IS INDUSTRIAL ECOLOGY A PROPER WAY TO INTRODUCE SUSTAINABILITY INTO TECHNICAL UNIVERSITIES?

E.Gay*, M.R. González-Siso, J.Quintana***, G.Vega******

Universitat Politècnica de Catalunya

C. Jordi Girona, 31
08034 - Barcelona, Spain
Phone: +34 93 405 43 75
Pàgina web: http://www.upc.edu/sostenible2015

eleonorag@gmail.com* , mrsiso77@gmail.com** , jqs77@hotmail.com***, guidovem@gmail.com****

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ABSTRACT

Industrial Ecology (IE) started as an emerging field in the seventies of the twentieth century in countries such as Japan and USA. Following this example, other countries have developed initiatives and methodologies in order to introduce Industrial Ecology principles in their academic backgrounds. In this manner, concepts of IE have been spreading continuously worldwide.

Thus, a comparison is made among academic backgrounds of IE which are taught in technical universities of Europe and Latin America, by comparing technological universities of Sweden (Royal Institute of Technology), Italy (Politecnico di Torino), Spain (UPC of Catalonia) and Peru (Universidad Nacional Agraria La Molina and Universidad Nacional Del Santa). These universities are chosen because they are located in countries that represent different levels of implementation of IE policies, from the official educational backgrounds of north Europe to first attempts of Latin America.

Our study is based on the quantification and qualification of diverse parameters. Such parameters include the existence of educational programmes, specialized departments and their projects, events and publications. Finally, an investigation of the existence of congress, conferences and public workshops is researched.

This article aims to determine academic differences between Europe and Latin America to reveal a scale of implementation of actual methodologies. Moreover, we propose the means to improve a comparative methodology of study and the possibilities to develop a multidisciplinary and multicultural scientific discipline, which is Industrial Ecology, as a way to introduce sustainability concepts into programmes of technological universities.

INTRODUCTION

This article was originated in order to answer our personal concern about different approaches of the same topic, which is the relationship between Industrial Ecology and Sustainability. We were curious of the diversity of manners of implementation, due to the social and historical differences, that were executed in the countries chosen on our study. We want to propose a way to learn why and how the different universities accomplish this objective. Furthermore, this question can be solved, but it can be a starting point to new concerns and from where you can look to IE with new perspective.

To tell if the IE is a good way to introduce sustainability in technical universities, it is necessary to know some characteristics that make a university is sustainable or not. Furthermore, some studies mention that the basic characteristics of a sustainable university is to have a strong emphasis on effective implementation of inter and transdisciplinary research and science, in which students should be able to cope with the complexities of the real problems and uncertainties associated with the future.[11].

There is an increasing awareness of the key role played by environmental and sustainability issues in the development of today's world. Nevertheless, this growing awareness must be accompanied by tools that are useful for those responsible for the future development of our society. One of the main ways in which industry can contribute towards sustainable development is through industrial ecology (IE). However, teaching these new topics is crucial to their dissemination in society, requires development of methodologies that facilitate understanding of this concept and, at the same time, render it attractive to students and to industrial leaders. [10].

Some barriers to sustainability, as identified by various authors, are freedom of individual faculty members, the incentive structure, lack of desire for change and the pressures of society [11]. This makes it difficult for a leader to propose substantial changes, as due to the plurality of teachers and researchers, it is difficult to reach consensus. It appears that the standardization of the European educational space is shown as an alternative to implementing sustainability items and IE, but in Latin American universities each university operates even scattered.

Didac Ferrer-Balas et al. in the paper "An international compartive analysis of sustainability transformation across seven universities" [11], argue that, for example, quality education requires a great deal of time and investment, and even this may be equally difficult to be a major transformation, which is exactly what you are looking for sustainability and industrial ecology. Additionally, if there is no social pressure to require certain features to the graduates, a university will have little reason to make substantial changes. To all this should be added to the budgets of each institution, since from the standpoint of management, is an important point for decision making.

Due to the complexity of sustainability in universities, a recent study conducted an evaluation method with the FLA (*framework, level and actors*), whose results show that there is no common pattern among universities evaluated. Each case has its own particularities, for example, is not predominant common axis of all of them. Another useful tool to measure the relationship between IE and sustainability could be the

network analysis, in which various departments of a university or universities have common goals [7].

We choose to perform our study among universities of UNALM and Universidad Nacional del Santa (Peru), UniOvi and UPC (Spain), Polito (Italy) and KTH (Sweden). Our decision is based in the fact that we have made our previous studies on these universities, so that we know the social and academic environment that surrounds them. The knowledege of the language that is mainly used by the university community has enabled us to perform a more detailed search. However, in the case of KTH, we performed a search for information only in English because we have no knowledge of Swedish. We have chosen this case because it represents the example of one of the most advanced universities in the fields of Industrial Ecology and Sustainability.

In the first attempts of the study, we found a vast heterogeneity of data, which resulted on difficulty of constructing a valid methodology for the various universities, as they were not showing the same categories of data, so the study must be adapted to each case.

KTH is the only case with structure-dependent planning. In this way, we found a Swedish department with the name of Industrial Ecology, with several lines of investigation open and an active academic community. By contrast, the other universities do not have a structure as planned as in the first case and, a result, the search becomes more complex. In the second group of cases, there is neither classification of data or projects groups by years, nor existence of specific areas of research. Finally, clear synergy and references between previous studies and new ones can not be proved.

OBJECTIVES

In the process of planet Earth formation, appearance of the molecules resulting in life was spontaneous, unplanned and isolated: blooming [13]. Later, when their numbers grew, relations were established, both physical and chemical association processes, due to proximity and content. In this way, we use this metaphor for understanding the stages of development of sustainability studies at technical universities and to develop a valid and useful classification, due to the emergence properties of the system. In conclusion, we want to test null hypothesis of industrial ecology as a proper way to introduce sustainability against alternative hypothesis, which defends it is not.

Our study is based on the quantification and qualification of diverse parameters. Such parameters include the existence of educational programmes, specialized departments and their projects, events and publications. Finally, we investigate the existence of congress, conferences and public workshops.

Results are shown in this paper belong to:

- General information research on web pages of the universities.
- Educational programmes of the universities and structure:
    - Studies before and after the main degree.
    - Existence of departments and research lines.
    - Publications
    - Existence of conferences and events.
    - Agreements between universities and sustainability centres.
    - Activities with social impact

METHODOLOGY

Methods used in this article are based in research strategies combined with comparison methodologies. We propose using the same methodology for technical universities that are the objective of this study, setting successive levels of accuracy of our research:

a) Search on the web of non-scientific information: public information.
b) Scientific databases: information about scientific activity.
c) Detailed investigation of the academic background given in Universities.
d) Aggregates of indicators of scientific activity, levels and complexity of the topics and courses taught on the faculties.

In order to accomplish the proposed research, we take into account that a system of equivalence has to being developed, because these Universities belong to different societies, historical and economical backgrounds and realities. As a consequence, equivalent levels of examination based on an objective methodology have to been used.

During our search, we had to discard two of the cases proposed in the beginning, UniOvi and Universidad Nacional del Santa. There are lack of information of the object of our investigation because both of them have not developed programs that take into account criteria of Sustainability and Industrial Ecology. We can deduce that academic education is not widespread in this area and therefore has not reached the first attempts at implantation in these places.

First step of the study proposed among the universities that give Sustainability and Industrial Ecology formation is the comparative among presence of courses at the universities of the study. This approach was not appropriated due to the ample quantity or courses, as well as the Spanish system is changing to join Bologne Process, which results in invalid approach.

We have chosen as the main source of information the websites of the faculties of study. Their websites content recognized data by the entire University. In some cases, we had to give up data that is not suited to this type, since the sources are not as reliable as in the first case.

To start with the research, we look for keywords in public internet browsers. To accomplish this task, we decide to use different languages, which are English, Spanish and Italian, because of the lack of unification of data on the websites of the universities that leads to an important part of the data that was missing. As a result of this approach we gather enough data to make a relevant study of the actual state of these universities.
In this way, words used in our study are the ones that correspond to the subjects that we study: Sustainability and Industrial Ecology. We decided to add two more concepts, "Sustainable development" and "Ecology", to ensure that no data is lost during the search and because the two disciplines are related to the object of our study. Moreover, some publications have these secondary words in its title, but when it delves into its contents, it is shown that includes multidisciplinary themes that correspond with our study.

As a second step of the study, we propose the comparison among second cycle studies, such as PhD or Master´s. We choose the second cycle of superior studies because is where sustainability or industrial ecology knowledge is taught or put into practice. Furthermore, both disciplines are dynamic examples of application of university spirit in solving real problems issues, giving tools to society in order to solve them.

RESULTS & DISCUSSION

The task of this paper is research in activities related to Industrial Ecology and Sustainability in different areas, programmes of study, thesis and research projects, departments, publications or events in the universities.

Number and repercussion of activities varies from one university to another, which can be used to test our hypothesis.

The case of KTH represents a broad implementation of Industrial Ecology policies, especially in the areas of research, publications and events, which can not be quantified due to the large amount of information.

The following step of the evaluation of universities was conducted on the basis of information from each university on graduate programs, such as master and doctorate. Data shows that KTH teaches ten programmes, UPC-Spain teaches six programmes, Polito teaches two and UNAML, four programmes. It is noteworthy that only the KTH and UPC have degrees in IE, which are five and one, respectively. In the case of Polito and UNALM, programmes are only those related to Sustainability.

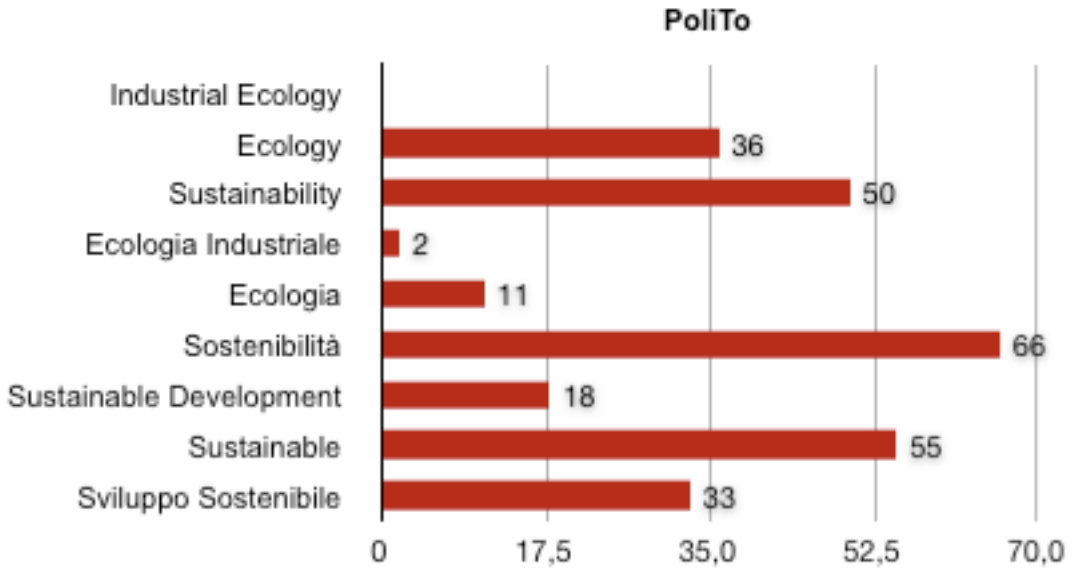

Fig.1 Number of publications related to sustainability and industrial ecology (IE) found at the Politecnico di Torino (POLITO).

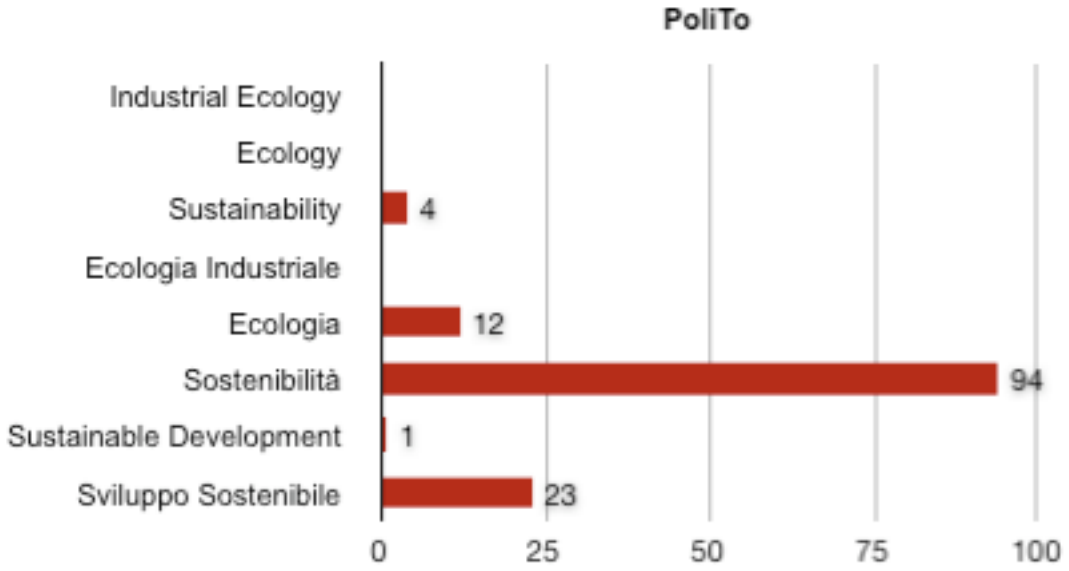

Fig.2 Number of thesis related to sustainability and industrial ecology found at the Politecnico di Torino.

In Figures 1 and 2 shows that the documents found on POLITO were greater sustainability issues in IE. For example, we found more than 240 publications and 122 theses related to sustainability issues, instead, on issues related to ecology and industrial ecology are only 49 publications and 12 theses, the latter all about ecology.

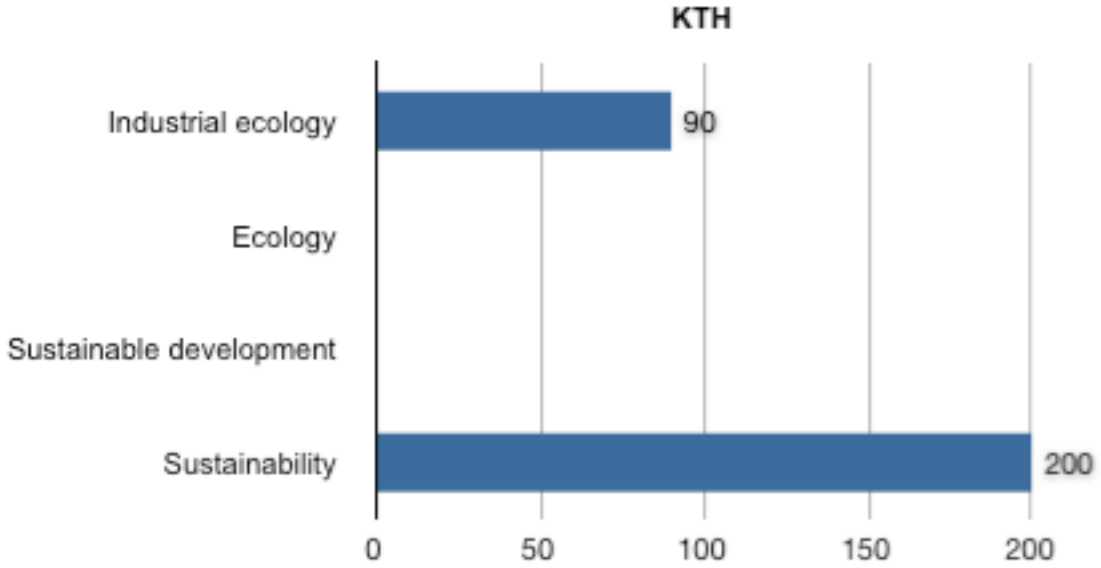

Fig.3 Number of publications related to sustainability and industrial ecology found at the Royal Institute of Technology (KTH).

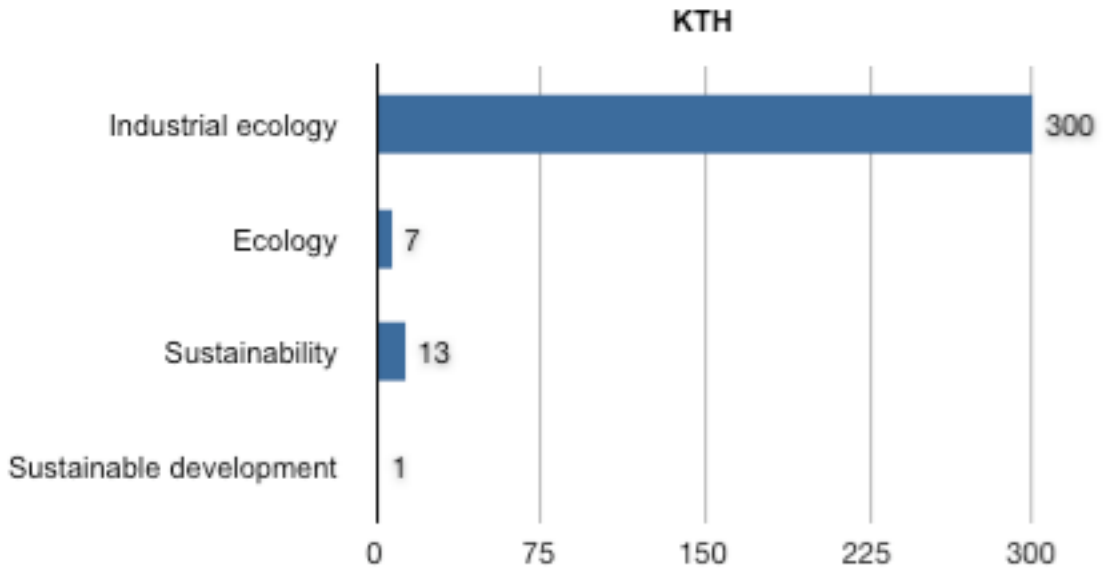

Fig.4 Number of thesis related to sustainability and industrial ecology found at the Royal Institute of Technology (KTH).

KTH publications are found in approximately 200 documents relating to sustainability and 90 on IE. However, that publications in IE are lower than those of sustainability, the thesis found in the field of IE is much greater than those related to sustainability issues. Thus, there is an average of 300 on IE and some 14 papers on sustainability. These can be seen in Figures 3 and 4.

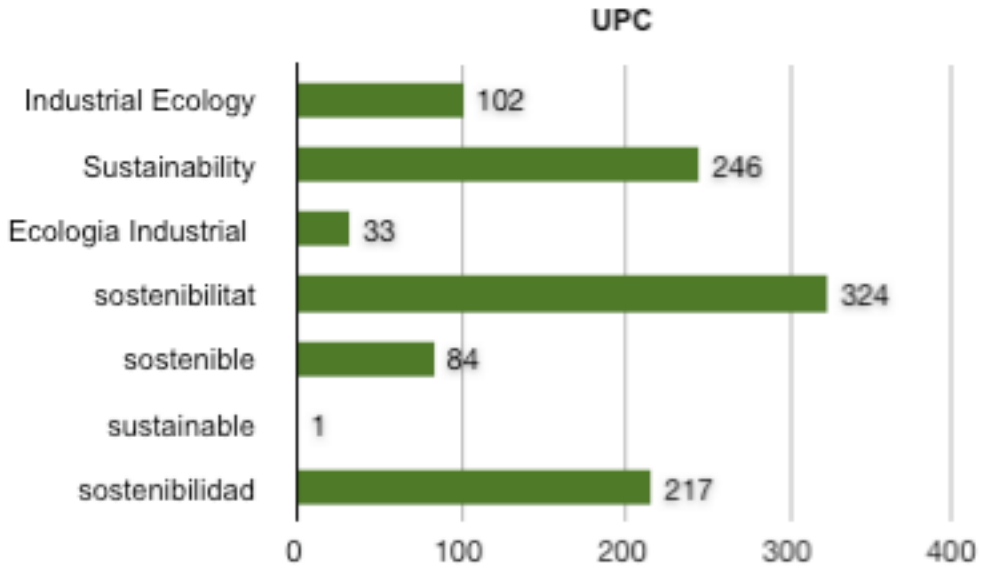

Fig.5 Number of publications to related found sustainability and industrial ecology at the Universitat Politecnica de Catalunya (UPC).

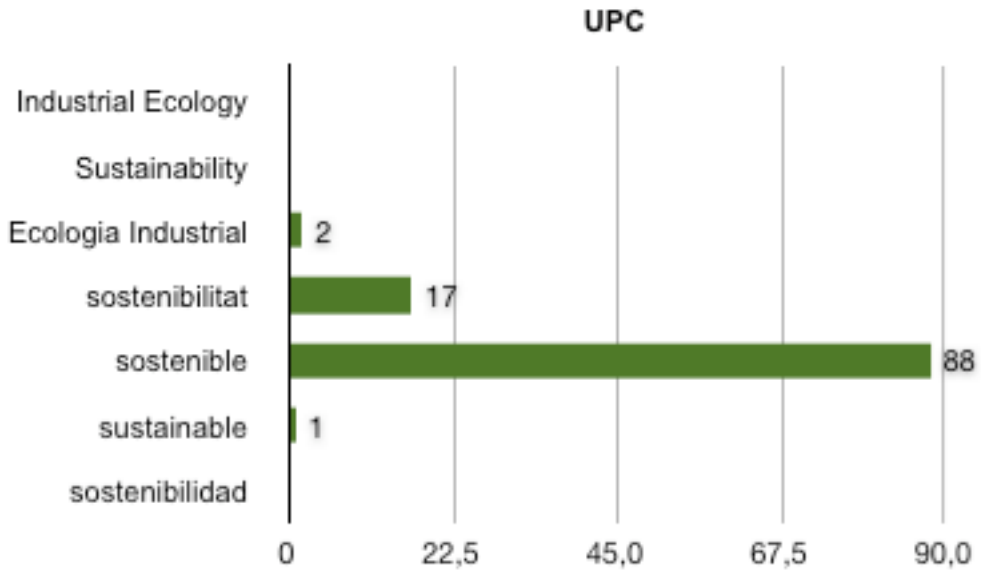

Fig.6 Number of thesis to related found sustainability and industrial ecology at the Universitat Politecnica de Catalunya (UPC).

The case of the UPC (Figures 5 and 6) presents a particularity, since according to data analyzed were found in recent years have been published over 800 papers related to themes of sustainability and nearly 135 papers on ecology and IE. Similarly with regard to theses issues sustainability are about a hundred works, while in terms of theses on topics IE only found two documents.

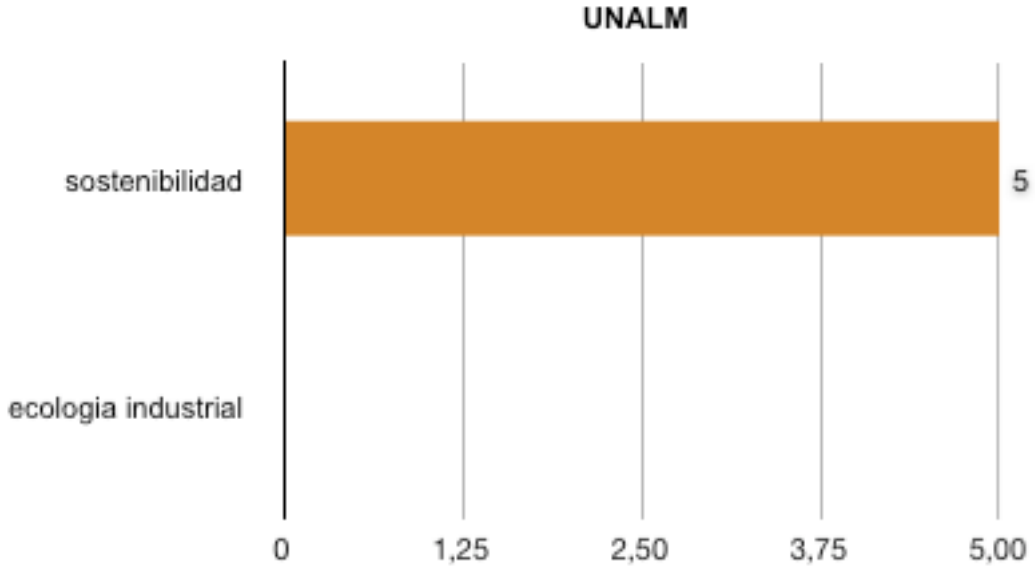

Fig.7 Number of publications to related found sustainability and industrial ecology at the Universidad Nacional Agraria La Molina (UNALM).

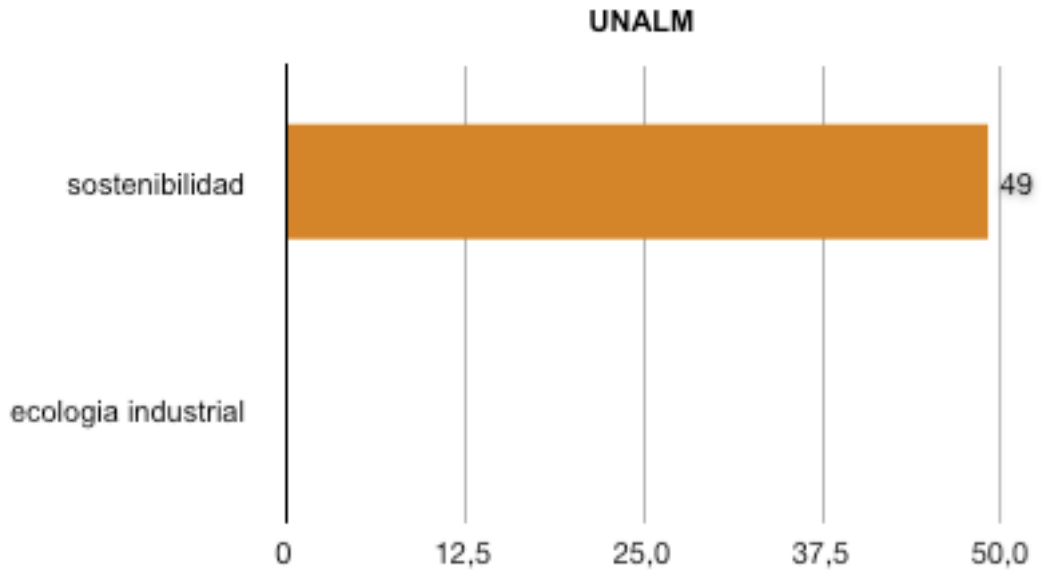

Fig.8 Number of thesis to related found sustainability and industrial ecology at the Universidad Nacional Agraria La Molina (UNALM).

In figures 7 and 8, details the data found in UNALM. This university is found 5 publications and 49 theses, all related to sustainability issues. Not found data files to the IE.

In general, what is seen is that there is no uniformity or pattern on the data found on publications and research (thesis) at each university. For example, KTH has a lot of research and publications in both subjects, however, at the UNALM, the data found only to sustainability. Respect to the UPC and POLITO, these universities would be an average, although it should be noted that in the case of UPC, the number of publications on issues of sustainability, not necessarily scientists, is high compared to other universities.
Data found on the organization of events, such as conferences or seminars were few. For example, the website of the UPC contained only 3 activities, 2 in the UNALM and none in Italy. By contrast, on KTH there are many events in different areas and departments.

It is important to note that all universities have between 2 and 4 departments related to Sustainability. KTH is the only case that has an IE independent department.

In summary, we can demonstrate that UPC university is notable for the large number of periodicals on topics of sustainability, as well as research papers and theses. There are some publications on the issue of IE, but theses are still few in this field.

In the case of Polito, we found several publications on issues of sustainability. Thesis and research are lower than those of the UPC-Spain. In contrast, the issue of IE has a higher number of publications and research papers.

KTH in Sweden, the amount of research on Sustainability and IE is very high compared to other universities. It also highlights the large number of events on both subjects, unlike other universities where it was found only an average of 3 events.

In UNALM university is increasing the number of thesis related to sustainability and the number of events. Regarding the issues of IE, there were no records in any of the fields

analyzed. However, research and publications are lower than the European universities.

CONCLUSIONS

We have developed a methodology that has helped us to approach to Universities that are studied in this article. However, differences between them have hindered this comparative study. Due to differences in approach according to each University, used names were different, so the comparison process was more complicated. As a result, we developed a system which valued the existence of training and publications. In the first case, we included second-degree and graduate programs, while the second, the variety of publications that take place in the University. We believe that the methodology developed in large part reflects the reality of University of study and has served as a reliable measure of their progress in the field of Industrial Ecology and Sustainability.

Speaking about the results, we can demonstrate there is a correlation of the nivel of implementation between Industrial Ecology and Sustainability in these technical universities. We can propose a scale of implementation of these new perspectives in universities by setting two extreme cases, KTH and UNALM. First one can be described as an example of planification with systemic perspective. In this way, has created a complex structure that allows interconnection between areas of knowledge, learning systems and projects. Moreover, in the second case this process is starting, so the structure is not developed at this time and there is a lack of this complex structure.

Cases of UPC and Polito represent intermediate states in which this structure is developed, which is different in each case due to methodological differences in the two universities.

In conclusion, this study may serve different groups of professionals, such as those responsible for internal affairs or researchers. It may help them as a reflection on the current state of the Universities and the need for educational programs more complex on research and education. It can also serve as an example and inspiration to those Universities that are beginning their journey on the path to Sustainability. Finally, those who already have a progress in this way, can look at the specific points that can be improved to create a complex and synergistically network of Sustainability and Industrial Ecology processes.

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