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Green Innovation at the Industrial level: A systematic review.

Innovación verde a nivel Industrial: Una revisión sistemática

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Abstract-- The Green innovation describes to the evolution of humanity toward capacity of invention to technological and environmental change for cleaner production and sustainable development. The existing literature about this concept is recent and no systematic review of the literature on the topic. The objective of this study is to synthesize the existing literature on Green innovation and identifies concepts and applications in the industries, based on the specialized search - Scopus database. The systematic literature review was conducted, including 24 articles. Despite of the research the relationship between green innovation in companies remains unclear but in the construction sector the green innovation can be a potential sector with ability to lead the process sustainable and responsibilities to the environment since conception, construction, use and disposal the structure.

Keywords-- Green innovation; Engineering; Systematic review, Industrial

Resumen-- La innovación verde describe la evolución de la humanidad hacia la capacidad de invención para un cambio tecnológico y ambiental y para una producción más limpia y un desarrollo sostenible. La literatura existente sobre el tema es reciente y no hay una revisión sistemática de la literatura. El objetivo de este estudio es sintetizar la literatura existente sobre innovación verde e identificar conceptos y aplicaciones en las industrias, en base a la búsqueda especializada de la base de datos Scopus. Se realizó una revisión sistemática de la literatura, que incluyó 24 artículos. A pesar de las investigaciones, la relación entre la innovación verde en las empresas sigue sin estar clara, pero en el sector de la construcción, la innovación verde puede ser un sector potencial con capacidad para liderar el proceso de manera sostenible y responsable con el medio ambiente desde la concepción, construcción, uso y eliminación de la estructura.

Palabras clave-- Innovación verde; Ingeniería; revisión sistemática, industrias

I. Introduction

Environmental pollution and the limitations use of natural resources have promoted the environmental protection and sustainable use of natural resources today [1]. Economic development which for many years has been a priority issue in developed countries, has put aside the protection of the environment and therefore has been unbalanced in most emerging countries, causing conditions such as high consumption of natural resources and environmental pollution [2]. It is difficult to change this situation in the short term, since the demands of resource naturals such as wood, minerals, energy, water, etc., in the world's population and traditional industries are high [1]. Due to the constant growth of the world population together with the severe increases in human excessive consumption, the demands for resources, especially energy and food, are expanding rapidly at unsustainable rates [3]. With the increase in the potential for the consumption of global natural resources, greenhouse gas emissions (GHG) have been produced that have generated a series of problems, such as environmental damage in oceans and rivers, perforation of the ozone layer, increased climate change and global warming [4]. The construction group consume more than 40% of total global energy and is demonstrated by more the 40% of global GHG emissions that are constantly emitted [5] and nowadays this number only falls to around 32% [6]. This has raised great public concern and people are increasingly alert to the importance of concept and application of green innovation in the construction industries and in other fields where it is applicable in relation to large industries [7].

Economic growth and broad progress in world markets have allied with energy use, which has led to an excessive increase in world energy demand, creating pressure on the application of energy resources [8]. Thus, the great decrease in natural resources and the increase in global warming has led industrial companies to have a significant pressure about the companies to leaving the practices that cause them environmental problems and learn to manage those that guarantee environmental sustainability with the main objective the care of the environment of and natural resources [8]. Currently, due to this high pollution and demand for natural resources, a new concept called green innovation has been implemented. This new concept aims to supply companies with high consumption of raw materials, developing technological advances in friendly products with the environment [9]. In this context is important that to achieved these aims it is necessary to make an effort specially in the choose to green suppliers. The selection of green suppliers is based on a set of ecological criteria to evaluate and monitor the selected suppliers. The ecological criteria include environmental aspects such as the level of control of polluting emissions, the certification of environmental management, the level of elimination of dangerous, corrosive, and flammable chemical products, etc. The benefits of choose a green supplier can be economics and the competitive advantages for the company, which is importance for the growth of the company [10]. In this way, the construction area has great potential to help achieve the future "Sustainable Development" [11], understanding this as that development that allows satisfying the needs of present generations without being compromised the capabilities of future generations to meet their needs. The economic growth through innovation in the construction sector has historically failed. This is mainly due to the high pressure of money and the long-term characterizations of the projects, including the high perplexity of the construction environment [12]. Some developed countries have done their best to promote new economic growth from the perspective of technical innovation, with the aim that their efforts adjust the efficiency in the use of natural resources and the capacity for environmental protection [1]. Innovation is a concept that will probably influence in the green growth through the development of new green technologies and sustainable production [13]. The OECD 2019 Organization for Economic Cooperation and Development, defines eco-innovation as "innovation that results in a reduction of environmental impact, regardless of whether or not that effect is intended. Currently, the companies try be better in this aspects promoting sustainable practices, from production processes to their products and even the management of their waste [13]. Likewise, given the foregoing, it should be noted that this review is based on the applications covering green innovation in all kinds of industries, as well as other advances that have been developed satisfactorily in context with green innovation. In this way, the fundamental objective of this article is to identify the relevant aspects of green innovation and its applications in industrial companies using a systematic literature review of existing databases, providing us with more comprehensive information on the subject.

II. Methodology

The review of scientific literature is a methodology that constitutes a form of research that consists of using different bibliographic and Internet sources to obtain data and results on certain topics and research from other authors, with the aim of theoretically supporting a certain objective with rigor methodological [14]. The systematic review requiere a protocol, in this case was incorporated (1) initial review, that defines the problem that will be studied; (2) definition of the objective and question problem; (3) strategy to search in databases will be selected; (4) criteria of inclusion and exclusion; (5) eligibility, that eliminates those studies that do not meet the pre-established criteria; (6) data collection; (7) quality assessment method; (8) synthetize the results [15], [16].

For the selection of bibliographic sources found in the scientific literature, was searched the articles in the SCOPUS database, clear inclusion and exclusion criteria were taken into account to guarantee the reduction of bias in the selection of research, all to ensure that the leaked studies answered the question that was originally asked. All articles found in specialized consultations, mainly in English, covering all countries from 2009 to 2020, covering topics related to the fundamentals or concepts and applications of green innovation in industries were included. Regarding the exclusion of articles, those articles that had nothing to do with the proposed topic and that were not from the Scopus database were also discarded, articles that only dealt with the topic of innovation or eco-innovation.

This interval of years was chosen since the concept of green innovation is a concept that by the year 2000 already had a definition; however, it gets a bigger boom from 2009 onwards due to the issue of caring for the environment and innovating efficiently.

For the search process, we started with the question asked which was "What is the concept and application of green innovation at an industrial level?", Hence protocols were established for searching the Scopus database. To be successful in this selection, the academic area in the field of engineering was taken into account, the last 11 years and the relationship with the main keyword described "Green innovation", in this way they were proposed for greater certainty in the area of I study other words which were "development" and "application", most of them were articles and reviews published in scientific journals.

III. Results and Discussion

The specialized search in the Scopus database yielded a total of 598 articles between 2011 and 2020, a filtering process was carried out in areas of engineering and environmental studies, as well as in reviews and articles where at the end of this process, there were 81 articles that were more related to the proposed keywords, task number one was performed, which consisted in the inclusion and exclusion of the articles with more relation with green innovation, so at the end of this process there were 24 articles. It was analyzed and answered our main research question and was identified the various applications that exist of green innovation in many industrial sectors, at the same time had taken into account the authors and the references published in articles and reviews. Shows the articles found by area, note that from the exclusion and inclusion that was delimited for this research, green innovation has a greater application in the construction area, this is reflected in the use of ecological materials for the construction of green and sustainable buildings that we can see currently applied.

Presents articles found per year. Its observable that the concept of "Green innovation" is a topic that is currently being developed and with the research on this topic in the last 10 years, not many articles related to green innovation were found, but we observed that in 2019 there was a development of concept and applications increasing.

The list the 24 articles used in the literature review. With the topic and that answer our research question, possibly for the year 2020 that is in process, there will be many more articles related to this topic in which the concept and application of green innovation in industries will be deepened much more.

A. Green Innovation

For the other hands, the search results show that there is a great variety of articles related to Green Innovation in the world, but in Colombia there are very few, and they do not go directly related with green innovation and they have not been published in the index databases. In developing countries, the industrial companies, are taking up the theme of "Green Innovation", this in order to contribute to the improvement of the environment and mitigate the pollution generated by their industries to the environment annually. In the past decade, integrated cross-disciplinary concepts and technologies for cleaner, more sustainable, green production and

innovations in the Asia-Pacific region have been widely developed and implemented [3].

One of the countries that has adopted this new concept is China, which has proposed in most of its industries green buildings, which consist in the reuse of waste to create new buildings, which can be efficient and impose new trends with environmentally friendly technologies. Likewise, the creation of an ecological coal mining based on a dynamic system obtaining results that improve the quality of life of the people who live nearby and the environment and the wall panels that are contributing to the improvement of pollution with the help of a future eco-innovation for the well-being of all people. On the other hand, the articles that did not meet the inclusion criteria dealt more than anything with the technological innovations of large companies, they sought to innovate in their products and services to satisfy the needs of customers, making inappropriate use of raw materials that find in nature, this is possibly due to the high demand that large industries have and it is not convenient for them to lower the quality of their products with recyclable waste.

In the case of the 24 articles analyzed, it is identified that they associate the concept and some applications of green innovation in industries, relate the term to the high pollution that large industries are generating, looking for new alternatives to mitigate the problem and contribute to the application the circular economy. The green innovation is one of the main pillars of sustainable as defined "mean through which firms eliminates or minimizes the negative impact of their operations on the environment" [27]-[36]. It is observed that not all industrial companies seek to contribute to the cause, since eco-innovation o green innovation can bring them high costs. It is should be noted that of the 24 articles, most were conceptual; and the rest exemplified some applications of green innovation in industries such as the development of lithium-ion batteries that have increased the growing demand with the aim of establishing a low carbon economy. The innovations generate in the industry great challenges and change to face a balance between industrial development and environmental sustainability [33]. In this way, the new trends proposed by some industries in developed countries to combat and mitigate the contamination of the water, soil and air matrices, making less use of natural resources, are addressed and known.

Green innovation as sustainable development and sustainable corporate development is applied by large companies and this is generating a competitive advantage compared to small and medium-sized companies. This requires that small and medium-sized companies apply this set of strategies and concepts so that they enjoy the benefits that large companies enjoy today and thus manufacture and provide a highly environmentally friendly service [27]. Green innovation generates the development and startup of green technologies, that can include monitor, trace, control, and prevent contamination and be vigilant for any irregularities in sources, while ensuring that the entire process of production, use of products and final dispositions has a minimal environmental impact [1].

B. Green innovation applications in the Construction Industry

The use of construction materials, for example; wood, cement, fine and coarse aggregate based on the raw material that nature provides, have been produce environmental problems in the world. Consequently, it is important to develop in the area of construction new materials sustainability that have the ability to offer performance compared to appearance, structural properties and durability [37], [38], [39], [40].

The green innovation in the area of construction denominated Green construction or Green building technologies (GBTs) generate positive impacts on the natural environment, public health, consumer confidence and improves the quality of life of people. Technologies such as green wall, green roof, blocks, bricks and green floors embedded in the architectural design and construction process. GBT innovation is important in the construction sector and the same time is one of the key factors that contribute to the green skills of construction companies that fostering development and environmentally sound sustainable management in developing countries [7]. The Chinese government has embraced an ambitious mining sustainability strategy, called "Green Mining Construction" in order to look for new trends to end and at the same time mitigate the problem that mining companies cause to both public health and the environment, creating soils deterioration irrecoverable [34]. The mining industries are a sector that generate the economic development of countries, but the mining operations can cause serious social problems and rapid environmental degradation [11]. In China the coal mining, rare earths, metals, phosphates, etc., are causing serious problems of pollution, especially air pollution and forest degradation, being the main country with the most

industrial companies, therefore, the largest generator of atmospheric emissions. Pollution shows serious risks to human and animal health [20].

On the other hand, new industries are also creating an innovative mechanism in the roofs of buildings. Human ingenuity has allowed continuous improvements in the quality of houses to provide protection against the main manifestations [37]. These ceilings have a waterproofing system that does not allow the penetration of rain, wind and running water and would lead to increasing expectations of keeping heat and coldness away from inside the space. As much as possible, the warm air generated by the chimney would be kept within the enclosure increasing the desire for comfort, stimulating advances in wall and ceiling technology to compress the daytime indoor temperature range within the human comfort zone. Materials and construction methods would be tested and refined to enhance the functions of the new use. The relentless climate of the Arctic lands and the shortage of adequate building materials would go hand in hand with people to use nature's soil and grass to build houses by putting into practice these new and profitable technologies [37]. This mechanism would be of great contribution to reduce emissions of atmospheric pollutants, and this methodology has been carried out in countries such as Spain, where they have placed gigantic walls to reduce air pollution. In Colombia we can also see this technology, in cities like Medellin; With the collection of organic waste from the houses, they make an organic compost that would be the fertilizer for these gigantic walls, this would be an ingenious idea to mitigate a silent killer such as air pollution.

In the construction industry the green innovation can be a potencial sector with ability to lead the process sustainables and thus be a pioneer in sustainable development [26]. For example, green roofs have been used by humanity since ancient times, because people lacked the usual building materials, such as stone and wood, and the means to make bricks and tiles; currently some buildings and homes use them but it should be more used due to the great benefits that it generates to both human beings in their lives and the reduction of greenhouse gases to the environment [24] the importance of creating ecological buildings in order to reduce carbon emissions and the energy they consume, green innovation is applied to the design and use of suitable materials to make this industry friendlier to the environment and provide better quality of life to human beings [5].

IV. Conclusions

The introduction of green businesses has various criteria such as economic viability, social responsibility, recognition of the impacts of the company in order to reduce the facts that are related to the control of the effects generated, making it understandable and visible that the Eco-innovative industrial companies positively impact the environment and the proper management of solid waste (comprehensive management stage). The systematic review presented a variability of results on green innovations in the industry managed by the industrial discipline, relating the high pollution caused by this branch of engineering, with green technology and innovation projects for development in a context of sustainability by time to offer a good or service without harmful behavior in the environment. In this way, each of the objectives was met and through the inclusion and exclusion criteria, it was possible to assertively and concretely know and further identify the impact of green innovation in the industrial field, , providing knowledge about the current status of each article at the time of selecting them, having great support in information with this new theme that large industries are applying in order to mitigate pollution and in the case of companies reduce the consumption of raw materials.

In the review of these articles it is observe in general that the researches shows the green innovation in the construction industry. The green innovation is a concept that to giving more options of comfort and responsibilities to the environment since conception, construction, use and disposal the structure.

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