainable environmental practices that are being implemented in the SMEs of the metal-mechanic sector, in order to point out the environmental programs and/or activities developed by the companies; For this purpose, it was based on the theoretical review on the subject that with the results it will be possible to contrast and discuss between the empirical evidence and the theoretical elements, which would be valuable information to generate strategies in the field of sustainability that allow strengthening the environmental practices of the SMEs of the metal-mechanical sector in Cartagena and improve their competitiveness and positioning in their commercial environment.

Theoretical references

The adoption of sustainable and environmental practices in small and medium-sized enterprises (SMEs) is not only an ethical imperative, but also a key strategy to improve their performance and competitiveness in the marketplace (Blume et al., 2017). First, SMEs that implement sustainable strategies tend to experience a reduction in operating costs through resource efficiency. For example, optimizing any type of resource as an input for production or human consumption of energy and water consumption decreases the environmental footprint and reduces significant expenses (Cardoso de Oliveira Neto et al., 2023).

In addition, sustainable practices in companies as a corporate strategy can open new market opportunities, new scenarios for competitiveness as well as new market segments focused on ecological production dynamics (Gallina et al., 2024). New generations of consumers increasingly value the environmental and social responsibility of companies (Cardoso de Oliveira Neto et al., 2023). According to a study by Nielsen (2015), 66% of consumers are willing to pay more for products from companies committed to sustainability. Thus, SMEs that adopt responsible practices can improve their brand image and increase their customer base.

The integration of sustainable practices can also foster innovation. The need to comply with environmental standards can drive SMEs to develop new, greener products and services, which in turn can differentiate them from competitors

(Severo et al., 2015). This is especially relevant in sectors where environmental regulations are often strict, as companies that anticipate these changes can position themselves as market leaders (Monteiro et al., 2019).

On the other hand, sustainability contributes to organizational resilience (Appiah-Kubi et al., 2024). In this sense, SMEs that adopt sound environmental practices facilitate their adaptive capacity to the vulnerability of changing environments, mainly regulatory and market expectations, allowing them to maintain their competitiveness in the long term (Krawczyk-Dembicka, 2017). In a global context trends mark a scarcity of resources and simultaneously an increase in corporate production, the ability of an SME to operate sustainably can be a determining factor in its future success and permanence in the market (Sæterbø et al., 2024; Sæterbø & Solvang, 2024).

Therefore, the metal-mechanical sector, like any other sector of the economy, requires sustainable practices that not only benefit the environment, but also represent a significant opportunity for SMEs to improve their performance and competitiveness (Abdul Basit et al., 2024). The implementation of these practices should be seen as a strategic investment and a bet to generate economic benefits and strengthen the company's position in the market (Ozturk et al., 2024).

The current discussion regarding global production from the viewpoint of small and medium-sized strategic business units focuses on aspects such as competitiveness (Sæterbø et al., 2024; Sæterbø & Solvang, 2024); sustainability (Appiah-Kubi et al., 2024; Pett et al., 2024; Shaik et al., 2024); innovation (Maziliauske, 2024; Oliveira et al., 2022); and, technological adaptability (Abdul Basit et al., 2024; Krawczyk-Dembicka, 2017) all of these, are necessary capabilities of each strategic business units to remain in the market(Krawczyk-Dembicka, 2017).

On the other hand, the theoretical discussion suggests the existence of a causal relationship between the size of firms and the way in which the aforementioned capabilities are managed for corporate profit, hence, larger firms "may have more resources and a more complex structure, which may affect the way in which aspects such as investment in innovation and technology are managed" (Krawczyk-Dembicka, 2017, p. 359).

However, the adoption of sustainable policies in SMEs has posed a great challenge for these emerging businesses, given the characteristics of this productive

segment, “there are many factors that persuade or discourage owners or managers of small and medium enterprises to adopt sustainable policies” (Abdul Basit et al., 2024, p. 79).

It is evident then, that leading productive practices focused on the use of technology and the adoption of sustainability in small and medium enterprises can benefit stakeholders and, at the same time, reduce adverse environmental effects and, generates a culture of consumption of products focused on clean processes in terms of production (Shaik et al., 2023, 2024).

Authors such as Abdul Basit et al., (2024) suggest that the main enablers for bringing SMEs closer to sustainability-based solutions focus on data management, sensor-assisted cyber-physical systems, green consumption, supplier support, technology roadmap, and a strong willingness to accelerate digital transformation in business.

On the other hand, the economic viability of new technologies remains a critical factor in the management of technology towards sustainable processes economic viability for the implementation of new technologies, this involves a large part of this sector (Monteiro et al., 2019). Therefore, SMEs must ensure that investment in new technologies is justified with a clear return. This includes analyzing implementation costs, maintenance and possible long-term savings (Krawczyk-Dembicka, 2017).

A sustainable organization is based on the appropriation of the elements that make up sustainable development by all members of the company, which results in synergy between the company, employees, society and different stakeholders aimed at generating social, environmental and economic value (Wheele, et al., 2003) (Székely & Knirsch., 2005) (Lewis, et al., 2015) (Cardona, 2023).

Methodology

The present research is cross-sectional and field-based. According to Hernández et al.,(2014) it is cross-sectional when data are collected at a single moment, its purpose is to describe variables and analyze their incidence and interrelation at a given moment. In turn, it is field-based, since the information collected, the analysis and the procedures used are obtained in the environment under study. This research is anchored in the quantitative paradigm.

The research design used in this study was non-experimental since the phenomenon was observed without manipulating the variables as they occur in their environment, which allows them to be analyzed to arrive at the results that are the object of the research. In this research, the data is in pie charts, to facilitate the interpretation of the results.

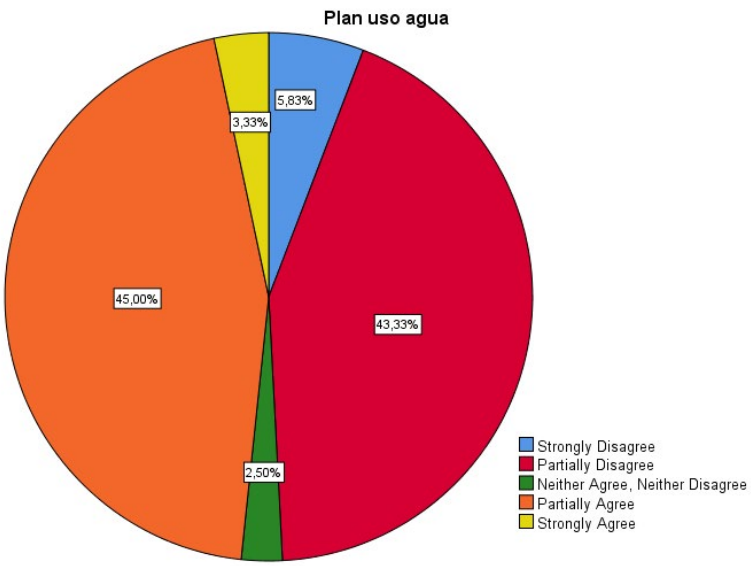
Now, according to the Cartagena Chamber of Commerce (2023), the population under study corresponds to six hundred and sixty-two (662) SMEs in the metal-mechanical sector of the CIUU classification with codes 2410, 2429, 2431, 2432, 2511, 2512, 2513, 2591, 2593, 2599, 2811, 2815, 2818, 2819, 2821, 2822, 2823, 2824, 2825, 2826, 2829, 2930, 3311 and 3312.

In this study, a non-probabilistic convenience sample of 120 SMEs was taken from the total population, due to the difficulties of access to this type of companies and the time and resource limitations of the research.

Analysis and Results

The following are the results of the survey applied to small and medium-sized companies in the metal-mechanical sector in the city of Cartagena de Cartagena, related to water use, energy consumption, recycling and gas emissions.

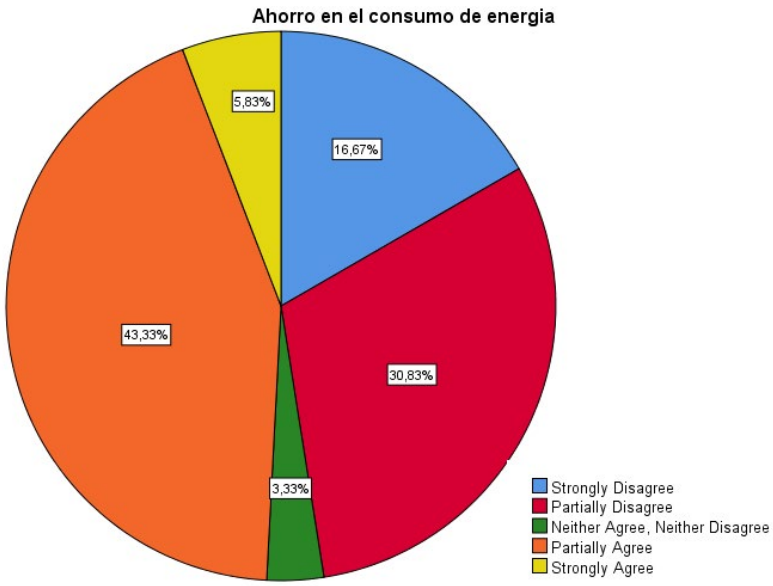
Graph 1. *Water saving plan.*



Source: Own elaboration

Graph 1 shows that the questionnaire applied to the companies showed that 45% partially agreed and expressed in a plan to save water for the development of their operations with the purpose of optimizing their resources; while 43.33% partially disagreed and 5.83% totally disagreed. This shows that there is a significant group of companies that have a certain level of awareness of water management and develop some actions to rationalize it and save costs in production. This contrasts with what UNESCO (2020) states that water depletion is one of the causes of biodiversity loss and ecosystem degradation, leading to a reduction in the resilience of ecosystems, making societies more vulnerable to climate and non-climate risks. Hence, it is necessary to generate practices that promote an efficient use of this precious resource, for its availability to society and industry, contributing to the welfare of a region.

Graph 2. *Energy consumption savings plan.*

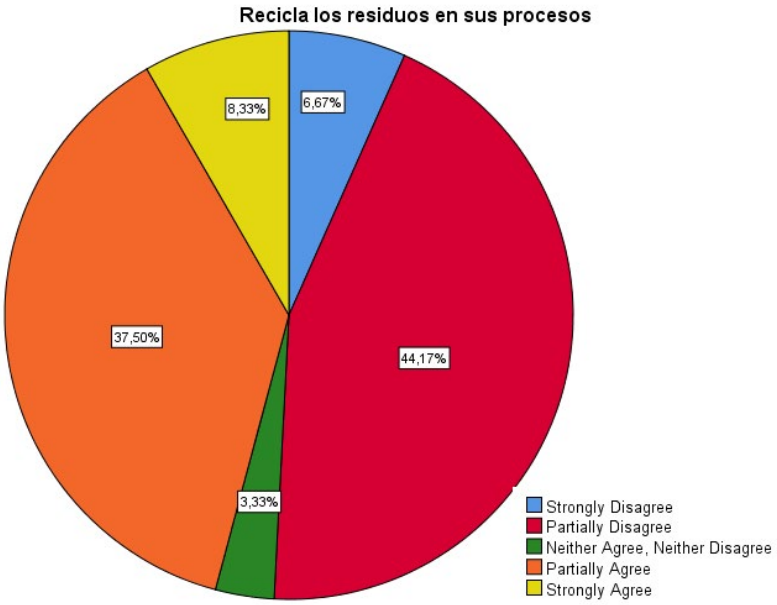


Source: Own elaboration

Graph 2 shows that 43.33% partially agree with a plan to save energy consumption. This agrees with Martínez (2021), who states that it can be easily reduced with responsible, planned consumption and the incorporation of new technology, more efficient lighting equipment and investment in renewable energies. Meanwhile, 30.83% partially disagreed and therefore do not implement it in their company and 16.67% totally disagreed. The consumption of electricity in this type of industry has a significant environmental impact because it is used in all stages of the

process of the service offered by the company (Rojas, 2023). Meanwhile, a small group of SMEs expressed total agreement (5.83%) and 3.33% neither agreed nor disagreed.

Graph 3. *Waste recycling.*

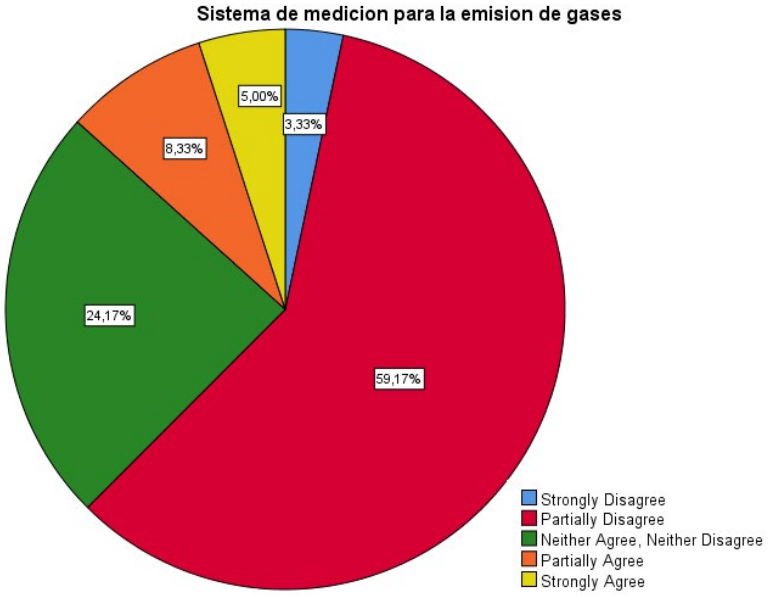


Source: Own elaboration

Graph 3 shows that 44.17% partially disagree with the recycling of waste in their production process. These results coincide with Palacios (2020), 59% of the service SMEs surveyed do not carry out recycling activities; they do not have adequate knowledge of the correct management of solid waste at the time of waste disposal. On the other hand, 37.50% and 8.33% are partially and totally in agreement with the management of recycling generated in their metal-mechanical activities. Quinteros (2021) states that it is crucial to develop an environmental culture in which SMEs in the manufacturing sector unify their strategies to efficiently manage waste, scrap and residues. This action not only favors sustainability but also promotes the continuous improvement of their operating processes.

Meanwhile, in relation to the measurement system for gas emissions, it can be seen from Graph 4 that most of the companies surveyed partially disagree with 8.33% and totally disagree with 59.17% with the implementation of such a system to evaluate the behavior of the gases generated in their operation. This result contrasts with the survey conducted at Constructora Valle Real S.A. and Construir S.A.,

Graph 4. *Gas emission measurement system.*



Source: Own elaboration

where managers indicated that they are aware of greenhouse gas (GHG) emissions. However, they do not have an information system that allows them to account for these emissions at each stage of the process (Lopez and Rodriguez, 2019).

However, 24.17% neither agreed nor disagreed with this process. But a minority group of these companies partially and totally agree with using a system that monitors the gases derived from productive activities, to take actions for their mitigation and to have a clean local environment. In this sense, Balanta and Rosero (2019) point out that the reduction of these emissions has a positive effect on the environment and direct benefits for the organizations.

Discussion

The results obtained from the surveys applied to SMEs in the metal-mechanic sector in Cartagena reveal significant findings about water use, energy consumption, recycling, and gas emissions.

Regarding water use, a representative group of companies are environmentally sensitive and develop actions to optimize their resources through savings plans in production processes. However, there is a considerable proportion of SMEs that

do not show interest in implementing measures for proper water management, indicating a lack of commitment to cost reduction and environmental sustainability. The Colombian Ministry of Environment and Sustainable Development (2018) states that "the efficient use and saving of water contributes to maintaining or increasing the availability of water and the improvement of these deteriorating and affecting conditions".

Energy consumption presents notable challenges, there is a significant proportion of SMEs that partially agree with a plan to save energy consumption; such an approach is in line with the study carried out by Carrera (2019) who conducted an investigation in 17 tourism SMEs in the Junín canton and proves that the introduction of more efficient and alternative energy technologies that replaced the conventional technologies currently used could generate savings in electricity consumption in these companies which translates into a more competitive cost structure.

Regarding waste recycling in their production processes reveals a diversity of opinions and degrees of commitment. A significant group of these companies show some resistance to the implementation of recycling practices, suggesting that, despite the growing global focus on sustainability, many have not yet fully incorporated these practices into their daily operations.

On the other hand, there is a considerable group of companies that recognize the importance of recycling and show a positive attitude towards waste management, which is an encouraging indicator that awareness of sustainability is beginning to penetrate the sector. This perspective is shared by Molina (2019) it was evidenced that a large part of the companies surveyed develop actions with the environment, in waste management, have adequate management of their final disposal, strengthening their relationship with the community.

In this same sense, Cabrera (2018) conducted a survey in the company Metal Mechanical Deanco S.R.L, found that 35% have adequate solid waste management, while 65% do not have such measures.

These results reflect the existence of SME groups that are aware of the importance of recycling in the metal-mechanic sector in Cartagena de Indias. In this environment, more targeted initiatives must be developed that promote awareness and facilitate access to the necessary resources so that all companies can move towards more sustainable operations.

The implementation of gas emission measurement systems is another aspect of analysis in this study. Most of the SMEs surveyed disagreed with the implementation of such a system, which shows a lack of awareness of the environmental impact of their operations. There is also a minority group that is in favor of using gas monitoring systems to take mitigation measures.

Rodrigo et al., (2016) in the survey applied to 40 SMEs in Cucuta and its metropolitan area stated, there is the possibility of evidencing that companies have a system for the control and treatment of atmospheric pollutant emissions, which translates into a reduction of the carbon footprint.

In sum, these results are related to the work of González (2019) who addresses the environmental practices implemented by SMEs, such as minimizing the consumption of energy, water and raw materials, recycling, among others. In that study, the author found that 41.2% strongly agreed and 39.2% agreed, 9.8% were indifferent, 7.8% disagreed and 2% strongly disagreed.

Based on these results, it is proposed to strengthen environmental sustainability practices in the metal mechanical industry in the city of Cartagena de Indias, developing a set of actions to increase its competitiveness and the generation of employment and welfare in the region.

It is essential that SMEs implement water management policies that go beyond simple savings plans. Comprehensive strategies should be developed that include water reuse, rainwater harvesting and internal wastewater treatment. Companies that are already environmentally sensitive can act as role models within the sector, sharing successful practices.

Energy consumption in SMEs must be approached responsibly, and they must be in constant search for more efficient technologies, such as the modernization of machinery, the use of automatic shutdown sensors or the installation of LED lighting in their facilities. Likewise, the diversification of energy sources, such as solar or wind power, will allow a significant reduction in costs in the medium and long term. It should be noted that partnerships with sustainable technology suppliers can facilitate the adoption of these alternatives, making their implementation more affordable.

Recycling should not be seen as a secondary option, but as an integral part of SME operations; they should adopt a circular economy approach, where waste is considered as resources that can be reincorporated into production processes. This involves recycling materials and redesigning products to facilitate their reuse at the end of their useful life.

On the other hand, SMEs should incorporate into their processes, state-of-the-art monitoring and emission control systems. This can be done by investing in the installation of real-time monitoring systems that allow them to identify and reduce their carbon emissions, which can translate into compliance with environmental standards, improving the company's visibility in the sector.

For SMEs in the metal mechanical sector to move towards greater sustainability from an environmental perspective, knowledge about these practices must be disseminated and updated. Companies should participate in educational programs that address energy efficiency, recycling, water management and emissions reduction. These programs should be designed to help SMEs understand current regulations, identify opportunities to exceed standards, and differentiate themselves in the marketplace as responsible and sustainable companies. These actions favor environmental protection and contribute to strengthening the competitiveness and operational efficiency of companies in a market that increasingly values sustainable practices.

Conclusions

The results of the research lead to the conclusion that, although some SMEs have begun to adopt sustainable environmental practices, they still face significant challenges in terms of awareness and the implementation of effective measures to reduce their environmental impact. It is precisely this lack of a culture of sustainability and the absence of monitoring systems in key areas such as energy consumption and gas emissions that prevent significant progress towards greater environmental responsibility.

It was also concluded that SMEs that have implemented water-saving and recycling measures show a better optimization of their resources, which not only reduces operating costs but also improves their competitiveness in an increasingly globalized market.

The research also highlights the urgent need for these companies to adopt more responsible practices, as the market increasingly values organizations that demonstrate a commitment to sustainability and finally, those companies that adopt sustainable practices will not only contribute to the protection of the environment but will also improve their profitability and market positioning.

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