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Greywater Treatment and Sustainability: Literature Scientmetric Analysis by VOS Viewer

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Abstract

Sustainability is of utmost importance in order to confront the threat of global climate change and water scarcity in most countries. For this reason, it has become necessary to treat and reuse gray water (water generated from sinks, kitchens, and washing machines), as it constitutes the largest portion of wastewater about 75% from wastewater[1] and is less polluted, to reduce consumption water.This study set out to understand the scientific underpinnings of gray water as well as the global advancements in the field of gray water treatment. To this end, it compiled a list of all the top journals and researchers worldwide, as well as the actual number of research papers published worldwide and the annual growth rate for the previous ten years.

The literature and research on gray water treatment during the last 10 years was studied from (2014 to 2023) and reviewed, and the data was collected and downloaded in Excel format with a total of more than 891 research papers through the Dimension website, which lists the details of authors and researchers in all universities and countries, while monitoring joint cooperation and comprehensive scientific citations and displaying them with images and data through the program. Viewer VOS and with the help of the term (grey water treatment). The rate of rise in research over the past ten years has been roughly 82.2%. This indicates a significant increase in the importance of sustainability in general and gray water treatment in particular.

Keywords: Greywater treatment, Scientmetric analysis, VOS viewer

1.Introduction

Today the world is facing the problem of climate change seriously. Rising temperatures and climate change have begun to change the world’s topography and the geography of the Earth. Therefore, there was a real interest in sustainability and the green economy, and here studies and research on alternatives suitable for environmental problems actually began.

The increase in demand for water and its scarcity in most regions of the world and the increase in the amount of wastewater thrown into rivers without treatment[2]. Treating graywater and reducing the amount of untreated wastewater has become a necessity and an appropriate environmental solution. Treated graywater provides quantities of water used for flushing toilets, watering crops, or washing garages, roads, and public spaces[3].Therefore, over the past ten years, global environmental institutions, in addition to specialized companies, have taken this task seriously and have begun to study this field at the level of treatment or reuse, calculating the quantity, and setting determinants for the quality of the water released.

2. Greywater Definition

The greywater (also wright as grey water) is defined as the effluent wastewater coming out of sinks, bathtubs, washing machines[4]. Gray water takes its name from the gray color it becomes after stagnation. This water is characterized by the fact that it does not contain organic materials[5] and fewer pathogens than blackwater [6].There are two types from greywater (GW): light GW and dark GW, light GW resource from basins, shower and baths. The dark GW came from laundry, dishwashers and kitchen sinks[7].

2.1. Greywater Characteristics

GW characteristics vary depending on the source of water discharge and they changing by time and place[8]. There are three factor relevant in the composition of greywater [9]. The water supply quality, the state of GW components conveyed from the dump, and the household-related activities[10], and the GW characteristics summarized in Table 1. And these characteristics are measured by some parameters.

Table (1): Greywater Characteristics[11]

Water Source type	Characteristics
laundry	Foam, Bleach, Hot water, High pH, Grease and Oil, Nitrate, Phosphate, Oxygen demand, Soaps, Salinity, Suspended solids, Sodium.
Dishwasher	Foam, Bacteria, High pH, Food particles, Odor, Hot water, Grease and Oil, Oxygen demand, Organic matter, Soaps and Suspended Solids.
Bathtub & Shower	Hair, Bacteria, Odor, Hot water, Grease and Oil, Soaps, Oxygen demand and Suspended solids.
Kitchen Sinks	Food particles, Bacteria, Odor, Hot water, Grease and Oil, Oxygen demand, Organic matter, suspended solids and Soap.

The GW conventional parameters are divided to three groups: physical parameters, chemical parameters and biological parameters[12].

The physical parameters are Temperature, turbidity, Total solid, total suspended solids and total dissolved solids[13]. The chemical parameters are pH, biochemical oxygen demand, chemical oxygen demand[14]. The biological parameters are total coliforms and faucal coliforms[15].

2.2.Quality of Greywater

The quantity and quality of GW exhibit seasonal variations and depend on the characteristic of user (number, age, habits, activities), composition of detergent and wastewater collection system[16]. Tables 2 show the quality of greywater generated in each part.

Table 2: Quality of Greywater Generated in Each Part[17]

Parameters	Bathroom	Laundry	Kitchen	Mixed	Swedish household
PH(mg/L)	7.1-7.6	8.3-9.3	6.5-7.7	6.7-7.3	7.5
TSS (mg/L)	58-78	188-315	134-625	89-353	153
BOD (mg/L)	26-300	48-380	47-1460	41-500	329
COD(mg/L)	86-587	58-1338	58-1340	77-1278	576
Total N (mg/L)	3.6-17	6-21	40-74	0.6-11	16
Total P (mg/L)	0.1- >49	0.1- >101	68-74	0.6 - > 68	9

2.3.Quantity of Greywater

The average typical generation of GW for households with piped water reticulation is estimated to in the range of (40 - 60) l/p/d (about 50 percent of total water use)[18]. On average, domestic water use is 100-110 L/person/day[19]and Over 50% of such water could be recovered from the GW and recycled.

3. Greywater Treatment

There are several processes available for treating GW, including sand filtration, aeration, electro flotation, pressure filtration, and biological treatment[20]. The GW reuse after treatment for toilet flashing, irrigation and garage washer [21].

3.1. Why Should GW be Reused?

GW is not as contaminated as toilet water. This water can be relatively easily treated on-site for reuse in non-potable contexts such as toilet flushing and garden irrigation. By intercepting greywater before it goes to the septic tank or the municipal wastewater system, and providing some treatment (in certain cases, no treatment may be required) the water may be reused to irrigate plants. With a little additional treatment, the water also may be used for toilet flushing[12] **.** Many researchers have raised or reviewed the concerns regarding the reuse of untreated greywater. These include:

- Risks to public health due to human contact with microorganisms
- Clogging of distribution system by hair and oil & grease
- Reduction in potable water consumption and sewage production
- Offensive odour caused by the formation of sulphide

- Pollution of soil, surface water and groundwater due to irrigation, infiltration, and groundwater recharge [22].

3.2.Greywater Treatment Technology

Raw GW treatment is a major storage and other use. The reuse of untreated greywater may lead to health risks and problems for humans, their environment, and their social conditions. GW must be treated according to certain standards before reuse. The treatment aims to overcome pathogens, organic matter and solids, and meeting the criteria for reuse[23] . Several researches were carried out on greywater treatment with various methods which differ in performance and complexity[24] .

3.2.1. Physical Treatment

Physiotherapy Systems Filtration might be utilized as one of the pre-treatment tools or post-treatment in the case when the contaminated particle size and filter porosity directly impact the efficiency of treatment. The effect is a very high flow level proportional to microfiltration, membrane filtration, nanofiltration, and ultrafiltration[25].

3.2.2. Chemical Treatment

Processes such as flocculation, electrocoagulation, adsorption, or advanced oxidation treatments that require chemicals for GW treatment methods reduce coagulation and filtration of suspended solids and organic matter in the GW, giving a high removal efficiency of pollutants[26].

3.2.3. Biological Treatment

Bio-treated GW systems are rotating biological contactors, batch reactor sequencing, bioreactors with diaphragms, fluidized bed, and reactor for up-flow of anaerobic sludge. In biodegradation and cone filtration, MBR technology has been established as a viable tool for high removal efficiency of pollutants of organic contaminants and microbial pollutants in GW [27].

4. Data Collection

The information was gathered via the Dimensions platform. The largest database of research funds accessible is called Dimensions, and it links grants to millions of patents, clinical trials, and published works. It offers access to more than 140 million documents (books, proceedings, and journals) that date back to the start of the 20th century and gives users access to several important scientific databases.

Dimensions as the database used as a source for the information. There are roughly 9,057 documents in the final database covering the years 2015 through 2024. According to the ANZSRC 2020 code, the most common research fields were environmental engineering, chemical engineering, environmental sciences, environmental management, and biological sciences. The average number of citations per document was 17.86, and there were over 162,000 citations overall.

There are 80 to 120 articles published annually. 2022 will witness the greatest number of publications, as Figure 1 illustrates.

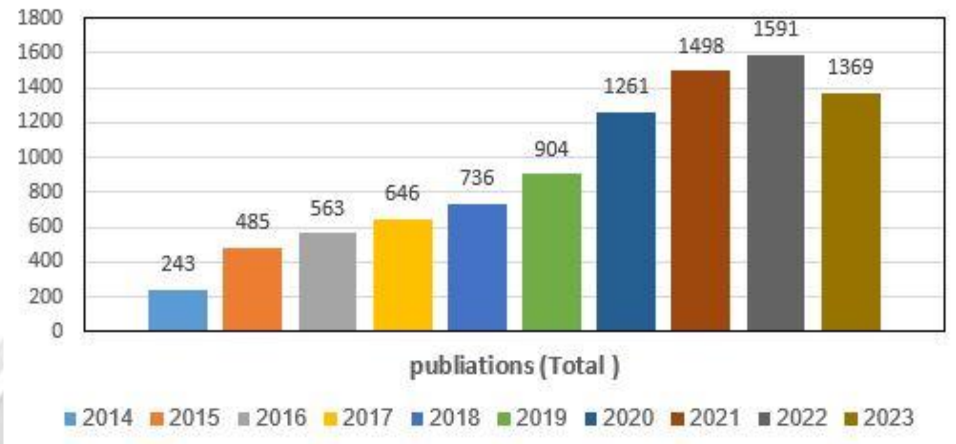

Figure 1: Annual Publication Citations and Scientific Output

In recent years, the average annual number of article citations has ranged from 10,000 to 20,000.as depicted in Figure 2.

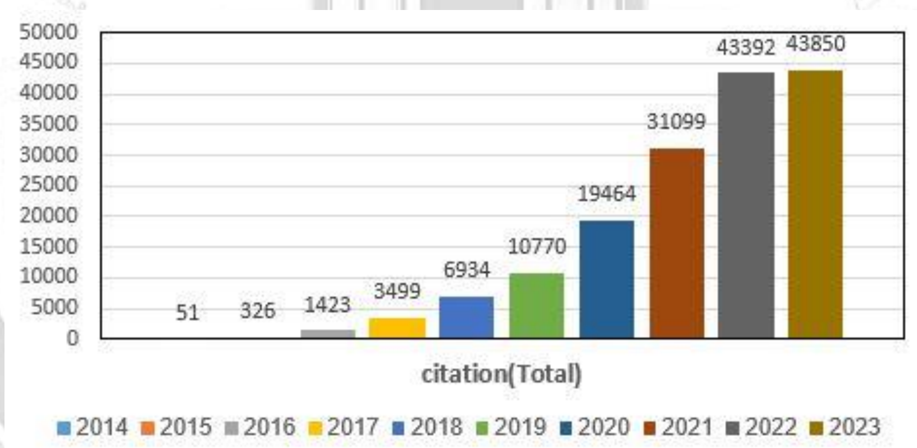

Figure 2: ***Annual Scientific Article Citations***

5. Methods of Analysis

Bibliometrics offers active, evaluative, and predictive scientometric analysis. Despite having its roots in the field of library and information science, it has subsequently expanded its acceptance and been used in many other disciplines, especially for quantitative studies based on academic outputs that are carried out by academic publications, institutions, and scholars. The bibliometric process can be carried out using a wide range of programming packages and tools, such as BibExcel, CiteSpace, Pajek, Gephi, Vos Viewer, and Histcite.

Maps and visualizations utilizing bibliometric data were produced using VOSviewer. This program uses a single architecture for both mapping and clustering, and its primary application is bibliometric network analysis. VOSviewer allows for the creation of overlay, network, and density visualizations, among other three types of visualizations.

5.1.Top Contributions

The list of e top 10 contributions from authors, research categories, and institutes. Table 3 shows that Adel Ali Saeed Al-Gheethi (Tun Hussein Onn University of Malaysia, Malaysia) is leading a team of researchers with 72 publications, including one about using greywater for irrigation as an alternative water source in the new water management strategy of the Middle East countries—which face a severe shortage of water resources, which shows the most 1op 10 in Authors [28]. Fellowes by Radin Maya Saphira Radin Mohamed in same collage (Tun Hussein Onn University of Malaysia, Malaysia) which have 52 publications, Yang Liu (University of Alberta, Canada) third one with 36 publications.

Table 3: The Most Top 10 in Authors

Top 10	Author	documents	citations	citations mean
1	Adel Ali Saeed Al-Gheethi	72	1,700	23.61
2	Radin Maya Saphira Radin Mohamed	52	984	18.92
3	Yang Liu	36	856	23.78
4	Ana B Deletic	33	1,028	31.15
5	Eberhard Morgenroth	31	949	30.61
6	Nicholas John Ashbolt	30	772	25.73
7	Björn Vinnerås	26	491	18.88
8	Enedir Ghisi	26	729	28.04
9	Eran Friedler	24	873	36.38
10	Jennifer Rae Mcconville	22	180	8.18

The Science of the total environment is the top one of source titles with 417 publications and 12,450 citations, followed by Water with 369 publications and 4,934 citations, the Sustainability third Organization with 271 publications and 3,573 citations, as shown in Table 4

Table 4: The Most Top 10 in Source Titles

Top 10	Organization	documents	citations	citations mean
1	The Science of The Total Environment	417	12,450	29.86
2	Water	369	4,934	13.37
3	Sustainability	271	3,573	13.18
4	Journal of Cleaner Production	270	9,061	33.56
5	Journal of Environmental Management	245	6,262	25.56
6	Environmental Science and Pollution Research	232	3,215	13.86
7	Water Research	194	8,709	44.89
8	Chemosphere	184	4,544	24.70

9	Journal of Water Process Engineering	166	3,112	18.75
10	Journal of Environmental Chemical Engineering	161	3,275	20.34

Table 5 shows the top 10 contributions made by Research Categories, Engineering the most top one with 5,251 publications and followed by Environmental Engineering with 3,502 publications and Chemical Engineering third one with 3,302 publications.as shown in table 5

Table 5: The Most Top 10 in Research Categories

Top 10	Research Categories	documents	citations	citations mean
1	Engineering	5,251	103,005	19.62
2	Environmental Engineering	3,502	69,284	19.78
3	Chemical Engineering	3,302	68,743	20.82
4	Environmental Sciences	2,542	46,918	18.46
5	Environmental Management	1,114	20,976	18.83
6	Biological Sciences	728	13,465	18.50
7	Chemical Sciences	665	16,103	24.22
8	Pollution and Contamination	659	15,570	23.63
9	Built Environment and Design	652	10,892	16.71
10	Earth Sciences	638	8,450	13.24

6. Measures of Co-Occurrence

The elements in the network visualizations are labeled and shown as circles. The count of the specified item determines the various sizes of the circles that are displayed. Based on their groupings, the items are positioned on the map. The cluster of each item determines its color as well. The relationship between the items is depicted by the lines connecting them in the graphic. The line is thicker where the link is stronger. In addition, the degree of relatedness between elements on the map is shown by their distance from one another.

6.1. Co-Authorship

Creating and analyzing a draft that includes field information on a co-author network of distinguished authors can serve as a useful starting point for various institutions wishing to develop collaborations between different research groups. Additionally, this data can help individual students identify potential collaboration partners, and publishers can form editorial teams using co-author agreements.

6.1.1. Authors

The quantity of articles that authors have co-authored establishes their link. The total number of authors (represented by 11 clusters; networks and circles are colored per cluster) is displayed for authors who have co-authored at least four publications.as depicted in Figure 3.

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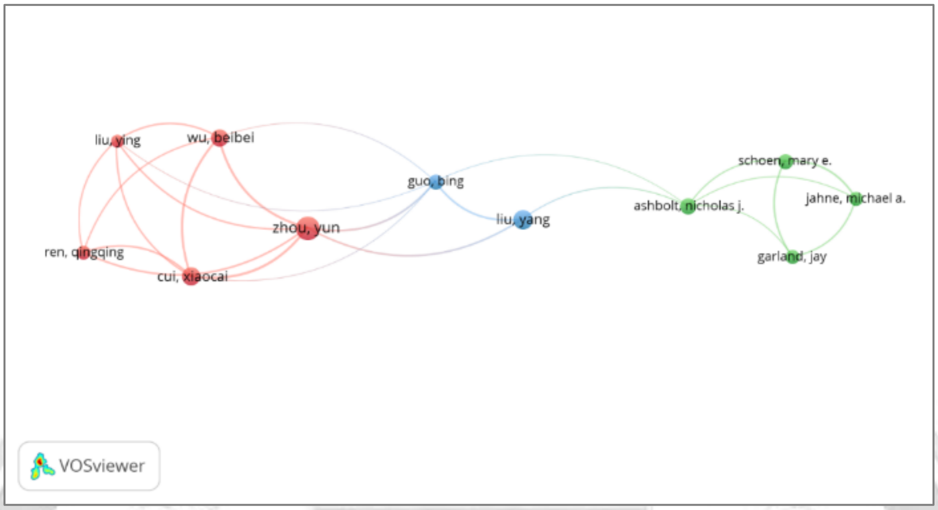

Figure 3: Co-authorship- Authors

6.1.2. Countries

About 33 countries are faced when it comes to co-authorships inside nations, and the strength of co-authorship links with other nations was computed for each nation. The nations with the strongest overall connectivity are covered by the network. The nodes show the overall strength of the link. Three clusters were identified by our analysis; the largest node in each cluster indicates its leadership status: the red cluster contains three components, the green cluster has two, and the blue cluster has one. China and India are conducting research in this area and are connected to 33 other countries through a network of co-author ships. As shown in Figure 4.

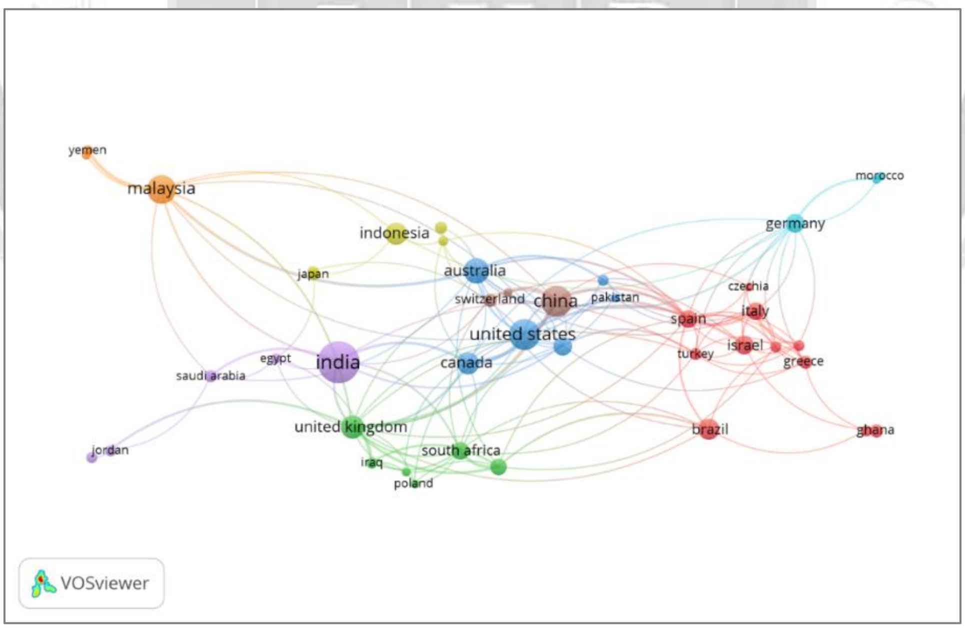

Figure 4: Co-authorship- Countries

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6.2.Citation

Citation analysis was done to identify the key research publications, sources, and countries. It is easy to analyze the highly cited publication and discover the important research area when document citations and citation groupings are identified.

6.2.1.Source

The result was a net with six major clusters, as seen in Figure. Every category is a representative of the top journal that publishes articles on related subjects. The Science of The Total Environment and the water the most top one in this field (figure 5).

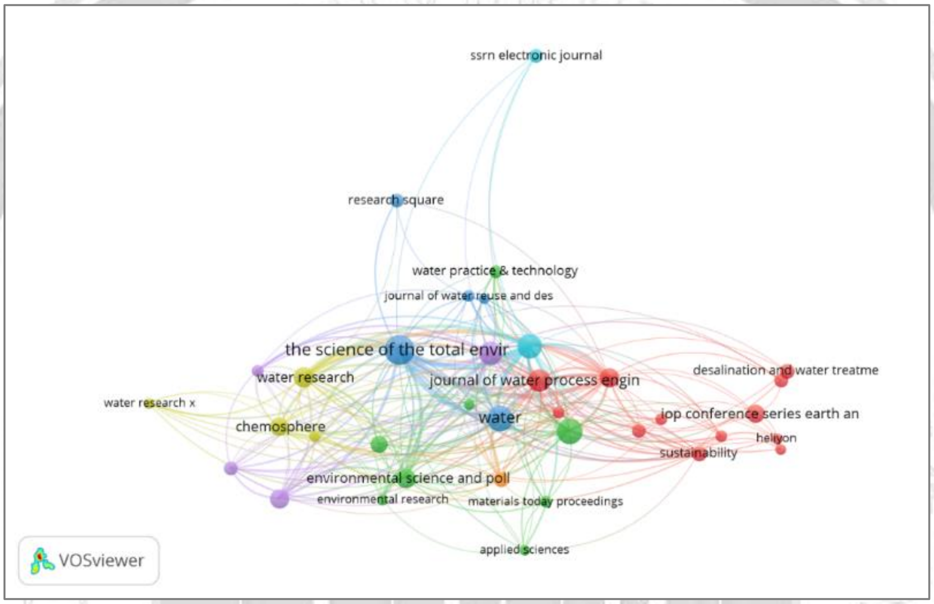

Figure 5: Citation- Source

6.3. Co-Citation

The author co-citation analysis, or co-citation analysis, is one of the most widely used methods in scientometric studies [29]. Understanding the process of specialization development can be aided by this type of examination [30]. Furthermore, because the citation network could omit some significant articles, the co-citation network is preferable to it.

6.3.1.Cited Source

The co-citation analysis in this paragraph is predicated on the publication's source. The VOS viewer produced a network with five large clusters, each of which symbolizes a prominent journal, as seen in Figure, that water research the most one and ecological engineering. As shown in Figure 6.

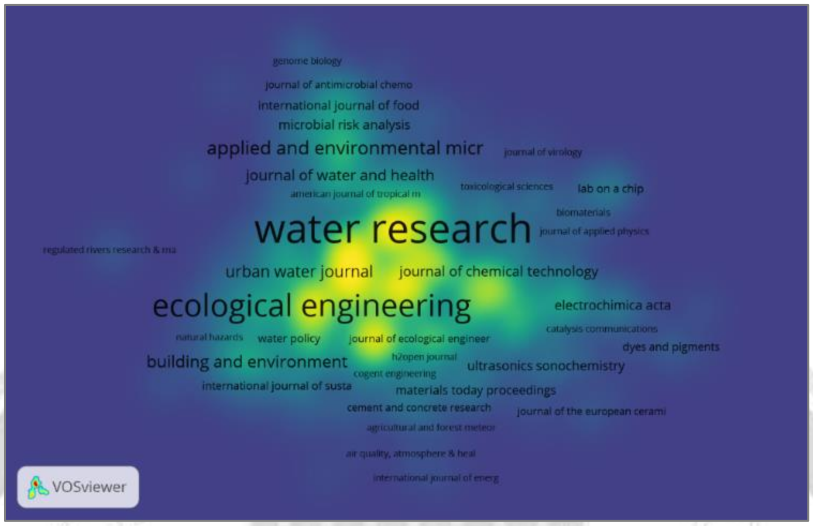

Figure 6: Co-Citation- Source

6.3.2. Cited Author

The most co-cited author is Friedler, Eran and Eriksson, Eva and also Vymazl, Jan and Detetic in the other side, as shown in Figure 7.

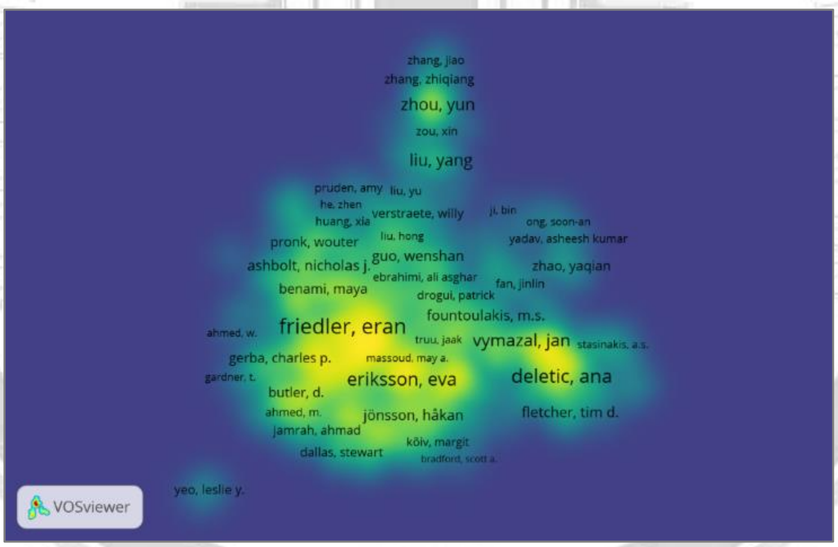

Figure 7: Co-Citation- Author

7. Summary

In this review, the most important "characteristics" and "specifications" for the quality and nature of gray water were studied:

- Grey water makes up the majority of wastewater, which means that treating and reusing it is important for the ecosystem and the preservation of our world.
- The type and manner of treatment for greywater depend on the physical and chemical impurities present. This can involve physical treatment, chemical treatment, or a combination of both.
- In order to promote sustainability and contribute to the green economy, there has been a notable growth in collaborative research and cooperation. The primary objective of this cooperative effort is to conserve water usage, which is a crucial aspect of achieving sustainability.

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استدامة المياه الرمادية ومعالجتها: مراجعة لتحليل البيانات في برنامج VOS Viewer

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الخلاصة

هناك اهمية قصوى للاستدامة من اجل مواجهة خطر التغير المناخي العالمي وشحة الماء في معظم البلدان ومن اجل ذلك أصبح من الضروري معالجة واعادة استخدام المياه الرمادية (المياه المتولدة من المغاسل والمطابخ والغسالات) حيث تشكل الجزء الاكبر من مياه الصرف الصحي وذات تلوث اقل، لتقليل من استهلاك الماء

الهدف من هذه الدراسة كان اولا الاطلاع على الاساسات العلمية للمياه الرمادية وثانيا معرفة التطور والتقدم في العالم بموضوع معالجة المياه الرمادية من خلال معرفة العدد الحقيقي للبحوث ونسبة الزيادة في السنوات العشر الاخيرة لجميع الدراسات في العالم وكذلك معرفة كل من المجلات الرائدة والباحثين.

حيث تمت دراسة ومراجعة الادبيات والبحوث الخاصة بمعالجة المياه الرمادية خلال السنوات العشر الاخيرة وتجميع البيانات وتنزيلها بتنسيق الاكسل بمجمل بحوث بعدد يفوق 800 بحث من خلال موقع Dimensionوالذي يسرد تفاصيل المؤلفين والباحثين في الجامعات والبلدان كافة مع رصد التعاون المشترك والاقتباسات العلمية الكلية وعارضها بصور وبيانات من خلال برنامج العارض VOS وبمساعدة المصطلح (معالجة المياه الرمادية). وبالأخير كانت نسبة الزيادة في البحوث في السنوات الاخيرة حوالي 82.2 % خلال عشر سنوات فقط و هي قفزة لاهمية الاستدامة بشكل عام و معالجة المياة الرمادية بشكل خاص.

الكلمات الدالة: معالجة المياه الرمادية، التحليل السينتومتري، عارض**VOS**