

**LAPPEENRANTA UNIVERSITY OF TECHNOLOGY**

Faculty of Technology

Master's Degree Programme in Chemical and Process Engineering

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**IDENTIFICATION OF THE EMERGING ISSUES IN RECYCLED FIBER  
PROCESSING**

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## ABSTRACT

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<b>Topic:</b> Identification of the Emerging Issues in Recycled Fiber Processing
<b>Department:</b> Chemical Technology
<b>Year:</b> 2009
<b>Project:</b> Master's Thesis. Lappeenranta University of Technology 98 pages, 11 figures, 9 tables, 3 appendices
<b>Supervisors:</b> Prof. Andrzej Kraslawski, Prof. Alexander Smolin
<b>Keywords:</b> Research issues, recovered paper, waste paper, recycled fiber, portfolio management, text mining, visualization, RefViz, CiteSpace.
<p>The objectives of this research work “Identification of the Emerging Issues in Recycled Fiber processing” are discovering of emerging research issues and presenting of new approaches to identify promising research themes in recovered paper application and production. The projected approach consists of identifying technological problems often encountered in wastepaper preparation processes and also improving the quality of recovered paper and increasing its proportion in the composition of paper and board.</p> <p>The source of information for the problem retrieval is scientific publications in which waste paper application and production were discussed. The study has exploited several research methods to understand the changes related to utilization of recovered paper. The all assembled data was carefully studied and categorized by applying software called RefViz and CiteSpace. Suggestions were made on the various classes of these problems that need further investigation in order to propose an emerging research trends in recovered paper.</p>

## **ACKNOWLEDGEMENT**

I express my deep appreciation to my Supervisor, Professor Andrzej Kraslawski for giving me the opportunity to study in LUT and for his constant support and understanding during my studies and especially in the process of writing my Master's Thesis. Also special thanks to Professor Alexander Smolin for his responsiveness and professional consultations during writing of my Master's Thesis. I also would like to thank all the teachers and staff of Chemical Technology Department of LUT for their various contributions to the successful completion of my studies at LUT.

I am warmly grateful to my family for their constant attention and moral and material support. I am also very grateful to my friends who have always supported me morally and spiritually.

## TABLE OF CONTENTS

ABSTRACT.....	i
ACKNOWLEDGEMENT.....	ii
TABLE OF CONTENTS.....	iii
List of figures.....	vi
List of tables.....	vii
Appendices.....	viii
1. INTRODUCTION.....	1
1.1 Objectives of work.....	1
2. RECYCLED PAPER.....	2
2.1 General aspects and basic statistics.....	3
2.2 Definitions.....	5
2.3 Main qualitative characteristics of recycled paper.....	9
2.4 Reasons of recycled paper using.....	9
2.5 Quality and purity of the recycled fiber.....	10
2.6 Contaminants in waste paper.....	10
2.7 The main technological operations in waste paper recycling.....	11
3. METHODS OF IDENTIFICATION EMERGING RESEARCH TRENDS.....	16
3.1 Project Portfolio Management.....	16
3.1.1 Definition and main goals of PPM.....	16
3.1.2 The essence of PPM.....	17
3.1.3 Available software for PPM.....	21

3.2 Text Mining.....	22
3.2.1 Process of text mining.....	22
3.2.2 Methods of text mining.....	24
3.2.3 Text mining and visualization tools.....	26
4. VISUALIZATION OF NETWORKS IN SCIENTIFIC PUBLICATIONS.....	29
4.1 OmniViz.....	29
4.2 RefVizTM.....	30
4.2.1 Running RefVizTM.....	31
4.2.2 Loading data and visualization.....	31
4.3 CiteSpace.....	34
4.3.1 Data collection.....	35
4.3.2 Access to the CiteSpace.....	36
4.3.3 Running data in software.....	37
5. RESULTS.....	39
5.1 Problem formulation.....	39
5.2 RefViz visualization.....	39
5.3 CiteSpace visualization.....	47
6. CONCLUSION.....	49
REFERENCES.....	50
APPENDICES.....	53

Appendix I.....	53
Appendix II.....	55
Appendix III.....	59

List of figures

Figure 1: World consumption of papermaking fiber.....3

Figure 2: Fibre furnish used in the production of paper and paperboard in the world in 2003 and 2020.....8

Figure 3: Model for organizing portfolio management.....18

Figure 4: Different diagrams used in portfolio management.....20

Figure 5: Text mining process.....23

Figure 6: OmniViz multiple visualization techniques.....30

Figure 7: RefViz user interface.....32

Figure 8: Matrix visualization window.....34

Figure 9: Information of a bibliographic record which is CiteSpace used.....35

Figure 10: Main CiteSpace interface.....37

Figure 11: CiteSpace visualization window.....38

List of tables

Table 1: Fibre furnish used in the production of paper and paperboard in the world in 2007.....	4
Table 2: The most common grades of waste paper.....	7
Table 3: Particle size and specific gravity of contaminants in waste paper.....	11
Table 4: Methods of text mining.....	24
Table 5: Text mining and visualization tools.....	27
Table 6: The results of the computer program RefViz (keywords: recycled paper)....	40
Table 7: The results of the computer program RefViz (keywords: recycled paper, waste paper, recycled fiber).....	42
Table 8: The results of the computer program RefViz (keywords: deinked pulp).....	43
Table 9: The results of the computer program RefViz (keywords: waste paper).....	45

## Appendices

### Appendix I: The results from RefVizTM (Galaxy visualizations):

View 1.1: Keywords: recycled paper (1458 articles).....	53
View 1.2: Keywords: recycled paper, waste paper, recycled fiber (140 articles)...	53
View 1.3: Keywords: deinked pulp (310 articles).....	54
View 1.4: Keywords: waste paper (791 articles).....	54

### Appendix II: Network visualization with CiteSpace:

2.1 Keywords network.....	55
2.2 Cited Reference network.....	56
2.3 Cited journal network.....	57
2.4 Cited author.....	58

### Appendix III: Network of article citation:

Table A: Enzyme treatment.....	59
Table B: Flotation.....	70
Table C: Properties of recycled paper and products which are made from waste paper (strength and brightness).....	77
Table D: Composites.....	84

## **1. INTRODUCTION**

In the modern world of paper and paperboard industry the recycled fibres in comparison with virgin fibers have a number of advantages that is why they become competitive in quality and scales of consumption. The relative prevalence of consumption of a recycled fibre as a highly profitable alternative semifabricate for development of paper and paperboard production objectively is carried to unsurpassed achievement of second half of XX century. It is expected, that this role of a secondary fibre will increase in XXI century.

But along with advantages also disadvantages exist; it is a permanent worsening of a wide range of variation parameters and papermaking properties in comparison with virgin fibres. These are negative features, first of all, outline those problems and problems which have been solved and will be solved in all stages of development of paper recycling process to manufacture the concrete kinds of paper and board. The problems cover all turnover cycle of paper for recycling, since collecting and maintaining of waste paper quality and finishing manufacture of paper and board with the set of consumer properties.

Scientists and researchers are faced with the challenges of identifying these actual and important problems in scientific literature and relating it to the development of given field of industry. These changes are caused by new discoveries, scientific breakthroughs and innovations. Detecting and understanding these emerging trends and the possibilities of exploiting opportunities has become vital for firms in global business. At an industrial level, these challenges have led to an increasing need to collect concrete information on the industrial change that can be used to address firm strategies needed in the future.

### **1.1 Objective of the work**

The objectives of this research work are discovering of emerging research issues and presenting the new approaches to identify promising research themes in recovered paper application and production.

## 2. RECYCLED PAPER

The amount of recycled paper in a country directly depends on the level of consumption of paper and board. For example, in Russia at the beginning of a 20<sup>th</sup> century, the consumption of paper was no more than 3 kg per capita in a year, while in Germany – 24 kg, and in the USA-34 kg. At the end of the century in the consumption of paper Russia remains no less than in 8...10 times behind (35kg in a year and 250...300kg respectively). [7]

It is development that was seen in the 1950s when the world paper and board production has increased interest in using waste paper as a source of raw material. It is explained on the one side by more strict environmental legislation, and on the other - economic feasibility. In addition, the use of recycled paper for the production of pulp and paper-based materials significantly reduce overall energy consumption, the consumption of fresh water. The proportion of waste paper in the total consumption of raw materials for paper and paperboard production increases annually.

However, in the processing of waste paper there are also problems and the main among them is the slow decline of its quality. The systematic repeated return of fibre in a process makes it almost inevitable. Reducing the strength characteristics of the recycled paper pulp is explained by the frequent affects on the fibers of various negative factors: hornification of fibers during drying and recycling, grinding, and so on. A change of properties of pulp is an objective fact; it must be skillfully and systematically fight with, using all available organizational and technical methods. [7, 9]

## 2.1 General aspects and basic statistics

Comparing to the wood pulp, the recycled fiber is not manufactured from the wood raw material by pulping, bleaching and refining processes. It consists of the waste of production and consumption of all types of paper and paperboard, suitable for use as a raw material.

The paper industry is the exceptional consumer of waste paper as secondary raw materials. Currently, recycled fibre plays an important role as a substitute for fresh fibers in the production of paper and paperboard and its use is growing rapidly. In 1980, the part of recycled fibre in the world fibre supply was 20%. In 2005, it had increased to 50%. The global recovery rate is expected to grow further to about 56% by 2020. [9, 10] Figure1 shows the world consumption of papermaking fiber.

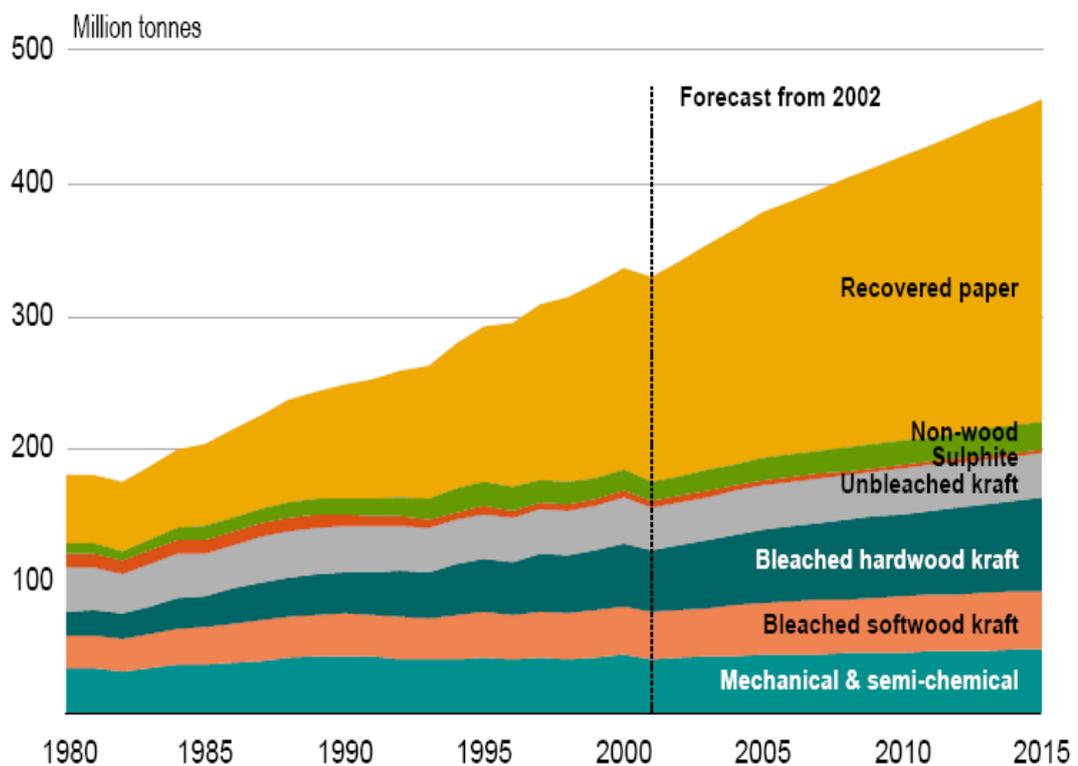


Figure 1: World consumption of papermaking fiber. [8]

Waste paper should find wide application in densely populated regions of the country with the highest consumption of paper per capita. Of course, the situation has been different from one region to another. As always, the paper and board sector is a faithful indicator of the level of industrialization and of the situation in each area and country, while paper/board recovery is also a good indicator of the standard of living. Table 1 shows fibres furnish used in the production of paper and paperboard in the world in 2007 [10].

Table 1: Fibre furnish used in the production of paper and paperboard in the world in 2007. [10]

Region	Virgin fibre (All grades of fibre - chemical, semichemical, mechanical and others)		Recovered paper	
	Production (million tons)	Consumption (million tons)	Total collection (million tons)	Consumption (million tons)
North America	75,78	69,17	52,41	35,61
Europe	51,50	56,13	61,95	53,35
Asia	42,53	56,74	79,03	103,39
Latin America	18,56	9,49	9,80	11,93
Africa	3,13	2,44	1,85	2,01
Australia	2,73	2,23	2,40	1,21
Total	194,22	196,20	207,44	207,49

## 2.2 Definitions

Depending on the origin of the collected waste paper recycled fibre is divided into two main categories:

1. Pre-consumer waste refers to paper or board residues collected from converters, printers, distributors, and transport organizations before the paper or board has been consumed in its intended end-use.
2. Post-consumer waste include paper or paperboard material consumed by various end users collected from households, offices, retail trade ect.

There are two key statistical parameters used in making comparisons of the relative importance of recycled fibre in different countries [6]:

*Recovery rate of a given region (%)* (1)

*Utilization rate of a given region (%) =* (2)

These parameters can be calculated for the whole country and for individual regions. The biggest degree of recycling of waste paper is Korea (73%), Britain (72%), and Germany (60%). The level of recycling in Sweden and Finland is the lowest. This happens because of not less than 85% of paper produced is exported. There is also a lower density and relatively low consumption of paper received and its processing in comparison with the level of its production. Calculations of the utilization rate do not include fibre losses, which normally are in range 10-25%. [7]

The most widely accepted grade structure worldwide is from the Paper Stock Institute of America. Specifications generally are agreed upon between buyer and seller. Very few grades are homogeneous; most are heterogeneous mixtures of various types of paper. The most common waste paper grades are shown in Table 2 [9].

Table 2: The most common grades of waste paper. [9]

<b>Grade</b>	<b>Definition</b>	<b>Source</b>	<b>Use</b>
Mixed	Paper of different quality; plus boxboard cuttings and mill wrappers	Office buildings	Construction paper and board production; boxboard grades
News	Old newspapers; over-issue news; magazines; telephone directories	Households	Recycled newsprint; utilized in paper and board construction; insulation; frequently used for deinking
Deinking	Deinking grades of white and colored paper, printed paper, coated book, groundwood and bleached sulfate papers and cuttings	Sheets/cuttings from converting plants	Colored and white ledger; coated book stock; essentially used in tissue
Pulp Substitutes	Unprinted grades of colored and white kraft; white and semi-bleached sheets, tab cards		
Old Corrugated and Solid Containers	Used corrugated containers; kraft bags; container plan cuttings	Retail stores, factories, and office buildings; trim from converting plants	Lineboard and corrugating medium

Figure 2 shows the world consumption of waste paper by paper grade in 2003 and 2020.

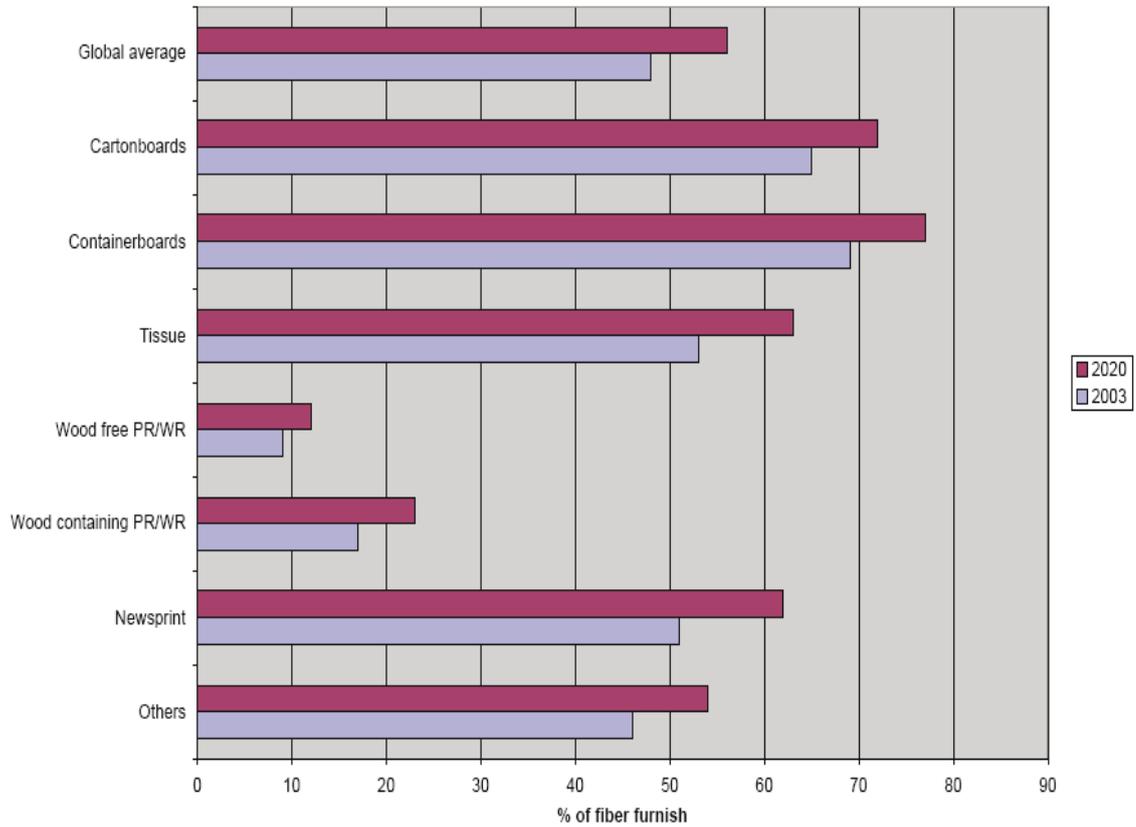


Figure 2: Fibre furnish used in the production of paper and paperboard in the world in 2003 and 2020. [6]

As shown in the figure in 2003 the share of recycled fibers is used in the manufacture of containerboard-70%, cartonboards-65%, tissue-53% and 50%- newsprint. In 2020, the share of secondary fibers will still be utmost (77%, 72%, 63% and 62% respectively).

### **2.3 Main qualitative characteristics of recycled paper**

The main qualitative characteristics of waste paper are the moisture, its composition, as well as the number and nature of nonpaper components.

The moisture content of the waste paper is particularly important to know for economic reasons, because the presence of water can lead to large production costs. Wet bales or wet areas in the bales of waste paper can also cause decay because of the biological decomposition of organic material. The level of humidity depends on many factors: the climatic conditions in the collection, transporting, packaging and storage of recovered paper, on the type of composition, content of secondary fiber, ash .

Nonpaper components are any foreign matter in waste paper which can cause damage to machines, process delay, or decrease the value of the finished product. Such items include: metal, plastic, glass, sand, synthetic materials, etc. These components can cause damage to equipment, or whether their presence makes the whole batch of recovered paper unusable. This also includes such kinds of paper and paperboard, which are not suitable for waste paper as raw material for paper and paperboard production, in particular: bituminized board, carbon paper, parchment and grease proof paper, wet strength paper, waxed paper.

### **2.4 Reasons of recycled paper using**

The recycled paper has particularly important value in the production of cardboard and paper for corrugating. Some types of cardboard are made only from recovered paper (testliner). Other kinds are a mixture of primary and secondary fibres. The driving forces behind this development have been the following: economic benefits; environmental issues; new technology in the areas of deinking, screening of impurities, fractionation, bleaching and web forming has promoted the use of recovered paper; the reducing volumes of solid waste for landfill.[6]

## **2.5 Quality and purity of the recycled fiber**

As mentioned above, recycled pulp (RCP) is in significant quantities or completely replaced by various types of primary semifabricates in the paper and paperboard composition. For this reason, the recycled fiber quality and purity requires high demands.

The term “quality of RCP” refers to an indication of its mechanical strength and whiteness. The notion of ‘purity of RCP’ includes optical, chemical, colloidal, microbiological, and technological properties. Also the availability of sticky substances affects the purity

The principal differences between the recycled fibers from cellulose are in the nature of their bonding ability. During drying, between cellulose microfibrils bonds are formed, which are not destroyed in the defibration process when the paper, turns into a waste paper. Recycled fibers in the papermaking process become rigid, fiber swelling decrease and as a result reducing bonding ability and deteriorate indicators of mechanical strength of paper sheet.

## **2.6 Contaminants in waste paper**

As waste paper is a secondary fibers material, which is a mixture of different products, types of paper and board, the recycling process is much more difficult than the primary (virgin) pulp production. Table 3 shows the most common pollutions and their specific gravity and particle size. In addition, it contains a certain amount of impurities and other unwanted components [6]:

- various additives used in the paper manufacture (fillers, pigments, coatings and other functional and technological additives);
- substances used in the processing of paper products (printing inks, coatings, adhesive, and laminates);

- materials that fall into the paper during its use and in the collection of waste paper, including wires, sand, stones, clips, clamps, etc.

Table 3: Particle size and specific gravity of contaminants in waste paper. [9]

Type of contaminant	Specific gravity, [g/cm <sup>3</sup> ]	Particle size, [μm]				
		<1	<10	<100	<1000	>1000
Metal	2.7-9					
Sand	1.8-2.2					
Fillers/coating particles	1.8-2.6					
Ink particles	1.2-1.6					
Stickies	0.9-1.1					
Wax	0.9-1.0					
Styrofoam	0.3-0.5					
Plastics	0.9-1.1					

## 2.7 The main technological operations in waste paper recycling

Development of papermaking properties of the recycled paper should be carried out at all stages of its processing at the expense of developing new and improving existing technology by using the newly created devices. All this must be done while reducing the unit cost energy, steam, fresh water, amount of waste, and fiber loss.

In the recycled paper process the stages defibration, cleaning, sorting and beating are required. This should be removal of unwanted components such as contaminants,

fillers, printing inks, hot melts, the components of polymer coatings, starches, resins, pigments, latex, heavy metals, etc.

There is an optimal technological scheme of recycled paper processing. When designing the installation and selection of technological schemes of waste paper processing is guided by the following:

- type of recycled paper processed and the required quality of waste paper;
- desired degree of technology flexibility and system as a whole;
- willingness of company to finance capital costs and operating expenses;
- allowed by the degree of financial risk.

Composition of recycled paper has a significant impact on the efficiency of its processing and the quality. Increasing demands for systems (equipment, technological lines) of waste paper processing, some elements of which- defibration, cleaning, sorting, beating, dispersion, concentration, processing of recycled water – are considered as a whole. The main technological operations, over the waste paper recycling are the following [9]:

- defibration;
- rough cleaning and sorting;
- additional defibration;
- a thin cleaning and sorting;
- condensation and fractionation;
- beating;
- storage.

The wastepaper recovery process is a set of technological operations to give the recycled fibers certain papermaking properties, with maximum removal of unwanted

components from recycled pulp: pollution and impurities of organic and inorganic nature.

Erroneously, the term “improvement of waste paper” means only operation to remove the printing ink (deinking) and bleaching. Wastepaper recovery is a comprehensive processing of secondary raw materials in pulp, which is steadily going on restoration, creation and development of its papermaking properties.

Stock preparation is essentially the four stages process. The first stage is the defibration of waste paper, rough cleaning, sorting, and further defibration. This stage allows to restore papermaking ability of recycled fibers and to obtain pulp, which can be used in composition of smooth layers of cardboard (without printing) and corrugating paper (fluting).

The second stage is a thin cleaning and sorting of recycled pulp, its addition beating and/or dispersion. The recycled fibers which are obtained after II level have sufficiently developed papermaking properties that allow its use in the production of smooth layers of cardboard with printing on its surface.

It should be noted that use of high quality recycled fiber makes it possible to obtain pulp, which can be used in composition of different types of paper (exercise-book paper, wallpaper, tissue, and other). For example, food packages such as “Tetrapak” made from bleached sulphate pulp, obtained after two levels of processing can be used in production of smooth layer of top-liner. But it must be borne in mind that about 30% of this waste paper make up plastic sheeting and other sticky pollution , which must be separated and send for processing.

The first two levels of recycling waste paper should be attributed to “mechanical” improvement, because they use mechanical operations such as: defibration, cleaning, sorting, beating, dispersion.

Third stage is the ink removing by flotation or washing, which is called deinking. The fourth is the bleaching or discoloration of recycled pulp. This step enhances the whiteness of recycled fibers significantly, but it does not reach the white color like “primary” fibers.

The last two stages of waste paper processing can be described as “chemical” improvement of recycled pulp, stressing that during these operations chemical reagents are used. At these levels recycled fibers consistently improve papermaking properties: increasing whiteness and smoothness of pulp; to certain extent, increasing indices of mechanical strength.

It should be emphasized the practical realization of IV stages of waste paper recycling (bleaching) a rather complicated and expensive process. This is due to the following factors [9]:

- the high cost of equipment and chemicals;
- a fairly complex technology;
- the need to build infrastructure for storage, preparation and dispensing reagents;
- a significant increase pollution of water production, and cost of its purification consequently;
- additional costs for training.

For the small businesses (with volume of recycled paper processing as high as 100 tons/day) IV application stage in recycling process should be declared economically impractical.

Reviewing the status of recycling and use of waste paper in composition of paper and paperboard in various regions of the world, including Russia, there are not many differences in the production and use of recycled fibers.

In Western Europe, Scandinavia and the United States the waste paper recycling is carried out in 2-4 stages (productivity up to 1500 tones/day), recycled paper is used as received for production of cardboard, corrugating paper, in composition of newsprint and tissue, and other paper for printing.

In Russia the waste paper processing is carried out at low and medium volume in 1-2 grade level. The recycled paper is mainly used in production of cardboard and paper

for corrugating. However, from plants which produce smooth layers of corrugated cardboard and fluting using RP, only few plants in Russia manufacture the products of high quality. Now-a-days, there are others fabricated products of low and medium quality. In the future it is suggested that the development of the recycling of the waste paper will be carried out not only by building new plants, but also by improving the technologies and renewing the equipment of the already existing technological lines.

### **3. METHODS OF IDENTIFICATION EMERGING RESEARCH TRENDS**

There are a lot of qualitative and quantitative research methods. In this work for identification of emerging research trends can be done using some of methods which include:

- Portfolio management
- Text mining

#### **3.1 PROJECT PORTFOLIO MANAGEMENT**

The field of portfolio management owes its origins to a document written in 1952, in which H. Markowitz [15] laid the foundation for the Modern Portfolio Theory (MPT). MPT allows determining the specific mix of investments generating the highest return for a given level of risk. Although Modern Portfolio Theory was originally developed for financial investments, in 1981, McFarlan [16] prepared the base for the modern field of PPM for IT projects. In the mid-1990s, the field of PPM acquired increasing attention.

In a recent publication, Jeffery and Leliveld report the results of a survey with 130 senior executives, 90% of whom were CIOs. The survey identified, among other things, that 25% of the respondents could be defined as optimally applying Information Technology Portfolio Management (ITPM), 45% as having or adopting it and 78% as planning to have or to keep it [17].

##### **3.1.1 Definition and main goals of PPM**

The term project portfolio management (PPM) is a management process designed to help an organization get and view information about all of its projects, then sort and prioritize each project according to certain criteria, such as cost, strategic value, and

impact on resources and so on. All of projects are carried out inside the organization sharing the same resource pool and strategic objectives. The projects contend for those deficient resources under the same management and/or sponsorship. The goals of PPM are alike the goals of managing a financial portfolio. The main goals dominate in the literature [12-14]:

- defining aims and objectives, i.e., clearly articulating what the portfolio is expected to attain;
- identifying, eliminating, and minimizing risk;
- monitoring portfolio performance, i.e., understanding the progress that portfolio is making towards the achievement of the aims and objectives;
- establishing confidence in achieving a desired objective;
- understanding, accepting, and making compromises.

### **3.1.2 The essence of PPM**

Generally, PPM *starts with the comprehensive list of all its projects* and enough descriptive information about each to allow them to be compared and analyzed. This information can include project name, business objective, and estimated duration, how the project supports the organization's overall strategies, estimated cost, and so on. Currently, such descriptive information is compiled in an electronic database so it may be analyzed and compared more easily.

After the project inventory is created, the *PPM process begins to examine each project and prioritize it* according to established criteria. The general list of projects is then thought-out in order to develop a balanced list of supported projects. Some projects will be given high priority and extensive support, some will be given moderate priority, and still others will be placed on hold or removed entirely from the list. Finally, *the portfolio management is reevaluated on a regular basis* (monthly, quarterly, etc.) to determine which projects realize their aims, which may need more support, or which may to be suspended. The decision process is characterized by changing and uncertain information, strategic considerations, dynamic opportunities, and multiple

goals, interdependences amount the projects and multiple decision-markets and locations. [11, 17]

Portfolio management is a dynamic decision-making process whereby a list of active projects in the business is constantly updated and revised.

Also PPM can be presented as a collection of programs, which together form the objective of the all business. Programs and the projects inside them are analogous to the projects that are then subdivided into subprojects [11]. Figure 3 illustrates this idea.

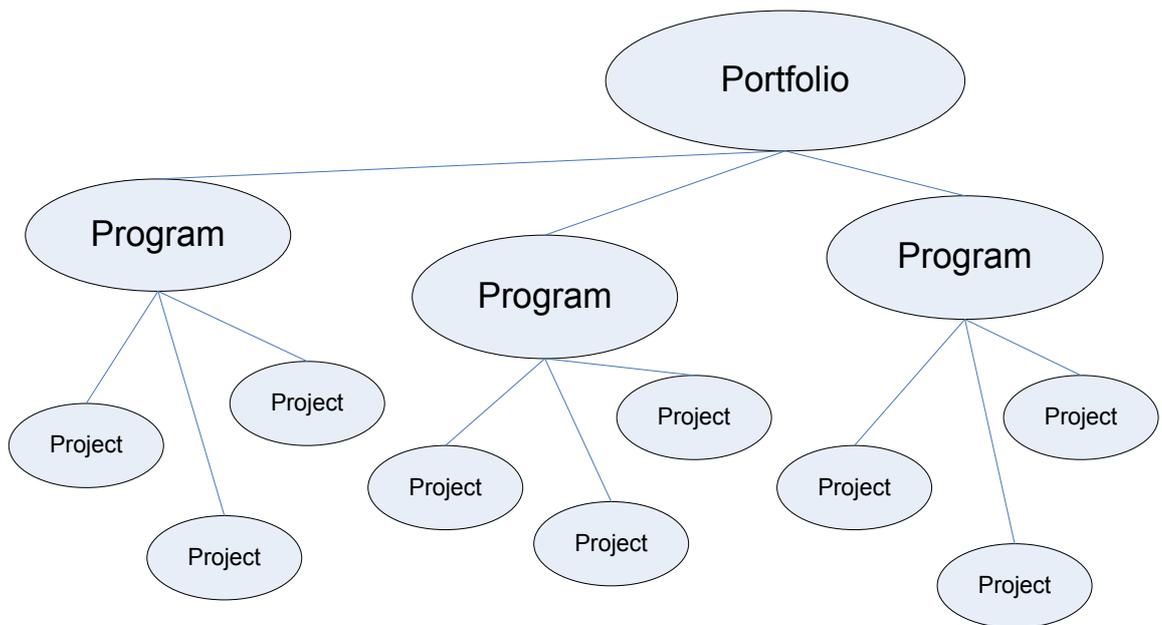


Figure 3: Model for organizing portfolio management [11].

Several papers discuss the key elements that form project portfolio management [1, 15-17]:

- Full view of the project portfolio: Organization developing a comprehensive list of all its projects and enough descriptive information about each to allow them to be compared and analyzed.
- Financial analysis: Several techniques have been created to measure the financial value of projects. However, the most important, one should choose a valuation methodology and successively apply it.
- Risk analysis: There are two main reasons for project failure - “the failure to assess individual project risk” and “the failure to consider the aggregate risk of the portfolio of projects”. Further, a project portfolio should not be chosen whereas only for individual characteristics of the investments, but it should be built based on the overall risk and recompense of the portfolio.
  
- Prioritisation, alignment and selection: The process of evaluation, prioritization and selection is one of the basic questions in portfolio management, which also accentuates on the idea that projects should not only be evaluated separately, but in the context of the whole portfolio since projects are very seldom independent from each other.
  
- Constraints: The following types of constraints should be controlled: budgets, human resources, staff capabilities, and infrastructure.
  
- Need for specialized software: The necessity of using specialized computer programs for project portfolio is a discussed question in the literature. Some authors consider that there is no need, while others think that specialized software is obligatory due to the time consuming process of updating all information needed for the decision making process.

The tools that can be used in portfolio management are usually graphical, represents different dimensions. Figure 4 represents several different diagrams that are used in PPM and evaluation of different projects.

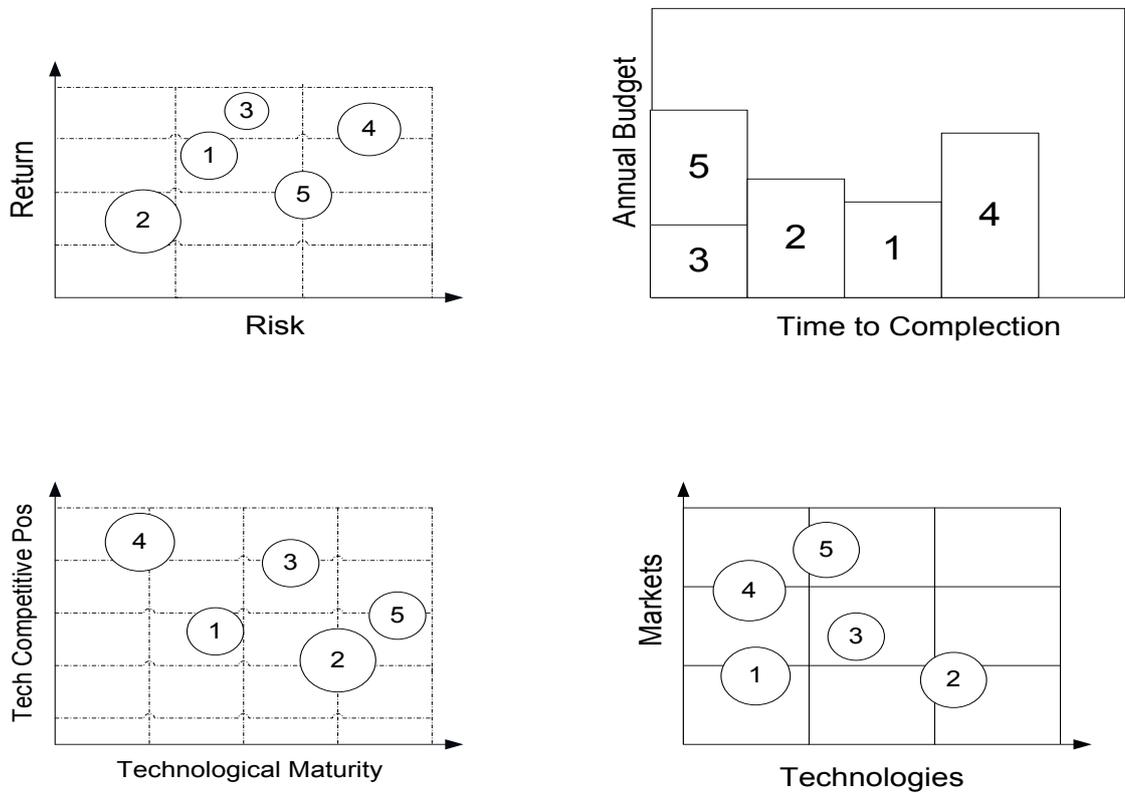


Figure 4: Different diagrams used in portfolio management [11].

Projects can be appraised against several objectives such as competitive position, impact, return, balance, timeframe and technology maturity, and many different diagrams can be used at the same time (e.g. Figure 2). Diagrams also offer the decision-maker a visual presentation of all the projects, their interdependencies, resource consumption and time [11].

### 3.1.3 Available software for PPM

Presently the amount of available software tools grows constantly, and it is impossible to maintain a complete and new list of suppliers and capabilities. There are more than 60 currently available tools in the marketplace. Some of them are presented below:

- 4c Portfolio Manager (General/ project scoring, modular, scalable/ client-server, web);
- Corporate Vision (IT, services/ planning, project & resource management/ web);
- Artemis 7 (IT, new products, gov/ project & resource management, scoring/ web);
- Augeo5<sup>TM</sup> PPM (IT, professional services, new products/ project visibility & control, scoring);
- Clarity<sup>TM</sup> (IT, new products/ project & resource management, modular, scoring/ web);
- PPM (IT, human resources/ project & resource management, alignment/ on-demand);
- EPS (R&D/ prioritization, customizable models/ web);
- Mariner<sup>TM</sup> (R&D, new products/ simulation, custom value models, risk analysis/ web);
- DPL Portfolio (General/ decision analysis modelling software with portfolio optimization)

The existing tools which are used for PPM differ in many ways, but all of them have a general feature: a database containing information about all projects. The objective is

to obtain a comprehensive view of projects and to make it easy to add, delete, and manage the different projects database. Portfolio management tools allow project data to be divided into blocks in different ways; it helps users to understand combinations of project and how project selection decisions affect that mix. Also almost of all software provide some project prioritization ability, but the quality of this ability differs substantially.

Many software programs are intended for certain industries and types of investments, while others have general goals. Specialized computer tools include models for estimating the benefits produced if the project is conducted.

### **3.2 TEXT MINING**

Text mining is a method for deriving high quality information from a set of unstructured textual data. In this regard, high quality information does not only include information that is relevant to the topic of communication, but also that which the user can understand.

#### **3.2.1 Process of text mining**

The process of text mining usually involves structuring the input text, generating trends within the structured data (text) and following estimation and explanation of the results (output). Figure 5 shows the text mining process. The results are typically produced in lists of tables, graphs, maps, documents, and charts. “High quality” in this method usually makes relation to some combinations of importance, newness, and interestingness [2].

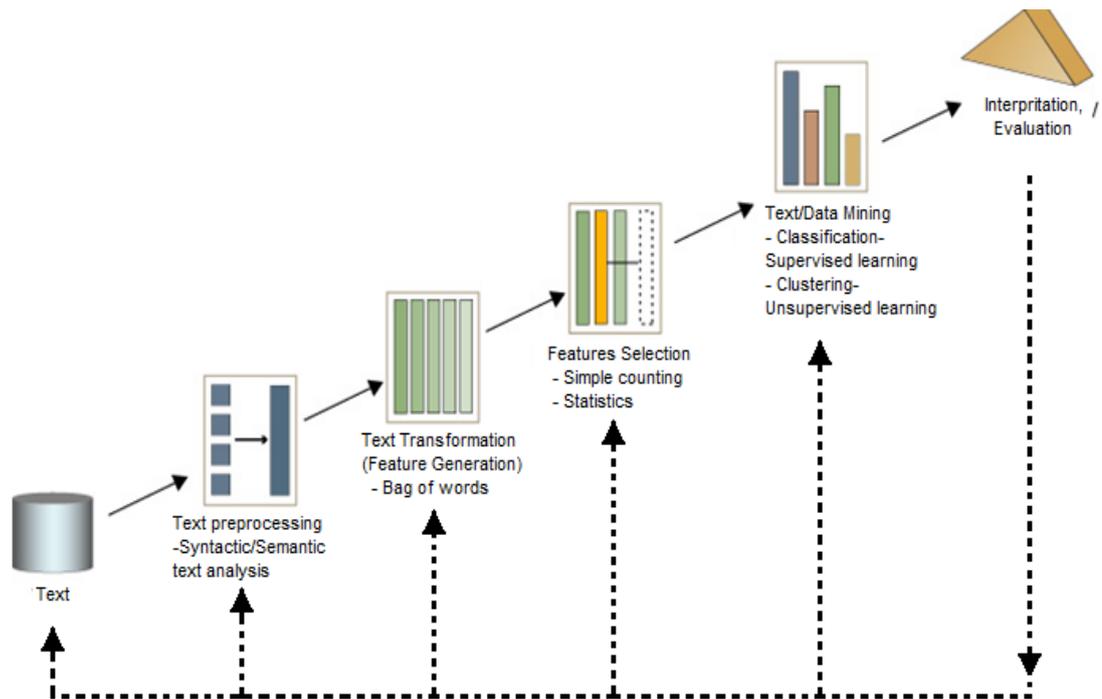


Figure 5: Text mining process [18].

There are several text mining data sources which include:

- 1) Structured bibliographic data sources (e.g., materials from database);
- 2) Unstructured text (for example full texts of documents and email messages);
- 3) Hybrid content (such as patents, where on the front page information is structured, but the rest text is not).

To facilitate the process of text mining, firstly the textual information is converted to numerical data. This transformation targeted at structuring the unstructured data and, therefore, the text mining methods will be similar to data mining after the text is converted to standard numerical forms. Data mining techniques apply the data in electronic tabulated form while text mining techniques is trying to see a document format and standard presentation for training option format called XML (Extensible Markup Language). A high degree of structured format for data is used to data mining method [3].

Data mining is an interactive process of creating predictive and descriptive models, by identifying previously unknown trends and patterns in large volumes of data across the enterprise, to support decision making. Text mining uses the same methods to analyze text-based documents. The information derived from text and data mining can be applied to realization strategic decision making.

Text mining and data mining have various information sources. Data mining concentrate on structured database of facts while text mining, patterns are often retrieved from natural textual language.

The text mining method has become useful in many applications and areas of interests and has adopted the variety of services (banking, security, commercials, job seeking, and marketing ect.). Text mining is becoming a very usable instrument for people who work with bulk information that can be obtained by indexing. This applies in scientific areas in which specific and important information is contained in the text.

### 3.2.2 Methods of text mining

In Table 4 text mining methods for analyzing quantitative and qualitative data from documents are presented.

Table 4: Methods of text mining

Method	Content of the method.
Information retrieval	The first step in text mining is to accumulate a set of relevant documents, which contain the necessary information. In general, these documents may be available or it may be necessary to carry out an initial search of these relevant documents prior to production. For example, a web page for your intranet search application clearly identifies relevant documents to web pages on the Internet [3]. When this occurs, since the document has already been determined, it is important to provide high quality of samples which are derived from the collection of data. Data sampling methods are used to select a

	<p>number of relevant documents, which are easy to work with, that happens in those cases when volume of data is very large. There is usually a source of these documents and user queries as a result of which took several documents that are relevant to the query.</p>
Information extraction	<p>The method is used to obtain certain information from a source of text documents as well as identify and correct inquiry. The request must be specific in order to discard the importance of information as to facilitate the processing of documents. An inquiry can be a word, combination of words or phrase which characterizes the information the user is looking for. Initially, it is necessary to determine the appropriate phrases and/or statements that contain the required information, then extract important information which is needed, and after that connect information and conclusions in a given form.</p>
Web mining	<p>Apply for detecting patterns from the Web. On the internet one can find a huge number of different and scattered information with little or no structure and thus makes web mining is difficult to implement. The information contained in internet is large, varied and scattered over the whole web with little or no structure and thus makes web mining a difficult task to accomplish. But there is key information which embeds in web pages and this has been found useful when the web is to be mined. Key information relates to specific information in web pages and this information will help to find web pages that are linked to each other. In addition, basic information helps in the classification of web pages. [4]</p> <p>Web mining uses the several approaches to extraction of structure data from internet. They are as follows: content mining which is mainly used to study information obtained by search engines and web spiders; structure mining studies information related to the construction of a website; usage mining is used to study information that concerns a specific user in web browser as well as information received from the</p>

	user can be presented in a web of transactions.[5, 19]
Clustering	Clustering is very important tool in identifying emerging research trends. It is a technique in which similar data objects are congregate into one group. If the data are arranged, some of its characteristics will be lost. In addition, one of the advantages in clustering is that it simplifies complex information or data. Using this technique, interesting structures or clusters can be detected directly from the data without relying on any background knowledge. Data clustering is useful in data mining, image analysis, in the field of machine learning, pattern recognitions, and bioinformatics.[2,18]

### **3.2.3 Text mining and visualization tools**

There are a lot of text mining and visualization tools available on the market to help in determination of concealed information about emerging technologies. Some of tools are presented in Table 5:

Table 5: Text mining and visualization tools [19].

No	Tool	Type of tool	Data sources	Capabilities
1	Omniviz	Visual-based data/text mining	Unstructured and structured information, chemical structures, numeric	Statistical analysis
2	Goldfire Innovator <sup>TM</sup>	Text mining	Unstructured personal data, patents, corporate data	Semantic analysis
3	TEMIS	Text mining	Structured and unstructured text from internet, email, patents	Natural language processing
4	RefViz <sup>TM</sup>	Text analysis and data visualization	Structured text from databases	Statistical and linguistic analysis
5	Quosa <sup>TM</sup>	Text mining based on clustering/extraction	Unstructured and structured materials from patents, internal documents	Statistical analysis
6	Vantage Point	Text mining	Structured information from bibliographic areas	Pattern matching
7	Aureka	Text mining and database provider	Patents from MicroPatent database	Statistical and keyword analysis

These various tools are premised on standard methods of analysis and major difference in their ability to use various sources of data and visualization in different ways (tables, graphs, matrices, and charts). Some of these tools were used in this work.

## **4. VISUALIZATION OF NETWORKS IN SCIENTIFIC PUBLICATIONS**

### **4.1 OmniViz**

OmniViz Inc. was founded in 2000 as a subsidiary of Battle Memorial Institute. The company proposed a number of visualization and resolution support products to the life science, chemical industries and healthcare [22].

OmniViz is an advanced visual informatics computer program which is designed to provide visualization of categorical data (e.g., structure descriptors or functional classification), numeric data (e.g., screening assay results), chemical structures, genome sequences (protein or nucleic acid), and text documents. Certain of this data can be applied in high-dimensional vector images. Other categories of data may take for definition of specific characteristics or descriptors, resulting in the generation of a new collection of attributes. The program can work with very large samples of data. OmniViz uses some of largely known visualization techniques which are presented on Figure 6.

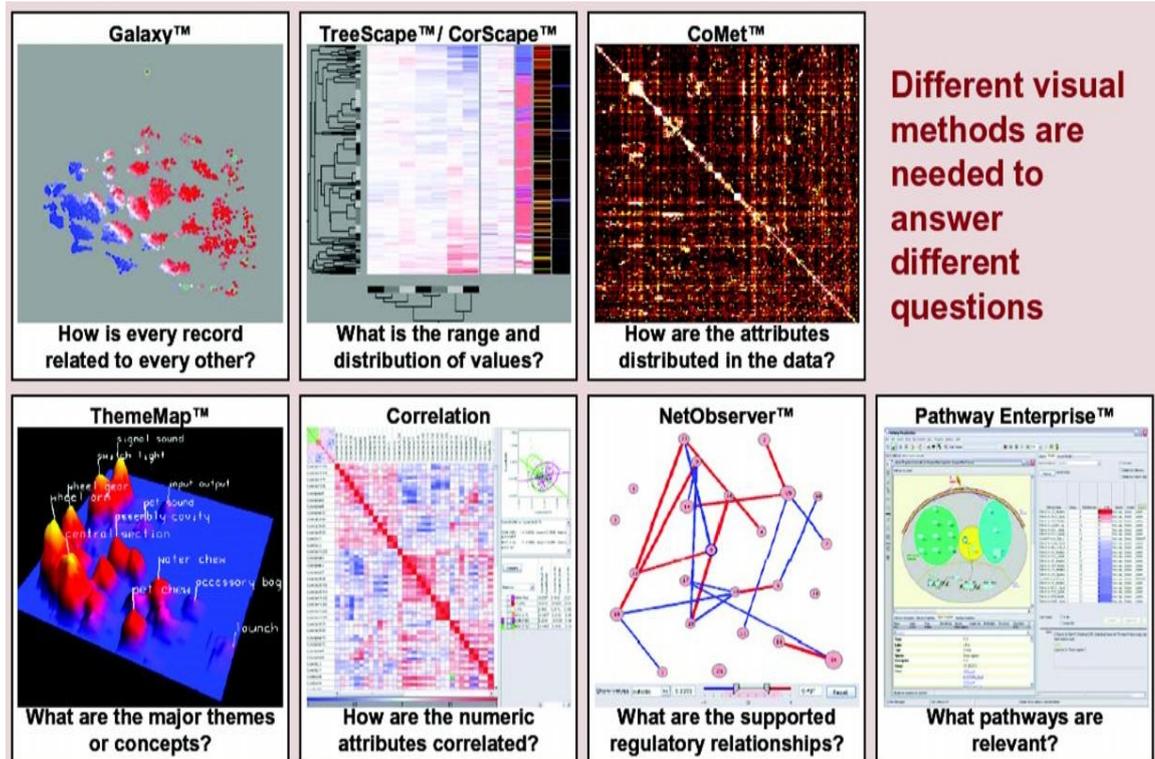


Figure 6: OmniViz multiple visualization techniques [24].

Its key advantage is that all data kinds can be visualized and analyzed together. To investigate the full range of connections within data the program permits to use of different visualizations and tools in connection with one another.

OmniViz is originally concentrated on visualization methods for viewing the results of analysis. To the areas in which the program can be applied include the following: research and development, field trials, clinical trials, finance, marketing, and others.

## 4.2 RefViz™

In 2003 OmniViz and Thomson Research Soft announced a data visualization and analysis tool RefViz™, specifically designed to help users to find major topics and themes in bibliographic references. It has potentialities to execute linguistic and statistical analysis.

RefViz™ is text analysis and visualization software which deal with structured data, such as titles, abstracts from databases or bibliographic information from ProCite, Reference Manager and EndNote.

The Reference Retriever™ is a key feature of RefViz™ which can be used to search online sources at the same time; it will identify and retrieve the relevant references in each data source and automatically create a visual analysis and presentation. The references can be analyzed by thematic content. In the program documents are arranged in thematic content and presented in two interactive visualizations that assist identification of main areas and themes of interests. The software minimizes the loss of important information because it uses advanced literature search. [19, 22]

#### **4.2.1 Running RefViz™**

The program free trial version can be downloaded from [www.refviz.com](http://www.refviz.com), double click to launch the RefViz™ installer. The trial mode allows using all features for 30 days.

To start RefViz™, choose Programs-RefViz from the Start menu. Open New View dialog appears. Figure 7 shows the RefViz user interface which is consists of four panels:

- the visualization window (upper-left panel);
- the keyword analysis window (upper-right panel);
- the reference window (lower-left panel);
- the advisor is in the lower-right panel.

#### **4.2.2 Loading data and visualization**

Before working with RefViz it is necessary collect the data. For this Elsevier database and Paperbase/PIRA (CSA) has been used. Information which is used by program includes title, authors, and abstract, year of publication, and references. Each data file should have “.txt” as the extension.

The main point of work RefViz is to divide a set of bibliographic data into topic groups. The program organizes electronic data using the following process: reading the contents, finding word, patterns and their associations, dividing the set of data into groups based on subject matter, and also arranges the resulting stacks according to subject matter. The results from RefViz™ are Galaxy and Matrix visualizations; they provide a perspective of the information content in a bibliographic collection. [22, 25]

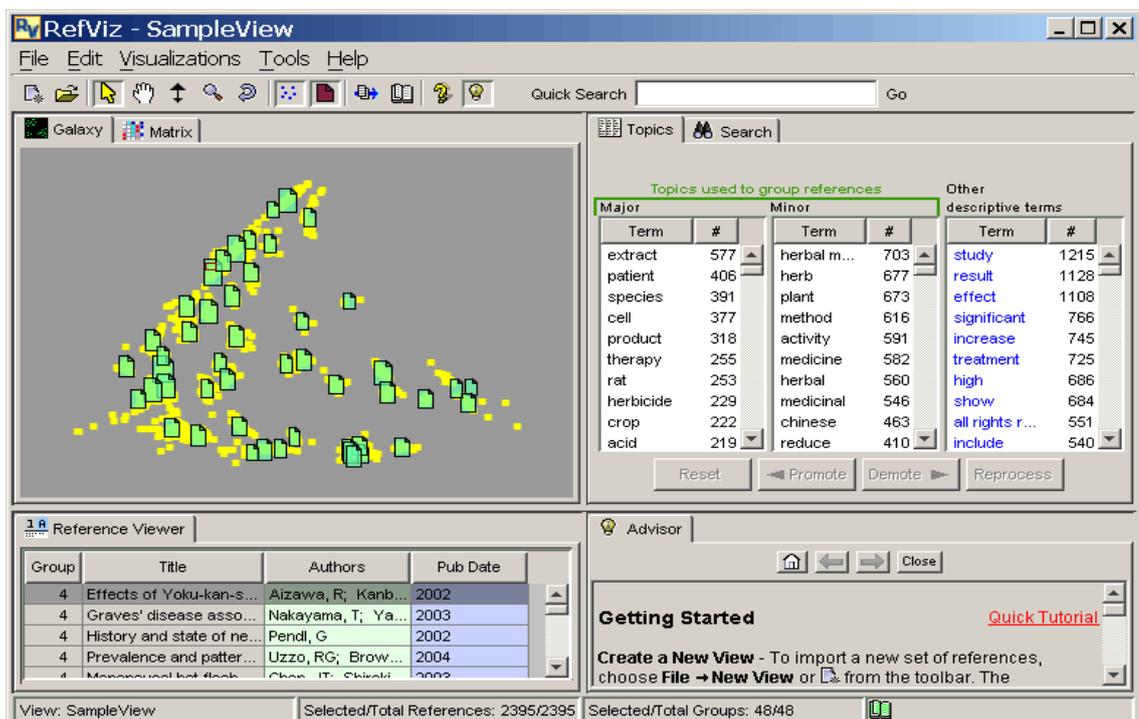


Figure 7: RefViz user interface [25].

## Galaxy™

The Galaxy™ visualization allows exploring thematic relationships in reference collection. Records are concentrated into groups based on the resemblance of words. In visualization each paper icon represents a group of references and each point a single reference. The software has several ways to select records in the Galaxy: use quick search; mouse click on individual items; click on group icons to select the group and all references that are part of that group. Selected points appear in the reference window information about the group, including 3 terms that help represent it and

differentiate it from the other groups, the group number and the number of references in the group.

### MatrixTM

The MatrixTM is a two-dimensional representation of the correlations between groups and concepts. The Matrix visualization can be used for inspect reference set in the following ways [25]:

- a quick review of the main concepts discussed in the group;
- considering topics that discussed together in the literature;
- understand the agreement and association between concepts.

Particularly, the MatrixTM can be combined to represent associations between the reference groups and their major topics or to represent the co-occurrence of major topics with other major topics in the references.

Figure 8 shows how the Matrix visualization window looks like. Visualization has rows, which represent the same groups observe in the Galaxy and columns represent the major topics. The color of cell indicates the importance of the association: red means the most important and interesting information to the group; blue – columns major theme occurs seldom or at all does not occur in the group; white shows that is no essential association between major theme and group in various directions [25].

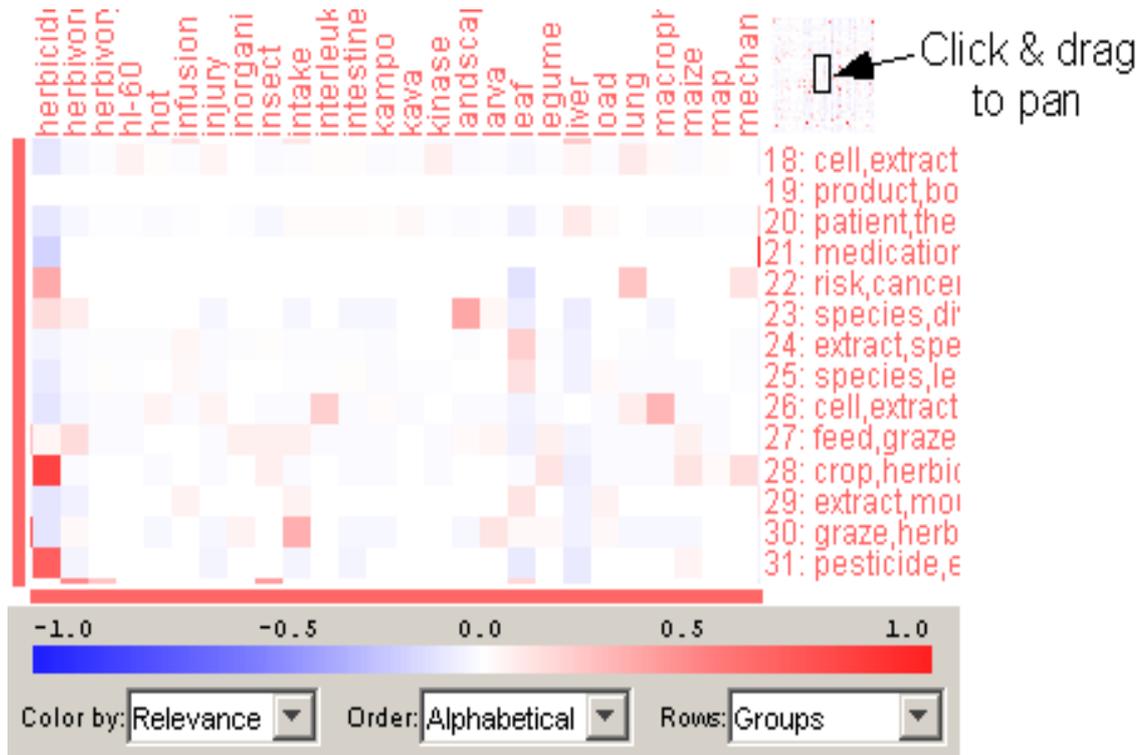


Figure 8: Matrix visualization window. [25]

There are two problems which RefViz should resolve: the bibliographic records are too short as a source of information and the keywords vocabulary to be too large. However, the program is actively used and number of potential users is growing rapidly. If program can improve its techniques and keep its unique market position, it shows that its full potential can be opened in the near future.

### 4.3 CiteSpace

CiteSpace is a publicly available java application for analyzing and visualization scientific literature. It was developed by Chaomei Chen in 2004. The goal is to find and visualize trends in scientific articles which help the analysis of emerging trends in a knowledge domain [22, 23].

### 4.3.1 Data collection

Before working with CiteSpace it is necessary to collect the data. For this has been used ISI Web of Science database. Information which is used by program includes title, authors, and abstract, year of publication, cited references, descriptors, identifiers and number of times cited (see Figure 9).

<p><b>AU</b> Galea, S Ahern, J Resnick, H Kilpatrick, D Bucuvallas, M Gold, J Vlahov, D</p>	<p><b>TI</b> Psychological sequelae of the September 11 terrorist attacks in New York City.</p>	<p><b>SO</b> NEW ENGLAND JOURNAL OF MEDICINE <b>LA</b> English <b>DT</b> Article</p>	<p><b>ID</b> POSTTRAUMATIC-STRESS-DISORDER; NATIONAL COMORBIDITY SURVEY; MAJOR DEPRESSION; NATURAL DISASTER; SOCIAL SUPPORT; OKLAHOMA-CITY; PREVALENCE; PSYCHOPATHOLOGY; SURVIVORS; SYMPTOMS</p>	<p><b>AB</b> Background: The scope of the terrorist attacks of September 11, 2001, was unprecedented in the United States. We assessed the prevalence and correlates of acute post-traumatic stress disorder (PTSD) and depression among residents of Manhattan five to eight weeks after the attacks. Methods: We used random-digit dialing to contact a representative sample of adults living south of 110th Street in Manhattan. Participants were asked about demographic characteristics, exposure to the event on September 11, and psychological symptoms after the attacks. Results: Among 1008 adults interviewed, 7.5 percent reported symptoms consistent with a diagnosis of current PTSD related to the attacks, and 9.7 percent reported symptoms consistent with current depression (with "current" defined as occurring within the previous 30 days). Among respondents who lived south of Canal Street (i.e., near the World Trade Center), the prevalence of PTSD was 20.0 percent.</p>	<p><b>CI</b> New York Acad Med, Ctr Urban Epidemiol Studies, New York, NY 10029 USA. Columbia Univ, Mailman Sch Publ Hlth, Dept Epidemiol, New York, NY USA. Med Univ S Carolina, Natl Crime Victims Res &amp; Treatment Ctr, Charleston, SC 29425 USA. Schulman Ronca &amp; Bucuvallas, New York, NY USA. Bellevue Hosp Ctr, New York, NY 10016 USA.</p>	<p><b>RP</b> Galea, S, New York Acad Med, Ctr Urban Epidemiol Studies, Rm 556, 1216 5th Ave, New York, NY 10029 USA.</p>	<p><b>CR</b> 2001, NY TIMES 1226, B2 *AM PSYCH ASS, 1994, DIAGN STAT MAN MENT *DEP HLTH HUMAN SE, 1999, MENT HLTH REP SURG G *US BUR CENS, 2000, STF3A DEP COMM BUR C</p>	<p><b>BLAZER</b> DG, 1994, AM J PSYCHIAT, V151, P979 <b>EATON</b> L, 2001, NY TIMES 1116, A1 <b>FOTHERGILL</b> A, 1999, DISASTERS, V23, P156 <b>FULLERTON</b> CS, 1999, AVIAT SPACE ENVIR MD, V70, P902 <b>GINEKI</b> EM, 2000, AM J COMMUN PSYCHOL, V28, P495 <b>GOENJIAN</b> AK, 2001, AM J PSYCHIAT, V158, P788 <b>GREEN</b> BL, 1990, J APPL SOC PSYCHOL, V20, P1033 <b>HANSON</b> RF, 1995, J CONSULT CLIN PSYCH, V63, P987 <b>HARVEY</b> AG, 1999, J CONSULT CLIN PSYCH, V67, P985 <b>KAWACHI</b> I, 2001, J URBAN HEALTH, V78, P458 <b>KESSLER</b> RC, 1995, ARCH GEN PSYCHIAT, V52, P1048 <b>KILPATRICK</b> DG, 1987, CRIME DELINQUENCY, V33, P479 <b>MADAKASIRA</b> S, 1987, J NERV MENT DIS, V175, P286 <b>MAZURE</b> CM, 2000, AM J PSYCHIAT, V157, P896 <b>NORTH</b> CS, 1999, JAMA-J AM MED ASSOC, V282, P755 <b>ORTEGA</b> AN, 2000, AM J PSYCHIAT, V157, P615 <b>POLE</b> N, 2001, J NERV MENT DIS, V189, P442 <b>RESNICK</b> H, 1999, J ANXIETY DISORD, V13, P359 <b>RESNICK</b> HS, 1993, J CONSULT CLIN PSYCH, V61, P99 <b>ROTHBAUM</b> BO, 1992, J TRAUMA STRESS, V5, P455 <b>RUBONIS</b> AV, 1991, PSYCHOL BULL, V109, P384 <b>RUEF</b> AM, 2000, CULTURAL DIVERSITY E, V6, P235 <b>SHAH</b> B, 1997, SUDAAN USERS MANUAL <b>SHALEV</b> AY, 1998, AM J PSYCHIAT, V155, P630 <b>SHALEV</b> AY, 2000, J CLIN PSYCHIAT, V61, P33 <b>SHERBOURNE</b> CD, 1991, SOC SCI MED, V32, P705 <b>SHORE</b> JH, 1989, J NERV MENT DIS, V177, P681 <b>TUCKER</b> P, 2000, J BEHAV HEALTH SER R, V27, P406</p>	<p><b>NR</b> 32 <b>TC</b> 179</p>	<p><b>PU</b> MASSACHUSETTS MEDICAL SOC/NEJM <b>PI</b> WALTHAM <b>PA</b> WALTHAM WOODS CENTER, 860 WINTER ST., WALTHAM, MA 02451-1413 <b>USA</b> <b>SN</b> 0028-4793 <b>J9</b> N ENGL J MED <b>J1</b> N. Engl. J. Med. <b>PD</b> MAR 28 <b>PY</b> 2002</p>	<p><b>VL</b> 346 <b>IS</b> 13 <b>BP</b> 982 <b>EP</b> 987 <b>PG</b> 6 <b>SC</b> Medicine, General &amp; Internal <b>GA</b> 534UY <b>UT</b> ISI:000174608600006 <b>ER</b></p>
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Figure 9: Information of a bibliographic record which is CiteSpace used: A-autors; B- abstract, title, descriptors, identifiers; C- cited references; D-times cited; E- year of publication. [20].

The input to CiteSpace is a collection of bibliographic data files in the field-tagged ISI Export Format. Each data file needs to start with “download” in its name and “.txt” as the extension (for example “download2009\_wastepaper38.txt”). The result should be saved in a folder because program cannot work with results which are saved in ordinary files. The outputs of Citespace can be including visualized co-citation network, document co-citation networks, co-occurring keywords and identifiers, journal co-citation network, co-authors and countries network. Each network is present in individual interactive window interface.

#### **4.3.2 Access to the CiteSpace**

CiteSpace can be run in two ways [21]:

- Downloading the demo from official website through the link <http://cluster.cis.drexel.edu/~cchen/citespace>
- WebStart (can be run directly from the same link and here everywhere the the latest version used).

CiteSpace have two main interface elements: main window and visualization window. Figure 4.2 shows the main window which is used for indicating the data and analysis. The second element is used for displaying visualization of a knowledge domain (see Figure 10).

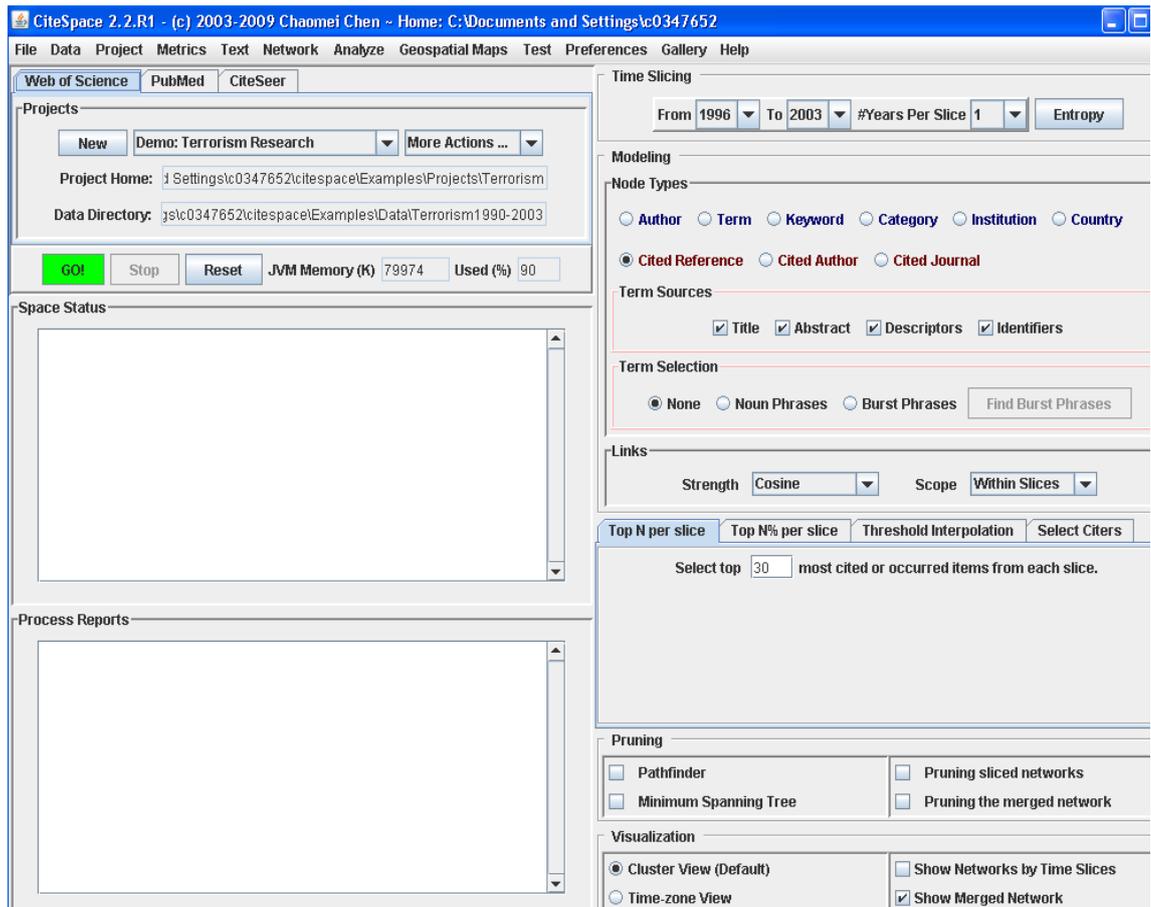


Figure 10: Main CiteSpace interface [21].

### 4.3.3 Running data in software

The next step after retrieving data from the Web of Science is to load this result into program. For this it is necessary to create a new project. There is a need to specify 2 directories: new data directory and project home, where there are saved images and other files generated by CiteSpace relating to new project. After creating the project you can choose the period of time with which you want to work, the node basis for analysis, arrange the threshold.

After selecting all the parameters, press the “Go” button. In the main CiteSpace interface you can see the number of nodes and links in the created network. New visualization window (Fig.11) appears when processing is completed.

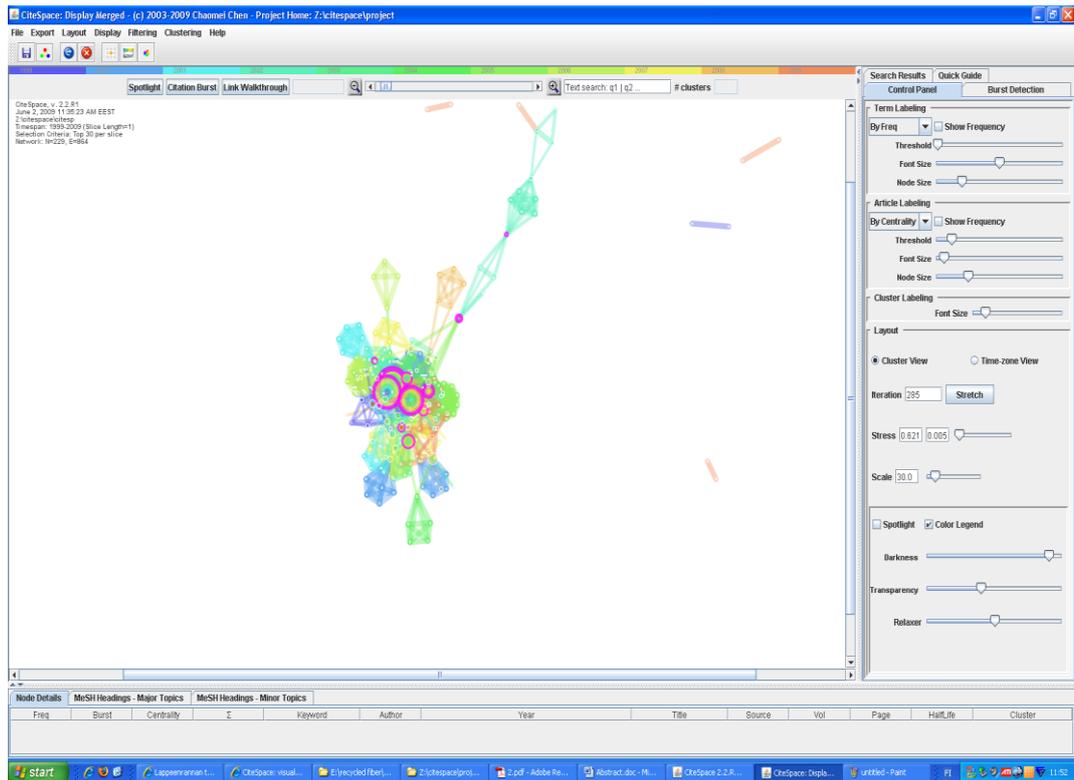


Figure 11: CiteSpace visualization window [21].

The analysis can be done many times with different thresholds and/or node parameters. For example, the number of times articles can be co-cited, but previously they could belong to a fixed cluster determine the thresholds frequency. Also the node and front size can be changed (increase or decrease). The current parameters and images can be saved after work.

## **5. RESULTS**

### **5.1 Problem formulation**

In this chapter the results of research work, which objectives are discovering of emerging research issues and presenting the new approaches to identify promising research themes in recovered paper application and production are describe. Different ways to obtain information in order to achieve the aims were discussed. There are two computer programs: RefViz and CiteSpace used in this work for visualization information from scientific literature. The main source of information which this work founded on is scientific papers.

The information search was carried out within the scientific papers associated with waste paper production and application. These documents were obtained from the ISI Web of Science database (for CiteSpace) and Paperbase/PIRA (CSA) database (for RefViz). CiteSpace could not analyze the data directly from the Paperbase/PIRA (CSA) that is why was conducted a further search in Web of Science. The keywords for search were “recycled paper”, “waste paper”, “recycled fiber”, “deinked pulp”. In order reduce the volume of articles, the search concentrate on articles, which were published between 1999 and 2009.

### **5.2 RefViz visualization**

A few visualization images were received with help of RefViz. The results are presented in Galaxy visualization (see Appendix I). The Galaxy visualization is an on line set of data which allows analyzing thematic relationships in reference collection. The Galaxy is a proximity map that is representing how references or groups of references that are near each other are related. This results in a logical flow of one concept to another across the Galaxy. [25]

The result of images analysis was compiled the tables. The groups, marked with the blue color are the groups among which the probable areas of emerging research trends were determined. For every table different keywords were used.

1) Keywords: recycled paper (1458 articles)

Table 6: The results of the computer program RefViz (keywords: recycled paper)

Basic existing areas			Potential interesting areas
Group	References	Top Topics	
27	133	mill pulp fiber	1) Hybrid-filler filled polypropylene/ (natural rubber) composites: Effects of natural weathering on mechanical and thermal properties and morphology. 2) Food-contact paper board based on recycled fibers: regulatory aspects: new rules and guidelines. 3) Removal of soft and flexible contaminants from recycled paper, in screens. 4) -Schongau PM9: installation of modern technologies for SC (B) paper making from 100% deinked pulp. - The deinking plant of the new PM3 of Haindi papier. 5) –Enhancement of the strength and flame-retardant properties of hand sheets made from deinked pulp. -Absorption abilities of paper, made from recycled paper. 6) –Direct mail target is 55% recycled: new targets for using recycled paper.
14	92	waste product process	
22	85	fiber pulp process	
21	83	mill machine capacity	
32	79	print waste UK	
6	71	product package fiber	
4	67	pulp process mill	
28	67	environmental waste energy	
34	59	waste industry market	
18	59	environmental forest print	
26	55	industry board consumption	
5	52	machine mill market	
29	52	recover price export	
33	49	product package environmental	
19	49	process water mill	
36	39	mill recover market	
10	33	corrugated package board	
3	33	board market corrugated	
23	33	print market ink	
7	32	machine fiber pulp	
9	28	market price product	
8	27	property strength fiber	
20	23	package food board	
11	18	European industry recover	
16	15	price recover export	
37	10	plant sludge power	
35	7	matussiere forest voiron	
13	5	emission fuel energy	
12	5	Forest FSC print	
1	5	machine Voith newsprint	
24	4	environmental magazine	
30	2	ink decrease aluminum	
25	1	target screen recyclable	
2	1	wrap surface property	

Analyzing data which is presented in this table, we can say that the main trends are those aimed to improve the quality of recycled paper and its products. Also there is an increase of the proportion of waste paper in composition of paper and paperboard and development of paper making technologies from 100% deinked pulp. The one of important aspect for this is a technology of ink removal which has improved continuously and can produce a deinked pulp with better mechanical strength properties and higher brightness than primary pulp.

2) Keywords: recycled paper, waste paper, recycled fiber (140 articles)

Table 7: The results of the computer program RefViz (keywords: recycled paper, waste paper, recycled fiber).

Basic existing areas			Potential interesting areas
Group	References	Top Topics	
10	27	pulp waste process	<p>1) –Drying conditions influence the physical properties of recycled paper.            -New approach to paper recycling.            - The quality of wastepaper and technological problems in its processing.            -Refining optimization of secondary fiber: use of Bijective Diagram technique.</p> <p>2) –Recovered paper quality declines as industry pushes higher use rate.            -Machine sorts waste paper.</p> <p>3) –Waste related with recovered paper processing: waste or valuable material.</p>
8	24	recycle waste fiber	
9	23	waste production material	
5	16	recycle waste production	
2	12	process ink recycle	
7	9	property water recycle	
4	8	recover quality sort	
11	7	pulp process deinked	
3	7	recover Europe grade	
6	1	wood water waste	
1	1	waste strength screen	

Table 7 shows that in scientific literature much attention is paid to the properties and quality of recycled paper.

3) Keywords: deinked pulp (310 articles)

Table 8: The results of the computer program RefViz (keywords: deinked pulp).

Basic existing areas			Potential interesting areas
Group	References	Top Topics	
17	40	pulp deinked mill	<p>1) Measurement nature and removal of stickies in deinked pulp.</p> <p>2) –Bleaching of deinked pulp: efficiency and limitation. –Strategies to control a deinking plant at optimum cost. –A new method of bleaching and color stripping for recycled fiber.</p> <p>3) Electronic commerce for recovered paper.</p> <p>4) –Biomethanation technology: an option for treatment of effluent generated in recycled fiber based mills. –Production of electric power from deinking sludge.</p>
12	34	pulp deinked fiber	
11	31	recycle fiber process	
10	29	line pulp deinked	
14	29	pulp deinked brightness	
7	23	deinked pulp dip	
3	22	pulp process deinked	
2	20	pulp deinking deinked	
9	16	recycle mill pulp	
13	14	recycle material fiber	
16	11	stickies pulp recycle	
5	9	water mill fiber	
8	8	recycle fiber property	
4	5	ink pulp print	
6	4	recover tab industry	
15	4	recycle print production	
1	3	screen operation size	

One of the biggest technical difficulties in using secondary fiber in paper production is stickies. They cause problems with the products quality, such as specks and holes in paper, and also runnability problems (for example sheet breaks). All of these problems cause lost of production and high cost for manufacturer. For this reasons, removal of stickies can be attributed to possible emerging trends. The properties of papers which are produced from waste paper depend on the quality of raw material, its composition, and degree of purification in the various processes in the deinking factory. Maintaining stocks of training in good order and optimal operating conditions is an important factor in a market competition, and appropriate methods of assessment are therefore essential to control deinking processes. The requirements of consumers for recycled paper are increased. Considering the growing demand for quality of paper manufactures develop and optimize the deinking process as well as the products from this process. It is so much promising area that will be interesting in future.

4) Keywords: waste paper (791 articles)

Table 9: The results of the computer program RefViz (keywords: waste paper).

Basic existing areas			Potential interesting areas
Group	References	Top Topics	
20	75	waste process fiber	<p>1) –Modification of paper properties by the pretreatment of wastepaper pulp with <i>Graphium putredinis</i>, <i>Trichoderma harzianum</i> and <i>fusant xylanases</i>.                      - Concepts of recovered paper preparation for packaging papers.                      -Application of steam explosion deinking technology to wastepaper.                      –Removing adhesives and dirt in reprocessing of wastepaper.</p> <p>2) –Pre-concentration and separation of heavy metal ions by chemically modified wastepaper gel.                      -Pore structure and adsorption properties of activated carbon prepared from granular molded waste paper.                      -Recycling printed paper. An evaluation of the deinking process.                      -Pioneer in production of climate neutral recycled paper.                      - Deflaking, deflocculation and refining in the area of recovered paper processing.</p>
3	64	recycle waste environmental	
12	53	recycle waste mill	
21	41	recycle process recover	
5	39	waste recycle industry	
6	38	recycle fiber property	
11	36	recover recycle mill	
17	33	recover market recycle	
14	32	process pulp waste	
22	30	UK recover consumption	
7	29	recover industry recycle	
10	25	recover stock UK	
16	24	waste rate ph	
19	23	recover price old	
25	22	pulp wastepaper bleach	
15	20	recover old occ	
23	19	recover price mill	
18	16	recover market European	
4	14	recover price market	

13	14	recover export China	3) –Influence of recovered paper furnish in deinking. - Cultivation of oyster mushroom and newsprint properties on waste paper with some added supplementary materials. 4) -Recycled paper thick and light enough for package cushioning. - New recycled-fiber technology to increase production capacity of fluting. 5) –BAT-Best Available Techniques in papermaking from recovered paper. -Improving the efficiency of recovered paper screening or how to control stickies effectively. -New screening systems with fine sots and stickies reduction in a white recycled paper line.
1	9	recover price producer	
24	6	process screen fine	
2	2	surface recycle print	
9	2	wastepaper recovery rate	
8	1	waste paper waste trade	

Fermentative treatment in the pulp and paper industry has become more and more interesting topic over the past few years. Enzymes are used in: wood debarking, pitch control, biobleaching, biopulping, deinking, effluent treatment and modification of recycled fiber. Technologies which enzymes use look very promising. Advantages include reduction of energy consumption, the environmental conservation, reducing costly virgin fiber usage (i.e. by using more recycled fiber).And again property improvement of recycled paper, deinking process, stickies removal.

Summarizing data that was obtained, it can be said that improving the quality and properties of recycled paper and its products, ink and stickies removal, enzyme treatment can be emerging research trends in recycled paper processing.

### 5.3 CiteSpace visualization

Citespace was used in this work to build a network; this application shows clusters of networks which enhances the identification of possible research trends between major clusters. The network of keywords helps to identify emerging themes which focus on scientific researchers in the field of recycled paper processing. Also the cluster of network presents the authors and their publications regarding waste paper production and application.

The following conditions and parameters were used for analysis:

- Keywords for search in Web of Science are “recycled paper”, “waste paper”, “recycled fiber”, “deinked pulp”;
- Was found 333 articles;
- Time slicing in computer program is from 1999 to 2009;
- Years per slice are “1”;
- For search were selected the following node types: “Keyword”, “Cited Reference”, “Cited Author”, and “Cited Journal”;
- Term sources are “Title”, “Abstract”, “Descriptors”, and “Identifiers”;
- Term selection is “None”;
- Strength was set to “Cosine”;
- Thresholding is as follows: 2, 2, 20; 4, 3, 20; 3, 3, 20;
- Visualization was set to “Cluster View (Default)”.

The images that were obtained are shown in Appendix II. Basically, the work was done with the keywords visualization network, because the rest were not so informative for the research work (for example, cited references and authors are old publication). The keywords network helps to determine the most interesting themes which the researchers focus on. Analysis of keywords may help to determine the most

frequently used words or phrases within a certain period of time, as shown in Appendix II (2.1).

There are a few disadvantages related to using keyword analysis as a tool for detecting research trends: a wide range of different words that may not have concerted meanings; group formed from combinations of diverse words provide a variety of meanings. Very often, it is important for most users to know the frequently used terms, and conditions that lead to new developments in the field of innovation. Generally, terms that could condition the environment for creation of new trends may be silenced for more familiar term.

Based on the data which are obtained the potential trends can be following:

- Enzymes treatment (9 nodes);
- Deinking chemistry (flotation (9 nodes));
- Improving properties of recycled paper (strength, brightness (11 and 8 nodes correspondingly));
- Composites (5 nodes);
- Surface chemistry, retention aids (3 and 5 nodes correspondingly).

Of course, these areas are actively researched at present time and may also be promising in the future.

Table A (see Appendix III) shows the most interesting articles about enzymes treatment. The number of possible applications of enzymes in pulp and paper industry has grown rapidly. These include contaminant removal and fibrillation of recycled fibers; enzymatic bleaching; freeness enhancement. Enzymes treatment is also associated with other turning points- improving strength properties of recycled fibers (Table C) and surface chemistry (Table D). Also studies in deinking process can be attributed to the emerging research trends. All trends which were selected are interconnected with each other.

## 6. CONCLUSION

The objectives of this thesis are discovering the emerging research issues and presenting the new approaches to identify promising research themes in recovered paper application and production.

The researches of scientific literature have shown that recycled paper has become the most important raw material for the paper and board production. At the present time problems connected with usage of waste paper are very relevant and each stage of processing may be potentially interesting for research.

Based on the content of this work and the results obtained, it could be suggested that the improving the quality and properties of recycled paper and its products, ink and stickies removal, enzyme treatment can be emerging research trends in recycled paper processing.

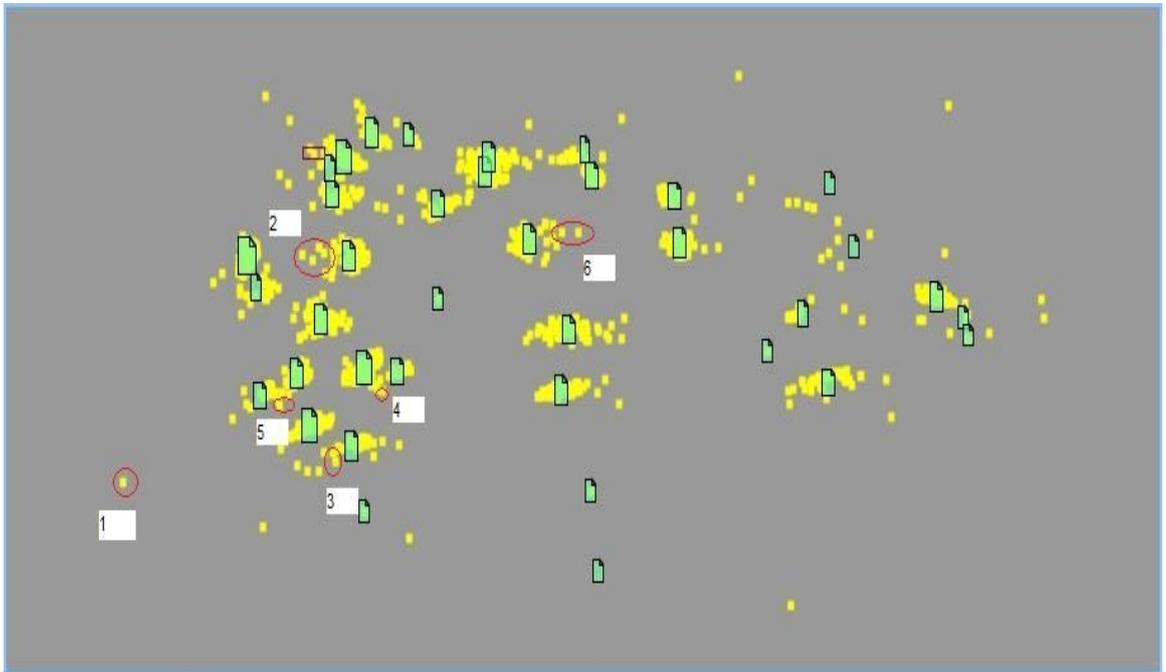
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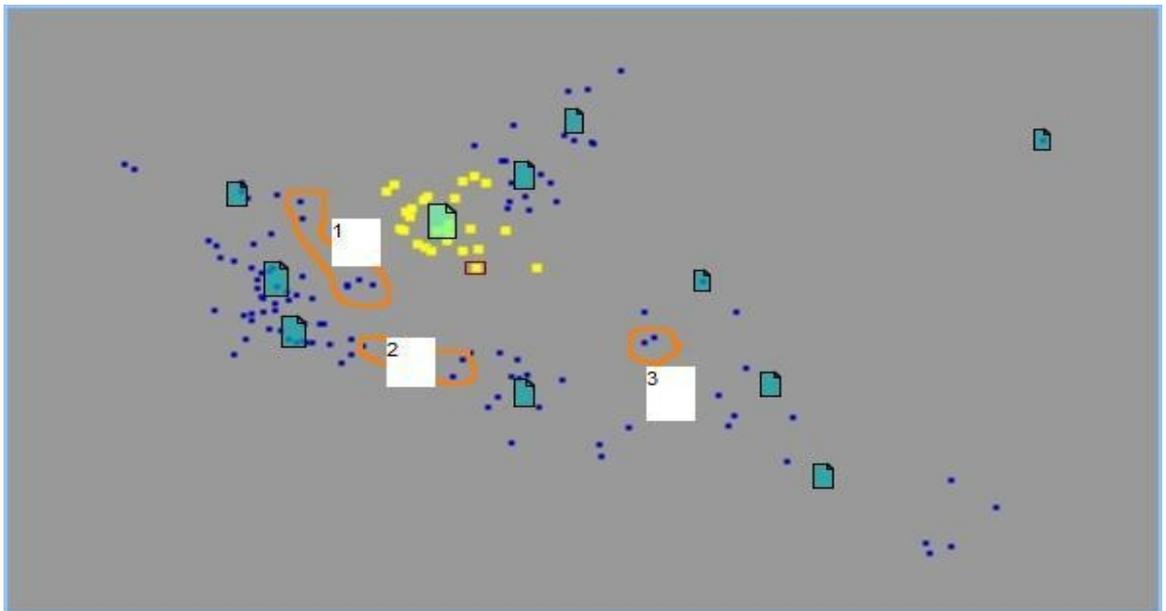
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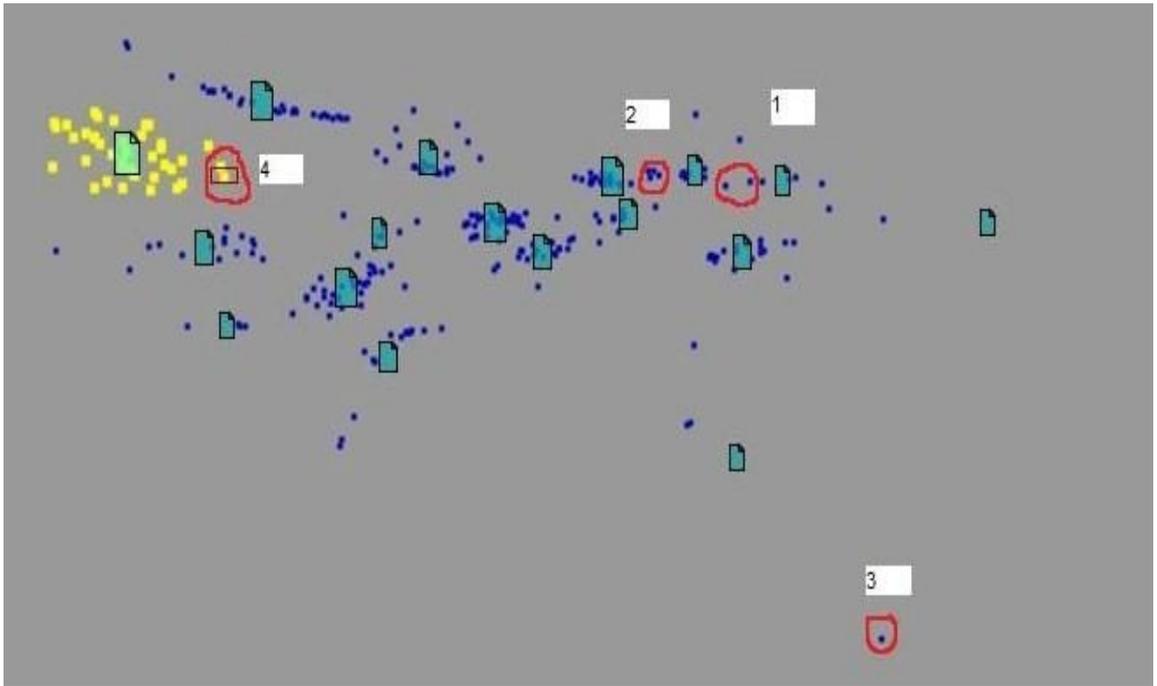
**APPENDIX I: The results from RefVizTM (Galaxy visualizations)**



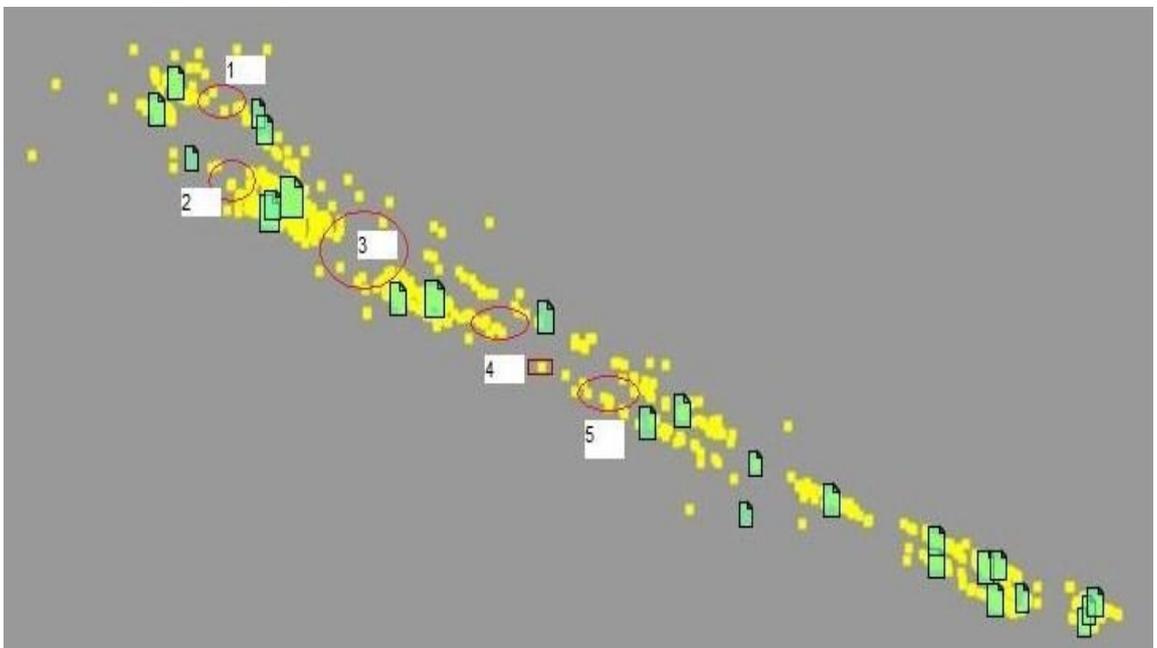
View1.1: Keywords: recycled paper (1458 articles)



View 1.2: Keywords: recycled paper, waste paper, recycled fiber (140 articles)



View 1.3: Keywords: deinked pulp (310 articles)

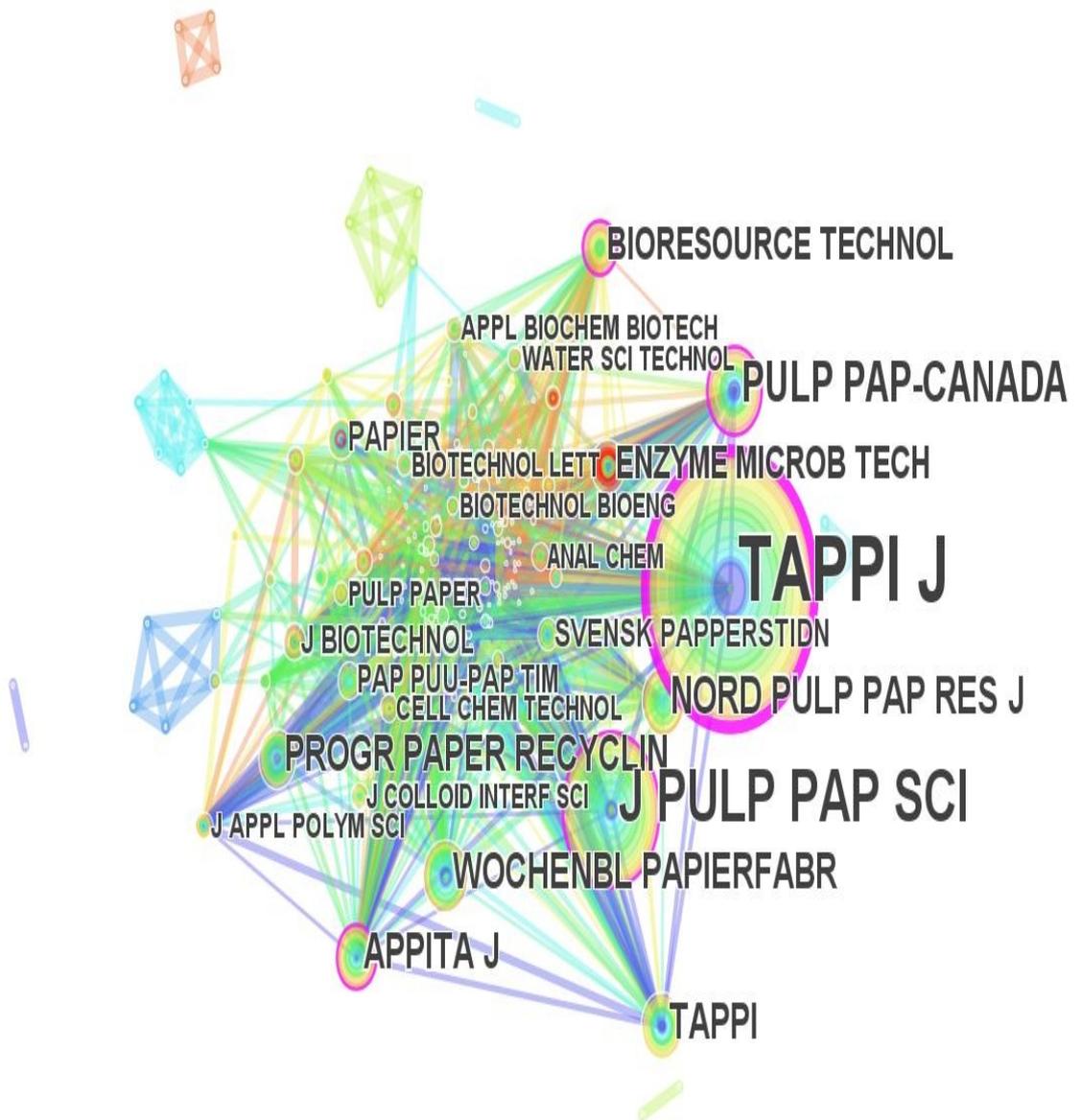


View 1.4: Keywords: waste paper (791 articles)





## 2.2 Cited Reference network



2.3 Cited journal network



## 2.4 Cited author

### APPENDIX III: Network of article citation

Table A: Enzyme treatment

N°	Title	Authors	Abstract	Bibliography
1	Chemical characterization of pulp components in unbleached softwood kraft fibers recycled with the assistance of a Laccase/HBT system	da Silva, Thiago Alessandre,  Mocchiutti, Paulina,  Zanuttini, Miguel A,  Ramos, Luiz Pereira	Oxidative treatments, without and with assistance of a Laccase-Mediator System (LMS), were characterized in relation to their effects on the chemical composition and strength properties of the fibrous fraction of an unbleached recycled softwood kraft pulp. Control treatments adding neither the enzyme nor the mediator were also considered. The LMS treatment caused a partial reversion of the detrimental effects of hornification. These observations were useful to explain why LMS-recycled fibers produce handsheets with 9.4% better tensile strength than the control pulps.	BIORESOURCES  <b>Volume: 2</b>  <b>Issue:4</b>  <b>Pages: 616-629</b>  <b>Published: NOV 2007</b>
2	Improvement of the fiber-bonding capacity of unbleached recycled pulp by the Laccase/Media	Mocchiutti, Paulina,  Zanuttini, Miguel,	The authors studied the oxidative and delignifying effects of the <i>Trametes hirsuta</i> laccase-HBT (1-hydroxylbenzotriazole) system (LMS) on the papermaking properties of an unbleached recycled	TAPPI JOURNAL  <b>Volume: 7</b>  <b>Issue: 10</b>  <b>Pages: 17-22</b>  <b>Published: OCT</b>

	tor Treatment	Kruus, Kristiina,  Suurnakki, Anna	softwood kraft pulp. The effects of pulp washing with a non-ionic surfactant (Tween 20) as a way to recover the enzyme and the effects of a final alkaline treatment were also analyzed. Compared with the control treatment, the LMS treatment reduced the kappa number of the pulp by 8% and increased fivefold the number of radicals as analyzed by electron spin resonance. The LMS treatment also increased the light-absorption coefficient by 19%, suggesting that the fibers were oxidized. Alkaline treatment subsequent to the LMS treatment did not produce additional delignification and slightly decreased the light-absorption coefficient. The authors also found that LMS treatment or LMS treatment followed by alkaline treatment increased the fiber tensile and compressive strengths. It can be concluded that enzymatic delignification, oxidized residual lignin, or both contributed to improving the bonding capacity of the recycled fibers.	2008
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3	Laccase treatment of recycled blue dyed paper: physical properties and fiber charge	Mohandass, Chellandi,  Knutson, Kristina,  Ragauskas, Arthur J.	Laccase treatment of recycled dyed pulp increased acid group content, tear index, tensile index, and color removal in a dose-dependent manner. Comparison of reactions subjected to different levels of oxygen supplementation showed the greatest beneficial effect for laccase treatment with slow oxygen bubbling. The experimental results indicate that laccase treatment increases fiber carboxylic acid content and tensile strength, in addition to reducing the color of the enzyme treated paper.	JOURNAL OF INDUSTRIAL MICROBIOLOGY & BIOTECHNOLOGY  <b>Volume:</b> 35 <b>Issue:</b> 10 <b>Pages:</b> 1103-1108 <b>Published:</b> OCT 2008
4	Effects of enzymatic treatment on cellulosic fibres from recycled paper. Analysis using a response curve experimental design	Taleb, M. Claudia,  Maximino, Mirtha G.	An enzymatic preparation consisting of cellulases and hemicellulases significantly affected the drainability and strength properties of an unbleached softwood Kraft pulp repulped in laboratory. The independent variables, treatment time and enzyme dose, were analysed using a central composite design for both the whole pulp and its fibrous fractions. Statistical analysis showed significant improvements in drainability. The effects of enzymatic treatments on	APPITA JOURNAL  <b>Volume:</b> 60 <b>Issue:</b> 4 <b>Pages:</b> 296-300 <b>Published:</b> JUL 2007

			strength properties were: increase in tensile index and apparent density and decrease in tear index and light scattering coefficients.	
5	Production of <i>Trichoderma reesei</i> Cel7B and its catalytic core on glucose medium and its application for the treatment of secondary fibers	Dienes, Dora,  Borjesson, Johan,  Stalbrand, Henrik,  Reczey, Kati	In this work, two recombinants of <i>Trichoderma reesei</i> strain QM9414 were used to produce intact Cel7B (endoglucanase 1, EGI) and the catalytic core of Cel7B selectively under glucose repression of other cellulases. For homologous expression in glucose medium the <i>gpdA</i> promoter from <i>Aspergillus nidulans</i> was used. Culture filtrates containing the intact Cel7B or Cel7B core were applied for secondary fiber treatment. The treatments caused improved drainage as shown by 16-17% decrease of the Schopper-Riegler (SR) values. The effects of cellulase treatment on pulp and paper properties showed that presence or absence of a cellulose-binding module (CBM) on Cel7B does not play a determinative role.	PROCESS BIOCHEMISTRY  <b>Volume:</b> 41  <b>Issue:</b> 9  <b>Pages:</b> 2092-2096  <b>Published:</b> SEP 2006
6	Preparation of cross-linked cellulases and their	Filos G,  Tziala T,	Hydrolysis of cellulosic wastes has been applied for environmental purposes and glucose	PREPARATIVE BIOCHEMISTRY & BIOTECHNOLOG

	application for the enzymatic production of glucose from municipal paper wastes	Lagios G, et al.	production. An enzymatic process is proposed for such treatment of municipal cellulosic wastes, and the optimum conditions are described. It was found that different conditions should be applied for the treatment of soft or hard paper wastes, the most characteristic being pretreatment of wastes and temperature of the treatment process. Optimization of enzyme characteristics was also examined after stabilization of the enzymes by cross-linking. Endocellulase was better stabilized after cross-linking with EDAC whereas, exocellulase was better with glutaraldehyde. The application of cross-linked enzyme in the waste paper treatment process resulted in about a 25% increase of glucose liberation.	Y <b>Volume:</b> 36 <b>Issue:</b> 2 <b>Pages:</b> 111-125 <b>Published:</b> MAY 2006
7	Treatment of recycled fiber with Trichoderma cellulases.	Dienes D, Egyhazi A, Reczey K	In this work, two commercial Trichoderma cellulase enzyme preparations were used to improve pulp properties of recycled paper. A blend of various cellulase components (Pergalase A40) was compared with endoglucanase III	INDUSTRIAL CROPS AND PRODUCTS <b>Volume:</b> 20 <b>Issue:</b> 1 <b>Pages:</b> 11-21 <b>Published:</b> JUL

			<p>(IndiAge Super L) based on their effect on drainage, water retention value, fiber length distribution and paper properties (air permeability, tensile index, burst index, tear index). Enzyme characteristics were investigated in order to establish the industrial applicability. The effects of enzymatic treatments on pulp and paper properties showed that the type of enzyme component is probably very important. Moreover, existence or absence of cellulose-binding domain might play a determinative role.</p>	2004
8	The control of sticky contaminant with enzymes in the recycling of wastepaper	<p>Park SB, Lee JM, Eom TJ</p>	<p>Enzymatic technology has been applied to the papermaking process of tissue and machine glazed paper on a plant scale to control sticky contaminant. This paper shows that the amount of sticky contaminants in screen rejects increased with the enzyme treatment and the content of toluene extract in the final product decreased on a mill scale. In addition to the effect of reducing potential sticky compounds, the burst strength and water absorbency of tissue paper treated with enzymes were enhanced to 110% of the</p>	<p>JOURNAL OF INDUSTRIAL AND ENGINEERING CHEMISTRY</p> <p><b>Volume:</b> 10 <b>Issue:</b> 1 <b>Pages:</b> 72-77 <b>Published:</b> JAN 2004</p>

			controlled paper.	
9	Improving linerboard properties with enzymatic treatment of the kraft component of the base sheet	Wong KKY,  Signal FA,  Campion SH	Enzymatically-treating kraft fibres with a crude cellulase, prior to mixing with the other fibre components of a linerboard furnish, may serve as a means to increase the freeness of the overall furnish. This treatment can also marginally improve short span compression strength of the resultant linerboard at 50 and 95% rh (relative humidity), although small decreases in burst and tear indices can occur. When the cellulase-treated furnish is refined back to the freeness of the control furnish, substantially higher short span compression strength can be achieved. The benefits are generally not attained by treatments with xylanase alone. The successful industrial use of cellulase will, however, require the achievement of the benefits at much lower enzyme doses.	APPITA JOURNAL  <b>Volume: 56</b>  <b>Issue: 4</b>  <b>Pages: 308-311</b>  <b>Published: JUL 2003</b>
10	Deinking of recycled mixed office paper using two endo-glucanases, CelB and	Geng XL,  Li KC	Treatment of MOP pulp with either enzyme followed by a floatation stage significantly reduced both dirt count and residual ink area and increased brightness. CelE	TAPPI JOURNAL  <b>Volume: 2</b>  <b>Issue: 7</b>  <b>Pages: 29-32</b>

	CelE, from the anaerobic fungus orpinomyces PC-2		appeared to have deinking effects superior to those of CelB. CelB was more effective than CelE at hydrolyzing pulp cellulose. Ink particles in MOP treated with CelB tended to be smaller than those treated with CelE. Ink particles smaller than 20 µm were not efficiently removed by flotation.	<b>Published:</b> JUL 2003
11	Biodeinking of mixed office waste paper by alkaline active cellulases from alkalotolerant Fusarium sp.	Vyas S,  Lachke A	Both the endoglucanases showed comparable patterns of their ability to release short fibers in the reaction mixture when filter paper was used as the substrate. The average size of released short fibers was determined by scanning electron microscopy ranged between 20 and 100 µm. The X-ray diffractograms showed that the crystallinity of the substrates does not vary significantly in the initial stages of the enzymatic action. The extracellular enzyme preparation was found to be suitable for deinking of mixed office waste papers. The enzyme treatment resulted in the increase in brightness with the reduction in ink counts of the recycled paper.	ENZYME AND MICROBIAL TECHNOLOGY  <b>Volume:</b> 32  <b>Issue:</b> 2  <b>Pages:</b> 236-245  <b>Published:</b> FEB 3 2003

12	A combined fungal and enzyme treatment system to remove TMP/newsprint mill white water substances	Zhang X,  Stebbing  DW,  Soong G, et al.	We assessed a combined fungal and enzyme system for use as an internal water treatment "kidney" in a TMP/newsprint mill with a closed water system. Our study concerned the ability of this fungal and enzyme treatment to remove various dissolved and colloidal substances (DCS) present in different white water samples. The growth of the white-rot fungus <i>Trametes versicolor</i> on these waters resulted in a significant decrease in the amount of total dissolved and colloidal substances. Fungal treatment removed more than 75% of the extractives and 62% to 71% of the carbohydrates originally present in the three white waters after 7 days. The resin and fatty acids content decreased by approximately 40% and 60% in the respective mill white water and model white water samples. The fungal and enzyme treatments also resulted in the polymerization of low molecular weight phenolics into higher molecular weight lignin-types of material.	TAPPI JOURNAL  <b>Volume: 1</b>  <b>Issue: 3</b>  <b>Pages: 26-32</b>  <b>Published: MAY 2002</b>
13	Enzymatic upgrade of old	Pala H,	The use of enzymes in secondary fiber (old	ENZYME AND MICROBIAL

	paperboard containers	Lemos MA, Mota M, et al.	paperboard containers) upgrading was investigated. The following aspects were analyzed: (1) the effect of several enzymes and (non-hydrolytic) cellulose-binding domains on the pulp and paper properties; (2) factors influencing enzymatic treatment of secondary fiber: enzyme dosage and reaction time: and (3) enzyme action on fractions with different fiber-length. In general, all the tested enzymatic preparations were able to improve the pulp drainability. In most cases this improvement was obtained at the expense of paper strength. The use of cellulose-binding domains allowed for the simultaneous increase in drainability and strength properties.	TECHNOLOGY <b>Volume:</b> 29 <b>Issue:</b> 4-5 <b>Pages:</b> 274-279 <b>Published:</b> SEP 5 2001
14	Control of colloidal dissolved materials in papermaking systems with high content of secondary fibers	Bobu E, Popa VI, Moraru T	CDM (colloidal dissolved material) control has become increasingly important in view of ever-increasing recycled fiber inputs and circuit closures.  In the first part of the paper, the authors demonstrate how the wet end characteristics are affected in a papermaking system which uses 100%	WOCHENBLATT FUR PAPIERFABRIKATION <b>Volume:</b> 127 <b>Issue:</b> 20 <b>Pages:</b> 1334-+ <b>Published:</b> OCT 1999

			<p>OCC and recycles 80% of its white-water.</p> <p>The second part of the study focuses on several options to limit the accumulation of CDM in papermaking systems. Specifically two solution concepts are considered retention of CDM in the paper web by means of chemical additions and decreasing the CDM content of incoming stock by enzyme treatment of OCC pulps. The CDM retention can be optimized by adding a combination of coagulants and flocculants. This worked better when about 70% of the anionic charge was neutralized and the zeta potential was maintained at a low negative level. The findings suggest enzyme treatment as an alternative to reduce the use of chemicals in papermaking systems with high recycled fibre inputs.</p>	
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Table B: Flotation

No	Title	Authors	Abstract	Bibliography
1	Effect of alkyl chain in alcohol deinking of recycled fibers by flotation process	Behin J,  Vahed S	<p>In this study, the effect of number of carbon atoms in alkyl chain of a simple deinking agent using different alcohols was developed. Four-step process involving pulping, washing, froth flotation, and another washing with a number of alcohols in pulping and flotation stages was employed. Conventional laboratory-scale flotation cell was used to study ink removal from pulp slurries obtained from water-based flexographic newsprint. We report the brightness and intensity of ink spot of handsheets formed of deinked fibers as deinking efficiencies. Application of alcohols with any alkyl chain instead of hydrogen peroxide in flotation</p>	<p>COLLOIDS AND SURFACES A-PHYSICOCHEMICAL AND ENGINEERING ASPECTS</p> <p><b>Volume:</b> 297</p> <p><b>Issue:</b> 1-3</p> <p><b>Pages:</b> 131-141</p> <p><b>Published:</b> APR 5 2007</p>

			stage gives higher brightness.	
2	Flotation de-inking of recycled paper aided with electric field technology	Shemi A,  Hsieh J		ABSTRACTS OF PAPERS OF THE AMERICAN CHEMICAL SOCIETY  <b>Volume:</b> 231  <b>Meeting Abstract:</b> 81-IEC  <b>Published:</b> MAR 26 2006
3	Quantification of macro and micro stickies and their control by flotation in OCC recycling process	Lee HL,  Kim JM	In this study, macro and micro stickies contained in linerboard stocks were measured to evaluate stickies removal efficiency of various process units, especially flotation, and to evaluate the benefits of using 3-ply forming technology to overcome sticky deposits on a Condebelt dryer. A reliable test procedure for measuring micro stickies was developed for the study. Screens and cleaners were found to be best for removing macro stickies and flotation was found to be best	APPITA JOURNAL  <b>Volume:</b> 59  <b>Issue:</b> 1  <b>Pages:</b> 31-36  <b>Published:</b> JAN 2006

			for removing micro stickies. Application of 3-ply forming with flotation for micro stickies removal enhanced linerboard quality and paper machine runnability.	
4	Comparison of internal and external mixer spargers in a laboratory de-inking flotation column	Hardie CA,  Gomez CO,  Finch JA	Column flotation has been introduced for waste paper de-inking to take advantage of low capital cost and excellent separation performance. Bubble generation employs a variety of systems; broadly, divided into two types: internal and external. They were compared in an industrial de-inking facility using a 10 cm diameter column.	CANADIAN JOURNAL OF CHEMICAL ENGINEERING  <b>Volume:</b> 82  <b>Issue:</b> 3  <b>Pages:</b> 504-509  <b>Published:</b> JUN 2004
5	Deinking flotation: influence of calcium soap and surface-active substances	Costa CA,  Rubio J	Recent studies have focused on columns without agitation and on reactor/separators. The work reported on here involved an investigation into the use of dissolved air flotation (DAF) to remove ink from old newspaper and	MINERALS ENGINEERING  <b>Volume:</b> 18  <b>Issue:</b> 1  <b>Pages:</b> 59-64  <b>Published:</b> JAN 2005

			<p>comparative studies with induced air flotation (IAF). Before the flotation treatment, the old newspapers were physically and chemically treated to detach the ink from the pulp. The experimental results demonstrated that ink removal was more efficient with the concomitant use of Ca (oleate) 2 and SDS in the two processes studied. The efficiency of the process was measured by the pulp's brightness and yield.</p>	
6	Effect of electrohydraulic discharge on the flotation deinking efficiency	<p>Makris SP,  Le T,  Carleton J, et al.</p>	<p>Pilot studies showed that sparking a slurry of recycled newspaper and magazine furnish decreased residual ink on fiber by 21%, increased brightness by 1%, and reduced fiber loss by 1% when the treated furnish was subsequently subjected to flotation deinking. No benefit was realized if the furnish was sparked</p>	<p>INDUSTRIAL &amp; ENGINEERING CHEMISTRY RESEARCH</p> <p><b>Volume:</b> 43</p> <p><b>Issue:</b> 23</p> <p><b>Pages:</b> 7552-7556</p> <p><b>Published:</b> NOV 10 2004</p>

			during deinking, possibly because the shock wave changes the bubble-size distribution.	
7	Dielectric and thermal properties of handsheets made from recycled pulp and their relationship with deinking efficiency and pulp quality	Basta AH,  Zhan HY,  Chen JX	This study evaluated the possibility of using dielectric and thermogravimetric analysis techniques as new procedures to profile deinking system efficiency and pulp quality. The procedures were applied to handsheets made from ONP/OMG deinked pulp sampled from two deinking systems at the Guangzhou Paper Mill, P.R. China.	APPITA JOURNAL  <b>Volume: 57</b>  <b>Issue: 1</b>  <b>Pages: 57-63</b>  <b>Published: JAN 2004</b>
8	Deinking of recycled mixed office paper using two endo-glucanases, CelB and CelE, from the anaerobic fungus orpinomyces PC-2	Geng XL,  Li KC	Treatment of MOP pulp with either enzyme followed by a floatation stage significantly reduced both dirt count and residual ink area and increased brightness. CelE appeared to have deinking effects superior to those of CelB. CelB was more effective than CelE at hydrolyzing pulp	TAPPI JOURNAL  <b>Volume: 2</b>  <b>Issue: 7</b>  <b>Pages: 29-32</b>  <b>Published: JUL 2003</b>

			cellulose. Ink particles in MOP treated with CelB tended to be smaller than those treated with CelE. Ink particles smaller than 20 µm were not efficiently removed by flotation.	
9	Flotation deinking with magnesium oxide as the alkali source	Stack K,  Featherstone A,  Baptist S, et al.	To reduce the amount of sodium hydroxide used or replace it with an alternative alkali such as magnesium oxide (MgO). This paper describes the results of laboratory work and mill scale trials undertaken to assess the viability of MgO as an alternative alkali source in flotation deinking.	TAPPI JOURNAL  <b>Volume: 1</b>  <b>Issue: 8</b>  <b>Pages: 16-20</b>  <b>Published: OCT 2002</b>
10	Aerosol-enhanced flotation deinking of recycled paper - Silicone oil offers an effective way of forming a layer on the bubble surface	Gomez CO,  Acuna C,  Finch JA, et al.	This work describes continuous on-site trials to test the oil coating technology in the deinking of recycled paper. The results showed that using the aerosol resulted in higher gas holdups and reduced air requirements to match plant	PULP & PAPER-CANADA  <b>Volume: 102</b>  <b>Issue: 10</b>  <b>Pages: 28-30</b>  <b>Published: OCT 2001</b>

			brightness gains.	
11	Deinking of recycled fibers in a flotation flow loop	van de Ven TGM,  Sauve CP,  Garnier G	Conventional laboratory-scale flotation cells, used to study ink removal from pulp slurries, have various shortcomings. In most cells it is difficult to control physical parameters such as the volume of air intake and the bubble size distribution. Moreover, the hydrodynamic conditions in such cells are different from those in industrial flotation cells. To overcome these difficulties we designed a new laboratory flotation cell, consisting of a flow loop and a flotation chamber.	COLLOIDS AND SURFACES A-PHYSICOCHEMICAL AND ENGINEERING ASPECTS  <b>Volume:</b> 192  <b>Issue:</b> 1-3  <b>Pages:</b> 53-60  <b>Published:</b> NOV 30 2001

Table C: Properties of recycled paper and products which are made from waste paper (strength and brightness)

No	Title	Authors	Abstract	Bibliography
1	Microstructure and Mechanical Properties of Gypsum Composites Reinforced with Recycled Cellulose Pulp	Carvalho MA, Calil C, Savastano H, et al.	The use of waste fibers for the reinforcement of brittle matrices is considered opportune for the sustainable management of urban solid residues. This paper examines the microstructure and mechanical properties of a composite material made of gypsum reinforced with cellulose fibers from discarded Kraft cement bag. Two different kinds of gypsum were used, natural gypsum (NG) and recycled gypsum (RG), both with an addition of 10% by mass of limestone. For the production of samples, slurry vacuum dewatering technique followed by pressing was evaluated revealing to be an efficient and innovative solution for the composites under evaluation. The composite was analyzed based on flexural strength tests, scanning electron microscopy	MATERIALS RESEARCH-IBERO-AMERICAN JOURNAL OF MATERIALS  <b>Volume:</b> 11 <b>Issue:</b> 4 <b>Pages:</b> 391-397 <b>Published:</b> OCT-DEC 2008

			(SEM) imaging, secondary electron (SE) detection, and pseudo-adiabatic calorimetry.	
2	Novel sources of fungal cellulases for efficient deinking of composite paper waste	Soni R,  Nazir A,  Chadha BS, et al.	<p>Twenty thermophilic/thermotolerant fungal strains were isolated from composting soils and screened for production of different enzymes (Endoglucanases, beta-glucosidase, Fpase and xylanases) to assess their deinking efficiency. Three isolates, <i>Aspergillus</i> sp. AMA, <i>Aspergillus terreus</i> AN1, and <i>Myceliophthora fergusii</i> T4I, identified on the basis of morphological and sequencing of amplified ITS1-5.8S-ITS2 rDNA region, showed significant deinking of composite waste paper (70% magazine and 30% Xerox copier/ laser print paper waste) as well as improved properties (brightness, tensile strength, tear index) of recycled paper sheets. The chosen strains <i>Aspergillus</i> sp. AMA, <i>Aspergillus terreus</i> AN1 and <i>Myceliophthora fergusii</i> T4I, showed 53, 52.7, and 40.32% deinking with increase in</p>	<p>BIORESOURCES</p> <p><b>Volume: 3</b></p> <p><b>Issue: 1</b></p> <p><b>Pages: 234-246</b></p> <p><b>Published: FEB 2008</b></p>

			brightness by 4.32, 3.56, and 3.01 % ISO, respectively.	
3	Ultrasonic treatment to improve the quality of recycled pulp fiber	Tatsumi D,  Higashihara T,  Kawamura S, et al.	The effect of ultrasound on the quality of recycled fibers was investigated. Ultrasound was applied to recycled pulp fiber suspension before ink removal by conventional flotation. The ultrasonic treatment induced an increase in the sedimentation volume of the fiber, which implies that the flexibility and bulkiness of the fiber increase. The results indicate that the ultrasonic treatment is effective in improving recycled fiber quality.	JOURNAL OF WOOD SCIENCE  <b>Volume:</b> 46  <b>Issue:</b> 5  <b>Pages:</b> 405-409  <b>Published:</b> 2000
4	Strength and processing properties of wet-formed hardboards from recycled corrugated containers and commercial hardboard fibers	Hunt JF,  Vick CB	This study compares strength properties and processing variables of wet-formed high-density hardboard panels made from recycled old corrugated container (OCC) fibers and virgin hardboard fibers using continuous pressure during drying. The results show that panels made from OCC fibers had 3 times the strength and 2 times the stiffness of panels made from virgin hardboard fibers.	FOREST PRODUCTS JOURNAL  <b>Volume:</b> 49  <b>Issue:</b> 5  <b>Pages:</b> 69-74  <b>Published:</b> MAY 1999

5	Combined de-inking technology applied on laser printed paper	Sui ZY,  Dong SJ,  Cui XJ, et al.	The combined de-inking technology of ultrasonic, UV irradiation and enzymatic methods was introduced into the de-inking process of HP laser printed paper. The purpose was to reduce the consumption of alkali or even preprocess without alkali absolutely for the purpose of environment protection. The de-inking effects of cellulase, amylase, lipase and their mixture were compared and the experiment results showed that combined enzymes of cellulase and amylase have the best de-inking efficiency which has a 12% increment of brightness. The de-inking efficiencies of several different de-inking technologies were compared, which can provide basis to establish combined de-inking technologies.	CHEMICAL ENGINEERING AND PROCESSING  <b>Volume:</b> 48  <b>Issue:</b> 2  <b>Pages:</b> 587-591  <b>Published:</b> FEB 2009
6	Modification of paper properties by the pretreatment of wastepaper pulp with Graphium putredinis,	Savitha S,  Sadhasivam S,  Swaminathan K	Grophium putredinis, Trichoderma harzianum and fusant were used in the present study to produce extracellular xylanases, an important industrial enzyme used in pulp and paper industry. A significant increase in pulp brightness and	BIORESOURCE TECHNOLOGY  <b>Volume:</b> 100  <b>Issue:</b> 2  <b>Pages:</b> 883-889  <b>Published:</b> JAN 2009

	Trichoderma harzianum and fusant xylanases		improvement in various pulp properties, viz. burst capacity, thickness and bulkness of the treated pulp were observed in comparison to the conventional chemical bleaching. Easy purification and high stability of these enzymes makes it amicable for industrial applications.	
7	Differential and synergistic effects of xylanase and laccase mediator system (LMS) in bleaching of soda and waste pulps	Kapoor M,  Kapoor RK,  Kuhad RC	Methods and Results: Soda and different grades of waste pulp fibres [used for making three-layered duplex sheets - top layer (TL), protective layer (PL) and bottom layer (BL)] when pretreated with either xylanase (40-0 IU g(-1)) or LMS (up to 200.0 U g-1) alone and in combination (one after the other) (XLMS) exhibited an increase in release of reducing sugars [up to 881.0% soda pulp; up to 736.6% (TL), up to 215.7% (PL) and up to 198-0% (BL) waste pulp], reduction in kappa number [up to 17.6% soda pulp; up to 14.0% (TL), up to 25-3% (PL) and up to 10.9% (BL), waste pulp], improvement in brightness [up to 20.4% soda pulp; up to 23-6%	JOURNAL OF APPLIED MICROBIOLOGY  <b>Volume:</b> 103  <b>Issue:</b> 2  <b>Pages:</b> 305-317  <b>Published:</b> AUG 2007

			(TL), up to 8.6% (PL) and up to 5.0% (BL), waste pulp] when compared with the respective controls.	
8	Fractioning in deinking plants - a new path in waste paper preparation	Aregger HJ,  Herd E,  Sket P, et al.	The development of waste paper preparation systems up to today installations took place in different stages. At the beginning the processed wastepaper was only used for low paper grades. By consistent development of the machines and systems, like screening, dispersing, and in special flotation, the use of the processed waste paper was extended to papers with highest quality demand.	WOCHENBLATT FUR PAPIERFABRIKATI ON  <b>Volume:</b> 134  <b>Issue:</b> 14-15  <b>Pages:</b> 853-858  <b>Published:</b> AUG 2006
9	Fungal enzyme treatment of newsprint mill white water: Impact on white water and paper properties	Stebbing DW,  Zhang X,  Soong G, et al.	This paper investigated the effects of a large-scale fungal enzyme treatment on newsprint mill white water and resulting paper properties. The large-scale treatment removed over 70% of the total extractive and nearly 100% of lignans, sterols, steryl esters and triglycerides present in the white water The enzyme addition catalyzed a significant reduction in colloidal	JOURNAL OF PULP AND PAPER SCIENCE  <b>Volume:</b> 30  <b>Issue:</b> 1  <b>Pages:</b> 3-8  <b>Published:</b> JAN 2004

			<p>particle size, while concurrently decreasing the zeta potential. Additionally, the average molecular weight of the phenolic compounds present in white water was increased after enzyme treatment.</p>	
10	<p>Bleachability of alkaline and neutral medium deinked waste paper stocks</p>	<p>Poppel EM,  Lado Z</p>	<p>The paper investigates the efficiency of three lignin retaining chlorine-free bleaching chemicals (sodium hydrosulphite, formamidine sulphinic acid and hydrogen peroxide) on both wood-free and wood-containing waste paper stocks, deinked on a pilot plant in alkaline or neutral systems.</p> <p>The effectiveness of deinking and bleaching steps in terms of kappa number, yield, metal content, COD charge, chemical consumption, as well as ash content, optical and strength properties, has been evaluated.</p>	<p>CELLULOSE CHEMISTRY AND TECHNOLOGY</p> <p><b>Volume:</b> 36</p> <p><b>Issue:</b> 3-4</p> <p><b>Pages:</b> 303-316</p> <p><b>Published:</b> MAY-AUG 2002</p>
11	<p>Disperser bleaching with hydrogen peroxide - A tool for brightening recycled</p>	<p>Seccombe R, Brackenbury K, Vandenberg D</p>	<p>Many mills are now installing post-flotation units to improve the overall cleanliness of the deinked fibre. The addition of chemicals to the disperser to improve the brightness has also</p>	<p>APPITA JOURNAL</p> <p><b>Volume:</b> 56</p> <p><b>Issue:</b> 3</p> <p><b>Pages:</b> 184-189</p>

	fibres.		been shown to have a beneficial effect on post-flotation deinking efficiency. Typical hydrogen peroxide disperser bleaching applications are outlined for a number of different waste paper furnishes including newspapers, magazines and office waste. Optimisation of a number of particular industrial applications is described. In all disperser bleaching cases reported, mill expectations of improved brightness and cleanliness are achieved with moderate additions of hydrogen peroxide.	<b>Published: MAY 2003</b>
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Table D: Composites

No	Title	Authors	Abstract	Bibliography
1	Thermal and melt rheological behavior of composites produced from waste paper and plastic	James AR,  Sbarski I,  Masood SH, et al.	The thermal and melt rheological properties of highly filled polymer composites produced from waste papers, Recycled Paper Waste (RPW) and Liquid Paperboard (LPB), in a post-consumer Stretch-Wrap (SR) matrix have been evaluated. Thermal testing has indicated that large amounts of	JOURNAL OF POLYMER ENGINEERING  <b>Volume: 27</b>  <b>Issue: 1</b>  <b>Pages: 55-74</b>  <b>Published: JAN-FEB 2007</b>

			<p>absorbed water are bound to the filler and, along with small levels of volatile emissions, would be released in compounding and moulding of the composite.</p>	
2	<p>The effect of silane treated- and untreated-talc on the mechanical and physico-mechanical properties of poly(lactic acid)/newspaper fibers/talc hybrid composites</p>	<p>Huda MS,  Drzal LT,  Mohanty AK, et al.</p>	<p>This paper evaluates the effect of the addition of silane treated- and untreated- talc as the fillers on the mechanical and physico-mechanical properties of poly(lactic acid) (PLA)/recycled newspaper cellulose fibers (RNCF)/talc hybrid composites.</p> <p>This suggests that these PLA hybrid bio-based composites have a potential to replace glass fibers in many applications that do not require very high load bearing capabilities and these recycled newspaper cellulose fibers could be a good candidate reinforcement fiber of high performance hybrid biocomposites.</p>	<p>COMPOSITES PART B- ENGINEERING</p> <p><b>Volume:</b> 38</p> <p><b>Issue:</b> 3</p> <p><b>Pages:</b> 367-379</p> <p><b>Published:</b> 2007</p>

Table E Surface chemistry, Retention aids

No	Title	Authors	Abstract	Bibliography
1	Toward evaluating retention aid performance for deposit control in newsprint furnishes containing recycled paper	Allen L,  Lapointe C	In addition to their usual functions of improving retention and drainage, retention aids are frequently used by industry to control deposits. Evaluating retention aid performance is an important aspect of optimizing paper machine operation. For mills employing deinked pulp (DIP), containing recycled newspaper and old magazine grade paper (which is often coated), such as evaluation is complex, due to the large number of potentially depositable materials introduced with the DIP. In this report, we make a first step toward addressing this challenge by measuring the retention of styrene butadiene rubber (SBR), one of the most deposit-prone contaminants in recycled coated paper.	NORDIC PULP & PAPER RESEARCH JOURNAL  <b>Volume: 21</b>  <b>Issue: 5</b>  <b>Pages: 710-715</b>  <b>Published: 2006</b>
2	Application of pyrolysis GC/MS in the development of a chemical retention and	Wells L,  Keech G,	The Optimization Of the chemical program on two newsprint machines Using 100% DIP at Abitibi Bowater, Thorold is described. For the first	PULP & PAPER-CANADA  <b>Volume: 109</b>  <b>Issue: 11</b>

	stickies control program for a 100% recycled newsprint mill	Allen LH, et al.	time, retention of contaminants front recycled paper was optimized using pyrolysis GC/MS. We discuss factors affecting machine performance, detailed selection criteria, and laboratory techniques used to evaluate the wide spectrum of available programs in terms of fines and filler retention, drainage and contaminant control. The performance of the program developed in laboratory trials was verified with a paper machine trial.	<b>Pages:</b> 17-23 <b>Published:</b> NOV 2008
3	Dendrimers: A new retention aid for newsprint, mechanical printing grades, and board	Allen L, Polverari M.	The use of amine-terminated dendrimers as retention and drainage aids in the production of newsprint, supercalendered mechanical printing grades, and board has been investigated in the laboratory with a dynamic drainage jar. The results suggest that dendrimers can be very effective retention aids for fines and ash in all three types of paper. In addition, they are very effective at flocculating dispersed resin in newsprint pulp slurries and hence offer promise for pitch control. Because of their	NORDIC PULP & PAPER RESEARCH JOURNAL <b>Volume:</b> 15 <b>Issue:</b> 5 <b>Pages:</b> 407-415 <b>Published:</b> 2000

			<p>exceptionally high positive charge densities, dendrimers proved effective in a lab-simulated, highly-closed papermaking system, and also in newsprint pulps containing recycled deinked pulp. In addition, they performed well in a peroxide-bleached SC furnish. Used in conjunction with a flocculant, dendrimers gave even higher gains in first-pass retention and drainage.</p>	
4	Effect of recycling on the properties of paper surfaces	<p>Brancato A, Walsh FL, Sabo R, et al.</p>	<p>AFM surface adhesion measurements made on virgin and recycled bleached kraft pulp show that recycling increases the apparent hydrophilicity of the fiber surface. Yet, the water retention values and strength decreases as expected, which is consistent with internal cross-linking of the bonding sites and a reduction in hydrophilicity. Recycling does not affect the amount of monolayer water bound to the fiber surface indicating that the pore water is reduced but not the water bound to fiber surfaces. It is proposed that the contact area</p>	<p>INDUSTRIAL &amp; ENGINEERING CHEMISTRY RESEARCH</p> <p><b>Volume:</b> 46</p> <p><b>Issue:</b> 26</p> <p><b>Pages:</b> 9103-9106</p> <p><b>Published:</b> DEC 19 2007</p>

			<p>between the AFM tip and the fiber is greater for recycled material than for virgin. This could be caused by fiber shrinkage, changes in the angle of contact, lamination of fibrils, or other processes. Hence, in this instance, the surface adhesion values are more a measure of the topography of the surface than of its chemistry. An application to newsprint is illustrated.</p>	
5	<p>Effects of the drying conditions and of the existing cationic starch in liner paper recycling</p>	<p>Mocchiutti P, Zanuttini M, Citroni M, et al.</p>	<p>The effects of drying on the properties of the recycled fibers of unbleached softwood kraft pulp are first analysed. It is shown how temperature and the drying conditions (under restraint or not) affect the papermaking properties of this pulp. The consequences of the presence of a cationic starch adsorbed onto the cellulosic fibers on the surface chemistry, the bonding capacity and the ability of the pulp to adsorb additional quantities of starch are also evaluated. It is found out that the detrimental effect of drying under no restraint is higher than under restraint. The cationic starch blocks the surface acid group and</p>	<p>CELLULOSE CHEMISTRY AND TECHNOLOGY</p> <p><b>Volume:</b> 40</p> <p><b>Issue:</b> 1-2</p> <p><b>Pages:</b> 87-91</p> <p><b>Published:</b> JAN-FEB 2006</p>

			<p>decreases the water retention value. Nevertheless, the beneficial effect of cationic starch on the papermaking properties is still manifested. The presence of up to 2.0% cationic starch on the recycled fibers does not affect the additional adsorption of similar amounts of cationic starch.</p>	
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