Strategic analysis of main research fronts in waste recycling science: Evolution from 2002 to 2012

Gaizka Garechana*, Rosa Rio-Belver, Ernesto Cilleruelo-Carrasco and Jaso Larruscain-Sarasola

*ggaretxana@gmail.com
University of the Basque Country (Spain)

Introduction

Waste recycling (WR) science is a highly interdisciplinary area that has been studied by the authors in previous papers (G. Garechana, Rio-Belver, Cilleruelo-Carrasco, & Gavilanes-Trapote, 2012; G. Garechana, Rio-Belver, Cilleruelo, & Gavilanes-Trapote, 2014), including the clustering and mapping of WR research (G. Garechana, Río-Belver, Cilleruelo-Carrasco, & Larruscain-Sarasola, In press) that unveiled the main scientific problems being addressed in this area. This paper takes the characterization of this scientific field a step further by building strategic diagrams (Callon & Penan, 1995), which describe the structure of the field in terms of internal coherence and centrality of the research problems being addressed by the WR scientific community.

Method

Early WR science tech mining analysis made it possible to identify important terms and issues in this area (G. Garechana, Rio-Belver, Cilleruelo-Carrasco, & Gavilanes-Trapote, 2011). The next step was to build a proper strategy to "capture" the research around WR science from scientific databases (G. Garechana et al., 2014), in collaboration with experts in the field (IHOBE, 2012). A total of 3,935 journal articles for the year 2002 and 14,982 for the year 2012 were downloaded and the information contained in "author keyword" field was analyzed by means of text mining tools in order to extract and clean the main concepts researchers are dealing with in WR science. Keyword co-occurrence matrices were built for the years considered and the normalized similarity between terms was computed using Salton's cosine. Hierarchical cluster analysis was used to group the keywords according to their similarity, with the resulting clusters being interpreted in collaboration with IHOBE specialists to relate each cluster to a research problem being addressed by the scientific community. Maps of science were then built using the keyword-keyword and intercluster similarities, identifying the dominant research areas in WR (G. Garechana, Río-Belver, Cilleruelo-Carrasco, & Larruscain-Sarasola, In press). These maps can be complemented by strategic analysis (Callon & Penan, 1995), analyzing the position of the clusters in a centrality-density plot, the first indicator refers to the role played by the cluster as a central node in the cluster network, the second quantifies the internal coherence of the cluster. The point of each cluster in a Cartesian coordinate system formed by the mean value of centrality and density for a given year, plus the quadrant changes across the years shows the current strategic situation of the cluster and its evolution. Density and centrality indicators have been calculated as described in Neff & Corley (2009).

Results & Discussion

Table 1 shows the full list of clusters identified in each year[1], the number in brackets indicates the corresponding node in strategic diagrams. 62.5% of the clusters in 2012 can be traced back to their equivalent in 2012.

Table 1. Full list of clusters indentified in years 2002 and 2012.

[1] Table 1 (24 rows, 4 columns) has been omitted due to length restrictions placed by the editors for this abstract

Figures 1 and 2 show strategic diagrams corresponding to years 2002 and 2012. Dark lines indicate mean values of centrality and density, and node size corresponds to the size of the keyword cluster, calculated by summing the number of keywords of which it is formed by the total number of occurrences of each keyword.

Fig 1. Strategic diagram corresponding to year 2002.

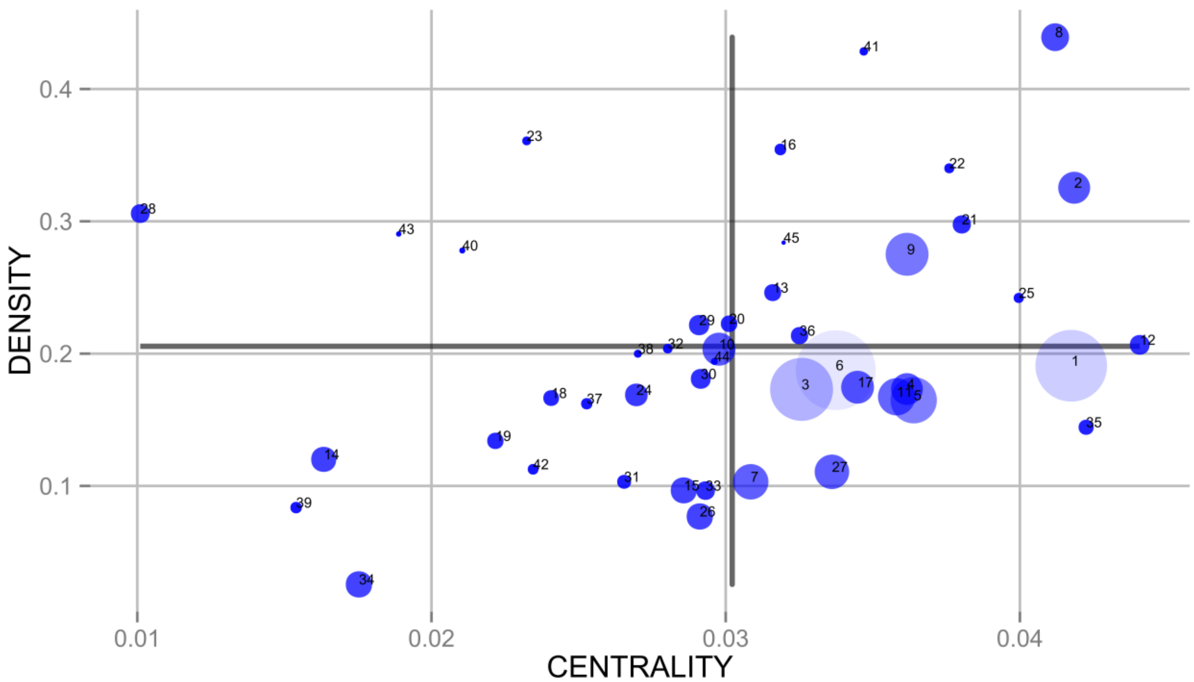
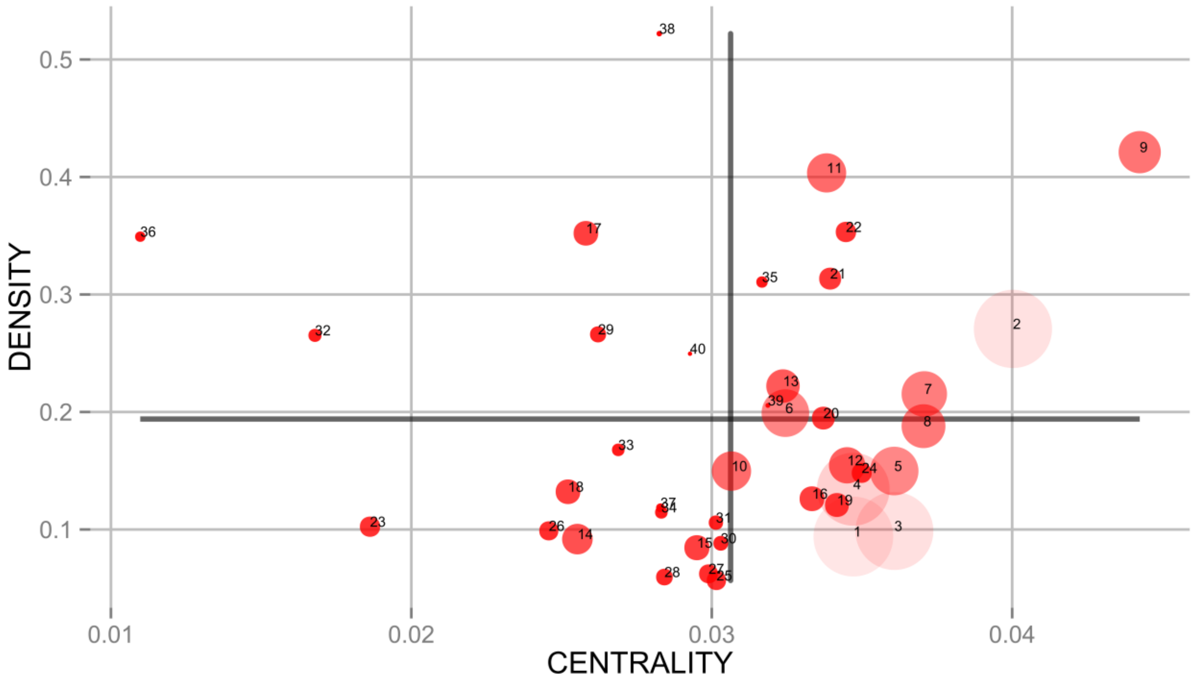


Fig 2. Strategic diagram corresponding to year 2012.



Clusters are distributed following a line approximately parallel to the bisector of the first quadrant, with many relevant (large) clusters located in the fourth quadrant. This fact is present in both years under study, being more noticeable for year 2012. As a consequence of this, WR could be described as a field formed by certain well-defined research areas that simultaneously displays significant signs of polycentric structure, this being a feature of scientific fields undergoing change (Callon & Penan, 1995).

Clusters related to water recovery lose centrality, with many of these shifting to the third quadrant. New clusters emerge in 2012 related with energy recovery from waste, most of these are located in the fourth quadrant, with the biomass combustion cluster in the first quadrant (strongly coherent and central field) and biodiesel research in the second quadrant (internally coherent, yet somehow isolated in WR research). Most of the clusters related with soil recovery lose density although maintain their centrality, and research concerning waste management remains stable with the remarkably relevant position of municipal waste and landfill management cluster. The "inverse logistics and circular economy" cluster presents itself as a coherent, albeit isolated, cluster in quadrant 2. Very few of the clusters that occupy the first quadrant in 2002 maintain their position in year 2012, and correspond to quite heterogeneous research issues: municipal waste and landfill management, filtration and membranes (physical separation techniques) and biodegradation techniques. More information about the clusters detected and the relationships between them can be found at the reference (G. Garechana, Río-Belver, Cilleruelo-Carrasco, & Larruscain-Sarasola, In press).

Conclusions

The WM field does not show any clearly defined, central cluster group in the studied interval. The overall composition of quadrants notably varies from one year to another. Research into energy extraction from waste sources is clearly relevant in 2012, and a good deal of these clusters are located in quadrant 4. Clusters in quadrant 4 are prone to move to quadrant 1 as research specialties grow and consolidate (Callon & Penan, 1995), consequently the evolution of research related to waste-to-energy techniques should be monitored.