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Capturing waste recycling science

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ABSTRACT

Many institutions from the public and private sector are interested in the characterization of the research taking place in waste recycling (WR) science. Tech mining analysis can be applied to scientific databases with this purpose in mind, but difficulties do arise when designing the search strategy to effectively capture this multidisciplinary area. This paper introduces the process followed to build a query system that aims to solve this problem. This system has been applied to a selection of scientific databases, and the steps followed to download and clean the data are detailed. Initial results are explained, indicating the relevance of each database and quantifying the overlap among them. The main subjects behind the retrieved data have been identified, namely, chemistry, biology and environmental sciences. A precision test conducted by random sampling indicated that, with a confidence level of 95%, the proportion of WR articles is between 74.2 and 79.2% of the retrieved items, while recall is expected to be high, according to available classifications. These results are deemed to be satisfactory enough for basing forthcoming tech mining analyses on this query system.

1. Introduction

There are many institutions from the public and private sector interested in the characterization and forecasting of the research taking place in waste recycling (WR) science. This is a highly multidisciplinary field that comprises knowledge coming from various branches of science, including social sciences [1]. In addition to this, the waste management industry is formed by a wide range of activities including collection, transport, processing, recycling/disposal and the monitoring of waste materials [2]. This variety of activities and scientific research areas adds extra complexity to the decision making process in this field, enhancing the need for timely and accurate information about what is going on in it.

Tech mining analysis can play a key role in the assessment of R&D policies in WR, providing valuable information about the worldwide scientific research that is being conducted, the main actors in the field and many other innovation-related indicators. Tech mining can be defined as the application of text mining tools to science and technology information, informed by an understanding of technological innovation processes [3]. Scientific publication databases are a reliable global source of information that can be effectively exploited via text mining in order to extract information about research taking place in WR. However, the problem arises from the very multidisciplinary nature of this science, which invariably calls for the building of an ad-hoc search strategy to capture the nucleus of this science from the databases, and clearly define its subfields. The aim of this paper is to provide an overview of the method followed to build a set of queries oriented to capture the scientific production in WR, for the eleven year interval 2000–2010. The database choice, as well as the downloading and data cleaning processes are described, and some initial results are reported. This work is previous to the elaboration of other tech mining studies oriented to WR research activity, including social network studies and the building of a WR map of science.

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2. Methodology

2.1. Precedents

The starting point of this paper is the work done by Garechana et al. [1] , tracking the cognitive changes experienced in WR science from the years 2005 to 2010, via tech mining tools. The criteria then followed to retrieve the items published in WR research were derived from the identification of the main underlying key cognitive areas in this field, represented by the Web of Science (WOS) Subject Categories (SC) .

A thorough study of the keywords found in the sample of Garechana et al. gave an overall impression of the major research topics in this field; however, some doubts remained as to what activities were to be included under the WR concept. These doubts led to the search of formal definitions, mainly on governmental and official public agency websites. An overall consensus was found, with some exceptions, about two facts of what WR can be considered as:

a) It does not only involve the remanufacturing or reprocessing of materials so that they can be used again, but also the collection, classification/separation of waste and the subsequent marketing of recycled products.
b) Recycling is not only about the reutilization of the spent materials in their original form. A discarded rubber tire might be reused as an industrial resource not in the form of recycled rubber, but in form of fuel for a cement kiln.

Some sources explicitly exclude the thermal combustion of wastes from the umbrella of WR [4], and obviously it would be as such in the case of mere incineration without energy recovery. However, the studies conducted by Garechana et al. (2012) and consulted experts point out that the Waste-to-Energy concept is an important area in waste management. Direct combustion methods are the least desirable option to recover energy from waste, and are subject to strict regulations [5] but other procedures aimed at obtaining fuel from waste are increasingly important. Taking these facts into account, the authors opted to choose the following inclusive definition of WR:

> "A method of recovering waste as resources which includes the collection, and often involving the treatment, of waste products for use as a replacement of all or part of the raw material in a manufacturing process." [6]

This definition is broad enough to include the recovery of many inputs like water or energy while considering the recycling process as a whole, including collection, characterization and classification of waste. Other available definitions are considerably broader but somehow ill defined: "Reusing materials and objects in original or changed forms rather than discarding them as waste" [6] while others put the energy recovery from waste under the definition of waste recovery, eluding the word "recycling" [7].

2.2. The query system

The work conducted by Porter et al. [8] to build a set of queries that define the boundaries of the science of nanotechnology has been a source of inspiration and methodology for this paper, as well as the process detailed in the work of Kostoff [9] to retrieve the literature corresponding to a particular area. The authors opted for a Boolean search term approach, given the fact that temporal and financial limitations of this study discouraged the alternative approach referred to as "bootstrapping" by Porter et al. [8], and considering on the other hand the advantages of modularity and flexibility derived from the Boolean approach.

2.2.1. Compilation of terms

An exploratory set of queries, based on the previously mentioned keyword study, was run on SCI and SSCI, and the results analyzed. The overview of WR activities and different types of waste sources given by Demirbas [2] was also a good starting point to define the subfields within WR. The items retrieved in this first attempt were examined by taking samples and reading the available fields, especially title and abstract, to determine if the results fitted in with the aforementioned WR definition. This process proved to be extremely effective to discover various synonyms and acronyms of WR related terms, as well as to identify some non-desired meanings of the initial keywords and "toxic terms". Important words in WR science were identified thanks to the reading of literally hundreds of titles and abstracts, and their suitability considered for including them in the queries. The correct interpretation of the retrieved items was considerably eased by the qualifications of the authors of this paper, the main author holding a university degree in chemical engineering and the second author a master's degree in environmental sciences. The analysis was further complemented by checking the glossary service of the European Environmental Agency [6] and US Environmental Protection Agency [10]. These two websites were intensively used as vocabulary source and qualified information point; both were selected due to their trustworthiness and the richness of their terminology services.

2.2.2. Adjusting retrieved items to WR

At this point, the researchers had collected a fairly lengthy set of keywords from various branches of WR, but when testing them via simple queries in various databases, the following problems arose:

– Some queries introduced significant noise in the sample, for example, retrieving publications about mere disposal or incineration of waste, did not deal with the aforementioned WR definition. A clear case can be found when retrieving publications about landfilling. Landfills produce various gases that can be used as an energy source [11], however, mere landfilling cannot be considered as WR, according to the chosen definition.