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A Bibliometric Analysis of Fifteen Years of Biogas Research Trend Between 2000-2015

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Abstract:
Biogas is a source of renewable energy which is generated through anaerobic process. Biogas is useful in generating heat which is used for fueling, electricity and cooking mostly in the rural areas. Biogas fuels are majorly gotten from agricultural waste, human waste and others. The objective therefore is to profile the research efforts and important trends in biogas research over fifteen year period from 2000 to 2015. A bibliometric analysis of the scientific outputs in biogas research was conducted based on documents retrieved from Scopus database using biogas as the search term. Key bibliometric dimensions were explored including: the countries and institutions contributing to biogas research literature, prolific authors, and global publication distribution during the period under review. A total of 14,468 documents were retrieved from the search conducted. China has the highest number of publications in biogas research. Furthermore, English language was the most dominant language in biogas research. Chinese academy of sciences is the leading institution in biogas research in terms of output, while Angelidak, Irini emerged as the most prolific author. In addition, most research works were published Article with 70.6% regarding several research subject areas, energy research trends upward globally. Also, English speaking researchers exceeds others.

Keywords: *Biogas, Biomass, Bibliometric analysis, Energy, Scientometric.*

I. INTRODUCTION

Biogas is a renewable source of energy that can be utilized for various energy needs from heating, power generation or mechanized transportation. Despite that, industries focusing on biogas production and waste suppliers has increased the production of gas due to the fermentation process between organic waste and manure (Hakawati, Smyth, McCullough, De Rosa, & Rooney, 2017). Production of biogas can be achieved through the breakdown of organic wastes materials (for example dairy manure, food waste, sewage) in the absence of oxygen, and it undergoes anaerobic digestion, Furthermore, biogas can be used for heating and electricity and fuel (El-Mashad & Zhang, 2010).

Biogas has increased drastically and has been used for several purposes, For example, industries that focus on waste treatment and organic waste tributaries, agricultural firm and stakeholders, household consumption for cooking (Hartmann, H., and Ahring, 2005). Uncontaminated and renewable source of energy like biogas fuel has been previously supplemented and substituted with a conventional source of energy like fossil fuel and oil. This has caused harmful damage to the environment and ecosystem (environmental pollution (Yadvika, Santosh, Sreekrishnan, Kohli, & Rana, 2004). In Thailand, due to the increase in the world population the use of energy source, has gone upward thereby, increasing the demand. The government of Thailand said in 2022 the production of a renewable source of energy such as biogas should be increased from 6.4% to 20.3%. Because Thailand has enough agricultural waste by-products, biomass, industrial waste and breweries waste that can be used for biogas production as stipulated by the government (Chaiprasert, 2011). The benefits of a renewable source of energy (biogas) in Poland has increased significantly (Budzianowski & Chasiak, 2011)

Also, some factors affecting biogas technology in Africa countries such as very high capital intensive, also

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inadequate channel for disseminating recent information on biogas technology and research. Low availability of materials for biogas production (Mulinda, Hu, & Pan, 2013). The demand for renewable energy by most countries all over the world gives policy and decision maker an edge because is one of the most vital demands (Ediger 2007).

II. BRIEF BACKGROUND AND RESEARCH CONTEXT OF BIOGAS PRODUCTION

Biogas comprises three (3) major components which are carbon dioxide (CO2), methane (CH4), and sulfuric components (H2S) (Coelho et al., 2006). Also, Anunputtikul and Rodtong (2004) said carbon dioxide (35–45%), hydrogen sulfide (0–1%), hydrogen (0–1%), nitrogen (0– 3%), methane (55–65%). Some biogas plants are processing residual sludge from wastewater treatment plants (Hänninen 2011).

Asia ranks as the highest continent in biomass production and research, with over 43% margin. Asia is closely followed by Europe, with Germany leading the (Bartłomiej, Kujawski, Buczkowski, & Cichosz, 2010). Germany biogas energy production increased to 56% in 2006. The environmental benefit of biogas usage cannot be overemphasised, particularly in the reduction of the release of CO2 into the atmosphere by burning wood, as of the case in the most rural area. (Smith, R. Uma, V.V.N. Kishore, K. Lata, Zhang, Rasmussen, & Khalil, 2000). Previously, energy crop, for example, Maize, legumes, and grasses were the major source at which biogas production i.e. anaerobic digestion process was done in the past. As awareness of biogas fuel increases several crops that have the potentials to generate energy are discover and a wide range of that crop are be grown by farmers (Bauer et al., 2007). Most industrious company processing the waste products from livestock production and processing, brewery processing, crop production, house waste. However, the range of several potential wastes from the feedstock, public wastewater, residual sludge, waste by-product during seafood processing, cow manure, poultry droppings, aquaculture wastewater, and public solid wastes (faeces) (Nakasaki, Tran, Idemoto, Abe, & Rollon, 2009; Richards, Herndon, Jewell, Cummings, & White, 1994). Food processing wastewaters may come from citrus processing, dairy processing, vegetable canning, potato processing, breweries, and sugar production (Sežun, Grilc, Zupančič, & Logar, 2011). In a research carried out by Bartlomiej et al 2012 tells that they are 24 major agricultural biogas industries, which are fully functioning in Poland (2012).

There are several challenges related to biogas research in most countries and these challenges slow the rate of biogas research. For example, the high cost of purchasing biogas equipment in Nigeria (Akinbami, Ilori, Oyebisi, Akinwumi, & Adeoti, 2001), in China the running of biogas plant and technology is capital intensive (Jiang, Sui, Wu, Yang, & Wang, 2007). And the extension of biogas in Sweden pose a treat to the storage and distribution of biogas (Lantz, Svensson, Björnsson, & Börjesson, 2007).

A bibliometric analysis was carried out by Kiriyama (2013), to evaluate the trend of global nuclear technology research in Japan, showing the yearly trend of paper distribution and R&D budget on nuclear technology annually. Furthermore, the number of nuclear research conducted by institutions in Japan, co-occurrence network analysis.

According to Guozhu (2015) after conducting a bibliometric analysis of activities on alternative energy and future direction of the research output based on science citation Index-expanded (SCI-E) during the period of 1994-2013. The study reveals that English language is the predominant language in explaining results in alternative energy research. Furthermore, a research was carried out by Mao (2015), the bilometric analysis on the past, current, and future of biomass energy research using Science Citation Index (SCI) of the web of science during the period of 1998-2013. A total of 33,072 documents were analyzed to ascertain the trend in biomass, While USA, China and India are among the most prolific countries in the trend of biomass research. Also, Chinese Academy of science was the institution with the most publication records (639). Yang (2013), also used a bibliometric method to access the current trend in solid waste research during the period of 1997-2011. All document were extracted from Science Citation Index, the research was mainly concentrated most prolific country, subject areas, document types on solid waste research.

The result reveals that anaerobic digestion, water waste, heavy metals are the most frequent topics on solid waste research. A bibliometric analysis research was also conducted by Wang (2013), study the global trends on anaerobic digestion of biomass for methane production research, using ISI Web of Science are the source for documents between the periods of 1994-2011. The

research focuses on publication distribution among countries, Institutions, authors.

The scientometric analysis research of production of bioenergy from biomass carried by (Konur, 2012) shows that 5892 papers have been published in that field. Most research is being done in English particularly journals, reviews, and conference proceedings. Furthermore, USA contributes 27% of publication making the country the most prolific single country behind Europe which has approximately 50%."A. Demirbas" is a most productive author in biomass and bioenergy.

According to the scientometric review done by (Torsten & Möller, 2013), the growth of research publication of organic farming and bioenergy from 2014 to 2011 was observed in 2001 and Europe (36 papers) followed by America and Asia with 5 papers each. During the period research over 46 articles were all over 32 journals. However, only 8 journals have more than two articles of organic farming and bioenergy research published in them.

III. ISSUES ON BIOGAS RESEARCH

Base on the increase in the demand for biogas fuel production and related disciplines globally, particularly China, Germany and USA and as well increase in bibliometric research. However, to the superlative understanding of the authors of the research output, there has been no prior bibliometric analysis focusing on the trends on biogas research, using Scopus database are their source as of the time of the study.

This comprehensive research is to fill up the gaps relating to the recent study, the main purpose of this bibliometric analysis is to show the relevant trends in biogas research during the period of 2000-2015. Indicating the most prolific author's, Secondly, distribution output among countries, productive document types, Sources types, Institutions and Yearly distribution of biogas publication and journal distribution. Furthermore, the author's keywords will be analyzed to show the major topics in the field of biogas research.

This research study reveals the trends of bibliometric analysis of biogas research during the period of 2000 - 2015. Secondly, the top keywords in the field of biogas research are been analysis, which will provide a medium for yet to come researches.

IV. METHODOLOGY

The various academic publication used in this review are all related to biogas research from the year 2000 to 2015 as retrieved from the Scopus which is the largest database for the abstracting of peer-reviewed literature which includes scientific journals, books, and conference proceeding which are frequently used by researchers for publication of high impact research outputs [Source required]. The search for these documents was carried out using the keyword "Biogas", with the years under consideration limited to from 2000 to 2015.

On the basis of the aforementioned, a total of 14,468 research publications related to biogas research were sorted out. This research also evaluated diverse parameters such as the most prolific document types used by researchers, most frequent subject area, authorship, contributions of the different country as related to biogas, and institution/affiliation. The downloaded data was exported from Scopus and converted to MS EXCEL to enable the data to be accurately analyzed.

V. RESULTS AND DISCUSSION

1.1. Country Contributions to Biogas Research

Table 1 shows the top 20 publication distribution of countries in biogas research. The data obtained from Scopus was analyzed and a total of 132 countries have contributed to biogas researches. It reveals that 12,327 out of a total of 14,468 publications were published by the top 30 countries. China has the highest number of publications with 2324 document (13.51%) in biogas research, followed by Germany with 1479 document (8.60%), United State of America is third with 1388 (8.07%), India with 997 document (5.79%), Italy with 786 document (4.63%). A downward trend observed in Netherlands, South Korea, Thailand, Turkey, and Malaysia 284, 284 (1.65%), 276 (16.0%), 259(1.51%), 251 (1.46%) and 240 (1.39%) publications respectively. Thus, China, Germany, and the United State comprise 30.18% of publication of biogas research globally.

Table 1: Most prolific Country Contributions to Biogas Research

1.2. Most Productive Authors in Biogas Research

Following the data sample of 14,468 research papers from Scopus database on biogas, an analysis was carried out to determine the top 15 most prolific authors in the field of biogas. As shown in Figure 2, the top 15 authors on these categories were selected based on the number of papers published ranging from 30 and above. The most

prolific author was Angelidaki, I. with 78 papers (2.10%), followed by Verstraete, W. with 52 papers (1.40%), thirdly by Li, X with 49 papers (1.32%), Taherzadeh, M.J. with 47 papers (1.26%) and Murphy, J and Steyer, J.P. with 43 papers (1.15%) each. Based on the top 15 ranking of authorship analyzed, Lanzini, A., Oeschsner, H., with 34 papers (0.91%) each. Making Dong, R and Friedl, A having the lowest paper published, 32 papers (0.86%) and (0.83%) respectively in Table 2.

Table 2: Most Productive Authors in Biogas Research

1.3. Yearly Biogas Publication Trends

Distribution in biogas research was at its peak in 2015 with a total publication of 2194 papers (15.6 %), followed by year 2014, 2013 and 2012 which have 2,120 papers (14.65%), 1765 papers (12.20%), and 1582 papers (10.93%) publications respectively as reflected in Scopus database. Also, the rate at which biogas research was done in 2000 was 198 papers (1.37 %) and later decreased to 173 papers (1.20 %) in 2001 but increase again in 2002 with 200 papers (1.38%) in Figure 1.

Figure 1: Yearly Distribution of Biogas Publication Trends

1.4. The Document Types Biogas Publication

In this paper, the analysis was done on the various document types widely used by biogas researchers in Scopus during the period of 2000 to 2015 and total 14,468 publications were sorted out. The analysis shows that the most prolific document type sourced by the scientists was Article with 10,220 papers (70.6 %) published, followed by Conference paper with 2,718 papers (18.8 %), Review with 696 papers (4.8 %) and a book chapter with 336 papers (2.3%). Less attention was given Erratum with 12 papers, Article in the press with 2 papers in Table 3.

Table 3: Most productive Document Types Biogas Publication

1.5. Biogas Research Publication Languages

English language is the foremost language used in publishing biogas research with 12789 (87.53%) documents during the period of this study. Several languages were used in research on biogas publications such as Chinese with 829 (5.67%) documents, German with 508 (3.47%) documents, and Spanish with 93 (0.64%) documents. In addition, French with 83 documents, Polish with 80 documents, Portuguese with 71 documents, Japanese with 48 documents, Russian with 21 documents, and Czech with 16 documents in Table 4.

Table 4: Most prolific Biogas Research Publication in Languages

1.6. Most Productive Institutions in Biogas Researc

A total of 160 institutions have contributed to biogas and related disciplines according to the 14,468 publications retrieved from the Scopus database. Among the 160 institutions, the top 15 affiliations involved in the biogas research was analyzed, and it shows most of that Chinese Academy of Sciences trend more on the subject of biogas research with 236 publication and these encourage most researchers on biogas The next-in-line of the top 15 affiliations is Denmark's Tekniske Univeritet with a total publication of 173 papers, followed by Lund Universities with 134 papers and closely followed by Ministry of Education China, China Agricultural University, and Tsinghua University with 126 papers each in Table 5.

Table 5: Top 15 Most Productive Institutions in Biogas Research

1.7. Subject Area Classification of Biogas Research

During the period of 2000 to 2015, several types of research done on the biogas related subject as reflected in data downloaded and analyze from Scopus database classification. Research on Energy has the highest paper publications with 4335 papers, closely followed by Environmental Science with 6035 (23.19%) documents published on it. Secondly, Energy with 4335 (16.66%), thirdly, Engineering with 3377 (12.98%). In Addition, Chemical Engineering 3322 (12.76%), Agriculture and Biological Sciences with 2259 (8.68%), Chemistry with 1266 (4.86) documents published during the period of this study. research on material science has the lowest documents among the top 10 subject areas with a number of 532 (2.04%) documents in Table 6.

Table 6: Top 10 Subject Area Classification of Biogas Research

1.8. Most Prolific Journal Title

Several journals were sorted out and the top 15 Journal publishing between 106 and 971 documents on biogas research are listed in the Table 7. The most prolific Journal was Bioresource Technology with a total number of 971(11.52%) documents published; followed by Water Science And Technology with 438 (5.20%)

documents published; Waste Management with 258 (3.06%) documents; Biomass And Bioenergy with 241 (2.86%). The first four journals are majorly focused on Biotechnology such as biogas and biomass. International journal of hydrogen energy and advance material research have 228 (2.71%) and 222 (2.63 %) documents published respectively in the field of biogas research.

Table 7: Top 15 Journal Title Distribution in Biogas Research

1.9. Keywords related to Biogas Research

Biogas is the most prolific keywords frequently used with 10411 (9.51%) documents. secondly, Anaerobic digestion with 4514(4.12%) documents. Thirdly, methane with 4198 (3.84%) documents. Biogas, anaerobic digestion, and methane with (17.47%) are the major keywords used in biogas research compare to other keywords like an article with 3376 documents, priority journal with 1810 documents and biomass with 1753 documents are growing intensively in Table 8.

Table 8: Keywords Trends in Biogas Research

VI. CONCLUSION

The main idea of this scientometric analysis of biogas publications during the period of 2000-2015, is to show how well research is been carried out on biogas for the period of 10 years. Different data were collected and different parameter was analyzed such the most prolific authors, affiliation, subject area, distribution output on biogas among different countries, types of the document most source by several scientists on biogas. This Scientometric analyzed research shows that countries are going into biogas research which become a global source of energy for household mostly in countries such as China which has 2324 papers published on biogas and making them the highest countries from Scopus database classification during 2000-2015. Followed Germany (1479 papers), United State (1388 papers) and India (997 papers). This study also reveals that out of the 14,468 publications download from Scopus that 12,798 research was done in the English language globally, even non-speaking scientist contribute also such as Chinese and German languages.

This study also revealed that biogas research is drastically increasing from 2002 with 200 papers to 2015 (2194 papers) but then was a little depletion between 2001 (173 papers) compare to 2000 (198 papers). The various affiliations were analyzed and the top 15 affiliations were listed showing Chinese academy of sciences topping all other institution with 236 publications on biogas research. The Denmarks tekniske Universitet also publish 173 research paper relating to biogas. The research also shows that article (10,220 paper), conference (2718 paper), and review (696 papers) has 94.2 % of document type sourced by biogas researcher during the period of 2000-2015. Top 15 authors in the field of biogas research during the period of 2000-2015, the result shows that Angelidak, I. is the most prolific author with 78 papers following by Verstraete, W., and Li, X. Also, Environmental, energy, engineering, chemical engineering, Agriculture, are the major subject area.

The various results and analysis will show researcher the rate at which biogas research is trending and provide useful references and easy access to materials. Most especially, serve as a medium for awareness and guideline to researchers and industries in the developing countries such as Nigeria, Ghana, Kenya, Senegal, Benin, Zambia Togo that have high amount of organic waste and manure to venture more into biogas research and production.

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VIII. REFERENCES

1. Akinbami, J.-F. ., Ilori, M. ., Oyebisi, T. ., Akinwumi, I. ., & Adeoti, O. (2001). Biogas energy use in Nigeria: current status, future prospects and policy implications. Renewable and Sustainable Energy Reviews, 5(1), 97–112. https://doi.org/10.1016/S1364-0321(00)00005-8
2. Anunputtikul, W., and Rodtong, S. (2004). Laboratory scale experiments for biogas production from cassava tubers. The Joint International Conference on “Sustainable Energy and Environment(SEE)".
3. Anil Rupnar & Pushpendra Chauhan, " Design, Development of Domestic Cookstove Suitable for Different Solid Biomass Fuel ", International Journal of Environment, Ecology, Family and Urban Studies (IJEEFUS), Vol. 6, Issue 6, pp. 15-22

4. Bartłomiej, I., Buczkowski, R., Iglińska, A., Cichosz, M., Piechota, G., & Kujawski, W. (2012). Agricultural biogas plants in Poland: Investment process, economical and environmental aspects, biogas potential. Renewable and Sustainable Energy Reviews, Vol. 16, pp. 4890–4900. https://doi.org/10.1016/j.rser.2012.04.037
5. Bartłomiej, I., Kujawski, W., Buczkowski, R., & Cichosz, M. (2010). Renewable energy in the Kujawsko-Pomorskie Voivodeship (Poland). Renewable and Sustainable Energy Reviews, Vol. 14, pp. 1336–1341. https://doi.org/10.1016/j.rser.2009.12.005
6. Bauer, A., Hrbek, R., Amon, B., Kryvoruchko, V., Bodiroza, V., Wagentristl, H., … Amon, T. (2007). The potential of biogas production in sustainable biorefinery concepts. 5th Research and Development Conference of Central and Eastern European Institutes of Agricultural Engineering. Retrieved from https://www.researchgate.net/publication/237296235_Potential_of_biogas_production_in_sustainable_biorefinery_concepts
7. Budzianowski, W. M., & Chasiak, I. (2011). The expansion of biogas fuelled power plants in Germany during the 2001 – 2010 decade : Main sustainable conclusions for Poland. Journal of Power Technologies, 91(2), 102–113.
8. C. Ranganathan & R. Balasubramani, " Scientometric Profile of Research Activities on Green Energy: An Indian Perspective ", IMPACT: International Journal of Research in Applied, Natural and Social Sciences (IMPACT: IJRANSS), Vol. 2, Issue 1, pp. 23-30
9. Chaiprasert, P (Division of Biotechnology, S. of B. and T. (2011). Biogas Production from Agricultural Wastes in Thailand. Sustainable Energy & Environmet Special Issue, 63–65.
10. Ediger, V. ¸S., and Akar, S. (2007). ARIMA forecasting of primary energy demand by fuel in Turkey. Energy Policy, 35(3), 1701–1708. https://doi.org/https://doi.org/10.1016/j.enpol.2006.05.009
11. El-Mashad, H. M., & Zhang, R. (2010). Biogas production from co-digestion of dairy manure and food waste. Bioresource Technology, 101(11), 4021–4028. https://doi.org/10.1016/j.biortech.2010.01.027
12. Guozhu, M., Liu, X., Du, H., Zuo, J., & Wang, L. (2015). Way forward for alternative energy research: A bibliometric analysis during 1994-2013. Renewable and Sustainable Energy Reviews, 48, 276–286. https://doi.org/10.1016/j.rser.2015.03.094
13. Hakawati, R., Smyth, B. M., McCullough, G., De Rosa, F., & Rooney, D. (2017). What is the most energy efficient route for biogas utilization: Heat, electricity or transport? Applied Energy, 206, 1076–1087. https://doi.org/10.1016/j.apenergy.2017.08.068
14. Hartmann, H., and Ahring, B. K. 2005. (2005). The future of biogas production. Risø International Energy Conference on Technologies for Sustainable Energy Development in the Long Term, Riso-R-1517(EN), Roskilde, Denmark, 163–172. Roskilde.
15. Himanen, M., & Hänninen, K. (2011). Composting of bio-waste, aerobic and anaerobic sludges - Effect of feedstock on the process and quality of compost. Bioresource Technology, 102(3), 2842–2852. https://doi.org/10.1016/j.biortech.2010.10.059
16. Jasvarinder Chalotra & Sarbjit Singh Sooch, " Design and Development of Bio-Digested Slurry Lifting Machine for Paddy Straw Based Dry Fermentation Biogas Plant ", International Journal of Agricultural Science and Research (IJASR), Vol. 7, Issue 5, pp. 503-510
17. Jiang, J., Sui, J., Wu, S., Yang, Y., & Wang, L. (2007). Prospects of Anaerobic Digestion Technology in China. Tsinghua Science and Technology, 12(4), 435–440. https://doi.org/10.1016/S1007-0214(07)70064-0
18. Kiriyama, E., Kajikawa, Y., Fujita, K., & Iwata, S. (2013). A lead for transvaluation of global nuclear energy research and funded projects in Japan. Applied Energy, 109, 145–153. https://doi.org/10.1016/j.apenergy.2013.03.045
19. Konur, O. (2012). The scientometric evaluation of the research on the production of bioenergy from biomass. Biomass and Bioenergy, Vol. 47, pp. 504–515. https://doi.org/10.1016/j.biombioe.2012.09.047

March - April 2020
ISSN: 0193-4120 Page No. 11154 - 11164

20. Kumar Shailendra, Singh Neelam Kumar & Khardiwar Mahadeo, " The Pattern of Dung Feeding and Maintenance Practices of Biogas Plants in the Chhattisgarh Plains, India ", International Journal of Agricultural Science and Research (IJASR), Vol. 9, Issue 3, pp. 221-228
21. Lantz, M., Svensson, M., Björnsson, L., & Börjesson, P. (2007). The prospects for an expansion of biogas systems in Sweden - Incentives, barriers and potentials. Energy Policy, 35(3), 1819–1829. https://doi.org/10.1016/j.enpol.2006.05.018
22. Mao, G., Zou, H., Chen, G., Du, H., & Zuo, J. (2015). Past, current and future of biomass energy research: A bibliometric analysis. Renewable and Sustainable Energy Reviews, 52, 1823–1833. https://doi.org/10.1016/j.rser.2015.07.141
23. XXIII.Mulinda, C., Hu, Q., & Pan, K. (2013). Dissemination and Problems of African Biogas Technology. Energy and Power Engineering, 05(08), 506–512. https://doi.org/10.4236/epe.2013.58055
24. Nakasaki, K., Tran, L. T. H., Idemoto, Y., Abe, M., & Rollon, A. P. (2009). Comparison of organic matter degradation and microbial community during thermophilic composting of two different types of anaerobic sludge. Bioresource Technology, 100(2), 676–682. https://doi.org/10.1016/j.biortech.2008.07.046
25. Pomin Li, Wei Te ,Wu & Ru Chu Shih, " Fermentation of Banana Fruit to Produce Butano ", IMPACT: Journal of Research in Applied, Natural and Social Sciences (IMPACT: IJRANSS), Vol. 1, Issue 1, pp. 53-60
26. Richards, B. K., Herndon, F. G., Jewell, W. J., Cummings, R. J., & White, T. E. (1994). In situ methane enrichment in methanogenic energy crop digesters. Biomass and Bioenergy, 6(4), 275–282. https://doi.org/10.1016/0961-9534(94)90067-1
27. Reham M. El-Bahbohy, Farida Shokry, Shady A. Mottaleb, Essam Darwish, Gehan Safwat & Naguiba Elghamrawy, " Enhancing Biomass Productivity and Photosynthetic Pigments Content of an Egyptian Anabaena Ambigua Blue-Green Alga Isolate ", International Journal of Agricultural Science and Research (IJASR), Vol. 6, Issue 3, pp. 513-524
28. Sežun, M., Grilc, V., Zupančič, G. D., & Logar, R. M. (2011). Anaerobic digestion of brewery spent grain in a semi-continuous bioreactor: Inhibition by phenolic degradation products. Acta Chimica Slovenica, 58(1), 158–166.
29. Smith, K. R., R. Uma, V.V.N. Kishore, K. Lata, V. J., Zhang, J., Rasmussen, R. A., & Khalil, M. A. K. (2000). Greenhouse gases from small-scale combustion devices in developing countries: phase IIa - Household stoves in India. Environmental Protection Agency, 600/R-00–0(June). https://doi.org/EPA-600/R-00-052
30. Torsten, S., & Möller, D. (2013). Mapping research at the intersection of organic farming and bioenergy - A scientometric review. Renewable and Sustainable Energy Reviews, Vol. 25, pp. 197–204. https://doi.org/10.1016/j.rser.2013.04.025
31. Wang, L. H., Wang, Q., Zhang, X., Cai, W., & Sun, X. (2013). A bibliometric analysis of anaerobic digestion for methane research during the period 1994-2011. Journal of Material Cycles and Waste Management, Vol. 15, pp. 1–8. https://doi.org/10.1007/s10163-012-0094-5
32. Yadvika, Santosh, Sreekrishnan, T. R., Kohli, S., & Rana, V. (2004). Enhancement of biogas production from solid substrates using different techniques - A review. Bioresource Technology, Vol. 95, pp. 1–10. https://doi.org/10.1016/j.biortech.2004.02.010
33. Yang, L., Chen, Z., Liu, T., Gong, Z., Yu, Y., & Wang, J. (2013). Global trends of solid waste research from 1997 to 2011 by using bibliometric analysis. Scientometrics, 96(1), 133–146. https://doi.org/10.1007/s11192-012-0911-6

Table 1: Most prolific Country Contributions to Biogas Research

#	Country	Number Of Publication	Percentage
1.	China	2324	13.51%
2.	Germany	1479	8.60%
3.	United States	1388	8.07%
4.	India	997	5.79%
5.	Italy	796	4.63%
6.	Spain	615	3.57%
7.	United Kingdom	496	2.88%
8.	Sweden	484	2.81%
9.	Canada	469	2.73%
10	France	421	2.45%
11.	Japan	414	2.41%
12.	Brazil	365	2.12%
13.	Denmark	349	2.03%
14.	Poland	344	2.00%
15.	Austria	316	1.84%

Table 2: Most Productive Authors in Biogas Research

#	Names Of Authors	Number Of Publication	Percentage
1	Angelidaki, Irini	78	2.10%
2	Verstraete, Willy Henry	52	1.40%
3	Li, Xiujin	49	1.32%
4	Taherzadeh, Mohammad	47	1.26%
5	Murphy, Jerry D.	43	1.15%
6	Steyer, Jean Philippe	43	1.15%
7	Li, Yebo.	38	1.02%
8	Santarelli, Massimo Gian	36	0.97%
9	Zhang, Ruihong	36	0.97%
10	Ahring, Birgitte K.	35	0.94%
11	Zheng, Zheng	35	0.94%
12	Lanzini, Andrea	34	0.91%
13	Oechsner, Hans	34	0.91%
14	Dong, Renjie	32	0.86%
15	Friedl, Anton	31	0.83%

Table 3: Most productive Document Types Biogas Publication

#	Document Type	Number of Publication	Percentage
1	Article	10220	70.64%
2	Conference Paper	2718	18.79%
3	Review	696	4.81%

4	Book Chapter	336	2.32%
5	Note	198	1.37%
6	Conference Review	92	0.64%
7	Short Survey	69	0.48%
8	Editorial	46	0.32%
9	Business Article	33	0.23%
10	Book	29	0.20%
11	Letter	14	0.10%
12	Erratum	12	0.08%
13	Article in Press	2	0.01%
14	Retracted	2	0.01%
15	Abstract Report	1	0.01%

Table 4: Most prolific Biogas Research Publication in Languages

#	Language	Number of Publication	Percentage
1	English	12798	87.53%
2	Chinese	829	5.67%
3	German	508	3.47%
4	Spanish	93	0.64%
5	French	83	0.57%
6	Polish	80	0.55%
7	Portuguese	71	0.49%
8	Japanese	48	0.33%
9	Russian	21	0.14%
10	Czech	16	0.11%

Table 5: Top 15 Most Productive Institutions in Biogas Research

#	Name Of Institutions	Number Of Publication	Percentage
1	Chinese Academy of Sciences	236	3.13%
2	Danmarks Tekniske Universitet	173	2.29%
3	Lunds Universitet	134	1.78%
4	Ministry of Education China	126	1.67%
5	China Agricultural University	126	1.67%
6	Tsinghua University	126	1.67%
7	Tongji University	124	1.64%
8	Sveriges lantbruksuniversitet	101	1.34%
9	Leibniz-Institut für Agrartechnik und Bioökonomie e.V. ATB	97	1.29%
10	Universiteit Gent	96	1.27%
11	Universitat Hohenheim	95	1.26%
12	Ministry of Agriculture of the People's Republic of China	95	1.26%
13	Politecnico di Torino	94	1.25%
14	Harbin Institute of Technology	92	1.22%
15	Zhejiang University	86	1.14%

Table 6: Top 10 Subject Area Classification of Biogas Research

#	Subject Areas	Number of Publication	Percentage
1	Environmental Science	6035	23.19%
2	Energy	4335	16.66%
3	Engineering	3377	12.98%
4	Chemical Engineering	3322	12.76%

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5	Agricultural and Biological Sciences	2259	8.68%
6	Chemistry	1266	4.86%
7	Biochemistry, Genetics and Molecular Biology	1150	4.42%
8	Immunology and Microbiology	793	3.05%
9	Physics and Astronomy	553	2.12%
10	Materials Science	532	2.04%

Table 7: Top 15 Journal Title Distribution in Biogas Research

#	Journal Title	Numbers of Publication	Percentage
1	Bioresource Technology	971	11.52%
2	Water Science And Technology	438	5.20%
3	Waste Management	258	3.06%
4	Biomass And Bioenergy	241	2.86%
5	International Journal Of Hydrogen Energy	228	2.71%
6	Advanced Materials Research	222	2.63%
7	Renewable And Sustainable Energy Reviews	219	2.60%
8	Nongye Gongcheng Xuebao Transactions Of The Chinese Society Of Agricultural Engineering	203	2.41%
9	Renewable Energy	168	1.99%
10	Applied Energy	161	1.91%
11	Water Research	155	1.84%
12	Energy Procedia	133	1.58%
13	Biocycle	126	1.50%
14	Chemical Engineering Transactions	108	1.28%
15	Energy	106	1.26%

Table 8: Keywords Trends in Biogas Research

#	Keywords	Number of Publication	Percentage
1	Biogas	10411	9.51%
2	Anaerobic Digestion	4514	4.12%
3	Methane	4198	3.84%
4	Article	3376	3.08%
5	Priority Journal	1810	1.65%
6	Biomass	1753	1.60%
7	Anoxic Conditions	1743	1.59%
8	Bioreactors	1716	1.57%
9	Carbon Dioxide	1655	1.51%
10	Biogas Production	1644	1.50%
11	Biofuels	1486	1.36%
12	Bioreactor	1349	1.23%
13	Anaerobiosis	1345	1.23%
14	Nonhuman	1321	1.21%
15	Fermentation	1292	1.18%

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Figure 1: Yearly Distribution of Biogas Publication Trends