The research progress and hot-spot analysis of biogas slurry based on literature metrology

Lu Feng1, Min Cai1, Fucheng Li1* and Shaohang Chen2

1College of Resource and Environment, Southwest University of Science and Technology, Mianyang, 621010, China
2Chengdu Haoyu Siyuan Environmental Technology Co Ltd, Chengdu, 610000, China
*Corresponding author’s e-mail: lfckind@163.com

Abstract. The objectives of this study were to analyze the research trends and research hotspots of biogas slurry utilization and treatment in the past 20 years (1996-2018) by literature metrology. In the early 21st century, relevant research has increased rapidly. A total of 175 SCI papers with biogas slurry as the keyword were retrieved on the Web of Science. Keywords co-occurrence graphs showed the biogas slurry, growth, yield and nitrogen were the core keywords. The top four journals in the number of articles are Bioresource Technology, Pakistan Journal of Botany, Applied Soil Ecology, Environmental Science and Pollution. The top three cited authors with high central node are Ryckebosch E, Serejo ML, Abdeen Frh. The top four countries with the number of published articles are China, India, Pakistan and Germany. In conclusion, the core development direction of this field is “biogas slurry-quality”, and subordinate line is “biogas slurry, waste water treatment, nutrient removal and activated sludge”.

1. Introduction

Biogas slurry is a kind of liquid residue after anaerobic fermentation of livestock and poultry manure and crop straw. The biogas slurry is rich in various nutrients required for plant growth and enriched with active resistant substances that stimulate crop growth. It is a liquid organic fertilizer with quick and slow effect [1-3]. The rational use of biogas slurry can improve the environmental quality of the soil, promote crop growth, reduce the cost of agricultural production, and at the same time alleviate the pressure of subsequent treatment of biogas slurry [4-6]. The content of total nitrogen and total phosphorus in biogas slurry is high, which cannot meet the requirements of direct discharge, and becomes a new source of pollution. The environmental impact on the local farms is becoming more and more obvious. Therefore, it is very urgent to strengthen the research on the utilization and purification technology of biogas slurry [7]. According to the investigation, the heavy metal Zn and Cu content in the excrement of livestock and poultry is excessive, and the pollution is the most serious, which may be related to the type of additive. The application of such high-level livestock manure as organic fertilizer to the soil will lead to an increase in the levels of heavy metals and organic matter in the soil, thus affecting the migration of heavy metals in the soil crop system [8-9].

Bibliometrics, with literature system and bibliometrics characteristics as research objects, is widely used for literature intelligence analysis, and then evaluates the status and level of scientific development in a certain field. By means of bibliometric method and information visualization software CiteSpace, this paper analyzes the current research status, researching hotspots and major
research countries of biogas slurry, providing some reference for relevant research.

2. Materials and methods

Bibliometrics is to describe, evaluate and predict the current situation and development trend of a specialized subject by means of various characteristics of literature and by means of mathematics and statistics. This study uses CiteSpace software an information visualization software developed by Professor Chen C, as a Java application for analyzing and visualizing co-citation networks[10].

CiteSpace is a software for visual analysis of knowledge maps. The research fronts are determined based on Title, Abstract, Descriptors, and Burst Terms, and internal connections between different research frontiers are found. This paper uses the analysis method of the connection point strength, hotspot word clustering and hot word emergence. The connection strength is used to analyze the interaction strength between the organizations. Hot word clustering is used to mine research hotspots within the specified time interval of keywords, while keyword highlighting reflects a sharp increase or decrease in a professional interest, which may last for a period of time. By detecting emergence words, it can reveal research hotspots in different periods[11].

2.1. Data source and processing

In this paper, the US Science Information Institute embedded database Web of Science database is used as the data source, and the CiteSpace 5.3.R4 31.8.2018 visual analysis software is used to conduct data mining on the relevant literatures of foreign biogas research. Through the keyword co-occurrence network, the development of foreign research topics in this field were analyzed.

In the literature search process, select the most influential high-quality journal database of the ISI data Web of Science core collection database to comb the domestic and foreign biogas research literature. The keywords is “biogas slurry”, the time span is 1996-2018, and the document category is “Article”. A total of 175 document records are obtained, which are saved in “pure text” format. The content of the record is “author, title, source publication, summary”, download and save as “download.txt”.

Keywords and research institutions were extracted from the sample data, the co-occurrence network map and the co-occurrence tree map were made, and the biogas slurry research in foreign countries was systematically sorted out. The main operation methods are: ①Year Per Slice: 1; ②Term Type: Burst Terms; ③Node Type: Keyword. In addition, CiteSpace was run to obtain the tree diagram of cited references, the national distribution diagram of the study and the keywords co-occurrence tree diagram.

3. Result analysis

3.1. Development trend of biogas slurry research

The related research of biogas slurry first appeared in the late 20th century, which was highly concerned by scholars from all walks of life. According to the annual distribution of biogas slurry content in foreign countries, the research on biogas slurry content in the world changes greatly, which shows that the content of biogas slurry content increased rapidly in the early 21st century. It can be seen from Figure.1 that the research trend of biogas slurry in foreign countries is more and more obvious. In recent years, the amount of published materials has shown an increasing trend. It can be seen that foreign countries are paying more and more attention to the research of biogas slurry.
3.2. Literature quality analysis

The quality of the source of literature journal determines the degree of attention and influence of the research content of the literature in this field. This study ranked the sources of foreign biogas research literature by a series of indexes such as the journal's content and total citation frequency. The higher the total citation frequency, the higher the degree of emphasis on academic journals in academic exchanges, and vice versa. In the Web of Science database, 175 documents were distributed from 66 publications, and there were 2 source publications with more than 6 articles. These 2 journals accounted for 9.09% of the total journals. There are 4 source publications with more than 4-5 articles, accounting for 11.69% of the total number of journals. There are 30 source publications with more than 2-3 articles, accounting for 43.51% of the total number of journals. According to Table 1, the top four are Bioresource Technology, Pakistan Journal of Botany, Applied Soil Ecology, Environmental Science and Pollution.

| Journal title                      | Amount | Proportion(%) | Journal title                      | Amount | Proportion(%) |
|-----------------------------------|--------|---------------|-----------------------------------|--------|---------------|
| Bioresource Technology            | 8      | 5.16          | Energy                            | 4      | 2.60          |
| Pakistan Journal of Botany        | 6      | 3.90          | Asian Journal of Chemistry        | 3      | 1.95          |
| Pakistan Journal of Botany        | 5      | 3.25          | Biology and Fertility of Soils    | 3      | 1.95          |
| Environmental Science and Pollution | 5     | 3.25          | Journal of Environmental Management | 3    | 1.95         |
| Acta Agriculturae Scandinavica Section B Soil and Plant Science | 4 | 2.60 | International Journal of Systematic and Evolutionary Microbiology | 3    | 1.95         |

3.3. Distribution of publications by authors

3.3.1. Important citations and author distribution. The highly cited literature is an important source of
knowledge in a research field. It is found that the degree of centrality is closely related to frequency, and the degree of co-occurrence frequency determines the size of the map node, and the position of the degree of centrality or density control node. The higher the frequency of citations, the higher the level of research in the discipline, and it is also the basis for judging whether it is a frontier hot spot and topic. Table 2 shows the top 10 highly cited literatures in the field of biogas slurry soil research from 1996 to 2018. The top 3 literatures are: Lu J, Yu FB and Terhoeven-urselmanst T. According to the statistical analysis of the high cited authors in Table 3, the first three high cited authors with high center degree are Ryckebosch E, Serejo ML and Abdeen Frh, and the center degree values are 0.12, 0.10 and 0.06, respectively.

### Table 2. Highly cited literatures statistics.

| Cited frequency | Centrality | References | Cited frequency | Centrality | References |
|-----------------|------------|------------|----------------|------------|------------|
| 10              | 0.06       | Lu J       | 6              | 0.02       | Muradov N  |
| 3               | 0.06       | Grztic I   | 5              | 0.02       | Das P      |
| 5               | 0.05       | Garg RN    | 3              | 0.02       | HO SH      |
| 8               | 0.04       | Terhoeven-urselmanst T | 10 | 0.01       | Yu FB      |
| 8               | 0.02       | Abubaker J | 8              | 0.01       | Yan C      |

### Table 3. Highly cited author statistics.

| Centrality | Author     | years | Centrality | Author     | years |
|------------|------------|-------|------------|------------|-------|
| 0.12       | Ryckebosch E | 2016  | 0.03       | Garg RN    | 2009  |
| 0.10       | Serejo ML   | 2016  | 0.03       | Terhoeven-urselmanst T | 2013 |
| 0.06       | Abdeen Frh  | 2017  | 0.03       | Fang MX    | 2014  |
| 0.05       | Yan SP      | 2017  | 0.03       | Bonmati A  | 2017  |
| 0.04       | Yan C       | 2015  | 0.03       | Das P      | 2016  |

#### 3.3.2. National statistics on high yield of biogas slurry research.

According to the citation and author distribution research statistics and retrieval, the biogas slurry research literature mainly comes from 13 countries. The foreign research on biogas slurry started in India, and the study of high efficiency utilization of biogas slurry increased gradually. By 2010, China and Pakistan began to attach importance to the study of biogas slurry. The hotspot of research is yield. State and region publication number analysis were conducted on 175 search results. As shown in the Figure 2, the top 10 sending countries were China, India, Pakistan, Germany, Australia, Bangladesh, Finland, Japan, Malaysia, and the United States. It can be seen from Figure 2 that the two clusters of literature reference frequency and medium centrality of China and India, Germany and Pakistan are prominent. It can be seen that countries around the world have begin to pay attention to environmental issues and pay more attention to the research of biogas slurry.
3.4. Foreign subject research hotspots
Measurement statistics and screening were conducted through CiteSpace to obtain the top 10 keywords and keyword center and analyze them. The higher the degree of keyword center indicates the more important the research in related fields, and vice versa. As can be seen from Table 4, the medium of biogas slurry, growth, yield and nitrogen has high centrality, indicating that these research fields are more important. By summarizing the centrality, biogas research can be divided into: biogas slurry, growth, yield, nitrogen, waste water treatment and other aspects. From the timeline map analysis of the key words in Figure 3, the research on biogas slurry in foreign countries takes “biogas slurry, anaerobic digestion, waste water” as the main line, and the “biogas slurry, waste water treatment, nutrient removal and activated sludge” as the auxiliary line. It is the core of the development direction in this field.
Table 4. The sorting table of keywords in the first 10 center degree of foreign biogas slurry field.

| Centrality | Keyword         | Years | Centrality | Keyword         | Years |
|------------|----------------|-------|------------|----------------|-------|
| 0.49       | Biogas slurry  | 2003  | 0.17       | emission       | 2012  |
| 0.32       | growth         | 2015  | 0.15       | methane        | 2014  |
| 0.29       | yield          | 2009  | 0.13       | Anaerobic digestion | 2011 |
| 0.27       | nitrogen       | 2009  | 0.12       | soil           | 2012  |
| 0.19       | Waste water    | 2013  | 0.11       | Activated sludge | 2017 |

4. Conclusion and discussion

This paper by CiteSpace software to analyze the countries and regions in the international journal articles in the past 20 years (1996-2018), focusing on the topic of “biogas slurry”. To a certain extent, it reflects the hot issues of concern in this field.

(1) From the characteristics of foreign development in this field and research hotspots, the “biogas slurry and anaerobic digestion and waste water” is the main line, and the “biogas slurry and waste water treatment and nutrient removal and activated sludge” is the auxiliary line. The corresponding research hotspots are also revealed by keyword co-occurrence maps and high-frequency keyword lists.

(2) From the perspective of international cooperation, China's research results in this field play an important role, which reflects China's emphasis on biogas treatment and efficient utilization. International cooperation between India, Pakistan and Germany also contributes to research in this field. The international cooperation and co-production map also shows that China’s international cooperation is slightly insufficient.

(3) From the perspective of journal source, Bioresource Technology and Pakistan Journal of Botany and Applied Soil Ecology and Environmental Science and Pollution have higher carrying capacity in this field and have higher influence.

Acknowledgment

This work was supported by China National Science and Technology Support Program (2015BAC05B05) and The Experimental Technology Research Project of Southwest University of Science and Technology (15syjs23).

References

[1] Wang, W. P., Zhu, F. X., Chen, X. Y. (2010) Effect of biogas slurry irrigation on soil quality and yield quality in Brassica chinensis (in Chinese). J. Journal of Zhejiang Agricultural, 22 (1): 73-76.
[2] Wang, W. P., Lu, X. M., Wei, Z. H. (2010) Influence of Applying Biogas Slurry on Yield and Quality of Citrus and Soil Environment (in Chinese). J. Journal of Agricultural Environment Science, 30 (11): 2300-2305.
[3] Yu, F. B., Luo, X. P., Song, C. F. (2010) Concentrated biogas slurry enhanced soil fertility and tomato quality. J. Acta Agriculturae Scandinavica, 60(3): 262-268.
[4] Han, X. L., Li, B. W., Liu, W. (2012) Effects of applying biogas slurry-based fertilizer on the yield, quality and nitrogen use efficiency of rape (in Chinese). J. Journal of Hebei Agricultural University, 35 (3).
[5] Ye, B. C., Zhang, D. Y., Ling, X. J. (2005) Biogas slurry of rice seed soaking test study (in Chinese). J. Journal of Anhui Agricultural Science, 33 (9): 1612-1612.
[6] Long, S. B., Zhang, Y. M., Fu, Z. B. (2007) Effects of different time and method soaking in Firedamp Liquid on Germaniation percentage and seeding quality of rice (in Chinese). J. Journal of Guizhou Agricultural Science, 35 (1): 42-44.
[7] Wu, S. B., Cui, C., Zhang, X. Q. (2013) Effect of Biogas Slurry on Yield Increase, Quality Improvement, Water and Soil Environment (in Chinese). J. Journal of Agricultural Machinery, 44 (8): 118-125.
[8] Tao, X. P., Dong, H. M., Shang, B. (2011) Comparison of Inhibiting Effects Between Fresh
Effluents of Anaerobically Digested Piggery Waste and Anaerobically Digested Dairy Waste on Plant Pathogenic Fungi (in Chinese). J. Journal of Agricultural Environment Science, 30 (7): 1443-1449.

[9] Shang, B., Tao, X. P., Chen, Y. X. (2011) Inhibitory Effect of Biogas Slurry of Cattle Manure on Vegetable Pathogens (in Chinese). J. Journal of Agricultural Environment Science, 30 (4): 753-760.

[10] Chen, C. (2006) CiteSpace II: Detecting and visualizing emerging trends and transient patterns in scientific literature. J. Journal of the Association for Information Science and Technology, 57(3): 359-377.

[11] Chen, C. (2009) CiteSpace II: Detecting and visualizing emerging trends and transient patterns in scientific literature. J. Journal of the Association for Information Science and Technology, 57(3): 359-377.