

## The Development of Cold Chain Management Research through a Bibliometric Approach Using Vosviewer

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### Abstract

This article reviews the development of cold chain management research through a bibliometric approach. Full comprehension of the management of the cold chain in Indonesia is especially important because Indonesia is one of the countries where two-thirds of it is an ocean area. In Indonesia's sea, there are many fishery resources with high export value. On the other hand, Indonesia's territory is so vast, making shipping from island to island will take quite a long time. This will have an impact on product quality if the management of the cold chain is not considered, especially for products that are easily damaged by changes in temperature. The freshness and safety of the product when it is received by the consumer can be maximized with the existence of cold chain management. The article data was retrieved from the Google Scholar database using the Publish-or-Perish Reference Manager application. The data results were obtained in the form of article mapping data per theme that the researcher has determined. Furthermore, the mapping data is processed using computational mapping analysis, namely VOSviewer. To facilitate the process of searching for articles, researchers must determine the terms to be studied first. The term used in the search using this publish or perish application is “Cold Chain Management” which resulted in 272 articles deemed relevant for the last 10 years (2012 to 2022). After doing research, the title "cold chain management" can be separated into 3 terms: management, cold chain, and cold chain management. The analysis shows that the term “cold chain management” is associated with 83 links, with an overall link strength of 128. Over the last decade, it is known that there have been ups and downs in the number of research publications on cold chain management. From 2012-2014 publications of the article moved horizontally and experienced a slight increase in 2015 to 27 journal publications. In 2016 the number of published journals decreased to 23 articles. On the other hand, from 2017 to 2018, the number of publications increased quite a lot to 37 articles. However, from 2019 to 2022 the number of publication was declined, and there were only 6 journals published in 2022. After this study, hopefully, there will be more research on cold chain management.

**Keywords:** bibliometric, computational mapping analysis, VOSviewer, cold chain management.

### A. INTRODUCTION

Management is the art of managing existing resources to achieve planned goals. Management is a term that can be studied both theoretically and practically. In theory, it is known as management science, while in practice management is associated with various fields within an organization. The focus of management science is the discovery and formulation of “laws of behaviour” that can increase productivity [1]. Practically management is here to ensure that all plans formulated in an organization can run

optimally. Cold chain management is one of the management fields that play an essential role in ensuring that goods can be sent and received by consumers in good condition.

Full comprehension of the management of the cold chain in Indonesia is especially important because Indonesia is one of the countries where two-thirds of it is an ocean area. In Indonesia's sea, there are many fishery resources with high export value. On the other hand, Indonesia's territory is so vast, making shipping from island to island will take quite a long time. This will have an impact on product quality if the management of the cold chain is not considered, especially for products that are easily damaged by changes in temperature. One product that is very sensitive to temperature changes during shipping is fishery products. Fisheries are all activities related to the management and utilization of fish resources and the environment ranging from pre-production, production, processing to marketing carried out in a fisheries business system [38]. In the fisheries business, there are three types of activities, namely capture fisheries, aquaculture and fisheries processing. Almost all products from the three types of fisheries business activities, if they are to be distributed to other areas from the place of production, need to be distributed in low temperatures. When there is an extreme increase in temperature, fishery products will experience quality loss, making them unfit for human consumption. In fact, based on data obtained from the Ministry of Maritime Affairs and Fisheries (KKP), the fish consumption rate in Indonesia reached 56.48 kilograms (kg) per capita in 2022. This number increased by 2.39% compared to 2021, where fish consumption in Indonesia reached 55.16 kg/capita [39]. The importance of managing temperature during shipping is the main foundation so that the fishery products delivered are well received and suitable for consumption by consumers. The freshness and safety of the product when it is received by the consumer can be maximized with the existence of cold chain management [2]. From this statement, it can be seen how important cold chain management is. Therefore, various innovations in cold chain management are needed so that new technologies and strategies for cold chain management can be applied by various companies. However, cold chain management research is currently not known with certainty whether it is still in demand or not.

One of the analytical techniques that can be used to find information and determine research developments in the cold chain management field of cold supply chain management, especially in fishery products, is Bibliometric Analysis. This analysis is in the form of a meta-analysis that examines research data in the form of bibliographies and quotes from various articles, journals, and other scientific works. This makes it easier for researchers to study various scientific works in a relatively shorter time.

Bibliometric analysis has been extensively researched in various fields including bibliometric analysis in supply chain management [3-5], bibliometric analysis in business management [6], bibliometric analysis in economics [7-11], bibliometric analysis in Computers & Industrial Engineering [12-13], bibliometric analysis in operations management [14-16], bibliometric analysis in green warehousing [17-18], bibliometric analysis in emergency management [19-21].

However, the analysis of research development in the realm of cold chain management using bibliometric analysis computational mapping data has not been carried out. Especially the bibliometric analysis over the last decade using the VOSviewer application. Therefore, researchers conducted this study.

The purpose of this research is to perform bibliometric analysis on article indexed by Google Scholar using VOSviewer software. Being a reference for future research in the realm of cold chain management on fisheries products is the advantage of this research.

## B. METHODS

Journals that have been published and indexed by Google Scholar are the material in this research because the database on Google Scholar is open source. Meanwhile, to get references to various studies related to the topic under study, the researcher uses a reference manager application, namely Publish or Perish. This application is used to facilitate researchers in conducting a literature review on the topic being researched.

In the article written by Al Husaeni and Nandiyanto [22], there is information on how to use and install the Publish or Perish software. In addition, there is also an information step by step to obtain data on the application. There is another article written by Azizah et al which explains step by step how to search for data references on Google Scholar in detail. [23]

There are various stages carried out in this research. The stages can be seen in Table 1 below:

**Table 1** Research Stages

| Stages             | 1                   | 2                               | 3   | 4  |
|--------------------|---------------------|---------------------------------|---|--|
| <b>Activity</b>    | Collecting the data | Processing of bibliometric data | Perform computational mapping analysis of bibliometric publication data | Analysis the results of computational mapping analysis |
| <b>Application</b> | Publish or Perish   | Microsoft Excel                 | VOSviewer   | -  |

Based on the research stages that have been presented in table 1, the first step in this research is to search for article data using the Publish or Perish application. By using this application, researchers can filter publications based on the keyword "Cold chain management" according to the title of this research. The research articles used in the search are in the range of 2012 to 2022. After getting a list of various articles from the search results in the Publish or Perish application, researchers must export the articles into two different file types. The two types of files are the research information system (.ris) and comma-separated value format (\*.csv).

The next step in conducting this research is to process the bibliometric data that has been saved in the form of a “csv” file. The Microsoft Excel application is used to calculate the number of article publications per year, the number of publications and the average article for ten years in accordance with predetermined terms. After getting the number of publications and then made into a graph.

Evaluating and visualizing the trends of bibliometric data was the third step in this study. At this stage the application used is VOSviewer. The search result article data using Publish or Perish saved in “.ris” format is mapped using Vosviewer. The results of using this application, researchers get three forms of mapping publications in the form of network visualization, density visualization, and network-based overlay visualization between existing items. Determining the number of terms that can be found repeatedly is needed in making bibliometric maps. The frequency set in this study is five times. In addition, researchers must also eliminate keywords that are less relevant to the title of this study, from 272 terms that have been found.

### C. RESULT AND DISCUSSION

#### 3.1. Publication data search results

The number of article data found using the Publish or Perish application in this study was 272. All articles listed are articles indexed in Google Scholar. The articles that appear are articles that meet the criteria that have been determined by the researcher. The criteria consist of three terms, namely management, cold chain, and cold chain management. The form of data obtained is article metadata. The metadata collected contains the research title, author's name, number of article citations, related URLs, year of publication, journal name, publisher, and article links.

Some examples of article data according to published research criteria are shown in table 2. The table shows the ten best articles that have the highest citation value and focus on the title in the realm of cold chain management.

All articles included in this study had a total of 29861 citations. Meanwhile, the number of citations per year was 2714 and the number of citations per article was 9.98. All articles have an average h-index of 20, and a g-index of 34. The average of the authors in the articles used is 3.34..

**Tabel 2** Cold chain management publication data

| No | Authors                                      | Title  | Year | Cities | Refs |
|----|--|--|------|--------|------|
| 1  | A Chaudhuri, I Dukovska-Popovska<br>...      | Decision-making in cold chain logistics using data analytics: a literature review  | 2018 | 99     | [24] |
| 2  | E Gogou, G Katsaros, E Derens, G Alvarez...  | Cold chain database development and application as a tool for the cold chain management and food quality evaluation                                | 2015 | 95     | [2]  |
| 3  | S Shashi, R Cerchione, R Singh...            | Food cold chain management: From a structured literature review to a conceptual framework and research agenda                                      | 2018 | 83     | [25] |
| 4  | Q Lin, Q Zhao, B Lev                         | Cold chain transportation decision in the vaccine supply chain   | 2020 | 79     | [26] |
| 5  | YY Chen, YJ Wang, JK Jan                     | A novel deployment of smart cold chain system using 2G-RFID-Sys  | 2014 | 66     | [27] |
| 6  | YH Hsiao, MC Chen, KY Lu, CL Chin            | Last-mile distribution planning for fruit-and-vegetable cold chains  | 2018 | 64     | [28] |
| 7  | S Rao, S Naftar, B Unnikrishnana             | Evaluation, awareness, practice and management of cold chain at the primary health care centers in Coastal South India                             | 2012 | 50     | [29] |
| 8  | S Sharma, SS Pai                             | Analysis of operating effectiveness of a cold chain model using Bayesian networks  | 2015 | 39     | [30] |
| 9  | N Ndraha, WC Sung, HI Hsiao                  | Evaluation of the cold chain management options to preserve the shelf life of frozen shrimps: A case study in the home delivery services in Taiwan | 2019 | 38     | [31] |
| 10 | X Xiao, Z Li, M Matetic, MB Bakaric, X Zhang | Energy-efficient sensing method for table grapes cold chain management   | 2017 | 35     | [32] |

#### 3.2. Research development in the field of cold chain management

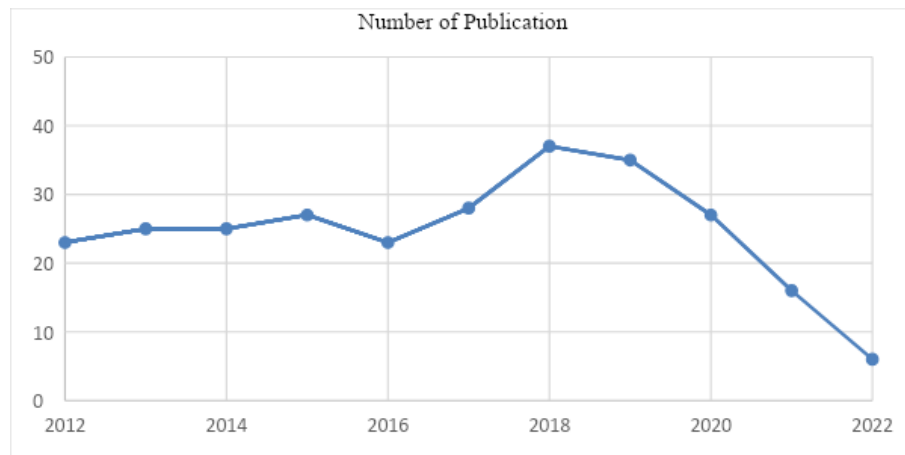
Table 3 shows the development of research published in Google Scholar indexed journals in the realm of cold chain management. From table 3, we can see that 272 researches in the realm of Cold Chain Management have been published during the period 2012-2022. With details of the number of articles published in 2012 amounted to 23 articles. While in 2013 there were 25 articles. In the following year, 2014 there were 25 articles published. In 2015 the number of publications rose to 27 articles. In 2016 there was a decrease to 23 articles. In 2017 it rose slightly to 28 articles. In 2018 it rose quite a lot to 37 articles. In 2019 there was a slight decrease to 35 articles. In 2020 it dropped significantly to 27 articles. In 2021 it fell again to 16 articles and in 2022 only 6 articles.

When viewed from the number of publications that have been carried out, it can be concluded that research in the field of cold chain management is still quite rarely carried out every year, especially in the last ten years, from 2012 to 2022. The development of research is quite volatile and even tends to move downwards as shown in Figure 1.

However, in 2016 instead of experiencing an increase, the number of journals published decreased to only 23 articles. But in 2017 it began to experience a significant increase until in 2018 there were about 37 articles published and indexed on Google Scholar. However, in the following year, it decreased, to only 35 articles published. The decline in journal publications in the field of management occurred continuously in the following year until the end of 2022. From the data shown in Figure 1, it can be seen that research in the field of cold chain management is moving slowly in terms of its development, even experiencing a significant decline from 2019 to 2022..

**Tabel 3** Development of cold chain management research

| Year    | Number of Publication |
|---------|-----------------------|
| 2012    | 23                    |
| 2013    | 25                    |
| 2014    | 25                    |
| 2015    | 27                    |
| 2016    | 23                    |
| 2017    | 28                    |
| 2018    | 37                    |
| 2019    | 35                    |
| 2020    | 27                    |
| 2021    | 16                    |
| 2022    | 6                     |
| Total   | 272                   |
| Average | 24.7                  |



**Figure 1.** Level of development in cold chain mangement research

### 3.3. Visualization cold chain management topic area uisng VOSviewer

In this article, computational mapping is carried out using the VOSviewer application. The field of cold chain management resulted 219 items when searched by computational mapping analysis. Each item related to the cold chain management field in the data mapping is divided into six clusters, namely:

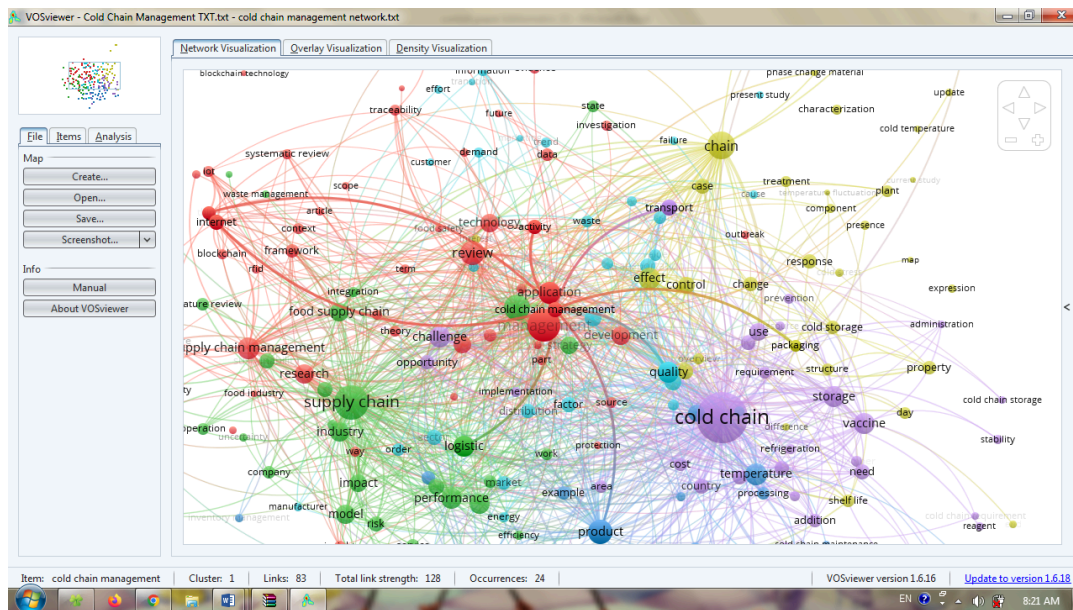
1. Cluster 1 (49 items) activity, application, article, blockchain, blockchain technology, chain management, cold chain facility, cold chain management, cold chain monitoring, concept, context, data, development, evidence, field, food industry, food safety, framework, future, inside, internet, investigation, iot, literature, management, outbreak, part, perspective, process, protection, regulation, research, review, rfid, scm, scope, source, supply chain management, systematic literature review, systematic review, technology, term, theory, thing, traceability, variety, way, wireless sensor network, year.
2. Cluster 2 (36 items) approach, business, carbon emission, case study, cold chain logistic, company, sustainable development goals, economy, efficiency, food supply chain, impact, industry, integration, literature review, logistic, loss, sustainability, model, operation, optimization, performance, problem, risk, service, state, strategy, supply chain, sustainable supply chain management, system, trade, uncertainty, vaccine supply chain, vehicle, waste management, sustainable supply chain, work
3. Cluster 3 (35 items) cold chain equipment, cold chain maintenance, cold chain system, collection, concern, condition, consumer, example, fact, fish, food product, green supply chain management, hour, importance, influence, inventory management, knowledge, link, low temperature, practice, preservation, prevalence, processing, producer, product, range, regard, retailer, safety, sample, standard, supply, temperature, time, tool
4. Cluster 4 (34 items) case, chain, change, characterization, cold, cold storage, cold stress, cold temperature, component, control, current study, day, different, effect, end, expression, generation, interest, level, map, nature, overview, packaging, phase change material, plant, presence, property, response, run, shelf life, structure, temperature fluctuation, treatment, update.
5. Cluster 5 (34 items) addition, administration, area, challenge, cold chain, cost, country, delivery, electricity, evaluation, facility, cold chain infrastructure,



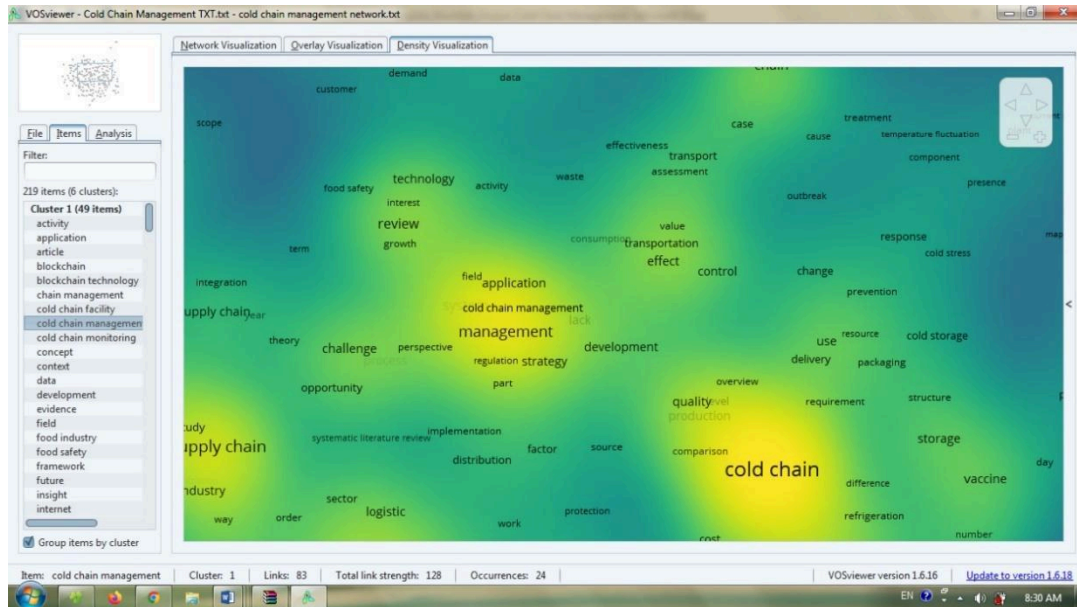
implementation, innovation, maintenance, majority, need, number, opportunity, point, prevention, reagent, cold chain requirement, refrigeration, refrigerator, requirement, resource, shipping, stability, storage, transport, use, cold chain storage, vaccine.

6. Cluster 6 (31 items) assessment, cause, comparison, consumption, customer, demand, distribution, effectiveness, effort, energy, environmental impact, factor, failure, growth, information, lack, life cycle assessment, manufacturer, market, marketing, order, present study, production, quality, sector, stage, transition, transportation, trend, value, waste.

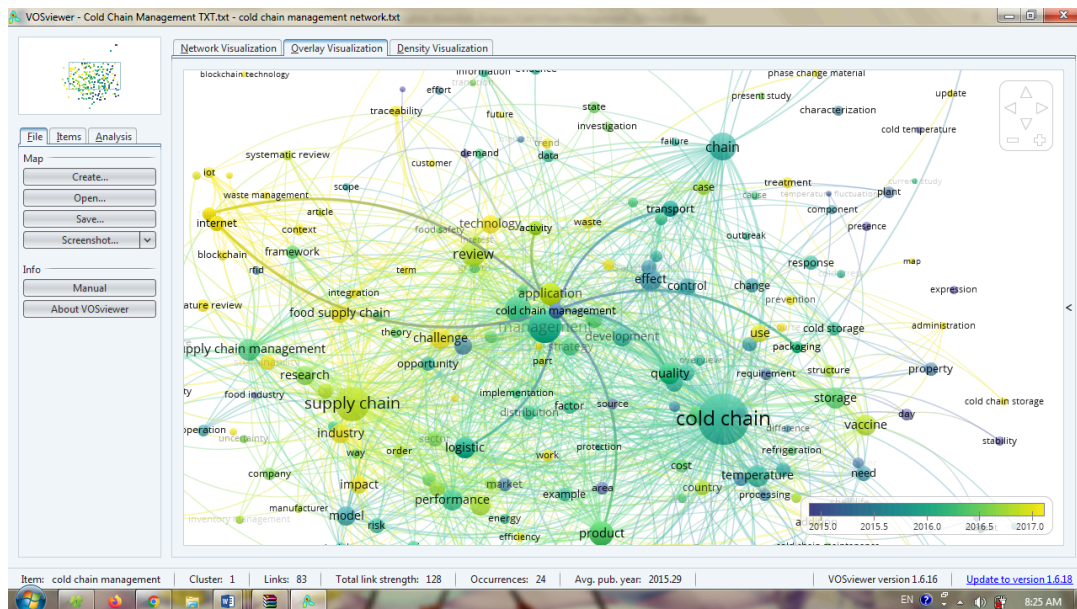
Each cluster obtained from mapping data processing using the VOSviewer application demonstrate the connection between one term and another. Each term in the VOSviewer application is displayed in the form of a circle with a different colour, making it easier for researchers to find the term that is the focus of the research. The circle for each term is small, medium or large. The size is determined by the occurrences number of each term. This statement is supported by the findings of Al Husaeni: The Size of the label is determined by the number of repetitions of the term found [22]. This study uses three types of data visualization mapping the results of data processing using the VOSviewer application consisting of network visualization (see Figure 2), density visualization (see Figure 3), and overlay visualization (see Figure 4). [33].



**Figure 2.** Network visualization of Cold Chain Management keyword



**Figure 3.** Density Visualization of Cold Chain Management keyword



**Figure 4.** Overlay Visualization of Cold Chain Management keyword

Figure 2 demonstrates the connection between each terms in form of a network through lines that have different colours. The colours in the lines in Figure 2 are the same as the circle colours in terms that often appear in various studies that have been carried out.

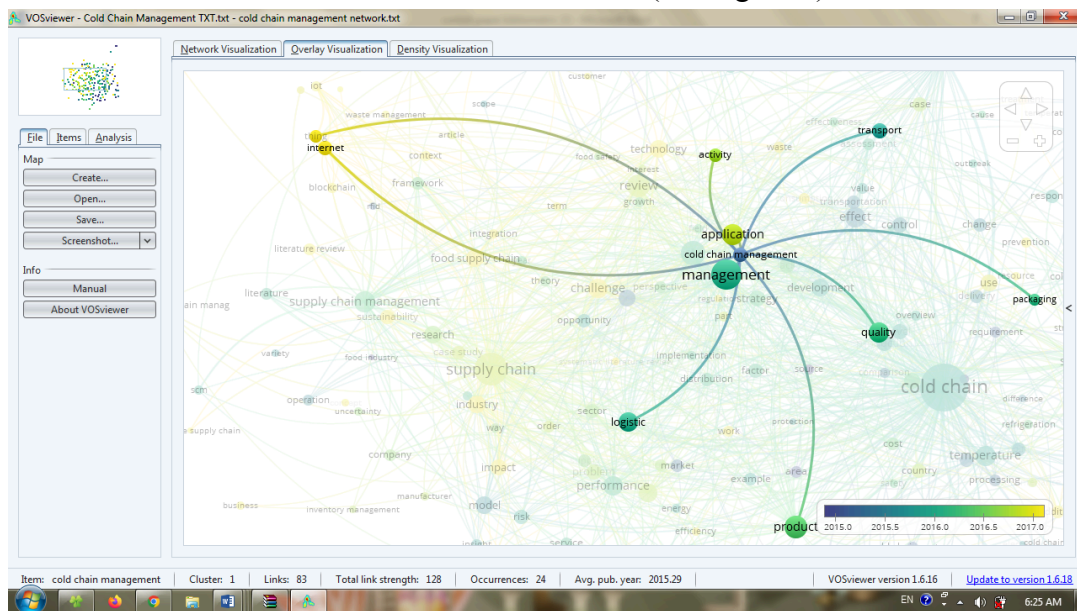
Figure 3 shows the density of research on various terms related to cold chain management. In Figure 3 there are only two colours blue and yellow. The blue colour as the background or the basic colour of the density visualization is displayed, while the yellow colour shows various terms that have been widely studied in previous journals. From the density visualization we will know that the brighter the color the more the term was found, and vice versa, the closer the colour is to the base colour, the less research has been done [22, 33, 34].



Figure 4 shows a stretch of terms that have been studied. Figure 4 is almost similar to Figure 2, but the difference is in terms of the colour of the term circle used. The colour in Figure 4 does not indicate how many terms are examined, but the colour shows the mean year of publication of the existing terms in each year. In addition, this overlay image also shows a line graph of the mean year of publication in each term and demonstrates range of year the term was studied a lot [22, 35, 36, 37]..

Figure 4 will be further clarified in Figure 5. This figure demonstrates the journal on cold chain management has been extensively researched from 2015 to 2017. Research using the term cold chain management was carried out in full, mostly about five years ago. Thus, it is very possible to carry out the latest research activities on cold chain management..

The three visualization pictures that have been given above (Fig. 2, 3, and 4), show various kinds of terms that have been studied previously. Each term listed in the image visualization is grouped into various clusters. From the existing clusters in data processing with VOSviewer, it can be concluded that research on cold chain management can be divided into three realm, the first is the cold chain term as a part of cluster 5 and has a total links of 205, the whole link strength is 1350, subtotal occurrences is 319. (see Figure 6). The second is a management term that is included in cluster 1. It has 163 links, the link strength is 499, and the occurrence is 114 (see Figure 7). The third is the term cold chain management. This term is part of cluster 1, has 83 links, 128 link strength, and the occurrences is 24. All the number has shown in total. (see Figure 8).



**Figure 5.** Overlay visualization of cold chain management term in 2015 to 2017

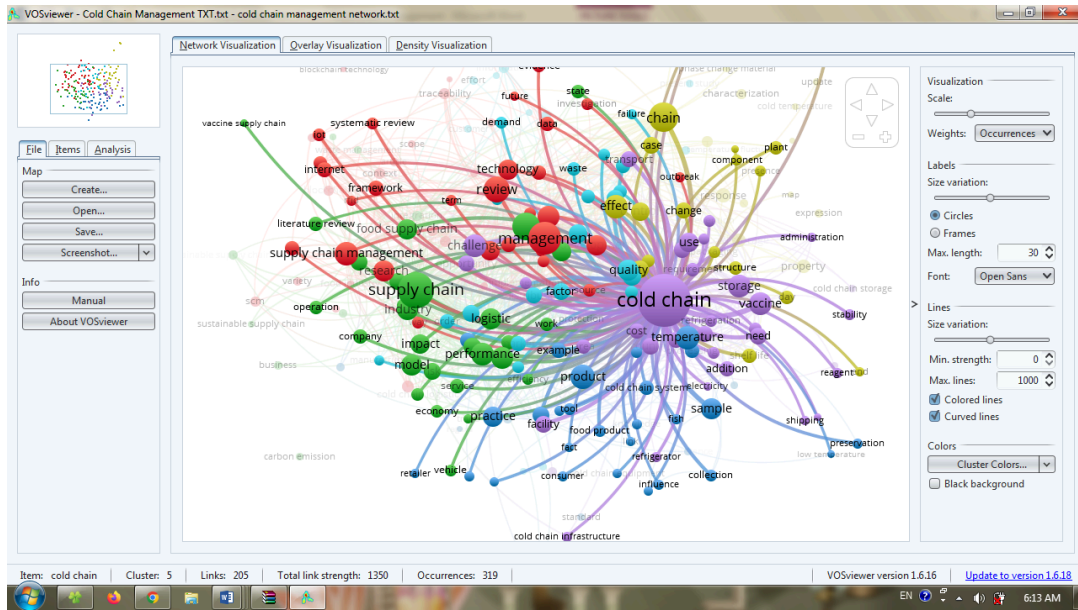


Figure 6. Network visualization of Cold Chain term

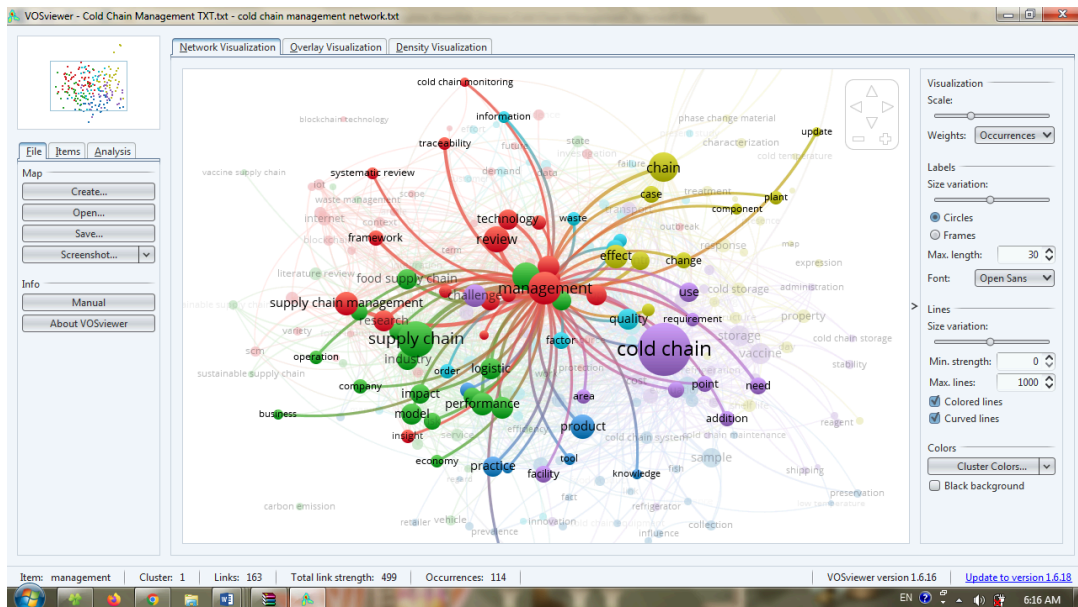
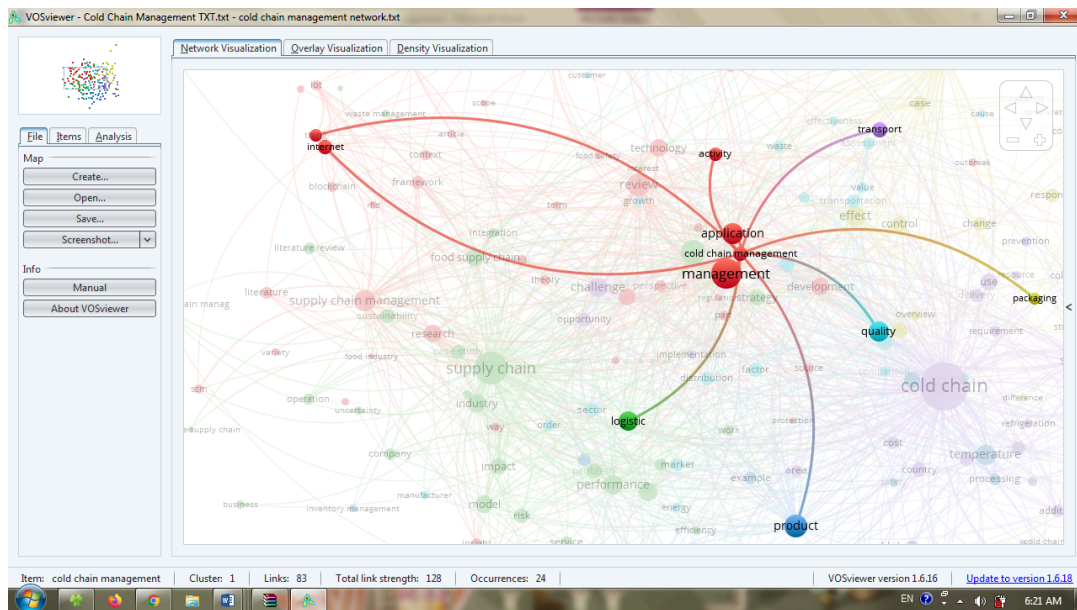


Figure 7. Network visualization of Management term



**Figure 8** .Network visualization of Cold Chain Management term

Figure 6 demonstrates a network of relations between the term cold chain and various other terms, including challenge, transport, use, administration, storage, stability, vaccine, refrigeration, cost, need, facility, refrigerator, shipping, reagent, country, requirement, cold chain infrastructure, addition.

Figure 7 shows a network of relationships between the term management and various other terms. Other terms that are related to the term management are systematic literature review, insight, development, application, research, activity, technology, review, theory, framework, supply chain management, systematic review, traceability.

The mapping data result that consisting of collected article make us realize that, the cold chain management keyword as a whole is still rarely used or discussed in various studies. Most studies only use terms or fields related to cold chain and management. With the presence of this study, other researchers can learn the latest study on cold chain management. In addition, hopefully in the near future there will be more research on cold chain management to add new insight into this field.

### 3.4.Explanation and Visualization cold chain management term and its relation to fisheries products

From the figure 8, it can be seen that one of the terms related to cold chain management is product. Examples of products that are usually distributed using cold chain systems include diagnostic materials, vaccines, lab samples, chemicals, meat, fish, processed food and beverages. These products require cold chain management because they are perishable products. Maintaining the temperature of perishable products below their optimum temperature shortly after harvest or production is a way to maintain the quality and safety of these products [40][41]. This is also reinforced by the results of research submitted by Kitinoja [42], regarding the benefits of the cold chain on perishable foods including fishery products, namely preventing discoloration and loss of texture, taste, and nutrition (biochemical changes) of the product itself, reducing water loss and shrinkage (physical changes), reducing physiological changes and reducing microbiological changes. Especially in capture fishery products, the quality degradation phase occurs very quickly. There are three stages after the dead fish is caught [43], namely:

- a. Prerigor phase: In this phase, the quality of the fish is still the same as when the fish was alive, so in this phase the fish is still very fresh, because it has just been caught.
- b. Rigor mortis phase: In this phase the fish has the same quality as when it was alive so it is still fresh, but the body condition gradually becomes stiff.
- c. Post rigor mortis phase: In this phase the fish meat has begun to decay, which is characterized by the texture of the body that is no longer elastic, when pressed using a finger, the fish meat is difficult to return to its original state.

From the above statement, it can be understood that cold chain management is a very necessary indicator for the distribution of fishery products. Although cold chain is the right handling method for fishery products, its application still faces a number of challenges. The cold chain is still fairly difficult to manage and operate, due to a number of challenging inhibiting factors, including: the existence of environmental conditions that cannot be controlled and are difficult to predict, limited infrastructure that does not support, and uncertainty of basic needs such as the availability of water and electricity usage. [44] Therefore, further research is needed related to cold chain management, especially in the fisheries sector, which needs to be improved again with the bibliometric applicator method. The sustainability of future research supports the advancement of innovation and renewable technology in the field of cold chain and increases the scientific theoretical basis related to the field.

#### **D. CONCLUSION**

Computational mapping analysis on research article bibliometric data is the aim of this research. All articles indexed on Google Scholar become the database in this research. Article searches are not directly on the Google Scholar web, but are searched through the Publish or Perish application. “Cold chain management” is the theme of this research. The Publish or Perish application found 272 articles related to the theme of “Cold Chain Management” in the period 2012 to 2022. During this period, research with the term cold chain management experienced a horizontal movement from 2012 to 2014, experiencing a slight increase in 2015, but after that, it fell again in 2016. Experienced the peak of research success in 2017-2018. After 2018 research continues to decline until 2022. The connection of cold chain management with perishable products that have a high sensitive value to temperature changes, one of which is fishery products, shows the effectiveness of good cold chain management handling and the need for expansion of cold chain management development. The results show that research opportunities in the field of cold chain management still have high potential for further research and can be associated with various terms of fishery products and various other terms.

#### **ACKNOWLEDGMENTS**

The author would like that all colleagues of Marine Logistics, Faculty of Serang Regional Campus, University of Education Indonesia for their support of all writing activities and facilities.

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