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SCIENTIFIC PUBLICATIONS IN SOCIETY: CORRELATION OF INDUSTRIAL ECOLOGY AND INDUSTRIAL CLUSTERS

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Abstract

Industrial clusters play an important role in the development of cities and regions. Industrial Ecology is an emerging research area in science for sustainable regional development and in solutions of development of production and society. This study aimed to verify the central scientific publication of Industrial Ecology and Industrial Clusters in academic society provided on web bases Capes and Scielo, aiming to identify the evolution of these themes and the relationship between them. Therefore identifies the evolution of the theme in the social and scientific spheres. To achieve the goal it was held a methodological procedure of literature review based on bibliometrics. For the application of the study we used steps of the instrument ProKnow-C. The keywords were surveyed in English and Portuguese, between the years 2000 to 2011. The results obtained through the methodological procedures indicated that the field of Industrial Ecology and its relationship with Industrial Clusters is still fruitful of studies. However, there was a descent of studies correlating themes. Given the initial checks, it is clear that publications and researchers are interest to deepen their research questions in this area. This study also identified new keywords and research opportunities to be enhanced, enabling the continuation of studies aimed at social, sustainable and regional development.

Keywords: Industrial Ecology, Industrial Clusters, Society.

1. INTRODUCTION

Regional concentrations of businesses and institutions connected by a particular locale feature fundamental advantages in a global economy, which are progressively linked to regional aspects of relationships, knowledge and motivation (Porter, 1998). Regional aspects are increasingly seen as important factors in the starting point of the development.

The concepts of production commonly give relevance to the main social training, improves productivity, innovation, ease of access to suppliers and skilled labor, among other aspects that enable increased competitiveness due to access of information. However, it's not often quote the relevance to the environmental impact of activities (Porter, 1998; Casagrande, 2004).

Aspects of Industrial Ecology are commonly used in industrial parks, as a means to optimize resources and minimize costs. The kind of symbiotic relationships based on

Industrial Ecology is defined as "industrial ecosystems", aiming to optimize the consumption of energy and materials. The effluent/waste of a process serve as raw material for other (Casagrande, 2004).

Seeking to identify environmental aspects in Industrial Clusters and aiming integration through proposals of Industrial Ecology, this research seeks to clarify the following questions: what is the correlation between Industrial Ecology and Industrial Clusters in scientific publication and in society?

Macedo (2010) argues that, when using the bibliometric review of literature, the completion of academic work points to new research or directs them more accurately, helping the researcher in decreasing the margin of errors in decision making of technical approach.

The technical question is not impartial and consists of issues of cultural, social and political order (Fonseca *et al.*, 2012).

In addition, the uncertainties of the transition of social order require intellectual knowledge capable of mapping the paths of society towards the future, guiding moral visions and political achievement (Burawoy, 2009).

The bibliometric review occurs by the "need for the study and evaluation of the activities of production and scientific communication" (Aguilar, 2006) on intellectual expression of technical knowledge in culture and in society.

Regardless of the method used, a set of variables that are part of the process of scientific activities must be considered, allowing your measurement so that the investigations carried out reach positive results (Nanda *et al.*, 2008).

The choice of an analysis based on bibliometrics is justified by the importance of raising the existing scientific production, by the importance of the issue in society as well as identifying topics in which there is significant production and performing a critical review to identify potential lines for development of research (Pizzani *et al.*, 2008).

Through the resulting material of bibliometric review, the goal is to continue in future research and narrow the material of scientific knowledge within the objective proposed.

2. METHODOLOGICAL PROCEDURES

As for the methodology for the development of research, the bibliometric review was chosen because it is a method designed to answer a specific question allowing "collect, select and analyze critically the studies". A survey from bibliometrics has as sources articles available in a database from original studies (Macedo *et al.* 2010).

To form the bibliographical portfolio, this research uses ProKnow-C instrument phases (Knowledge Development Process-Constructivist), proposed by Ensslin *et al.* (2010). The ProKnow-C is divided into two phases of application: selection of raw articles database and filtering of database articles.

Developing the research steps based on ProKnow-C methodology, the first three perform selection of the raw articles database, making the data definition, keywords definition and the search for articles in the bases with the keywords. In the following steps is the second stage, making the articles database filtering, eliminating repeated texts, refining the material by reading the title, aligning by scientific recognition and then by the full reading of the articles.

Noronha *et al.* (2008) point out that the main indicators taken from the bibliometric study can be presented in several ways.

This research has the main objective to present the evolution of the literature and approach of the topic in society. In the following topic, describes its implementation.

3. DEVELOPMENT OF RESEARCH AND DATA ANALYSIS

As development strategy, established a series of steps for performing bibliometric review. The three initial steps are based on ProKnow-C instrument, in order to form the bibliographic portfolio. The following steps are directed in filter, define and analyze the relevance of the proposed theme, in addition to checking the incidence in publications and identify new keywords.

Step 1: database - we opted for Journals Portal of Personnel Improvement Coordination of Higher Education (Capes – Portal de Periódicos da Coordenção de Aperfeiçoamento de Pessoal de Nível Superior), for being a virtual library that collects and provides the production of international scientific society for teaching and research institutions in Brazil. It also allows specific search in various fields.

The Capes Journal Portal provides access to selected texts in more than 30 thousands international periodicals publications in all areas of knowledge. In addition, 130 reference bases, ten bases dedicated exclusively to patents, in addition to books, encyclopedias and reference works, technical standards, statistics and audiovisual content. Also includes a selection of sources of scientific and technological information of free web access. Searches can be made by Subject, Periodic or Base; in the case of this research is the search delimited to the field Subject (Periódicos Capes, 2012).

The searching by subject is done through the insertion of a term, and makes simultaneously the query into multiple collections of the Portal, being held in a set of predetermined bases with coverage in the knowledge area selected by the user. Can be simplified or advanced.

To allow combinations of keywords, this research used as criterion the Advanced Search, which allows you to "insert an extra term to the search, the choice of the field of research and their combination using boolean operators" (Periódicos Capes, 2012).

Step 2: checking for keywords – the second time, some keywords was tested in order to check the existing con-

tent (in a total of 14 different searches), in addition to establishing a period of publications between the year of 2000 to 2011, with tested selections in three fields: by title, subject, or all fields; and in two knowledge bases - multidisciplinary or in engineering.

The research in the multidisciplinary scope is made in a set of ten pre -determined basis for the portal: Academic Search Premier - ASP (EBSCO), Cambridge Journals Online, Highwire Press, Nature (NPG), Oxford Journals (Oxford University Press), SciELO.ORG, Science (AAAS), ScienceDirect (Elsevier), SpringerLink (MetaPress) e Wiley Online Library.

When performed in the area of knowledge of engineering, the search occurs in 11 pre-determined bases: ACM Digital Library, ACS Journals Search, Emerald Fulltext (Emerald), IEEE Xplore, IOPscience (Institute of Physics--IOP), Nature (NPG), Royal Society of Chemistry, Science (AAAS), ScienceDirect (Elsevier), SpringerLink (MetaPress) and Wiley Online Library.

After testing the words highlighted in table 1, was observed, through a reading of titles, that the results, even when recurring in engineering, contained a range of various subjects involving the keywords, making the bottleneck of the purpose of the research.

An example is the search five. Even with the quoted terms, brought most of the results below the preset period of time. By have been scanned, few results above the year 2000 submitted relevant titles.

To get the keywords submitted, it appears that the scan is made on a "multidisciplinary" basis shows no results aligned to the objective of this research, delimiting the theme approach.

Also noted that the search keywords in Portuguese, the only search that showed results was ten, however for being a search performed with compound words and the search criteria be in "all fields" and "results" presented multidisciplinary feature a range of coverage that does not select relevant titles related to the research topic.

Table 1. Checking keywords

SEARCHS	KEYWORDS		FIELDS			KNOWLEDGE AREA		TOTAL
			SUBJECT	TITLE	ALL FIELDS	MULTI-DISCI-PLINARY	ENGENEERING	
1	Cluster	Industrial Ecology		X		X		1
2	Cluster	Industrial Ecology	X			X		219
3	Business Network	Industrial Ecology		X		X		0
4	Business Network	Industrial Ecology	X			X		102
5	"Business Network"	"Industrial Ecology"	X			X		61
6	Business Network	Industrial Ecology	X				X	108
7	Cluster	Industrial Symbiosis			X		X	2529
8	Cluster	Industrial Symbiosis		X			X	1
9	Cluster	Industrial Symbiosis	X				X	63
10	Redes de Empresas	Ecologia Industrial			X	X		179
11	Redes de Empresas	Ecologia Industrial	X			X		0
12	Redes de Empresas	Ecologia Industrial	X				X	0
13	APL	Simbiose Industrial	X				X	0
14	Simbiose	Industrial		X			X	0

Source: Own elaboration

Have the search carried out in the area "Engineering" brought best titles related to the topic of research. Among the seven searches conducted in this area, it was found that, when it made the cut for titles, six search and search nine were those that showed better relevance in results.

108 results search six articles, for examining titles, it was possible to select four texts, and search nine out of a total of 63 articles, seven were chosen.

Due to the results of publications in Portuguese have been almost nil and considering the importance of publications on the subject at the national level, it is the next stage of research.

Step 3: checking exclusively in the Scielo - the Scielo interface provides access to its serials collection via an alphabetic list of titles, subjects, or by a search module of the serial titles - by subject, names of publishers institutions and publish location. The interface also provides access to full text of articles via author index and subjects, or by a search form of articles that search its elements, such as author, words in the title, subject, words from the text, and year of publication (Scielo, 2012).

In this portal was held the integrated research, scanning in the summary in regional level. The search was made through the compound keywords "Industrial Ecology" and "Clusters". To do this combined search, there

was no relevant results, therefore, we opted for individual search of two variables.

The first keyword used was "Industrial Ecology". They found eight articles in the above search terms; after reading their titles, dismissed five unrelated to the topic. Therefore, we selected three articles.

The same criteria was used to select items with the keyword "Clusters". Of these, there was obtained a result of 33 articles. After reading the titles, it was possible to select two titles that have some relationship between clusters and some related term to Industrial Ecology. Also tested the keyword "Industrial Symbiosis" in the same search criteria, and this presented a result equal to zero.

Step 4: analysis of the journals – after selected the 11 publications through the Capes Portal and five through the Scielo portal, was made an analysis of the journals in order to refine the analytical material, checking your impact factor and Qualis.

Step 5: selection by Qualis Capes classification - this criterion considered Qualis ≥ B3 in Engineering III or ≥ B1 in other areas.

Regarding searches through the Capes Portal, search by keywords for Business Network and Industrial Ecology, with the result of four titles, it was found that only two

Table 2. Verification of periodic publications

	ARTICLES	YEAR	PUBLICATION	JCR	QUALIS	KNOWLEDGE AREA
Business Network+ Industrial Ecology	1	2010	IEEE Conference			
	2	2005	Environmental Science & Technology	4,827	A1	Engeneering III
	3	2009	978-1-4244-2902-8/09/IEEE	n/e	n/e	
	4	2003	Journal of Business Ethics 48: 301–315	1,125	A1	Management, financial, turism
Cluster + Industrial Symbiosis	1	2009	IEEE - 978-1-4244-3541-8/09	n/e	n/e	
	2	2010	Clean Techn Environ Policy	1.12	B1	Engineering II
	3	2011	Business Strategy and the Environment	n/e	A2	Management, financial, turism
	4	2010	Proceedings of the IEEE	5,151	A1	Engineering III
	5	2009	IEEE - 978-1-4244-4639-1/09	n/e	n/e	
	6	2010	IEEE - 978-1-4244- 7618-3 /10	n/e	n/e	
	7	2008	IEEE - 978-0-7695-3480-0 - 2008	n/e	n/e	
Industrial Ecology	1	2008	Argumentos (Méx.) [online].	n/e	B3	Psicology
	2	2009	Argumentos (Méx.) [online].	n/e	B3	Psicology
	3	2003	RAE electronica	n/e	B3	Engineering III
Clusters	1	2010	Ambiente e sociedade. [online].	n/e	B2	Engineering III
	2	2009	Ciência Rural (UFSM. Impresso)	n/e	B1	Engineering III

Source: Own elaboration

Table 3. Selection by Qualis Capes classification

	YEAR	PUBLICATION	JCR	QUALIS	KNOWLEDGE AREA
Business Network + Industrial Ecology	2005	Environmental Science & Technology	4,827	A1	Eng III
	2003	Journal of Business Ethics 48: 301–315	1,125	A1	Management, financial, turism
Cluster + Industrial Symbiosis	2010	Clean Techn Environ Policy	1.12	B1	Eng II
	2011	Business Strategy and the Environment	n/e	A2	Management, financial, turism
	2010	Proceedings of the IEEE	5,151	A1	Eng III
Industrial Ecology	2003	RAE electronica	n/e	B3	Eng III
Clusters	2010	Ambiente e sociedade. [online].	n/e	B2	Eng III
	2009	Ciência Rural (UFSM. Impresso)	n/e	B1	Eng III

Source: Own elaboration.
*n/e = not found.

remained in this analysis stage. Two of the articles are publications in conferences, so they're not in journals with impact factor or Qualis. Already the search by keywords Cluster and Industrial Symbiosis, which presented the initial results of seven titles, had four papers dropped by the same criteria.

In Scielo portal scan, it was found that the three titles for the keyword "Industrial Ecology" left only one publication, and for the keyword "Clusters" remained the two titles.

Step 5: in-depth analysis – the analysis criteria for nine selected articles is to analyze the following aspects: the objective of the research, type of study realized, research method, results and new keywords identified.

4. DISCUSSION OF THE RESULTS

The two earliest works analyzed were obtained by means of key words Business Network + Industrial Ecology in the Portal Capes.

Quantifying Economic and Environmental Benefits of Co-Located Firm - the goal of the research conducted by Chertow *et* Lombardi (2005) was to check the industrial symbiosis network originated in Guayama, Puerto Rico, to the participants and the community. The research quantifies the economic and environmental costs and benefits to participants, and concludes that there are substantial benefits, although they are irregular in the participating organizations. Policy intervention can be a viable means to motivate the most common occurrences of exchanges of resources between groups of companies. The article does not highlight keywords, therefore sought to identify a to be tested on new research. Industrial Symbiosis Network has been identified.

On the Ethics of Corporate Social Responsibility: considering the Paradigm of Industrial Metabolism: the objective of the work of Korhonen (2003) been to suggest a conceptual methodology to consider the ethics of environmental management tools of the companies. The work includes two steps that are necessary for a change of the current unsustainable paradigm still dominant and toward a more sustainable paradigm. In the first stage the work is metaphorical, paradigmatic and normative. Then a practical phase, analytical, descriptive and positive. The method is applied in common tools of industrial metabolism of ecological footprints, environmental life cycle assessment and Industrial Ecology. The study reveals that the three tools can be used in "business ethics" especially when the first stage of the method is applied to the use. Keywords identified at work: Business Ethics, Corporate Social Responsibility, Ecological Footprints, Environmental Life Cycle Assessment, Industrial Ecology. We sought to identify in the text some differentiated term to test on new research. Was found Environmental Management Tools.

The three following papers also were results of Portal Capes search, in these cases by means of the words Cluster + Industrial Symbiosis.

An assessment of inter-firm networks in wood biomass industrial cluster: lessons for integrated policymaking – the work of Anbumozhi *et al.* (2010) had the objective of analyzing the obstacles in the local community for the actions based on improved environmental performance of small businesses operating in the cluster. Was made a case study examining the factors of development of network drive inside an industrial cluster of wood with existence of emerging synergy. Also analyzes the implications of the development of new models of environmental and economic planning. SWOT analysis was used. The

study found that the benefits of integrative strategies of sustainable development include the efficient sharing of local resources, environmental quality, and equitable distribution of the socioeconomic benefits. As a result of the case study, it was found that accelerate Community actions for the effective use of biomass through an integrated policy framework is a promising way for these regions develop in a sustainable way. Keywords identified at work: Industrial cluster, Community networks, Social-capital, Wood biomass. We sought as well to identify in the text some term to test on new research. Have been identified Inter-firm Networks, Integrated Environmental Planning.

Assessing collective firm behavior: comparing industrial symbiosis with possible alternatives for individual companies in Oahu, HI - Chertow's research and Miyata (2011) investigated whether the individual or collective action of firms to minimize the flow of resources is economically and environmentally preferable. The research is based on the experience of a cluster of companies of a portion of the Campbell Industrial Park in Honolulu, Hawaii, on the island of Oahu. An assessment was made on the basis of the price and amount of data collected during the interviews with the participants. As a result of research it was concluded that the industrial symbiosis solutions, when visible, are often preferable, especially on an island. Companies that fail to consider symbiotic solutions to resources are put at risk. Keywords are identified in the work: Environmental Strategy; Material Flow Analysis; Environmental Management; Industrial Ecology; Industrial Symbiosis; Hawaii; Industrial Clusters. We sought to identify in the text some differentiated term to test on new research. Was found Collective firm.

Research on the co-evolution of industrial cluster development and entrepreneur learning based on knowledge capitalization – the research of Hu et Wang (2010) conducted a systemic study based on CoEvolution symbiosis approach and focusing on the mutual promotion of the development and business activity. The research was done through an analysis of the relationship between entrepreneurial activities and regional economic development in an empirical study in 53 economic development zones of China. Explores the mechanisms through which entrepreneurs "co-evolve" with the cluster. It is concluded that the symbiotic relationship between cluster and entrepreneurs not only brings boost to business activity, but also leads to a transformation of knowledge throughout the cluster. Keywords identified at work: Coevolution, Global Knowledge Introduction, Local Knowledge Spillover, Knowledge Capitalization. Not been identified new terms related to the topic of this article.

The three papers described below were resulting from the search through the Scielo portal, being the first resulting from the word "Industrial Ecology" and the rest of the word "Clusters".

Implementation of Eco-Technologies towards industrial ecology – Giannetti et al. (2003) have made a reflection on conceptual changes caused by development/implementation of eco-technologies from the perspective of Industrial Ecology. A review of the technical and scientific literature with unconventional technologies to show the state of the art in metal removal of liquid effluents. The research was done through the definitions of fundamental concepts and examples of cleaner production, which were presented with the purpose of opposing approaches and illustrate the current form used for minimization of the environmental impact in the tannery industry. After the discussion of the concepts and the analysis of the literature, it was possible to propose the use of mining industry wastes for treatment of effluent from tannery industry in the southern region of Brazil. Keywords identified at work: Industrial Ecology, Regional, Cleaner Production. We sought to identify in the text some differentiated term to test on new research. Environmental technologies have been identified.

Local productive arrangements and practices of social and environmental management: an analysis of the furniture hub of Arapongas – Demajorovic and Silva (2010) verified the role of productive clusters settings for dissemination of socio-environmental management practices in micro and small enterprises. The work was carried out in three phases that systematized related informations on the main socio-environmental impacts generated by small enterprises. Identified the main economic, social and environmental aspects related to the furniture industry of the Industrial Clusters and an empirical research of quantitative character to identify practices, tools and social-environmental responsibility initiatives present. The work found that "deepen the knowledge about the potential of Industrial Clusters for dissemination of socio-environmental responsibility practices is an essential factor for ensuring the sustainability of small organizations in its widest sense". Keywords identified at work: local productive arrangements. Socio-Environmental Responsibility. Micro and small enterprises and Socio-Environmental Impacts. We sought to identify in the text some differenciated term to test on new research. Socio-environmental Management has been identified.

Factors of incorporation of environmental requirements in the process of developing products in custom furniture industry – the study of Azevedo et Nolasco (2009) identified environmental requirements in local productive arrangements of furniture. A case study in se-

lected companies through an intentional sampling, non-probability, in order to give priority to the qualitative information collection. The research method was through data collected in semi-structured interviews and on-site visits. The results indicated that the economic factors influence how companies respond to environmental issues and the lack of trained professionals in the area of developing sustainable products provides increased difficulties in structuring the industry. Keywords identified at work: Life Cycle, Production Process, The Furniture Industry. We sought to identify in the text some differenciated term to test on new research. Sustainable Production Process has been identified.

5. FINAL CONSIDERATIONS

Bibliometric studies include a series of texts and are used in various areas of knowledge. Several have been drawn up on the basis of different features, but always with a focus on seeking out and obtaining scientific production indicators (Noronha *et al.*, 2008, Ferreira, 2010).

Despite the small sample, even after all the selection criteria employed, were checked two projects developed by Chertow (2005; 2010), with a representation of 20%. In addition, the two research were more related to the objective of this article, indicating a possibility of references for further research related to the theme.

Of the eight texts analyzed, it was possible to identify that even resulting from searches by keywords tested industrial cluster + industrial symbiosis and the selection of titles, the research of Hu *et* Wang (2010) verified the approach of "CoEvolution" of enterprise symbiosis, which although quite significant for knowledge, is outside the central objectives of this research.

Seeking to identify the environmental aspect in Industrial Clusters, its integration through Industrial Ecology proposals and find new keywords, the present study reached their goals in the fields of engineering and has identified the relation of the theme with other areas of knowledge, as well as use rise in society, although the topic is still profitable in multidisciplinary research.

The analysed data served to identify the themes, verify the authorship, language, year of publication, even with the small sample of jobs obtained.

In addition, the research found, through the analysis of the main researches realized on national and international scientific society, tools and research directions, allowing and endorsing the continuity of future studies. This result enables the improvement and strengthening of this area of knowledge for both the academic production as for society.

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