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REVIEW

The Role of Irrigation Water Filters in Ecosystem Functioning and Agricultural Ecology: A Bibliometric Study (2003–2024)

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ABSTRACT

Reuse of irrigation water after appropriate filtration has emerged as one of the most important strategies for addressing global water scarcity and improving the sustainability of agricultural systems. This study reviews the research progress on filtration technologies and the reuse of secondary water through a comprehensive visual and bibliometric analysis of the relevant scientific literature. Using tools such as R Studio, VOSviewer, and the Bibliometrix R-package, a total of

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374 publications published between 2003 and 2024 were retrieved from the Web of Science database and systematically analyzed. The collected literature was examined with respect to publication trends, disciplinary distributions, leading journals, contributing countries, institutions, and authors. Additionally, an in-depth keyword analysis was conducted to explore co-occurrence networks, thematic clustering, and emerging research frontiers. The results indicate three distinct developmental stages in this field: a slow and exploratory phase beginning in 2003, followed by a period of moderate growth around 2013, and a rapid expansion phase that has been evident since 2018. Research outputs primarily span environmental sciences, engineering, water resources management, and agricultural sciences. The findings highlight an increasing global interest in sustainable water reuse and the need for continued innovation in filtration methods to enhance water quality and agricultural productivity. Future scientific efforts should emphasize the development of advanced, cost-effective filtration technologies, the reduction of environmental risks, and the promotion of large-scale water reuse practices to alleviate water shortages and support resilient agricultural systems.

Keywords: Irrigation System; Filtration; Agriculture; Wastewater; Ecology Water Reuse; Irrigation Water Pollution

1. Introduction

In recent times, wastewater treatment and reuse have become crucial tasks [1]. Micro-fibrillated cellulose filtration is extensively used in this area, with numerous studies being carried out [2]. Its key benefits include high efficiency, low energy consumption, cost-effectiveness, straightforward processes, and no secondary pollution [3]. Later on, an ultrafiltration-based method was explored for the fractionation of oligosaccharides and peptides from the subcritical water hydrolysate of macroalgae [4]. Despite the upward thrust in the reputation of drip irrigation, customers have encountered a full-size assignment with waste clogging. In order to tackle this issue, the implementation of a display screen filter has appreciably improved the effectiveness of the irrigation system. Concurrently, scientists additionally investigated the doable for irrigation water reuse and assessed the effectiveness of using a sand filter for the tertiary remedy of irrigation water [5]. In the modern age of water scarcity, the significance of utilizing water accurately and enforcing revolutionary strategies for recycling and treating water is extensively acknowledged [6]. Membrane filtration has been diagnosed as a handy science for irrigation water treatment, with research focusing on the impact of microbes and heavy metals in water on agriculture and soil fertility [7]. According to the lookup findings, up-flow anaerobic sludge blanket (UASB) reactors exhibit great promise in enhancing the satisfaction of irrigation water treatment [8]. Over the previous decade, there has been widespread development in irrigation water filtration technologies, making it critical to pick the most superb option [9]. High water quality is a quintessential aspect now, not simply in drip irrigation, but additionally in the ordinary irrigation system. Another trouble is the uncertainty of the fee of water treatment, a viable barrier to the adoption of irrigation and recycling [10]. One fascinating test evaluated the feasibility of the usage of low-cost filtered municipal irrigation water for irrigation. Irrigation water from all companies in the metropolis is blended and filtered through a nylon mesh [11]. In water-scarce areas, the reuse of irrigation water for agricultural or irrigation functions is the first-class choice to minimize water shortage and amplify productivity [12]. Irrigation water usage was filter and a display screen filter [13]. The modern-day research explored a filtration technique for water reuse involving a filter factor developed from coal manufacturing waste, crammed with a sorbent made from rice husk. The filter factor facets a cylindrical cavity, and a special coaching approach was devised. This system enhances the feasibility of treating drainage effluents for crop irrigation, broadens the variety of drainage water sorts that can be utilized, and simplifies the setup of filter elements [14]. In agriculture, using reclaimed water (post-treatment through municipalities) has the viability of water reuse, even though its lack of ability to comply with environmental requirements suggests a necessity for additional research [15]. Various technologies have been developed for irrigation water treatment; however, the pleasantness of recycled water regularly falls short of meeting requirements for reintroduction into the primary water source, posing a continual project with no clear resolution. Reusing irrigation water is identified as a necessary method for mitigating water scarcity, specifically in a time of an increasing number of constrained water resources[16].

The use of bibliometric analysis can facilitate the analysis of publications in a particular field of research. As opposed to narrative reviews of scientific literature, which are often influenced by the researcher's bias, this approach analyzes the metadata of scientific publications quantitatively. Although publication numbers can indicate a topic's importance, a bibliometric analysis is susceptible to flaws. While bibliometrics can provide insights into research trends, narrative literature reviews are better suited for gathering scientific knowledge and identifying research gaps in a specific research area. Bibliometric review research in science has been conducted regarding various research aspects, e.g., Aeromonas hydrophila infection[17], sludge dewatering research[18], English linguistics[19], soil salinity[20] and pollution in water[21], grain storage[22], filtration process[23].

The aim of this study is to analyse key themes and important areas in irrigation water filtration research, using historical bibliometric information to identify new patterns and highlight international research in this area. The Web of Science database shows that the period 2003–2024 was more fruitful for filtering irrigation-related studies, which prompted us to focus on this period. Throughout this period, there has been a noticeable absence of bibliometric analysis of irrigation water filtration in the research literature, particularly across regions.

2. Materials and Methods

Global library of filtration in irrigation system analyzed in the Web of Science database during 2003–2024. First, we searched for the keywords "Irrigation system" and "Filtration" in the article title, abstract, and keyword section, and found 374 published papers during the above time period. In the process of skimming, we found that most articles do not fully cover filtration in an irrigation system (**Figure 1**). Through this refinement, we finally recorded 374 papers and converted them to CSV and RIS extensions. VOSviewer software version 1.6.18 citation is used to analyze bibliographic coupling, themes, co-authorship, co-occurrence, citation, and co-citations.

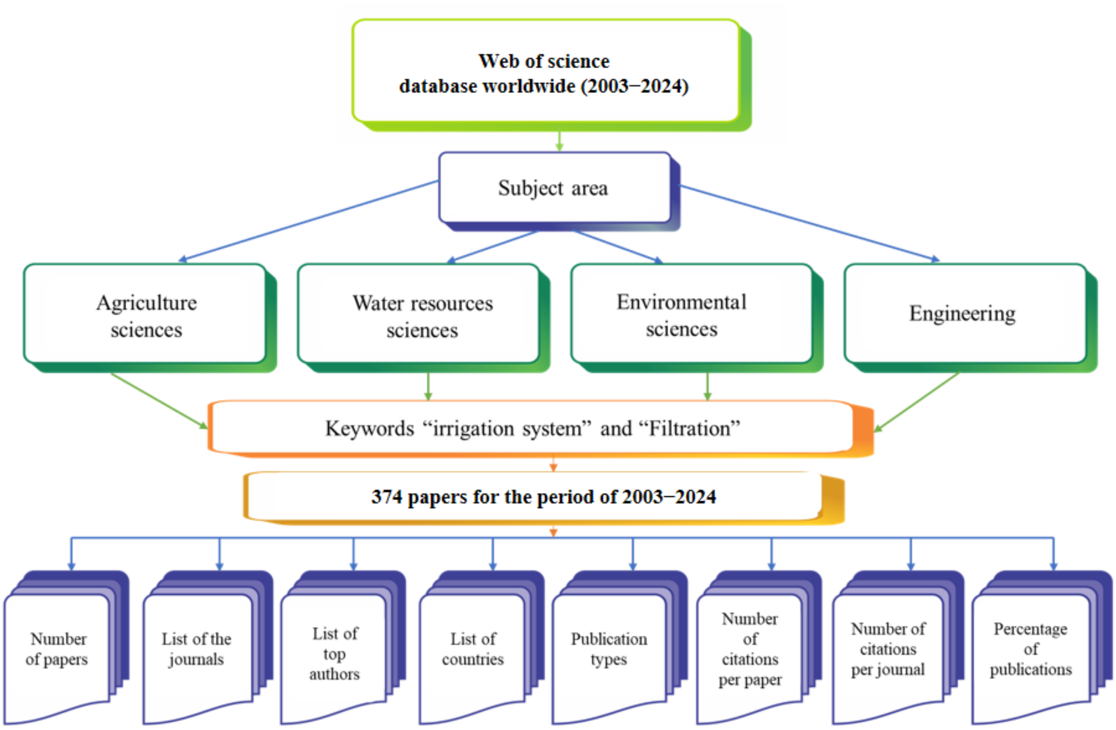

Figure 1. Flowchart of the methodology.

3. Results and Discussion

3.1. Published Papers on Filtration in Irrigation Systems

To understand the development of filtration in irrigation systems in agriculture, annual publications and citation trends were analyzed, as shown in **Figure 2**. The publications on filtration in irrigation system research have come from 78 countries scattered all over the globe. **Figure 2** shows that between 2003 and 2024, from 5 articles in 2003 to 8 articles in 2024, there is a general upward trend with a slight decline from 2005–2015. We deduced that researchers are paying high concentrate on filtration in irrigation systems in the agriculture sector.

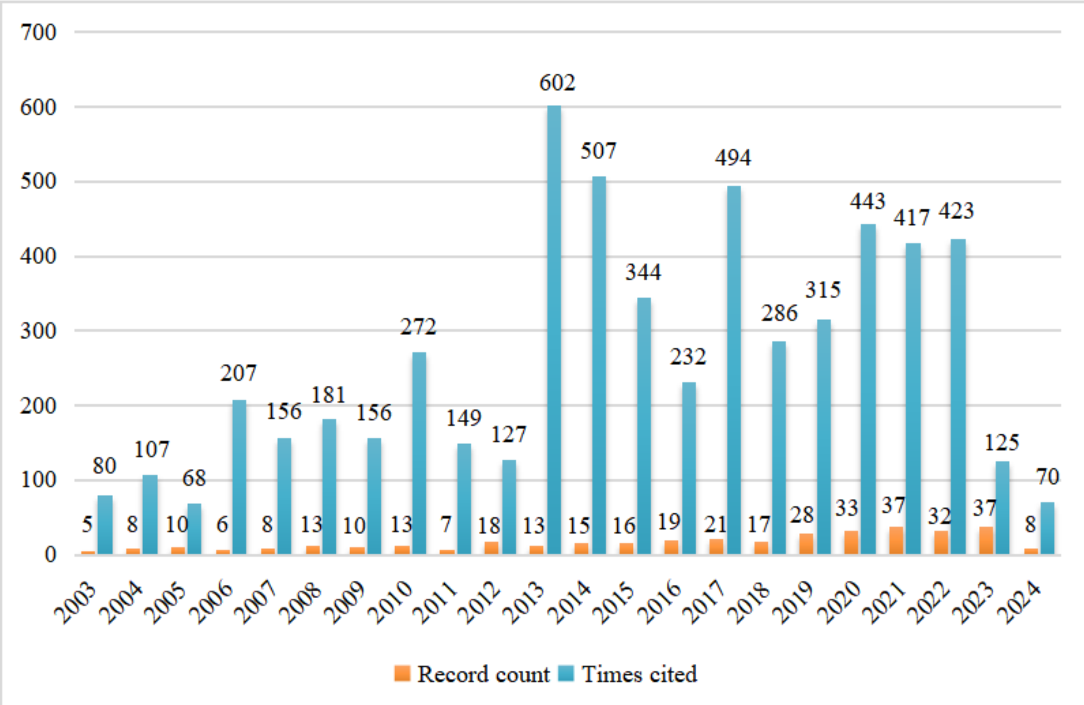

Figure 2. Number of papers on filtration in irrigation systems and their derivatives by the year of publication in the world.

In the early stage (2003–2012), there were fewer studies with a lower average score and fewer continuous publications than in other periods. Pioneering efforts by Taiwan scientists opened a scientific field of research on agriculture.

Filtration in irrigation system research started to accelerate in the second stage (2013–2018) with continuous publications (17 papers a year on average). A new chapter in the history of filtration in irrigation was opened by the release of the Universal Filtration Loss technology as a complete technology in 2014.

3.2. Top Authors on the Irrigation System and Filtration

In any region of the world, authors play an important role in developing a particular field of research. In this section, the most prolific authors are analyzed to provide insight into their research contributions. **Table 1** presents a total of 15 different leading authors who have worked on publishing articles on filtration in irrigation systems over the past two decades. Among these authors, Fiaz U is a top contributing author with 32 articles from the Air University of Islamabad (Pakistan).

3.3. Top Institutions on the Filtration in Irrigation Systems

Overall, institutions are ranked based on the quality of papers published by their researchers. A total of 1022 papers on filtration in irrigation system reduction were published by 651 different institutions from 2003 to 2024. To identify the most influential and productive institutions in the field of irrigation filtration, we analyzed the publications of the top 15 institutions. In **Figure 3**, among the top 15 institutions, 6 are from the United States, 3 are from China, 2 are from Spain, and 1 each from Egypt, Brazil, Israel, and Australia. These prolific institutions contributed around 15.2% of the total output. Among these, University of Girona occupies the 1st position in record rank (37 records), followed by University of California (11 records).

Table 1. List of top productive authors in research on filtration in irrigation systems and their derivatives' issues around the world.

No.	Author	Countries	Record Count	% of 374
1.	Fiaz U	Pakistan	32	8.556
2.	Sandhu C	Germany	28	7.487
3.	Rokochynskiy A	Ukraine	27	7.219
4.	Wu JH	Taiwan	27	7.219
5.	Ferrier MD	Scotland	12	3.209
6.	Ferrin D	USA	12	3.209
7.	Vo TDH	Vietnam	9	2.406
8.	Dana DA	Israil	8	2.139
9.	Costantini M	Italy	7	1.872
10.	Chinivasagam HN	Australia	6	1.604
11.	Buriakovsky N	Israil	5	1.337
12.	Koyuncu I	Turkey	5	1.337
13.	Martikainen K	Finland	5	1.337
14.	Pacheco A	Mexico	5	1.337
15.	Puig-barguées J	Spain	5	1.337

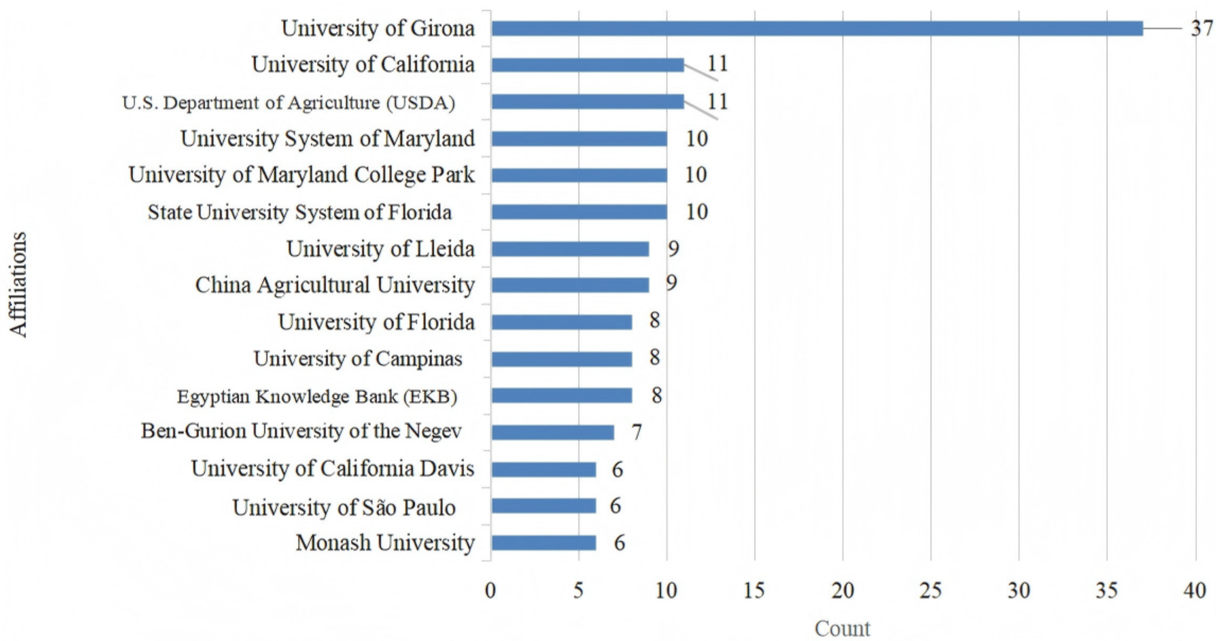

Figure 3. List of top institutions on filtration in irrigation system.

3.4. Top Cited Papers on Filtration in Irrigation Systems

The number of citations is correlated with the quality and novelty of the research. The ten most cited articles on irrigation systems are presented in **Table 2**. A total of 6469 publications on filtration in irrigation systems were cited during this period. These 10 documents are cited 2379 times and represent 36.7% of total citations.

Table 2. List of top-cited publications on filtration in irrigation systems.

No.	Title	Journal	Corresponding Author	Country	PY	TC
1.	Anaerobic membrane bioreactors for irrigation water treatment: A review [24].	Chemical Engineering Journal	Skouteris, G	Spain	2012	264
2.	Irrigation water reclamation and reuse in China: Opportunities and challenges [25].	Journal of Environmental Sciences	Lyu, S	China	2016	250
3.	Characteristics and treatment of greywater-a review [26].	Environmental Science and Pollution Research	Ghaitidak, D	India	2013	212
4.	Permeable pavement as a hydraulic and filtration interface for urban drainage [27].	Journal of Irrigation and Drainage Engineering	Sansalone, J	Italy	2008	155
5.	Best available technologies and treatment trains to address current challenges in urban irrigation water reuse for irrigation of crops in EU countries [28].	Science of the Total Environment	Rizzo, L	Italy	2020	150
6.	Recent advances in advanced oxidation processes for removal of contaminants from water: A comprehensive review [29].	Process Safety and Environmental Protection	Giwa, A	Italy	2021	134
7.	Effect of filter, emitter and location on clogging when using effluents [30].	Agricultural Water Management	Duran-Ros, M	Spain	2009	112
8.	Effective treatment of shale oil and gas produced water by membrane distillation coupled with precipitative softening and walnut shell filtration [31].	Desalination	Zhang, Z	USA	2019	101
9.	Irrigation water reclamation by advanced treatment of secondary effluents [32].	Desalination	Petala, M	Greece	2006	100
10.	Biofilters for Stormwater Harvesting: Understanding the Treatment Performance of Key Metals That Pose a Risk for Water Use [33].	Environmental Science & Technology	Feng, W	Aus-tralia	2012	99

3.5. Top Co-Authorships and Keywords on Filtration in Irrigation Systems

In the bibliometric analysis of WOS data, using VOS viewer and RStudio software, it is possible to create maps of keywords, co-authorship, and bibliographic combinations. For this, we download files in .txt, .ris, and .csv formats from the database. Downloaded files were uploaded to the VOS viewer and RStudio program, and to create maps of co-authors and bibliographic composition (**Figures 4** and **5**). Only authors with at least 7 articles on the issue of filtration in irrigation systems are included. As a result of the analysis, 23 objects were identified, distributed across 6 clusters: cluster 1 (6 objects), cluster 2 (5 objects), cluster 3 (4 objects), cluster 4 (4 objects), cluster 5 (3 objects), and cluster 6 (1 object). The total link strength was 410, with 67 links.

Keyword analysis yielded 2128 keywords. A total of 35 items were identified after exclusion of general keywords with a low relevance score and those with low occurrence (by default, 131 occurrences of a keyword were selected to strengthen the co-occurrence results). Each retrieved keyword is represented as a node based on the overall link strength, creating a network map of all keywords. The network map in **Figure 5** illustrates the co-occurrences of keywords among the 33 top authors. The size of each associated node determines the importance of the keyword.

A total of 35 items is distributed across 3 clusters: cluster 1 (constructed wetlands, disinfection, drinking water, effluent, management, reclaimed water, reclamation, removal, reuse, system, technologies, ultrafiltration, irrigation water. Irrigation water treatment and water reuse), cluster 2 (auxiliary elements, clogging, drip irrigation, emitter, filter, filtration, head loss, media, performance, sand, water and water quality), cluster 3 (greywater, groundwater, irrigation, micro-irrigation, quality, soil, systems and irrigation water). The total link strength is 1330, with 378 links.

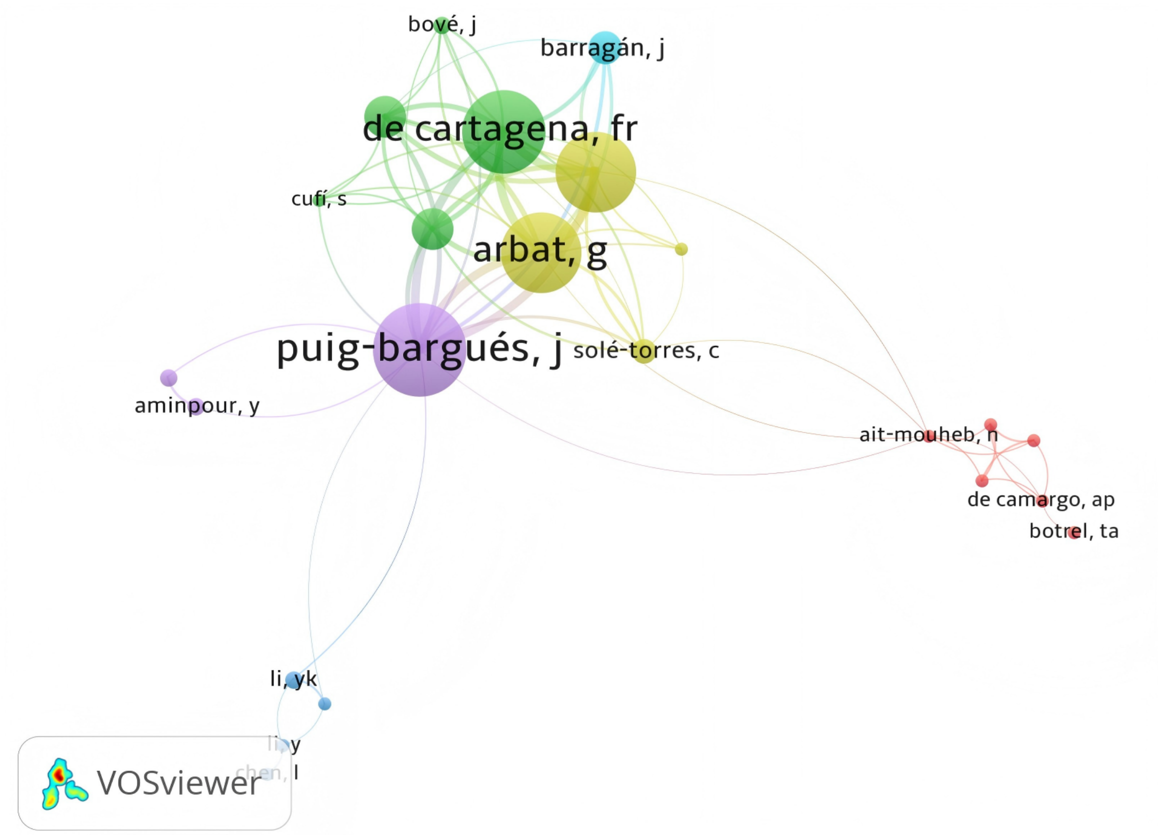

Figure 4. On reduction filtration in irrigation system excellent network map by co-authors.

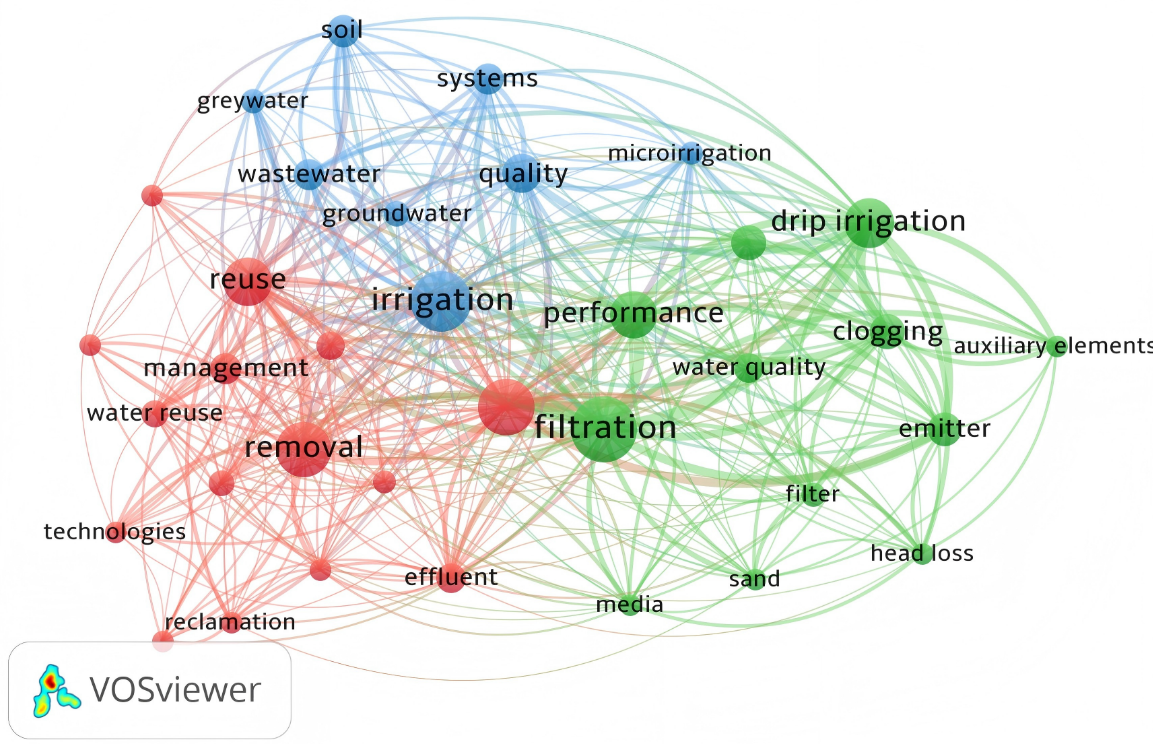

Figure 5. Keyword co-occurrences analysis with at least 3 occurrences.

4. Discussion

4.1. Technological Development of Filters in Irrigation Systems

This research aimed to analyze contemporary perceptions of irrigation systems and to identify breakthroughs via the evaluation of scientific literature and a targeted search in the area. The evaluation revealed that articles published in the recent few years, particularly the last 10 years, have helped a lot to understand irrigation systems.

The purpose of this research was to take a look at the modern-day perception of irrigation structures and to perceive developments by reviewing scientific articles and looking into this field. The research evaluated printed articles published in the past many years that have made sizable contributions to the study of irrigation systems, in particular in the past decade. The research categorized the yearly output of publications pertaining to filtration across different nations from 2003 to 2024 into three separate developmental phases. Additionally, the study classified the annual manufacturing of articles centered on filtration in international locations between 2003 and 2024 into three wonderful developmental periods: the introduction period (2003–1012), the period of slight growth (2013–2018), and the period of stable growth (2019–2024).

Based on the two topics of irrigation system and filtration, this article was released compared to 374 publications and high-frequency phrases, respectively. The results show that the five most popular studies of irrigation systems are irrigation water treatment, irrigation, micro irrigation systems, drip irrigation systems, and groundwater irrigation systems. The top five hotspots for filtration are water infiltration rate in soil, microfiltration technology, irrigation water filtration medium, membrane filtration of irrigation water, and filtration materials. In addition, biofiltration systems, evaluation of filtration, sand filtration systems, flotation-filtration systems, complex irrigation systems, sustainable irrigation systems, residential irrigation systems, irrigation systems, screen filters, and screen filters are joint research focuses of both parties. By analyzing the limitations of current research and future research directions, the results show that although filtration in irrigation system hold great promise in many aspects, they still have certain limitations.

During the initial phase, interest in filtration topics concerning irrigation systems started with a focus on the relationship between field and infiltration rates, which saw a significant rise. A period of modest growth emphasized the importance of reducing filtration in irrigation systems, impacting the effectiveness of publications worldwide. The subsequent stable growth phase indicated a solidification of research efforts in this academic domain across various subtopics. The first published article, dating back to 2003, detailed a laboratory soil column experiment aimed at identifying parameters governing water infiltration in a cracked paddy field. The study examined several variables, such as soil texture, water depth, fracture apertures, cultivation methods, and suspended particles, to quantify their effects on infiltration curves and the closure mechanism of a fractured plow pan. Experimental findings revealed that increased fracture aperture and water depth only led to temporary enhancements in infiltration rates [34]. A total of 8 papers on total filtration were written in 2004, with more water filtration seen in their studies. As for the year 2005, there were in-depth studies on the use of irrigation water in agriculture, and several important scientific studies have concluded basic equations.

Development of equations for calculating the head loss in effluent filtration in micro irrigation systems using dimensional analysis [35]. *Irrigation Water Reclamation by Advanced Treatment of Secondary Effluents* was written in 2006. The aims of this research encompass assessing the efficacy of an advanced treatment system designed for reclaiming secondary municipal effluents and examining the environmental standards of the treated effluents. Secondary effluents from a conventional activated sludge process were directed into an advanced irrigation water treatment setup comprising a moving-bed sand filter, a granular activated carbon adsorption bed, and ozone disinfection. The plant's performance was gauged by analyzing the physicochemical, microbiological, and ecotoxicological attributes of the reclaimed water. Sand filtration facilitated approximately 45% removal of turbidity, while carbon adsorption predominantly enhanced the elimination of organic matter, surpassing an 80% removal of total organic carbon. Treated effluent quality, achieved post-ozonation with an ozone dosage of 26.7 mg/L, adhered to the corresponding guidelines proposed by food crop irrigation and recreational impoundments [36].

As of 2007, there was still no domestic innovation focused on decreasing water filtration. However, targeted research efforts were conducted on effluent and its quality indicators, leading to the attainment of desired outcomes.

In 2008, AM Hassan Ali published an article discussing the reuse of urban irrigation water for drip irrigation and evaluating its effects on soil properties in a semi-arid region.

To minimize the environmental impact of the research experiment, the drip irrigation system was regulated, and modern additional water flow control was adjusted according to pan evaporation measurements [37]. In 2008, 13 articles on filtration were published, primarily focusing on water filtration studies.

4.2. Irrigation System

The relationship between filtration in irrigation systems is closely related. Several equations have been developed to calculate head losses in disc, screen, and sand filters in irrigation water applications that include not only losses but also filtration rate, filtration area, water density and viscosity, volume, and flow through the filter. Speed was also there. Experiments on the analysis of head losses through filters 115, 130, and 200 PC disc filters, 98, 115, 130, and 178 PC screen filters, and five effluents with a sand filter with an effective grain size of 0.65 mm, and the equations were satisfactorily corrected with experimental data. In 2015, head loss equations for self-cleaning screen filters in drip irrigation systems were created through dimensional analysis. This method produced two equations for calculating head loss when using a mix of tap water and sand water. Eleven parameters related to filter characteristics were identified as affecting head loss. The developed equations were satisfactorily adjusted using experimental data. While the adjustments were significant, the regression coefficients varied and were not always high, providing new information that differed from similar studies. Inefficient irrigation systems hinder the sustainable development of agriculture, particularly in remote areas, impacting the population's standard of living. Globally, there is a significant focus on researching and adopting water-saving technologies. Drip irrigation requires water of a specific quality, ensured by filters. Sand filters are widely used in agricultural water-saving drip irrigation systems because of their effectiveness in retaining irrigation water [38] (**Table 3**).

Table 3. Types of filtrations and their varieties, efficiency indicators.

№	Types of Filtrations	Key	Efficiency	Authors
1	The anaerobic membrane bioreactor	Bioreactors were mainly tested under mesophilic or thermophilic conditions. Application of thermophilic conditions allowed treatment of high organic loading. Chemical oxygen removal, total oxygen removal of up to 99% and pathogen removal of up to 100% total oxygen removal have been reported. Therefore, it has been determined that the treated water can be discharged directly into the water bodies or, if the effluent meets the irrigation standards of the area, can be reclaimed for unlimited crop irrigation.	90%	Puig-Bargués, J., Barragán, J., Ramírez de Cartagena, F. [39]
2	Sand media filter	The effectiveness of sand filters with effective sand diameters of 0.32, 0.47, 0.63, and 0.64 mm has been considered.	85%	Wu, W., Chen, W., Liu, H., et al. [40]
3	Membrane filtration	Initially, irrigation water undergoes thorough cleansing in a membrane machine that consists of prefiltration, ultrafiltration, nanofiltration, and reverse osmosis, reaching high-quality results.	–	Liu, Z., Muhammad, T., Puig-Bargués, J., et al. [41]
4	Sand filter	In this research, two mattress sand filter columns were utilized, measuring 0.425 and 0.9 meters in depth, and each having a diameter of 0.3 meters. They have been loaded intermittently with artificial milkhouse leachate over a duration of 439 days, experiencing various hydraulic and natural loading rates.	92%	Paraskeva, CA; Papadakis, VG; Kanellopoulou, DG; Koutsoukos, PG; Angelopoulos, K [42]

Table 3. *Cont.*

№	Types of Filtrations	Key	Efficiency	Authors
5	Screen, disc and a combination of screen and disc filters	The learn about investigated the overall performance and computerized backwashing effectiveness of three filtration structures used in micro-irrigation structures beneath one-of-a-kind inlet pressures (300 and five hundred kPa) over a duration of extra than 900 hours with organic irrigation water.	–	Duran-Ros M, Puig-Bargués J, Barragán J, de Cartagena FR [43]
6	Land filter	The approach concerned preliminary pretreatment via coarse sorting and placement in cure ponds, accompanied by the aid of imposing FILTER technological know-how in the pasture area. This device efficiently managed variable volumes and nutrients in the irrigation water.	95%	Asirifi I, Kaetzl K, Werner S, Heinze S, Abagale FK, Wichern M, et al. [44]
7	Slow sand filter	Thirteen sluggish sand filters have been utilized in the experiment, with every filter composed of two 1-meter sections of 10.16 cm (4-inch) diameter pipes that have been flanged together.	–	Ait Melloul A, Flata K, El Fadeli S, El Abbassi A, Pineau A, Barkouch Y. [45]
8	Screen filter	In order to check out the influence of filter setup on head loss and filtration efficiency, a display screen filter was chosen as the focal point of this study. By inspecting two filtration strategies and adjusting the pitch awareness the use of numerical simulations and experimental computational fluid dynamics tests, we aimed to examine and analyze the ensuing head loss and trapped volume.	88%	Hasani AM, Aminpour Y, Nikmehr S, Puig-Bargues J, Maroufpoor E. [46]

4.3. Filtration

The topic of water filtration is important, but the need to reduce filtration is increasingly critical. As technology advances rapidly, water quality indicators become more relevant. In drip irrigation, the filter's role is crucial because using unpurified water can negatively impact the efficiency and lifespan of the irrigation technology. The study investigated head loss and clogging in irrigation water filters based on their filtering quality. The filters examined included 115, 130, and 200-micron disk filters; 98, 115, 130, and 178-micron screen filters; and a sand filter with a single sand layer having an effective diameter of 0.65 mm. In this study, however, the input and output angle of the filter, the diameter of the filter hole D(S), the technical parameters, and the hydraulic analysis of the filter were analyzed on a data basis. As of 2021, a significant issue is the use of sediment-laden water, which is likely to clog irrigation systems and potentially cause extensive damage. Immersion tanks have been employed to allow particles to settle before water is utilized in drip irrigation, thereby reducing particle load and clogging risk. However, these tanks are often ineffective at preventing clogging caused by biological and organic materials. This study proposes using a horizontal root fracture (HRF) to address composite blockages in irrigation systems with herpes simplex virus (HSV).

4.4. Filters in Irrigation

Water filters used in irrigation systems to improve water quality for irrigation water treatment and water-saving technologies include: Irrigation water is initially processed using a membrane system (including prefiltration, ultrafiltration, nanofiltration, and reverse osmosis). This process yields pure water and other organic by-products. Although membrane filtration is an expensive process, its advantage lies in the effective utilization of agro-industrial irrigation water. When using irrigation water, it must be filtered, a process that poses challenges. Jaume Puig-Bargues and his team conducted a significant experiment in irrigation water treatment by employing dimensional analysis to create equations for calculating head loss in disc, screen, and sand filters. These equations consider variables such as filtration rate, filtration area, water density and viscosity, mean particle size distribution, volume through the filter, flow rate, and concentration of suspended solids in the irrigation water. The

Buckingham method was used for this analysis. Experiments on filter head loss were performed on disc filters of 115, 130, and 120 μm, and screen filters of 98, 115, 130, and 178 μm, along with sand filters having an effective grain size of 0.65 mm, using five different irrigation waters. The equations aligned well with experimental data, though the effluent and filter type influenced the adjustments. Proper selection and effective use of water filters are part of the irrigation system. Choosing the right water filters and using them efficiently is significant for an irrigation system. One way to beautify water effectivity is through as it should be reusing water. A number of countries are leading the way in implementing initiatives, and researchers are also doing a lot of work in this area. Their main goal is to make easy filtering systems that use little energy while still making sure that water quality is a top concern.

4.5. Limitations

This paper is no longer beyond its limitations. During our search, we may have overlooked some studies that are used in various scientific databases. Although bibliometric evaluation can provide useful views on current and expected trends in irrigation facilities and filtration, it does not always perceive the actual implementation of these trends. In addition, prescriptive screening techniques may introduce biases, which may further affect the final assessment results. Choosing the right parameters and algorithms is important for a quantitative literature review of the use of VOS visualization software. It should be understood that using the same parameters and algorithms can lead to different results. These results may also contain synonymous terms, which require merging and verification of relevant data. Although the software helps to extract effects from literature data, the synthesis of search points and the prediction of future search trends require the input of educated people. In conclusion, the use of advanced digital applied sciences and smart devices to enhance filtration and adjust other conditions in irrigation systems can help monitor, control, and predict the necessary elements of agricultural operations. This science helps decision-making techniques by identifying optimal methods to achieve goals such as irrigation water reuse, filters, water conservation, and environmental issues.

5. Conclusions

Filtration in irrigation system have seen significant progress in recent years with increased research interests. Irrigation water reuse and agricultural reuse research 2003–2024. Irrigation water reuse can be divided into three phases: the initial development phase from 2003 to 2012, followed by it is in the phase of rapid growth from 2013 to 2018, and from 2019 to 2024. The 374 articles were divided into categories: 374 Web of Science categories, with the top five: agriculture, environmental engineering, water resources, soil science, and hydrogeology. This categorization reflects the interdisciplinary nature of irrigation studies on the use of water filters, and recovery is published in 164 journals, with Biosystems Engineering and Desalination and Water Treatment Journal as the most effective journals publishing a total of 34 articles. The journal with the highest average number of citations per paper is Chemical Engineering Journal, with 68.39 citations per article. A total of 77 countries participated in research on filtration in irrigation system use and reuse. Algeria is the most efficient country, with 77 articles. Spain has the highest average quote, with 42.71 pieces of paper. In addition, some involve relatively close cooperation between different countries. Cooperation and global efforts to solve problems between different countries are manifested in problems with water filters. The most effective institution is the University of Girona. A total of 1479 authors contributed to research on filtration in irrigation system and recovery, and the most effective author is Fiaz U, with 32 papers. Keywords such as “micro-irrigation”, “clogging”, “reclaimed water” and “ultrafiltration” show increasing returns attention and may become new research points. These cracking keywords mean switching to innovative methods of checking filtration in irrigation system processes showing that new approaches are being explored to increase efficiency and sustainability. Research on secondary water treatment has grown and diversified significantly. Field passed from the initial stage to the stage of rapid development the importance of solving problems related to filtration is increasing the treatment of secondary waters. Cooperation between researchers, institutions, and countries plays an important role in facilitating knowledge sharing and technology development. Future research should focus on the development of green and sustainable technologies by increasing secondary water treatment and reuse efficiency, promoting sustainable use of water resources, and mitigating environmental pollution.

Author Contributions

M.X. and B.M.—Oversaw the coordination among co-authors and final manuscript revisions. M.X.—Conceptualized the study and led the overall research design. Contributed significantly to the writing of the manuscript, particularly the introduction and conclusion. B.M.—Supervisor. Conducted the literature review and compiled data on research trends and publication analysis. Z.K.—Provided expertise in bibliometric analysis and data visualization. Led the analysis of scientific output, co-authorship networks, and keyword mapping. Also supported in reviewing and refining the results section. M.K.—Focused on the categorization of document types, subject areas, and institutional affiliations by country. Contributed to statistical interpretation and assisted in developing the thematic classification framework. S.S.—Assisted in data collection and extraction from bibliometric databases. Participated in the analysis of annual trends and top journals. Helped prepare visual figures and charts for publication. M.B.—Supported in identifying and analyzing the top-cited articles and funding sponsors. Q.E.—Participated in reviewing and editing the manuscript. Helped synthesize the findings related to international authorship trends and scientific collaboration. M.A.—Provided input on implications for future research and practical applications. Assisted in developing recommendations for enhancing international cooperation and sustainability. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

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