Journal of Energy & Environment

Journal homepage: journal.uniten.edu.my/jee

ISSN: 1985-7462

Bibliometric Analysis of Sediment Concentration Prediction Using Artificial Neural Network

H. M. Mustafa [a,b], G. Hayder[c,d], A. Mustapha[e], K. F. Kushiar[f], S. M. Tahir[g] and E. H. O. Elsadig[h]

[a] College of Graduate Studies, Universiti Tenaga Nasional (UNITEN), 43000 Kajang, Selangor Darul Ehsan, Malaysia (hauwa.mustafa@uniten.edu.my)
[b] Department of Chemistry, Kaduna State University (KASU), Tafawa Balewa Way, P.M.B. 2339, Kaduna, Nigeria
[c] Institute of Energy Infrastructure (IEI), Universiti Tenaga Nasional (UNITEN), 43000 Kajang, Selangor Darul Ehsan, Malaysia gasim@uniten.edu.my)
[d] Department of Civil Engineering, College of Engineering, Universiti Tenaga Nasional (UNITEN), 43000 Kajang, Selangor Darul Ehsan, Malaysia
[e] School of Postgraduate Studies, Department of Computer Studies, Bayero University, Kano (BUK), Nigeria (amatullahimusty@gmail.com)
[f] Asset Management Department, Generation Division, Tenaga Nasional Berhad, 59200 Kuala Lumpur, Malaysia faizal.kushiar@tnb.com.my)
[g] Department of Biological Sciences, Kaduna State University (KASU), Tafawa Balewa Way, P.M.B. 2339, Kaduna, Nigeria (smtahir@kasu.edu.ng)
[h] Faculty of Engineering, University of Tabuk

Keywords

sediment
prediction
bibliometric review
subject area
ANN
water quality

Abstract

This bibliometric review is aimed at documenting, synthesizing research trends, and suggest future directions in the applications of artificial neural network (ANN) for prediction of sediment concentration over the past 21 years (1998 to 2020). Through bibliometric analysis, we analyzed 158 documents extracted from the Scopus-indexed database. We analyzed meaningful information on the document type, research trends, publishing activity by authors and journals, subject area, most active countries, the language of documents, and keywords. Microsoft excel and related figures extracted from the Scopus website was used in computing the data aggregate. Documents, author, and journal source analysis was used to identify the key authors and most active sources that contributed to the knowledge pool in this research field. Our review found that the highest number of publications in this area were from Asia, Europe, and North America with Iran taking the lead. Also, we found that the prediction of sediment concentration using artificial neural networks requires more research data. This research literature has significant contributions to both economically developed and developing countries. This study is limited to data extracted from the Scopus database in October 2020. Furthermore, ANN tool such as Particle Swarm Optimized Cascade-Forward Neural Networks can be used to improve the prediction of sediment concentrations in hydrological field.

1. INTRODUCTION

Sediment is a material that is broken down by weathering and erosion. These materials are often transported through fluvial processes, and they are categorized depending on their composition or grain size. In most cases, sediment concentrations at river banks, deltas, or the bottom of waterfalls are caused by physical processes of transportation, detachment, or deposition. The concentration and size of sediment are mainly influenced by precipitation, soil properties, vegetation, and topography [1]. However, sediment formation due to the aggregation of solid particles leads to blockage of drainage networks and water turbidity, which degrades the quality of drinking water and prevents sunlight from penetrating deep into the water.

Sediment concentration information study is useful in designing channels, dams, and reservoirs, movement of pollutants in lakes, rivers and estuaries, conservation of aquatic ecosystem, and environmental impact assessment [2]. Several methods available have been used for the quantification of sediment transport. The general practice is to statistically evaluate and correlate the sediment discharge time series and streamflow data [3], [4]. The stochastic simulation and statistical analysis are attractive alternatives because sampling and monitoring of simultaneous sediment discharge and streamflow records are not possible for relatively long periods to allow definitive deterministic correlations between the discharge of streamflow and sediment concentration. However, artificial intelligence (AI) methods are regarded as efficient tools for modeling complex nonlinear systems [5]. These models usually do not take the internal mechanism into account, but build models by the correlation of inputs and outputs. Currently, AI has been used for

predicting various water-related regions [6]. Furthermore, an artificial neural network (ANN) is among the computational methods used in hydrological science. ANN is a nonlinear input-output mapping method that is suitable for complex nonlinear models and can learn from observations without specific mechanics. It normally delivers results faster and more precisely than its physical counterparts, but only within the spectrum of values observed in the data used to construct the model [7]. ANNs have self-learning abilities that allow them to generate a satisfactory outcome when more data is provided. ANN models have been identified as a significant tool for monitoring and prediction of runoff-sediment yield in the field of hydrology. Nagy et al. [8] used a feed-forward ANN model in predicting the sediment discharge in rivers through which the input parameters reflected the riverbed and sediment information. The study demonstrated that the neural network models could be effectively extended to sediment transport modeling, and the accuracy of the ANN predicted results could be enhanced by increasing the learning input patterns with a wide range of variables.

Khan et al. [9] used historical data collected from 2008-2010 for the estimation of water discharge and sediment concentration of River Ramgang using ANN tools. The outcome of the research gave a satisfactory result as R2 value of 0.99 was obtained for the optimal network. This study confirms the functional potential and effectiveness of the ANN techniques in simulating complicated nonlinear, river system, and real-world processes in the Himalayan scenario. Singh & Khan [10] applied ANN techniques for the estimation of sediment load in the Himalayan Bhagirathi river. The outcome of the analysis showed that when the Lavenberg-Marquardt algorithm was enhanced with nonlinear autoregressive and exogenous input architecture, high coefficient values (0.89-0.97) were obtained.

Presently, bibliometric analysis is a technique used for mapping defined documented records, and it is regarded as an alternative method for the evaluation of library and information science academic topics [11], [12]. Also, bibliometric data is used in evaluating comparative analysis in scholarly papers of scientific studies [13], [14]. The bibliometric study is based on the belief that experimental observations and empirical findings will ultimately be published in international scientific journals where they can be read and quoted by other scholars. Pritchard et al. [15] described bibliometrics as the application of mathematical and statistical tools to publications and other channels of communication. Bibliometric methods have been applied in the evaluation of the quantity and quality of published documents to obtain trends or patterns of a specific research area [16]. Mao et al. [17] conducted a bibliometric analysis in the field of contaminated soil remediation to determine the current research activities and trends in this area. Data based on journal articles extracted from 1995 to 2016 using the science citation index (SCI) of the Web of Science and social sciences citation index databases was used for the study. Ho & Goethals et al. [18] conducted a bibliometric analysis of the current challenges and research hotspots of lakes and reservoirs. 147, 811 data retrieved from the sciences citation index (SCI) from 1955 to 2019 was used for the systematic bibliometric review. The findings demonstrated that there are strong differences in the problems and hotspots of rivers and lakes that can lead to improved decision-making support for the two water bodies. Therefore, to gain more knowledge into the global trend of ANN applications in sediment predictions, this short review employed VOS® viewer and Microsoft excel to provide detailed analysis of document type, research trends, publishing activity by authors and journals, subject area, most active countries, the language of documents, keywords and ideas for potential research in this field.

The objective of this paper is to present the trend of past study on applications of ANN in sediment concentration prediction. This review paper is organized as follows: introduction and query methodology of the study is presented in section 1.0 and 2.0, respectively. The next section discussed the results obtained from the 158 documents retrieved from the Scopus database. The conclusion segment thereafter discusses the limitations and recommendations for future research. The Scopus database is structured to integrate a robust, citation database and curated abstract with enriched data and related scholarly materials. So far, Scopus indexes 24, 600 titles out of 75 million materials and has over one billion cited references since 1970.

2. QUERY METHODOLOGY

Data retrieved from the Scopus database as of October 2020 was used for this study. We comprehensively searched the Scopus database from 1998 to October 21, 2020, using the following terms: “sediment concentration using artificial neural networks” OR “sediment prediction”. We focus on the title of the articles because it represents the relevant topic which is significant with the research area and aim of the study. The title of an article should incorporate information that attracts readers’ interest, as it is the first element that readers will observe [14]. Furthermore, we restricted our search to only journal articles and conference papers. Based on the question, a total of 192 records were collected from the bibliometric analysis. Publications that were excluded contained related topics on estimation of other water quality parameters using other mathematical modeling tools such as random rainforest, decision trees, generalized regression neural network, and multivariate adaptive regression splines. In the case of papers that could not be judged by reading the title and abstract, secondary screening was conducted by reviewing the quality of the specified records. The flow chart of the research is presented in Fig. 1 (PRISMA format) [19]. For purposes of this research, data aggregation and evaluation of the document types, years, authors, journal sources, subject area, countries, and keywords was performed using Microsoft® excel software, and related figures were extracted from the Scopus website. Additionally, VOS®

viewer (version 1.6.15) software was used to obtain the keywords visualization map.

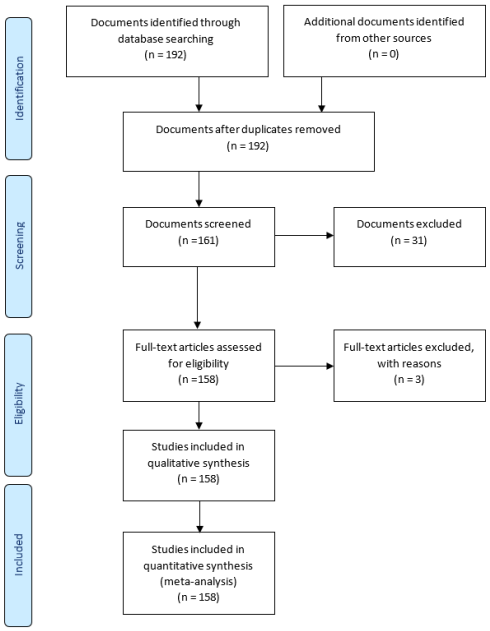

Figure 1. PRISMA Flow Diagram.

3. RESULTS AND DISCUSSION

Based on the 158 data extracted from the Scopus database, we analyzed the bibliometric attributes such as paper type and quantity, subject area, most active countries, document and source types, and keyword analysis. Most of the findings are presented as percentage and cumulative percentage. The co-occurrence of all keywords and author keywords was mapped using VOS® viewer.

A. Publication type and quantity

A total of 192 documents appeared on the Scopus database when sediment concentration prediction using ANN was used as keywords. First, we conducted a preliminary screening to remove articles not too related to our search keywords and also articles from book chapters. Most of the publications were research articles drawn from journal articles (154), 3 conference papers, and one review paper. From the chart, research article publications are the largest, and can substantially indicate advances and improvements in the usage of ANN in water quality monitoring and forecasting. Thus, we concentrated on the review and assessment of 158 papers after the initial screening. Fig. 2 shows the chart of the document type analysis from this study. Journal articles represent 97.5% of the articles published on this topic, followed by conference publications (1.9%) and then review papers (0.6%).

B. Research Trends (Document per year)

Fig. 3 and Table 1 represents the trends of publication on sediment concentration predictions using ANN between

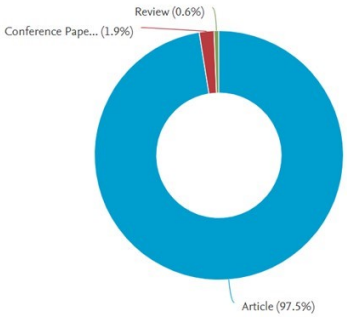

Figure 2. Chart of the Document Analysis.

1998 and 2020. Table 1 shows the total number of publications (TP), percentage (%), and the cumulative percentage of papers published from 1998 to October 2020. The highest number of papers published in this area was obtained in 2015 and 2020 with 14 publications each. In particular, in the years 1998, 1999, 2001, and 2005 only 1 paper was published in this area, with 0 publication in the year 2000. The trend of publications began to grow from the year 2002 upward to the year 2020 with research paper publication falling within 2 to 13. So far, the year 2010, 2015, and 2020 has the highest number of publications with 13, 14, and 13 articles, respectively. This indicates that more research is required in this area. It is expected that the number will increase in 2020 as the significance of applying artificial intelligence tools and big data is now becoming popular. The trends of the research are presented in Figure 3.

Table 1. Year of Publication

YEAR	TP	Percent (%)	Cumulative %
1998	1	0.63	0.63
1999	1	0.63	1.27
2001	1	0.63	1.90
2002	5	3.16	5.06
2003	2	1.27	6.33
2004	6	3.80	10.13
2005	1	0.63	10.76
2006	3	1.90	12.66
2007	3	1.90	14.56
2008	8	5.06	19.62
2009	9	5.70	25.32
2010	13	8.23	33.54
2011	4	2.53	36.08
2012	12	7.59	43.67
2013	11	6.96	50.63
2014	8	5.06	55.70
2015	14	8.86	64.56
2016	10	6.33	70.89
2017	9	5.70	76.58

C. Publishing activity by Author

Based on our data, 160 researchers from different institutions have published in this field. Table 2 describes the top contributing authors, organizations, and the total number of publications. As presented in the table, Kisi Ozgur published the most articles (6), followed by Wang Fan,

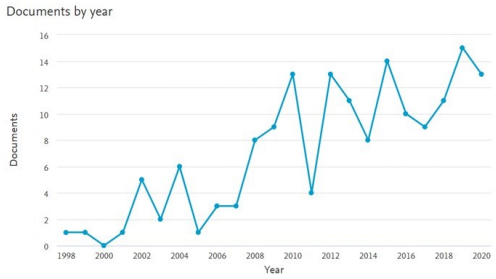

Figure 3. Graph of Number of Documents Published Against Year.

Zhou Bin, and Zounemat-Kermani Mohammad Zounemat with four publications each. The most influential affiliating organizations in this topic is the Indian Institute of Technology Roorkee (6), followed by Zhejiang University (5), University of Tabriz (5), Canik Başari Üniversitesi (5), and Universiti Putra Malaysia (4).

Table 2. Most Productive Authors

AUTHOR NAME	TCP	Percent (%)	Affiliation	Country
Kisi, O.	6	3.80	Ilia State University	Georgia
Wang, F.	4	2.53	Hangzhou Normal University	China
Zhou, B.	4	2.53	KU Leuven	Belgium
Zounemat-Kermani, M.	4	2.53	Shahid Bahonar University of Kerman	Iran
Bonakdari, H.	3	1.90	Université Laval	Canada
Ebtehaj, I.	3	1.90	Université Laval	Canada
Shui, L.T.	3	1.90	Universiti Putra Malaysia	Malaysia
Viguri, J.R.	3	1.90	Universidad de Cantabria	Spain
Wang, X.	3	1.90	Zhejiang Institute of Hydraulics & Estuary	China
Abdallaoui, A.	2	1.27	Université Moulay Ismail	Morroco

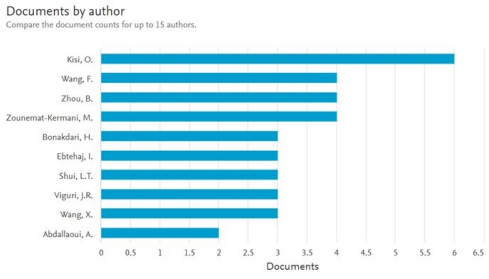

Figure 4. Trends of the Most Productive Authors.

D. Publishing Activity by Journal

The 158 documents extracted from the Scopus database appeared in 101 journal sources. Table 3 present the top 15 journal sources with the most articles on sediment concentration prediction using Artificial neural network (ANN). Also, the number of publications, percentage, publisher name, cites core, percentile, scimago journal ranking (SJR), and source normalized impact per paper (SNIP) details of the journal sources are presented in the table. This was done to provide concise information on the contributing sources. The leading journals are the Journal of Hydraulic Engineering, Journal of Hydrology, Environmental Science and Pollution Research, and Environmental Monitoring and Assessment which fall within the Q1 and Q2 percentile. The field of sediment prediction using ANN covers a broad area of water quality monitoring and management of water resources.

E. Subject area

As can be seen in Table 4, this current research classifies published documents based on the subject area. The subject area with the largest share of articles has also been listed. Among them, the subject field with the most published papers in sediment prediction was environmental science (63.92%). The next is engineering with 25.32%, followed by earth and planetary sciences with 24.68%. However, other subject areas published articles in this area such as chemistry, social sciences, material science, and energy etc. The 15 most active subject areas are presented in Table 4.

F. Most active Countries

43 countries contributed to the articles on Sediment concentration. Table 5 shows the top 10 countries with the largest number of publications, while the patterns of each country's publications are shown in Fig. 5. Based on the authors' affiliation, the analysis of the contributing nations were counted. For example, if the article is co-authored by four authors, two of whom are from the US and two from Malaysia, it would be counted as one for the United States and one for Malaysia. The highest number of papers in this area was published in Asia, Europe, and North America with Iran taking the lead. About 14.56% of the included research were from Iran, followed by China with 13.92% and then India (13.92%).

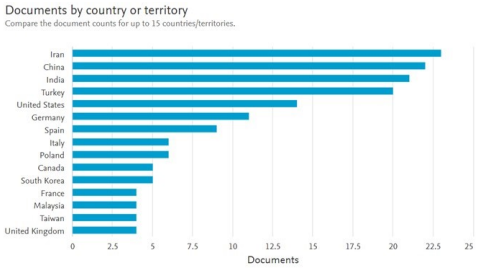

Figure 5. Trends of the Contributing Countries

G. Languages of Documents

From Table 6, English language is the universal language for most of the publications in this research area (150, 94.94%). Other encountered languages include Chinese, Turkish and

Table 3. Most Active Source Title.

SOURCE TITLE	TP	Percentage (%)	Publisher	Cite Score	SJR 2019	SNIP 2019	Percentile
Journal of Hydraulic Engineering	6	3.8	Taylor & Francis	5.1	0.956	1.966	Q1
Journal of Hydrology	6	3.8	Elsevier	7.2	1.684	1.829	Q1
Environmental Science and Pollution Research	5	3.16	Springer nature	4.9	0.788	1.027	Q2
Environmental Monitoring and Assessment	4	2.53	Springer nature	3.4	0.571	0.952	Q2
International Journal of Remote Sensing	4	2.53	Taylor & Francis	4.6	0.928	1.205	Q1
Journal of Hydrologic Engineering	4	2.53	ASCE	3.2	0.685	0.864	Q2
Remote Sensing of Environment	4	2.53	Elsevier	15.4	3.541	3.225	Q1
Water Science and Technology	4	2.53	IWA publishing	2.9	0.471	0.693	Q2
Chemosphere	3	1.9	Elsevier	8.8	1.53	1.635	Q1
Hydrological Processes	3	1.9	Wiley-Blackwell	6.2	1.429	1.203	Q1
Hydrological Sciences Journal	3	1.9	Taylor & Francis	4.7	0.92	1.028	Q1
Water Resources Management	3	1.9	Springer nature	5.4	1.007	1.331	Q1
Water (Switzerland)	3	1.9	MDPI	3	0.657	1.074	Q1
Analytica Chimica Acta	2	1.27	Elsevier	8.7	1.414	1.384	Q1
Applied Soft Computing Journal	2	1.27	Elsevier	10.2	1.405	2.52	Q1

Note: TP = total number of publications

Table 4. Subject area.

Subject Area	TP	Percentage (%)
Environmental Science	101	63.92
Engineering	40	25.32
Earth and Planetary Sciences	39	24.68
Agricultural and Biological Sciences	20	12.66
Chemistry	12	7.59
Computer Science	11	6.96
Chemical Engineering	8	5.06
Social Sciences	8	5.06
Biochemistry, Genetics and Molecular Biology	7	4.43
Materials Science	5	3.16
Multidisciplinary	5	3.16
Energy	3	1.9
Medicine	3	1.9
Physics and Astronomy	3	1.9
Mathematics	2	1.27
Pharmacology, Toxicology, and Pharmaceutics	2	1.27
Business, Management, and Accounting	1	0.63
Decision Sciences	1	0.63

Note: TP = total number of publications

Table 5. Top 10 Countries contributed to the publications.

COUNTRY	TP	Percentage (%)
Iran	23	14.56
China	22	13.92
India	21	13.29
Turkey	20	12.66
United States	14	8.86
Germany	11	6.96
Spain	9	5.7
Italy	6	3.8
Poland	6	3.8
Canada	5	3.16

Note: TP = total number of publications

French. However, one of the documents has been published in dual languages.

Table 6. Languages of Documents.

Language	TP	Percentage (%)
English	150	94.94
Chinese	6	3.8
Turkish	2	1.27
French	1	0.63

Note: TP = total number of publications

H. Keywords

Keywords are the core word extractions provided by researchers in research or articles. The reasoning behind co-occurrence and keyword analysis is that the keywords of an author sufficiently reflect the substance of the article [20]. The co-occurrence of keywords happens when two keywords appear together in an article, implying that the two terms have a relationship. In this research, to explore the predominant themes within sediment concentration estimation using ANN, keyword analysis was implored in extracting information about the frequency and centrality of the keyword co-occurrence. This finding is significant because of the implementation of ANN in predicting sediment concentration centres on its practicability in providing a satisfactory outcome. Similarly, Table 7 displays the top most frequently occurring keywords. Further analysis of the authors and index keywords was performed using the VOS® viewer.

I. Visualisation Map

i. Network visualization map of all keywords

Based on our search, documents in this study contain the phrase "sediment concentration using artificial neural network" OR "sediment prediction" in its title, abstract, or the assigned keywords. Analysing the index keywords of all documents in more detail, we discovered 4 main keyword clusters (Fig. 6) using the VOS® viewer. VOS® viewer is a

Table 7. Top Keywords.

KEYWORD	TP	%
Artificial Neural Network	117	74.05
Neural Networks	79	50
Suspended Sediment	49	31.01
Sediments	46	29.11
Concentration (composition)	40	25.32
Sediment	39	24.68
Rivers	35	22.15
Sediment Transport	33	20.89
Numerical Model	30	18.99
Suspended Sediment Concentrations	30	18.99
Regression Analysis	27	17.09
Water Quality	24	15.19
Algorithm	22	13.92
Artificial Neural Networks	22	13.92
Sediment Concentration	22	13.92
Environmental Monitoring	21	13.29
Forecasting	20	12.66
Prediction	17	10.76
River	15	9.49
Backpropagation	14	8.86
Mean Square Error	14	8.86
Algorithms	13	8.23
Fuzzy Neural Networks	13	8.23
Modeling	13	8.23
Turbidity	13	8.23
Water Resources	12	7.59
Cadmium	11	6.96
Heavy Metals	11	6.96
Sediment Yield	11	6.96
Water Pollution	11	6.96
Artificial Intelligence	10	6.33

Note: TP = total number of publications

software application used to build and simulate bibliometric networks [21]. Our search phrase is naturally at the centre of the keyword and forms a cluster with the keywords suspended sediments and hydrology which describe the field in general. The biggest cluster around the general keyword shows a focus on environmental monitoring such as prediction of sediments, water quality, water sampling, and water pollution. Furthermore, keywords in this cluster are linked to chemical analysis, rain and river pollution as well as keywords showing a focus on water quality parameters to keyword co-occurrences. Another keyword around the general keyword artificial neural network shows a focus on water pollutants represented by keywords such as heavy metals (cadmium, nickel, chromium, and lead) and trace metals.

Similarly, Cluster 2 focused on hydrological modeling and soft computing methods which are further linked to keywords that include rivers, streamflow, dataset, fuzzy inference, estimation methods, error analysis, root mean square errors, and regression analysis. However, cluster 3 focused on the catchment area which is linked to keywords like river basin, erosion, runoff, sediment transport, watershed, vegetation, and climate change. Finally, cluster 4 focused on theoretical models which comprised of keywords that include algorithms, correlation, genetic algorithm, radial basis, support vector machines, forecasting, optimization, and sensitivity analysis. The map visualization of all the keywords is presented in Figure 6.

ii. Network visualization map of author keywords

To obtain the network visualization map of this section, we further analyse the author keywords using VOS® viewer software. Fig. 7 represents a network diagram of the author keywords in which the colour, circle size, thickness of connecting lines, and font size in the map represent the frequency of the relationship between the keywords [21]. Linked keywords, as shown in the same colour, are usually listed together. In this study, the map reveals that artificial neural networks, sediment concentration, water discharge, mathematical models, forecasting, and rivers which are in purple are co-authored together and are related.

4. LIMITATION OF THE STUDY

This study employed a specific query to locate the initial list of past works published as indexed by Scopus. The research data used in this study is limited to the Scopus database. Nevertheless, the Scopus database has been used for earlier bibliometric related studies. Even though Scopus is among the most extensive online databases that index all scholarly works, it does not entirely cover all available sources. Thus, some exclusions are very much expected from this study. Furthermore, no search query is 100% perfect for capturing all the scholarly works in this area. Also, the shortfall of data availability hampers research. During this review, the authors found it difficult to extract a large number of data. A need, therefore, exists to expand research in this field. Futhermore, the authors observed that there is a need for more academic collaborations to expand research data in this field. Scholar partnerships promote the exchange of knowledge, reduce the cost of doing research, and increase research quality [22], [23]. Additionally, during the screening process articles that applied other machine learning methods and flood predictions that cover general parameters were excluded. Despite these limitations, this study presents a concise information on the current trend of sediment prediction research globally.

5. CONCLUSION

This research presents the pattern of earlier studies in the field of sediment concentration prediction using artificial neural networks (ANNs). Overall, bibliometric details of 158 documents related to this field of study were extracted from the Scopus database. We analyzed useful data on paper type, research trends, publishing activity by author and journal sources, subject area, most active countries, the language of documents, and keywords based on 158 documents extracted to obtain the useful frequency and trend of publication in this area for further reference and purpose. The results obtained showed that the highest number of publications was obtained in the year 2015 and 2020. 43 countries contributed to the publication of research articles

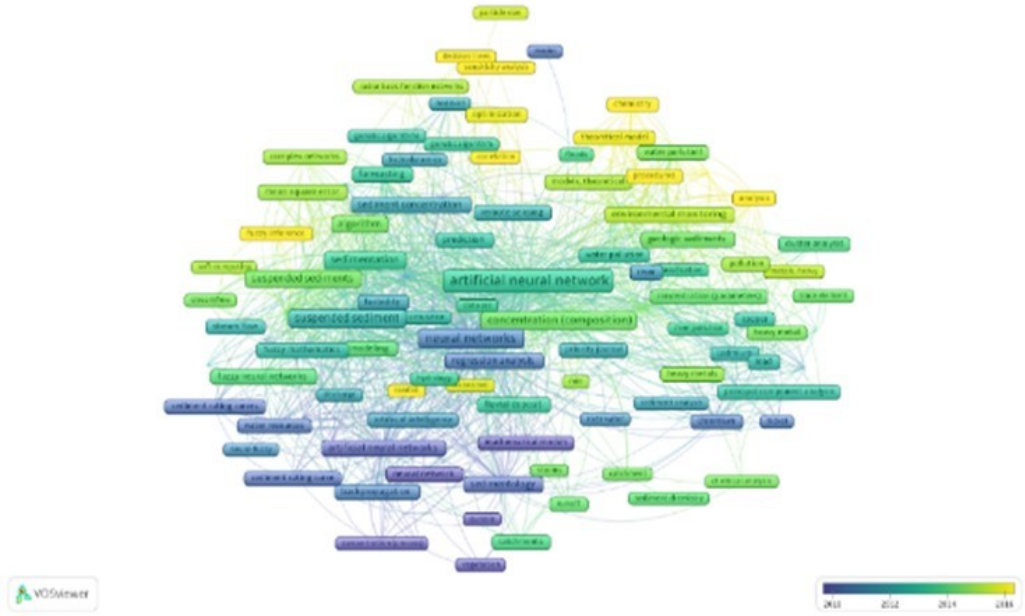

Figure 6. Network visualization map of all keywords.

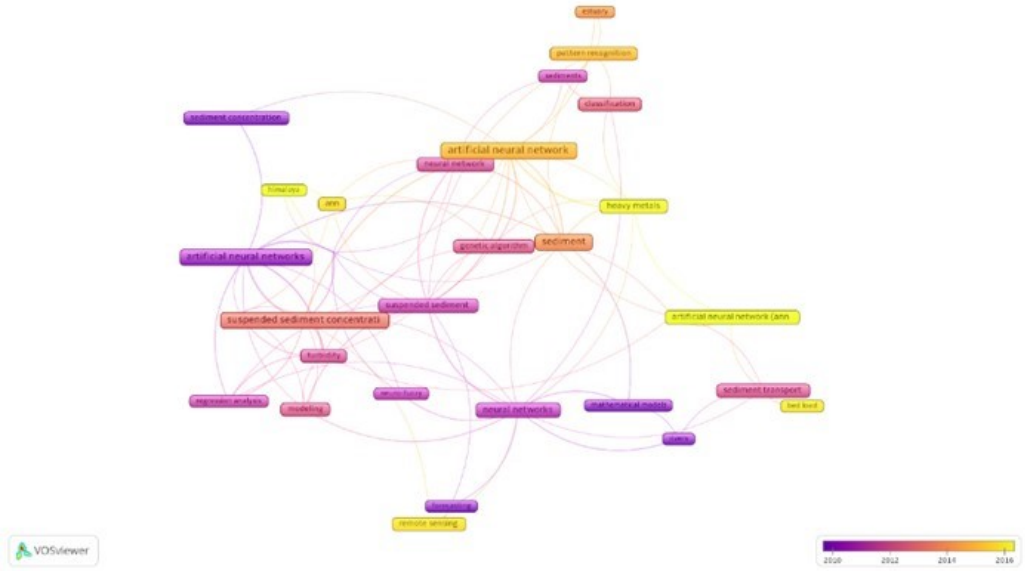

Figure 7. Network Visualization Map of Authors Keywords.

in this field. Also, we found the most prominent subject areas to fall in environmental sciences, engineering, earth and planetary sciences, chemistry, and computer science. Further, this research revealed that Kisi Ozgur published the most articles (6) and the leading journal sources are ranked in Q1 and Q2. This analysis provides a comprehensive overview of the artificial neural network (ANN) related research conducted in the field of sediment concentration prediction as well as it will help researchers, policymakers, and practitioners to better understand the development of water monitoring and water management resources. In this field, future research can be conducted using information extracted from google scholar, the web of science, or a combination of Scopus and web of science database. Future AI bibliometric analysis research should be dedicated to filling the gaps between other machine learning applications and sediment prediction.

ACKNOWLEDGMENTS

The authors would like to acknowledge the Tenaga Nasional Berhad (TNB) research and development fund (Seeding Project-TNB Generation) under UNITEN R&D Sdn. Bhd. (URND) U-TG-RD-19-05. The authors also would like to acknowledge Universiti Tenaga Nasional (UNITEN).

REFERENCES

[1] A. M. Melesse, S. Ahmad, M. E. McClain, X. Wang, and Y. H. Lim, "Suspended sediment load prediction of river systems: An artificial neural network approach," *Agricultural Water Management*, vol. 98, no. 5, pp. 855–866, Mar. 2011. DOI: 10.1016/j.agwat.2010.12.012.

[2] M. Alp and H. Cigizoglu, "Suspended sediment load simulation by two artificial neural network methods using hydrometeorological data," *Environmental Modelling & Software*, vol. 22, no. 1, pp. 2–13, Jan. 2007. DOI: 10.1016/j.envsoft.2005.09.009.

[3] Z. Skoklevski and S. Velickov, "Suspended load transportation process within vardar river basin in the republic of macedonia," in *Proceedings of the XIXth conference Danube Countries on the Hydrological Forecasting and Hydrological Bases of Water Management, Osijek, Croatia*, 1998, pp. 15–19.

[4] T. Rosen and Y. Xu, "A hydrograph-based sediment availability assessment: Implications for mississippi river sediment diversion," *Water*, vol. 6, no. 3, pp. 564–583, Mar. 2014. DOI: 10.3390/w6030564.

[5] H. Aksoy, G. Mahe, and M. Meddi, "Modeling and practice of erosion and sediment transport under change," *Water*, vol. 11, no. 8, p. 1665, Aug. 2019. DOI: 10.3390/w11081665.

[6] S. Heddam, H. Sanikhani, and O. Kisi, "Application of artificial intelligence to estimate phycocyanin pigment concentration using water quality data: A comparative study," *Applied Water Science*, vol. 9, no. 7, Sep. 2019. DOI: 10.1007/s13201-019-1044-3.

[7] V. Nourani, M. T. Alami, and M. H. Aminfar, "A combined neural-wavelet model for prediction of ligvanchai watershed precipitation," *Engineering Applications of Artificial Intelligence*, vol. 22, no. 3, pp. 466–472, Apr. 2009. DOI: 10.1016/j.engappai.2008.09.003.

[8] H. M. Nagy, K. Watanabe, and M. Hirano, "Prediction of sediment load concentration in rivers using artificial neural network model," *Journal of Hydraulic Engineering*, vol. 128, no. 6, pp. 588–595, Jun. 2002. DOI: 10.1061/(asce)0733-9429(2002)128:6(588).

[9] M. Y. A. Khan, F. Tian, F. Hasan, and G. J. Chakrapani, "Artificial neural network simulation for prediction of suspended sediment concentration in the river ramganga, ganges basin, india," *International Journal of Sediment Research*, vol. 34, no. 2, pp. 95–107, Apr. 2019. DOI: 10.1016/j.ijsrc.2018.09.001.

[10] N. Singh and M. Y. A. Khan, "ANN modeling of the complex discharge-sediment concentration relationship in bhagirathi river basin of the himalaya," *Sustainable Water Resources Management*, vol. 6, no. 3, May 2020. DOI: 10.1007/s40899-020-00396-6.

[11] L. Zhao, J. Deng, P. Sun, J. Liu, Y. Ji, N. Nakada, Z. Qiao, H. Tanaka, and Y. Yang, "Nanomaterials for treating emerging contaminants in water by adsorption and photocatalysis: Systematic review and bibliometric analysis," *Science of The Total Environment*, vol. 627, pp. 1253–1263, Jun. 2018. DOI: 10.1016/j.scitotenv.2018.02.006.

[12] Y. Zhang, S. Pu, X. Lv, Y. Gao, and L. Ge, "Global trends and prospects in microplastics research: A bibliometric analysis," *Journal of Hazardous Materials*, vol. 400, p. 123 110, Dec. 2020. DOI: 10.1016/j.jhazmat.2020.123110.

[13] C. Rehn, D. Wadskog, C. Gornitzki, and A. Larsson. (2014). "Bibliometric indicators – definitionsand usage at karolinska institutet," [Online]. Available: https://kib.ki.se/sites/default/files/bildarkiv/Dokument/bibliometric_indicators_2014.pdf.

[14] A. Ahmi, A. Tapa, and A. H. Hamzah, "Mapping of financial technology (fintech) research: A bibliometric analysis," *International Journal of Advanced Science and Technology*, vol. 29, no. 08, pp. 379–392, 2020.

[15] A. Pritchard *et al.*, "Statistical bibliography or bibliometrics," *Journal of documentation*, vol. 25, no. 4, pp. 348–349, 1969.

[16] W. M. Sweileh, S. W. Al-Jabi, A. S. AbuTaha, S. H. Zyoud, F. M. A. Anayah, and A. F. Sawalha, "Bibliometric analysis of worldwide scientific literature in mobile - health: 2006–2016," *BMC Medical Informatics and Decision Making*, vol. 17, no. 1, May 2017. DOI: 10.1186/s12911-017-0476-7.

[17] G. Mao, T. Shi, S. Zhang, J. Crittenden, S. Guo, and H. Du, "Bibliometric analysis of insights into soil remediation," *Journal of Soils and Sediments*, vol. 18, no. 7, pp. 2520–2534, Feb. 2018. DOI: 10.1007/s11368-018-1932-4.

[18] L. Ho and P. Goethals, "Research hotspots and current challenges of lakes and reservoirs: A bibliometric analysis," *Scientometrics*, vol. 124, no. 1, pp. 603–631, Apr. 2020. DOI: 10.1007/s11192-020-03453-1.

[19] D. Moher, A. Liberati, J. Tetzlaff, and D. G. Altman, "Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement," *PLoS Medicine*, vol. 6, no. 7, e1000097, Jul. 2009. DOI: 10.1371/journal.pmed.1000097.

[20] N. Comerio and F. Strozzi, "Tourism and its economic impact: A literature review using bibliometric tools," *Tourism Economics*, vol. 25, no. 1, pp. 109–131, Aug. 2018. DOI: 10.1177/1354816618793762.

[21] N. J. V. Eck and L. Waltman, *Vosviewer manual*, Jan. 2020.

[22] L. Cisneros, M. Ibanescu, C. Keen, O. Lobato-Calleros, and J. Niebla-Zatarain, "Bibliometric study of family business succession between 1939 and 2017: Mapping and analyzing authors' networks," *Scientometrics*, vol. 117, no. 2, pp. 919–951, Aug. 2018. DOI: 10.1007/s11192-018-2889-1.

[23] H. K. Baker, N. Pandey, S. Kumar, and A. Haldar, "A bibliometric analysis of board diversity: Current status, development, and future research directions," *Journal of Business Research*, vol. 108, pp. 232–246, Jan. 2020. DOI: 10.1016/j.jbusres.2019.11.025.