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Moving Bed Biofilm Reactors for Wastewater Treatment: A Review and Analysis using VosViewer

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Abstract

Moving bed bioreactor technology is one of the innovative solutions in wastewater treatment, which merges efficiency in biological treatment with design flexibility. This technique is based on the use of tiny plastic carriers (media) that freely move inside the reactor, providing a large surface area for the creation of biofilms containing microorganisms responsible for the breakdown of organic wastes and nutrients like phosphorus and nitrogen. Salient benefits from MBBR technology include handling variable organic loads, less land area compared to conventional systems like activated sludge, and a reduction in energy consumption. It also finds its application in various fields that include domestic and industrial wastewater treatment-related segments, such as food and pharmaceutical industries, and even the reuse of treated water for irrigation or any other industrial purpose. For these objectives to be reached, several technological challenges still have to be addressed, such as the improvement of carriers' distribution inside the reactor, the avoidance of clogging of biofilms, and pollutant removal efficiently under extreme conditions. Recent developments in carrier design, including hybrid or nanomaterials, along with the possible combination of MBBR technology with other advanced technologies, like as UV sterilization or reverse osmosis, have improved performance. The current research tries to give a general review of the MBBR technology and its role in wastewater treatment.

Further, it analyzes the scientific research published about MBBR technology by using VOSviewer to: Explore the research trends within the sphere, analyze the scientific citations to identify the most important research sources. Investigate research cooperation at the country and institutional levels and identify the main researchers and influential scientific journals in this specialty. In such a way, the current study is supposed to present the development of scientific research about MBBR technology and may contribute to orienting future studies toward the most important aspects to be improved.

Keywords: Moving Bed Biofilm Reactors, MBBR treatment, Scientometric analysis, VOSviewer

1. Introduction

In the past decades, there has been an increasing interest in research on wastewater pollutants, which are mainly accountable for river pollution [1]. Most Middle Eastern and North African nations struggle to manage wastewater efficiently due to poor equipment maintenance, high energy costs, and limited access to modern technology [2]. It is important to achieve such a goal using environmentally friendly, cost-effective, and eco-friendly technologies [3]. The moving bed bioreactor (MBBR) system has been developed as an innovative wastewater treatment solution, striking an effective balance between high efficiency and a compact operational footprint [4]. The primary idea of the MBBR system is the incorporation of floating plastic media, which has a high surface area for the growth of biofilm and also increases the robustness of the microorganisms that take part in the degradation of organic pollutants [4]. It has been noted from studies that in the process of eliminating high concentrations of organic matter, expressed in terms of BOD and COD parameters, the MBBR system is more efficient in comparison to most conventional systems [5]. This is credited to the biofilm's extended effective sludge retention time that reduces the loss of microorganisms and prolongs their retention in the system [5]. The MBBR design is compact and also space-saving, which suits applications in urban areas where there is limited space, because large volumes of water can be treated in relatively small basins [6]. By simply raising the media fill ratio, system flexibility can be enhanced without subjecting the tank infrastructure to major modifications [7]. Another important advantage is that less excess sludge is generated, which also lowers secondary treatment as well as end disposal costs [8]. Due to their high clogging and corrosion resistance, the plastic media employed in MBBR are lower maintenance and have an extended working life [8]. Research in hospital wastewater application has proved that MBBR can effectively remove pharmaceuticals at high levels—up to 80% under certain circumstances—improving the environmental quality of the wastewater after release [9]. Current research has confirmed that intermittent feed control has improved the removal of micropollutants in MBBRs [10]. To further augment the biodegradation of drugs that pose problems in degradation, some studies have also targeted the innovation of novel sponge carriers with successful results for eliminating these pollutants [11]. Researchers have used mathematical modeling of biofilm growth in MBBR systems to gain a deeper understanding of how organic retention time influences the effectiveness of the system [6]. In industrial dairy and petrochemical wastewater treatment, MBBR was shown to achieve high removal percentages of organic compounds and nutrients [6]. MBBR can be combined with membrane filtration or intermittent aeration for overall improved efficiency and reducing harmful biological emissions [7]. MBBR design enables the concept of a circular economy by allowing the recovery of nutrients such as nitrogen and phosphorus for re-use in industry or agriculture [6]. The system is an economically viable alternative as it is easy to operate and cheaper to build and maintain than more complicated conventional systems [8]. Extended-period investigations in many nations have confirmed that MBBR can decrease operational breakdowns and downtime expenses without sacrificing treatment effectiveness [7]. To meet the highest quality standards for treated water, researchers are still working to improve media design and operating condition control techniques [10]. In response to the increasing demand for environmentally friendly solutions, MBBR is becoming a popular and efficient wastewater treatment method that satisfies the standards of sustainable development.

2. Wastewater Treatment Systems

- **Primary treatment**: (preliminary treatment – primary treatment). Preliminary treatment depends on the quality of the water and can sometimes be omitted [12].

- **Secondary treatment** (biological treatment).

- **Tertiary treatment** (advanced treatment) involves a combination of physical, chemical, and biological processes.

- **Sludge treatment and disposal**.

3.Description of MBBR

MBBR is a modern technology in wastewater treatment that has been widely used for effective and efficient removal of organic contaminants, nitrogen, and phosphorus from wastewater. The system utilizes thousands of small plastic carriers, which have a large surface area for biofilm growth [13]. These carriers move freely within the reactor, enhancing the contact between the wastewater and the biofilm, thereby increasing the efficiency of the treatment process.

MBBR has good efficiency and robustness; hence, it is widely applied today in municipal and industrial wastewater. Since the existing conventional wastewater treatment systems are fairly easy to upgrade, MBBR has quite a few installations in upgrading the older wastewater treatment systems. Applications range from nitrification and denitrification to biological phosphorus removal. The patent holder for this media is AnoxKaldnes®, which manufactured the first biofilm carrier for the MBBRs system. Polyethylene has a density of 0.95 g/cm3, variations in size (diameter and height), and is divided into circular sections with longitudinal ridges (or fins) on the outside surface [14]. Some of the carrier elements are described in

Table 1: Characteristics of some (Kaldnes) carriers

	K1	K2	K3	K5	F3	Z-200	Z-400
Nominal diameter (mm)	9.1	15	25	25	46	30	30
Nominal height (mm)	7.2	15	10	3.5	37		
Density	0.95	0.95	0.95	-	-	0.95	0.95
Surface area	500	350	500	800	200	-	-

4. Factors Affecting the MBBR System

Several aspects influence the biological performance of an MBBR system, including hydraulic retention time (HRT), dissolved oxygen (DO), the shape and size of the carriers, carrier fill percentage, diffusion and mixing, and oxygenation rate. Each of these elements will be discussed in the following sections.

4.1.Carrier size and shape

Properties of carriers utilized in MBBR technology play the leading part in the effectiveness of the treatment; the size and shape directly affect the area of growth and hydrodynamic conditions inside the reactor. Small carriers offer a larger surface area per unit volume, enhancing the system's ability to treat high organic loads; however, they may increase flow resistance and result in higher energy consumption because of the need for intensive mixing to avoid reactor clogging [15]. Large carriers mix easily and, thus, they consume less energy. However, their application may affect treatment efficiency due to the limited surface area of the carrier [16]. Concerning the geometrical form, cylindrical, crossed, or internally finned geometric designs enhance the adhesion of microorganisms and homogeneous distribution of biofilm, contributing to improved oxygen transfer and carrier movement inside the reactor [16]. For example, one study illustrated that holders with rough surfaces or hollow designs enhance biomass retention and reduce its separation under aggressive hydrodynamic conditions [17]. These should be balanced against operational requirements, such as intensity of aeration and flow rate, for stability in the system [18].

Table 2: The physical characteristics of the medium employed in the associated growth processes

Name	Surface Area	Dimensions(mm)
Anoxkaldness K1	500	7mm, 10 mm
Anoxkaldness K3	500	12mm, 25 mm
Anoxkaldness Matrix	800	4mm, 25 mm

4.2.Effect of percent fill

According to [20], the reactor volume is filled with media only up to 70.0%, although 67.0% is typical. As the author explains, the most important factors in determining how much media should be added to the reactor are the characteristics of the wastewater and the specific treatment goals. All agree that 70.0% of the total area is explained by the loss of adhesion of biofilms to the outer world of the media. Building on the findings of [21], this study examines the effects of increasing the carrier fill ratio in the reactor. The authors determined that reducing the carrier fill ratio from 5% to 20% reduced microbial aggregate sizes to 49.6 from 73.5 µm. This is attributed to carrier particle competition and suspended particle competition. According to research carried out by Shrestha [22] using MBBR type filter, it was noted that the MBBR System possessed higher COD release treatment capacity at 20% carrier loads with similar organic loading conditions since the carriers possess an ability to offer even mobility within 12 L reactor and utilize sensible surface areas supporting microbial growth.

4.3.Effect of diffuse and mixing conditions

Good mixing is required for the agitation of water and dispersion of biofilm carriers (media) to facilitate increased contact between oxygen, microorganisms, and pollutants. The major effects are:

- Good mixing ensures an even distribution of wastewater and biofilm, which increases the degradation of nitrogen and organic matter (COD/BOD).
- Mixing reduces sludge buildup and prevents the formation of dead zones where treatment efficiency is compromised [16].

- The aeration system influences both oxygen transfer and carrier movement within the reactor. Proper aeration is essential to sustain aerobic bacteria involved in oxidative processes such as nitrification and the decomposition of organic matter. Among available options, fine-bubble diffusers are more efficient at transferring oxygen than other diffuser types [23].

4.4. Impact of HRT

Hydraulic residence time (HRT) is one of the significant operational parameters to assess the functionality of MBBR treatment plants, it indicates the duration wastewater stays within the reactor in contact with biofilms settled on plastic substrates. The removal efficiency of organic pollutants and nutrients (nitrates and phosphates) is directly influenced by HRT values [16]. When the HRT was increased from 4 to 8 hours, COD removal efficiency improved from 75% to 90% because the extended retention time allowed for microorganisms to break down complex substrates. Nonetheless, increasing the amount of HRT above the optimum (which is normally on the order of a few hours to half a day, depending on the design of the system) results in higher operating costs and no real increase in performance [17].

In contrast, short HRT (<3 h) is also linked to low denitrification efficiency, due to missing nitrification and denitrification processes, which occur more rarely in systems with high organic loads [20]. In addition, it is noted that careful control of HRT in balance with other factors such as oxygen concentration and organic matter load is necessary to achieve a balance between efficiency and economic sustainability, as reported [22].

5. Applications of MBBR

The moving bed biological reactor (MBBR) process is a new and effective wastewater treatment process. It is characterized by its ease of operation and high efficiency in breaking down organic content and contaminants. The process has been found to have several uses for most wastewater sources, such as municipal, industrial, and medical, depicting its versatility and ability to work under various operating conditions. The following table depicts the most important real-world applications of the MBBR system for wastewater treatment.

Table 3: MBBR performance for COD, BOD_5, and nutrient removal

Application	Experiment Scale	Treatment Performance	Reference
Domestic Wastewater (Synthetic) Treatment	Lab-scale reactor	94% COD removal 44% total Ortho-phosphorus 50% filtered Ortho-phosphorus removal	Prendergast J. et al., [24]
Poultry Slaughterhouse Wastewater (Synthetic) Treatment	Lab-scale reactor	BOD5, TKN, and TP removal The efficiency of MB-ASBR was 1-2, 2-3, and 10-12% higher than Conventional SBR >95% removal efficiency for MBASBR at all organic loading rates	Sirianuntapiboon S. and Yommee S. [25]

Recycled Paper wastewater	Lab scale reactor (GACSBBR)	HRT varied as 48, 24, 12, and 8 hours, Higher, 92 % COD removal, and 99	Osman et al., [26]
Sugar Industry Wastewater (Synthetic)	Pilot Plant	COD and BOD removal > 80% Stover-Kincannon (error=6.40%) and Grau (error=6.15%) models provided good results for CT optimization	Faridnasra et al.,[27]
Domestic Wastewater Treatment	Lab Scale Reactor	Improved COD removal by 30%, carrying fill percentage and 1.5 to 3.5 aeration time hrs. MBBR Design: SLR- 3 to 7.50 g COD/m2.d VLR- 0.350 to 0.7 kg COD/m3.d HRT- 2.25 to 4.5 hrs F/M- 0.1 to 0.180 d-1 MBBR efficiency in COD removal 16.0% > SBR	Shaha S. et al., [28]

6. Previous Studies

Bahaa [29] conducted an experimental study on nutrient removal from wastewater using the MBBR system. The system achieved removal efficiencies of 82% for ammonium, 76.7% for phosphorus, and 70% for total nitrogen.

Kawan [30] highlighted the MBBR system as a powerful alternative to conventional treatment technologies. It combines suspended and attached growth processes and has proven to be effective in removing BOD, COD, and nutrients like nitrogen and phosphorus, with low operational and maintenance costs.

Jasem [31] evaluated the performance of the MBBR system in treating wastewater from Al-Batoul Hospital in Baqubah, Iraq. The system achieved removal efficiencies of 79.5% for BOD_5, 74.5% for COD, 78% for total suspended solids (TSS), and a nitrification efficiency of 79%.

Czarnota [32] assessed the performance of a wastewater treatment plant in Poland using the MBBR system. The plant demonstrated high removal efficiencies: 98.9% for BOD_5, 95.3% for COD, and 97.6% for TSS.

Najeeb [33] conducted studies on the application of electrochemical coagulation (EC) and indirect electrochemical oxidation (EO) for treating hospital wastewater in Al-Diwaniyah. Aluminum electrode electrochemical coagulation achieved 99.45% COD removal efficiency with low energy consumption (26.079 kWh/kg COD).

Bhandari [24] proposed a general method for hospital wastewater treatment, summarizing both conventional and innovative technologies. While conventional methods remove less than 80% of BOD, COD, and TSS and are ineffective against pharmaceuticals and resistant bacteria, innovative approaches such as AOPs, ozone, and nanofiltration showed high efficiency. Combining biological processes with advanced oxidation achieved over 98% removal of pharmaceutical compounds and resistant microorganisms.

Tsitouras [35] focused on the sequencing batch moving bed biofilm reactor (SB-MBBR) for treating cheese production wastewater. Nitrification was not feasible in a single reactor due to competition between nitrifiers and heterotrophs. However, two SB-MBBRs in series successfully oxidized TAN and removed carbon and phosphorus, offering an efficient on-site solution.

Zhang [36] examined the treatment of oil shale retorting wastewater using the MBBR system. COD concentrations ranged between 5000–10000 mg/L and NH_4-N between 3000–5000 mg/L. The system achieved removal efficiencies of 83.46% for COD and 82.08% for NH_4-N. The study emphasized the role of nitrifying bacteria like Nitrosomonas in nitrogen removal.

Dutra [37] investigated the biodegradability of polybutylene succinate (PBS) microparticles in MBBR systems. The system efficiently removed organic matter and ammonium while promoting the degradation of PBS microparticles through ester bond hydrolysis and the formation of degradation products. This highlights the MBBR's potential in addressing microplastic pollution in wastewater.

7. Description of VOSviewer

VOSviewer is a software tool created by the Centre for Science and Technology Studies (CWTS) at Leiden University that is designed for the construction and visualization of bibliometric networks. Networks can be composed of journals, researchers, organizations, or keywords from citation, co-authorship, or co-occurrence data. VOSviewer excels at representing large bibliometric maps clearly and intuitively. It enables scientists to reveal prevailing research trends, topical clusters, and knowledge gaps within a particular scientific field, hence making it an essential tool in systematic literature reviews and research mapping exercises.

8. Data Collection

These data were obtained using the Dimensions platform. Dimensions is the world's biggest database on research funding connected to millions of patents, clinical trials, and publications [38]. Dimensions grant a user access to 151 m of materials, conferences, and journals starting from the beginning of the twentieth century up to today, plus many crucial scientific databases.

Dimensions, where the data were housed, served as the primary source for extraction. This database contains around 8,528 papers between 2016 and 2025. Under the ANZSRC 2020 code, for "Moving Bed Biofilm Reactor" (MBBR) environmental engineering, chemical engineering, and environmental and biological sciences management were the most frequent research topics. The number of citations was 20.15, and there were more than 111,548 total citations. 2022 will have the most publications, as the chart shows.

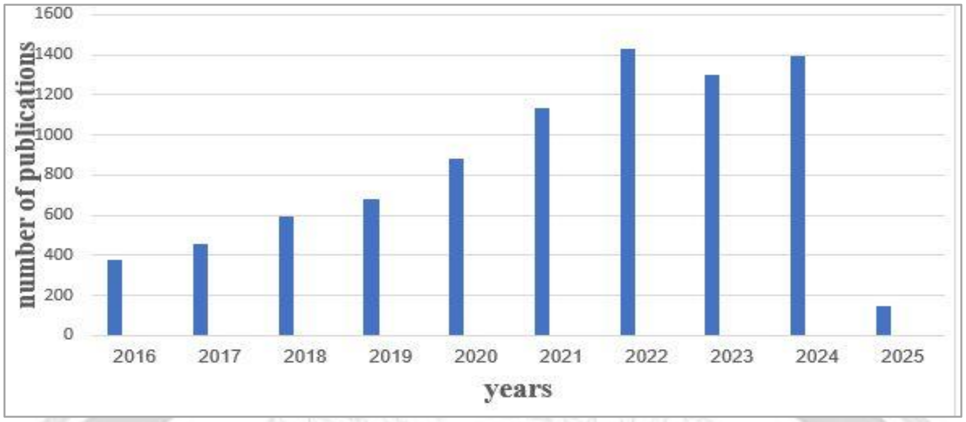

Figure 1: The visualization shows the number of publications published each year

9. Methods of Analysis

Bibliometrics provides active, judgmental, and predictive scientometric research. Despite its origin in library and information science, it has become progressively well-liked and applied among various disciplines and is primarily for quantitative studies into academic products presented in the format of academic works produced by academicians, institutions, and academic journals. There are various programming tools available for bibliometric analysis, including CiteSpace, BibExcel, Gephi, Vos Viewer, and Histcite. VOSviewer was used to create maps and visualizations of bibliometric data. VOSviewer has one architecture for charting and clustering, and its major use is bibliometric network analysis. VOSviewer can provide overlay, network, and density visualizations, among others.

9.1. Top Contributions

The list highlights the top ten donations by writers' research classifications and institutions. Table 4 reveals that Yong-Zhen Peng (Beijing University of Technology, China) leads a team of researchers that have published 106 papers, including one on [Advanced Denitrification of Municipal Wastewater Achieved by Partial ANAMMOX in Anoxic MBBR][39]. Fellows include Hong-Qiang Ren (Nanjing University, China), with 55 publications, and Kai Bester (Aarhus University, Denmark), with 48 publications.

Table 4: Top 10 contributions by authors, institutes, and nations.

Top	Authors	documents	citations	citations mean
1	Yong-Zhen Peng	106	4,959	46.78
2	Hong-Qiang Ren	55	1,805	32.82
3	Kai Bester	48	1,739	36.23
4	Liang Zhang	42	2,305	54.88
5	Jun Feng Su	39	1,028	26.36
6	Yu-You Li	38	1,228	32.32
7	Charles B Bott	35	840	24.00
8	Qiong Zhang	35	1,103	31.51
9	Xiyao Li	34	1,054	31.00
10	Henrik Rasmus Andersen	33	1,777	53.85

Table 5 shows that Bioresource Technology is the top source title, with 476 articles and 17,126 citations, followed by The Science of the Total Environment, with 372 publications and 15,987 citations, and Chemosphere, with 277 publications and 8,820 citations. The Top Ten Sources Titles

Table 5: Top 10 in Source Titles

Top 10	Organization	documents	citations	citations mean
1	Bioresource Technology	476	17,126	35.98
2	The Science of The Total Environment	372	15,987	42.98
3	Chemosphere	277	8,820	31.84
4	Journal of Water Process Engineering	527	4,016	14.60
5	Water Research	214	12,683	59.27
6	Journal of Environmental Management	198	4,796	24.22
7	Chemical Engineering Journal	195	6,834	35.05
8	Journal of Environmental Chemical Engineering	171	4,232	24.75
9	Desalination and Water Treatment	153	916	5.99
10	Water	151	1,445	9.57

Table 6 shows the contributions of the top ten research categories, with Engineering dominating with 5,536 articles, Chemical Engineering second with 4,906 documents, and Environmental Engineering third with 4,691 publications, as seen in Table 6

Table 6: presents the top ten research categories.

Top 10	Research Categories	documents	citations	citations mean
1	Engineering	5,536	111,548	20.15
2	Chemical Engineering	4,906	99,217	20.22
3	Environmental Engineering	4,691	93,342	19.90
4	Biological Sciences	1,651	38,020	23.03
5	Environmental Sciences	1,468	35,151	23.94
6	Agricultural, Veterinary, and Food Sciences	817	21,916	26.82
7	Microbiology	816	23,439	28.72
8	Industrial Biotechnology	728	22,363	30.72
9	Chemical Sciences	510	10,633	20.85
10	Pollution and Contamination	496	17,223	34.72

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10. Measure of Co-Occurrence

The elements in the network visualizations are labeled and represented as circles. The count of the provided items dictates the sizes of the circles displayed. The elements are arranged on the map according to their groups. The cluster of each item also influences its color. The image depicts the relationship between the things through the lines linking them. The line becomes thicker where the link is stronger. Furthermore, the distance between map pieces indicates their degree of relatedness.

10.1. Co-Authorship

Creating and assessing a draft that includes field information on a co-author network of noteworthy writers might be a good starting point for various institutions looking to create collaborations with different research groups. Furthermore, this data can assist individual students in identifying possible collaborative partners, while publishers can build editorial teams through co-author agreements.

10.2. Authors

The publications they co-authored define their link. The total number of authors (represented by ten clusters; circles and networks are colored per cluster) is shown for writers who have co-authored at least three publications. As demonstrated in the picture

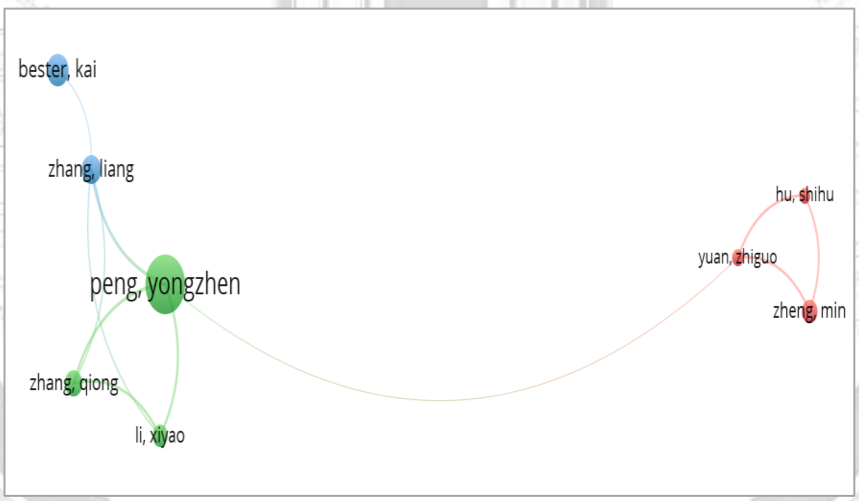

Figure 2: Co-authorship- Authors

10.3. Countries

The size of the node represents the number of research papers published in that country. The larger the node size, the greater the number of research papers published in that country. The lines between the nodes represent the size of research cooperation between countries, i.e., the number of joint research papers between two countries. Here we find China playing a pivotal role in research cooperation in this field, as shown below:

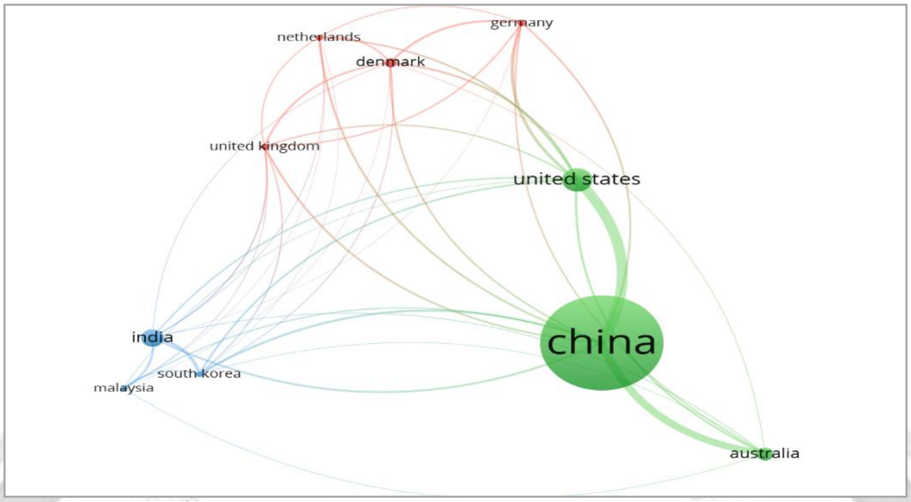

Figure 3: Countries Graph

10.4. Citation

Citation analysis was used to identify key research papers, sources, and nations. When document citations and citation groupings are established, it is simple to examine highly cited publications and identify important study areas.

10.5. Source

The main objective of this analysis is to assess the influence of various journals or research sources in terms of the number of citations their publications have received. It also helps in identifying the most influential journals within the scope of research. In the visual output, journals represented by larger nodes are those with higher citation counts, such as Bioresource Technology, which stands out as a leading source.

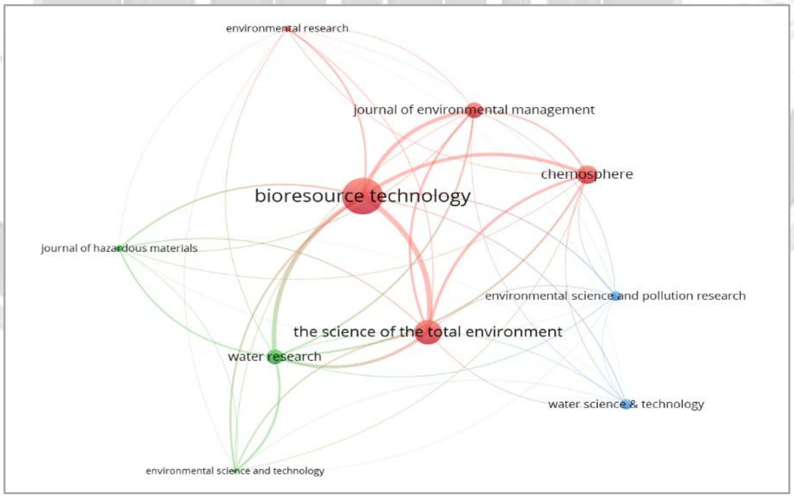

Figure 4: Source-Citation

10.6. Co-Citation

The researcher's co-citation analysis, or co-citation evaluation, is a prominent tool in scientometric research [40]. This form of analysis can help researchers understand how specialties evolve. In addition, the co-citation network is superior to the citation network since it is less likely to ignore essential articles.

10.7. Citation Source

The analysis of co-citations in this section is based on the publication's origin. The figure depicts the VOS viewer-created networking clusters, each representing a notable journal, with Bioresource Technology standing out the most. As seen in the figure below.

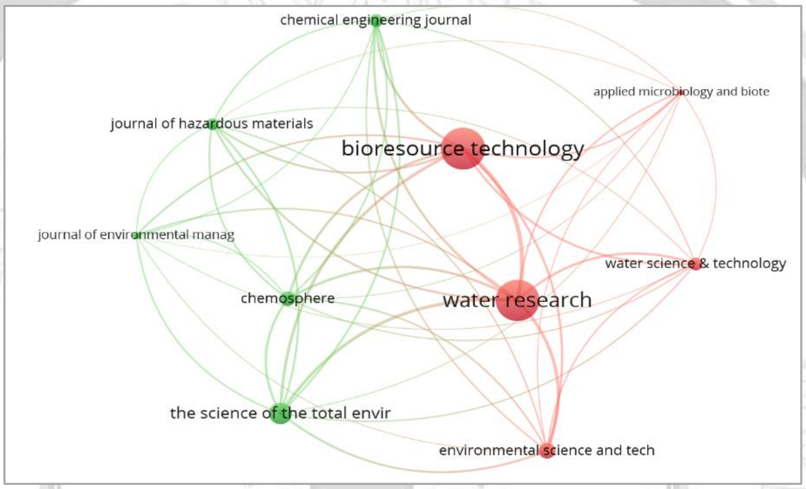

Figure 5: Co-Citation- Source

11. Conclusions

This research reconfirms that the Moving Bed Biofilm Reactor (MBBR) is an effective and modern technology in wastewater treatment. The MBBR has a high capacity for the elimination of organic pollutants, suspended particulate matter, and nutrients like nitrogen and phosphorus. The hybrid characteristics of operational behaviors of the system, both attached growth and suspended growth, render it more stable under varying load conditions and justify its application in municipal, industrial, and hospital wastewater treatment.

MBBR technology has been characterized as cost-saving, easy to operate, and with the potential to support decentralized treatment schemes. Various studies have documented removal efficiencies greater than 80% for key parameters such as BOD, COD, TSS, and NH_4-N, thus solidifying the feasibility of the technology under different operation environments.

However, based on a bibliometric analysis through VOSviewer, current literature tends to concentrate mainly on short-term operational performance, while topics such as long-term environmental assessment, energy conservation, and material optimization remain to be investigated. Research efforts in the future should be aimed at developing more effective and sustainable biofilm carriers, as well as optimized aeration methods, to conserve energy and improve overall system efficiency.

Overall, MBBR is an earnest and worthwhile solution to the wastewater challenges of the present, but it needs to be approached with novel system design and integration of complementary technologies to address future environmental demands.

Key recommendations:

Establish nano-carriers for increasing the efficiency of MBBR.

Combine MBBR with end technologies (like reverse osmosis)

Use bibliometric analysis tools (such as VOSviewer) to guide future research.

Integrating MBBR technology and data analysis tools accelerates the development of sustainable solutions that support global water security.

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مفاعلات الأغشية الحيوية المتحركة لمعالجة مياه الصرف الصحي: مراجعة وتحليل باستخدام VOS Viewer

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الخلاصة

تعد تقنية المفاعل الحيوي المتحرك أحد الحلول المبتكرة في مجال معالجة مياه الصرف الصحي، والتي تجمع بين الكفاءة في المعالجة البيولوجية ومرونة التصميم. تعتمد هذه التقنية على استخدام حاملات بلاستيكية صغيرة (وسائط) تتحرك بحرية داخل المفاعل، مما يوفر مساحة سطح كبيرة لإنشاء أغشية حيوية تحتوي على كائنات دقيقة مسؤولة عن تحلل النفايات العضوية والمغذيات مثل الفوسفور والنيتروجين. تشمل الفوائد البارزة لتقنية المفاعل الحيوي المتحرك التعامل مع الأحمال العضوية المتغيرة، ومساحة أرض أقل مقارنة بالأنظمة التقليدية مثل الحمأة المنشطة، وانخفاض استهلاك الطاقة. كما تجد تطبيقها في مجالات مختلفة تشمل قطاعات معالجة مياه الصرف الصحي المنزلية والصناعية، مثل الصناعات الغذائية والصيدلانية، وحتى إعادة استخدام المياه المعالجة للري أو لأي غرض صناعي آخر. لتحقيق هذه الأهداف، لا يزال يتعين معالجة العديد من التحديات التكنولوجية، مثل تحسين توزيع الحاملات داخل المفاعل، وتجنب انسداد الأغشية الحيوية، وإزالة الملوثات بكفاءة في ظل الظروف القاسية. ساهمت التطورات الجديدة في السنوات الأخيرة، المتعلقة بتصميم الناقلات – على سبيل المثال، المواد الهجينة أو النانوية – وإمكانية دمج تقنية MBBR مع التقنيات المتقدمة الأخرى – مثل التعقيم بالأشعة فوق البنفسجية أو التناضح العكسي – في تحسين الأداء. يحاول البحث الحالي تقديم مراجعة عامة لتقنية MBBR ودورها في المستشفيات لمعالجة مياه الصرف الصحي.

علاوة على ذلك، يحلل البحث العلمي المنشور حول تقنية MBBR باستخدام VOSviewer من أجل: استكشاف اتجاهات البحث داخل المجال. تحليل الاستشهادات العلمية لمعرفة أهم المصادر في البحث. التعاون البحثي على مستوى الدولة والمؤسسون تحديد الباحثين الرئيسيين والمجلات العلمية المؤثرة التي تتعامل مع هذا التخصص. بهذه الطريقة، من المفترض أن تقدم الدراسة الحالية تطور البحث العلمي حول تقنية MBBR وقد تساهم في توجيه الدراسات المستقبلية نحو أهم الجوانب التي يجب تحسينها.

الكلمات الدالة:- مفاعلات الأغشية الحيوية ذات السرير المتحرك، معالجه بواسطة Mbbr ، التحليل العلمي القياسي، VOSviewe