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La Educación Superior y una Producción más Limpia

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Alexis Sagastume Gutiérrez
Universidad de la Costa
asagastu1@cuc.edu.co, Barranquilla, Colombia

Juan José Cabello Eras
Universidad de la Costa
jcabello2@cuc.edu.co, Barranquilla, Colombia

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Abstract-- Universities are essential towards Sustainable Development (SD) and Cleaner Production (CP), which assess the relation between the economic and the environmental performance of companies (two of the pillars of SD) can bridge universities with companies of the production and service sector. CP stands as a rapid developing branch of science and can be used as a way to SD, while ensuring high impact researches in universities. Additionally, CP can turn into an alternative source of incomes through consulting to companies and the government.

Keywords-- Cleaner Production, Higher education, sustainable development, Education.

Resumen-- Las universidades son esenciales en el camino hacia el desarrollo sostenible y la producción más limpia. En particular, la producción más limpia, que evalúa la relación entre economía y medioambiente (dos pilares del desarrollo sostenible) de empresas del sector de producción y servicios, puede servir de puente entre las universidades y el sector de producción y servicios. La producción más limpia es una rama de rápido desarrollo de la ciencia que puede ser utilizada como un camino hacia el desarrollo sostenible, mientras investigaciones e alto impacto en las universidades. Adicionalmente, la producción más limpia puede ser una fuente de ingresos a través de consultorías a compañías del sector de producción y servicios y al gobierno.

Palabras claves-- Producción más Limpia, Educación Superior, Desarrollo Sostenible, Educación

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I. Introduction

Current consumption patterns of modern society, combined with the rapid scientific and technic development of the production and service sector (PSS) to satisfy the actual demand of goods and services, promote the high consumption of energy and raw materials obtained from nature. The extraction of natural resources increased exponentially since the industrial revolution, which combined with the increased emission wastes resulted in the actual environmental situation [1]. This development path aims for a sustained growing, thus increasing the emission of wastes and residues [2]. Furthermore, this development path has increased the gap between the reach and the poor [3, 4]. To address the interrelation of society, economy and environment with development, Sustainable Development (SD) was defined [5].

SD requires, on the one hand, policies for its realization [6]. On the other hand, necessitates higher education institutions (HEI), which are cornerstone in the education of decision makers, entrepreneurs and academics [6, 7, 8, 9]. Furthermore, the research developed in universities can result in new approaches to address the implementation of SD at local and regional levels with economic, social and environmental benefits [6, 10]. However, different barriers can be found in the relation university-industry [11, 12].

Cleaner production (CP), acknowledge as a path towards SD, have been defined as [12]: an integrated and preventive strategy, applied to processes, products and services to increase efficiency and reduces risks to humans and the environment and specifically aims at:

- Production efficiency: by optimizing the productive use of natural resources (i.e. materials, energy, water) in production cycles
- Environmental Management: by minimizing the adverse impacts of industry on the environment
- Human development: by minimizing the risks to people and communities, and supporting their development.

The implementation of CP allows to reduce the environmental impacts of an economic activity while improving its economic performance. However, the implementation of CP in the production and service sector (i.e. industry, hotels, small and medium size enterprises, etc.) is still limited [13], thus requiring promotion, advertising and capacity building [6]. HEIs are instrumental in the implementation of CP [6, 7, 8, 14, 15], which is also the case for Latin America [16, 17, 18]. This work aims at discussing the potentialities of CP to bridge the productive and service sector with HEIs, towards an increased implementation of CP linked to capacity building and high quality research.

II. Higher Education Institutions (HEI) in the promotion of CP.

HEIs are a necessary platform to promote CP, and three ways are indicated to this end:

1. Undergraduate education: Introducing CP in the curriculum of different carriers
2. Capacity building: Developing training programs (postgraduate courses) for professionals of the PSS
3. High quality research, consulting and capacity building: Open cleaner production centers (CPC) to support research and training programs as well as consulting in the production and service sector.

Introduce CP in the curriculum of different carriers directly impacts the education of stakeholders, decision-makers, entrepreneurs, professionals (i.e. engineering, economists, architects, etc.), politics, etc. Certainly, the technologies of information and communication plays an important role in this case [19, 20, 21, 22]. Within this approach, wastes, residues and emissions are considered economic losses to be addressed through CP strategies. Therefore, wastes and emissions are addressed following the waste management hierarchy [23]:

1. Eliminate or reduce the waste generation at its origin
2. Recycle and reuse (the recycling can be in site or off site)
3. End of pipe treatment
4. Controlled deposit

CP training programs for professionals of the PSS, impacts on the environmental and the economic performance of companies, promoting its competitiveness [6, 9]. Moreover, there is the possibility to find research topics of mutual interests for both the academia and companies of the PSS, during training and consulting activities. Finally, opening CPC can support the training, consulting and researching activities. CPC can support master and doctoral programs, which can provide training and support researching activities towards a wider an improved implementation of CP [6, 9].

The benefits of bridging HEI with the PSS can potentially result in mutual benefits for companies and HEIs [6, 9, 10]. In general, cleaner production centers (CPC) can consult for both: companies (to implement CP strategies, etc.) and for the government (to develop sound environmental policies and to promote CP). Furthermore, consulting can account for a source of founding to economically support the CPC activities.

Given the different socio-economic development stages, different industry infrastructures, socio-economic profiles, cultures and challenges existing in every country, no universal approach exists to introduce CP [24]. To this end, the program developed a project to create CPCs in different countries, while some HEIs used different approaches to promote and implement CP:

- HEIs pioneered the creation and development of the national pollution prevention network in the United States. Likewise, in some European countries HEIs aided in the implementation of CP strategies in industry, especially in SMSE [25, 26].
- The International Institute for Industrial Environmental Economics (Lund University, Sweden) in collaboration with UNEP organized and held the program "Educate-the-Educator" [27], to train 32 professors from Africa, the Middle East, Asia–Pacific, Central and Eastern Europe and Latin America–Caribbean, on how to introduce the CP and preventive environmental strategies approaches into undergraduate and graduate educational programs. The results from this program increased the implementation of CP and preventive environmental strategies on the educational and research activities of different HEIs.
- A collaboration project between Graz University of Technology Austria) and the Faculty of Chemistry and Chemical Engineering (University of Maribor, Slovenia) created a CPC. This project resulted in the transfer of CP expertise from Graz University to the University of Maribor and later on to the industrial sector in Slovenia. The CPC eventually turned into a spin-off company consulting on CP with a more business oriented approach [28].
- A similar approach was use in the Brock University (Canada), where a workshop on CP was held to provide professional of wine production with the required tools to develop CP assessments at their wineries [29].
- Based on the economic success of the knowledge-based economies and their increased need for human resources training to support local economies, a program to infuse the CP approach in the design of higher education academic programs was developed [30]. Results show a methodology to design academic programs infused with the CP approach under different constrains.
- The CPC in the University of Cienfuegos is an example of how to promote and implement CP strategies at a local scale, supported by international cooperation and bridging a HEI and the PSS on CP. The creation of the Cleaner Production Center (CPC) (which followed the UNIDO-UNEP methodology outlined by the CPC program UNIDO-UNEP [24])) was funded in the framework of a VLIR (Vlaamse Interuniversitaire Raad, Belgium) project (("A Center for Cleaner Production to contribute to the socio-environmental development of the province of Cienfuegos, Cuba"), in collaboration with the Free University of Brussels (VUB) and the University of Leuven (KU/Leuven). This initial project aimed at strengthening the capacity building and awareness raising activities at UCf and to develop research activities based on two pillars: academic (strengthening the capacity building on CP and implementing a Master program in CP for professionals of the PSS) and development (development: to improve the efficiency and the environmental performance of companies by means of CP) [6, 9]. The development of the CPC was foresee in different stages, always supported through VLIR projects [23]:
  1. Establishment (Project: A Center for Cleaner Production to contribute to the socio-environmental development of the province of Cienfuegos, Cuba (2008-2012))
  2. Strengthening: (Cleaner production in the city of Cienfuegos, Cuba (2013-2015))
  3. Consolidation: (Cleaner production network in Cuban HEIs and doctoral program in CP at UCf (2016-2019))

  So far the center contributed to reduce the consumption of raw materials and the emission of pollutants in some of the most environmentally impacting companies of the city [10, 23, 31, 32, 33, 34, 35, 36, 37, 38], also assessing the quality of life that is affected by both the environmental and the economic performance of companies [23] [39]. The success of this strategy lies upon the master program, where professionals of the PSS develop CP strategies to complete their thesis. These strategies are implemented by the master students from within the companies, supported by the promoters and other professors from the center, rather than been implemented by outsiders from the companies. This facilitates the implementation of the strategies and reduces the barriers usually faced to introduce CP in the PSS.
- The Department of State of the U.S. funded the project "Pathways to Cleaner Production in the Americas" implemented between 2012 and 2015 in collaboration with 9 universities from the U.S. and from Latin America and the Caribbean [40, 41]. This project aimed at capacity building by introducing CP in the undergraduate education and capacity building for postgraduate professionals, and also to the implementation of CP in SMSEs. Results show benefits for universities, industry and SMSE through an experiential learning. In general, capacity building brought students and potential employers closer, while companies improved their operations and CP was institutionalized to train students in the concepts of CP and sustainable development. Additionally, universities became more engaged in addressing local sustainability challenges.

III. Discussion

There are different approaches to introduce CP using HEIs, namely:

1. Undergraduate academic programs: to introduce CP on the curricula of undergraduate programs [27, 30].
2. Postgraduate academic programs: to train, on the approach of CP, either university professors or the staff from companies of the PSS [27, 29].
3. Bridge HEIs and industry on CP: HEIs to introduce and develop CP networks to implement CP strategies in industry and in SMSEs [25, 26].
4. Use CPCs to promote and implement CP on the PSS [6, 9, 28].

The first two approaches aims at introducing CP on the formation of stakeholders, decision-makers, politics and entrepreneurs among others. This is essential to advertise, not only the environmental consequences of pollution, but also its social and economic implications. However, HEIs entails other activities like researching which are not foreseen on these approaches. Moreover, the bridging HEIs and industry on CP can aid the networking between different universities and support researching activities towards sustainable developmental solutions. Furthermore, this approach can promote training activities for the staff of industry. Although is not clear if the training of undergraduate students on CP can be promoted within this approach. Finally, using CPCs to promote and implement CP can include all of the other approaches as shown in [6, 9]. However, this is not always the case as can be seen in [28].

In general, a CPC is an opportunity to promote CP from:

- Within HEIs in undergraduate and postgraduate academic programs.
- Outside HEIs through join research between academics and staff from companies of the PSS.

Additionally is an opportunity to networking, at national and international levels, with HEIs, research centers and environmental pollution agencies, among others to further promote CP and SD.

V. Conclusions

CP, acknowledge as a way towards sustainable development, stands as an opportunity for universities to positively impact the environmental and the economic performance of companies from the PSS. HEIs are cornerstone to successfully introduce the CP approach in the management of companies from the PSS. The most complete approach to introduce CP through HEIs is the creation and development of cleaner production centers, which can alternatively become in a source of funding (in the mid to long term) by consulting companies. This approach permits to integrate all the activities that HEIs must to engage (i.e. capacity building at undergraduate and postgraduate levels, high quality research, networking and international cooperation). Furthermore, a CPC can eventually became in a consulter for the government towards the development of more comprehensive and sound environmental policies. In face of the lack of resources, international cooperation can contribute in the creation and development of CPCs within HEIs by providing the founding and the expertise on CP.

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