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Original Research Article

Bibliometric Analysis of 100 Top-Cited Articles on Neem Indexed in the Web of Science

Abimbola K. Onasanya[1], Olayinka K. Oderinde[2*], Tosin Y. Akintunde[3,7], Omonike O. Shonekan[4], Isaac S. Bankole[5], Babatunde O. Fadimu[1], Taha H. Musa[6,7,8*]

[1]*Forestry Research Institute of Nigeria (FRIN), Jericho, PMB 5054, Ibadan, Nigeria*
[2]*Department of Chemical Sciences, Chemistry Unit, Faculty of Natural and Applied Sciences, Lead City University, 200255, Ibadan, Nigeria*
[3]*Department of Sociology, School of Public Administration, Hohai University, Nanjing, China*
[4]*Department of Pharmaceutical Chemistry, Faculty of Pharmacy, University of Lagos, Lagos, Nigeria*
[5]*Ogun State Institute of Technology, Igbesa, Ogun State, Nigeria*
[6]*Biomedical Research Institute, Darfur College, Nyala, South Darfur 63313, Sudan*
[7]*Department Epidemiology and Health Statistics, School of Public Health, Southeast University, Nanjing, Jiangsu 210009, China*
[8]*Organisation of African Academic Doctors (OAAD), Off Kamti Road, PO Box 25305000100, Nairobi, Kenya*

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ABSTRACT

Recently, there has been a surge in interest in evaluating research accomplishments based on publications using bibliometric tools. This study aims to investigate the top 100 most cited articles in Neem using bibliometric analysis while also providing readers with a practical guide for determining the most influential publications over the past decades. VOSviewer 1.6.6, the "Bibliometrix app" in R. studio cloud, and SPSS were used to analyze the data. The top 100 highly-cited articles in Neem, which included 91 articles and nine reviews, were published between 1971 and 2017. The articles received a total citation score of 14,186 (citations ranging from 65 to 1,531), with an average total citation score of 141.9 and a total citation score per article of 10.07. 398 authors from 22 countries contributed a total of 100 publications, with Bhattacharyya KG being the most productive and influential. Researchers from India published about 45 percent of the articles and had the highest number of citations (8637). The Banaras Hindu University in India was discovered to be the top-ranked institution, with six publications and 1,491 citations. The top 100 literature was published in 72 journals, with the Journal of Ethnopharmacology publishing nine papers. The findings of this study provided extensive information and research direction for future research in this domain, including the most influential journals, countries, authors, institutions, and articles and mapping co-authorship and reported keywords.

Keywords: Bibliometric analysis, Neem, Web of Sciences, Keyword analysis, VOSviewer.

Introduction

Azadirachta indica (A. indica), also known as Neem, is an evergreen, fast-growing tree plant native to India. It thrives favorably in tropical and subtropical regions. It has persistent foliage of 5-8 pairs of leaflets. The flowers are panicles shaped white or yellowish with green drupe-shaped 1-2cm fruits that turn yellow-green on maturation. Neem has a deep root system that enables it to survive under dry weather conditions and stony or sandy areas. [1] The leaves, twigs, barks, fruits, seeds, and roots of Neem have contributed immensely to the well-being of humans. A indica A. Juss has been reported as one of the most versatile medicinal plants that have gained worldwide importance due to therapeutic (hypolipidemic, hypoglycemic, immunostimulant, hepatoprotective) insecticidal properties. [2,3]
Historically, the medicinal uses of different parts of Neem are well documented in the Indian Sanskrit document. [4] Neem seed oil comprises of both saturated and unsaturated fatty acids, namely; palmitic (11.90%, C16:0), stearic (29.96%, C18:0), and arachidic acids (2.94%, C20:0) as saturated fatty acids, together with oleic (50.04 %, C18:1) and linoleic acids (5.15%, C18:2) as unsaturated fatty acids.[5] The neem seed oil has been widely utilized in soap, wax, and lubricants.[6] Also, azadirachtin, the most active compound of Neem, is toxic for insects, while the bitterness of Neem is mainly due to the accumulation of limonoids.[7] Several chemical components of different parts and extracts of Neem have also been reported to possess remarkable anti-inflammatory, anti-arthritics, hypoglycemic, antipyretic, spermicidal, antifungal, antibacterial, antimalarial, immunomodulatory, antitumor, diuretic,[8–10] anticancer, and antibiofilm.[11,12] Azadirachtin, which is extracted from neem seeds, has several adverse effects on insect pests, including pest repellency, feeding inhibition, decreased oviposition, sterilization, behavioral changes, and increased mortality.[13] Since ancient times, the smoke produced by burning dried leaves of A. indica has been used as a mosquito repellent,[14] and neem oil has been reported to have remarkable potency as spermicides and contraceptives. [2] Recently, to reduce global warming, researchers' attention has been drawn to alternative energy sources such as biofuels, particularly from non-edible foods such as neem,[1] and this has led to neem oil being widely explored as a renewable energy source for biofuels production [15–21] and as eco-friendly industrial coatings.[22,23]
This paper aims to provide an extensive bibliometric analysis of neem-based academic publications by presenting the most significant advancements in the field of neem research between 1971 and 2017 using the Web of Science database. Numerous bibliometric studies have been conducted on various research domains,[24–26] allowing for a

*Corresponding author. E mail: oderinde.olayinka@lcu.edu.ng; taha.hm99@yahoo.com
Tel: +234-8032801872, +86-18013970553

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better understanding of research progress and dynamism. This study thoroughly examines the top-100 cited articles on Neem overpass year form documents in the Web of Sciences database.

Materials and Methods

Search strategy

We conducted a bibliometric analysis of Neem articles published in Web of Science (https://apps.webofknowledge) database and Indexes: SCI-expanded and SSCI. Databases from August 31, 2021, using the following search terms ("Neem", "Neem tree", "*Azadirachta indica*", "*Melia azadirachta* L", "Arya Veppu" , "Azad Dirakht", "Nimba" ,"Margosa", "Neeb" "Nimtree", "Vepu", "Vempu", "Vepa Bevu", "Kohomba', "Indian Lilac", "Mwarobaini". Boolean operators "OR" were used in the "title" tab of the Web of Science database for searching the research papers, while limiting the search article published (research articles" OR "reviews".) fields. Timespan: All years. Indexes: Science Citation Index Expanded (SCI-EXPANDED), Social Sciences Citation Index (SSCI), and Arts & Humanities Citation Index (A&HCI). Also, bibliometric characteristics such as year of publications, authors, journals, institutions, country of origin, organizations, funding agency and research categories, keywords, etc., were assessed. In addition, the Journal Impact Factor (IF) was obtained from the Journal Citation Report (JCR) published in 2020. Furthermore, the identification of the top 100 most cited neem documents based on the citation time was screened by two reviewers (THM and OO) independently and identified as the 100 top-cited studies on Neem research. The data were downloaded from Web of Science. No ethical approval is required for such bibliometric analysis. [24–26]

Statistical analysis

Data was analyzed using Bibliometrix, R package, [27] HistCite, [28] VOSviewer.Var1.6.6 (Leiden University, Leiden, The Netherlands). [29]

Results and Discussion

Descriptive statistics of the data

A descriptive analysis of the top 100 articles was performed based on the number of citations received. The top 100 cited articles were published in 72 journal sources between 1971 and 2017, and 398 authors contributed to their publication, with 3.98 authors per document and a 4.32 collaboration index (Table 1). Figure 1 also shows the annual number of publications and the Global Citation Score of the articles.

Leading author's analysis

The top 10 authors in Neem research include Bhattacharyya KG with (NP = 6), Sharma A (NP = 5), and Verma VC (NP = 5). Other authors with h_index, author's positions, total citations, number of publications, and active years are listed in Table 2.

Analysis of top 100 cited articles on Neem

The top 100 articles were published between 1971 and 2017 and included 91 articles and 9 reviews (Table 3). These articles received a total of 14186 citations and a Citation range of (65-1531). Shankar published the first top-ranked article, SS *et al*., in the JOURNAL OF COLLOIDS AND INTERFACE SCIENCE journal and received the highest citations of 1531 score, followed by Schmutterer's review article in ANNUAL REVIEW OF ENTOMOLOGY, which received total citations of 862 score. [30]

Journal influence and quality analysis

Of the accessed journals for the high citations on Neem research, the journal with the highest number of top 100 cited articles was Journal of Ethnopharmacology, with nine (9) followed by Journal of Hazardous Materials with four (4), as other journals in the list share two (2) articles each (Table 4). As the number of citations indicates the journal's influence, publications indicate journal productivity.

Table 1: Descriptive Statistics of the data

Description (n = 398)	Results
Timespan	1971:2017
Sources (Journals, Books, etc)	72
Country or region	22
Institutions	140
Documents	100
Total citations score	14186
Citation range	65-1531
Average years from publication	16.4
Average citations per documents	141.9
Average citations per year per doc	10.07
References	4097
Document types	
Article	91
Review	9
Document contents	
Keywords Plus (ID)[a]	454
Author's Keywords (DE)[b]	290
Authors	
Authors	398
Author Appearances (AA)[c]	461
Authors of single-authored documents	9
Authors of multi-authored documents	389
Authors collaboration	
Single-authored documents	10
Documents per Author	0.251
Authors per Document	3.98
Co-Authors per Documents	4.61
Collaboration Index (CI)[d]	4.32

[a]: Frequency distribution of keywords associated with the document by WoS; [b]: Frequency distribution of the authors' keywords'; [c]: Number of author appearances; [d]: The scientific collaboration on the social process by which two or more researchers are working together to produce new scientific knowledge.

Authors, institutions, and countries of origin

The country of origin is designated as the country of the first affiliation of the first author. Out of the 22 contributing authors' countries in Neem research, India has the highest productivity with (NP=54) articles, followed by United States of America (NP=5) articles only (Table 4). Furthermore, India is the most influential country in terms of the total number of citations of research (TC=8637), followed by Germany (TC=1028), and finally the United States of America (TC=631). Figure 2 depicts the relationship between countries and the research link.

Top institutions in neem research

Table 5 lists institutions that have produced at least three (3) neem-related publications. As can be seen, Banaras Hindu University and Gauhati University both had (n=6) articles, followed by Annamalai University and University Copenhagen, both of which had (n=5) articles. Table 6 shows that Vellore Institute of Technology (VIT) University published (n=4) articles, while the other members of the list each had (n = 3) articles.

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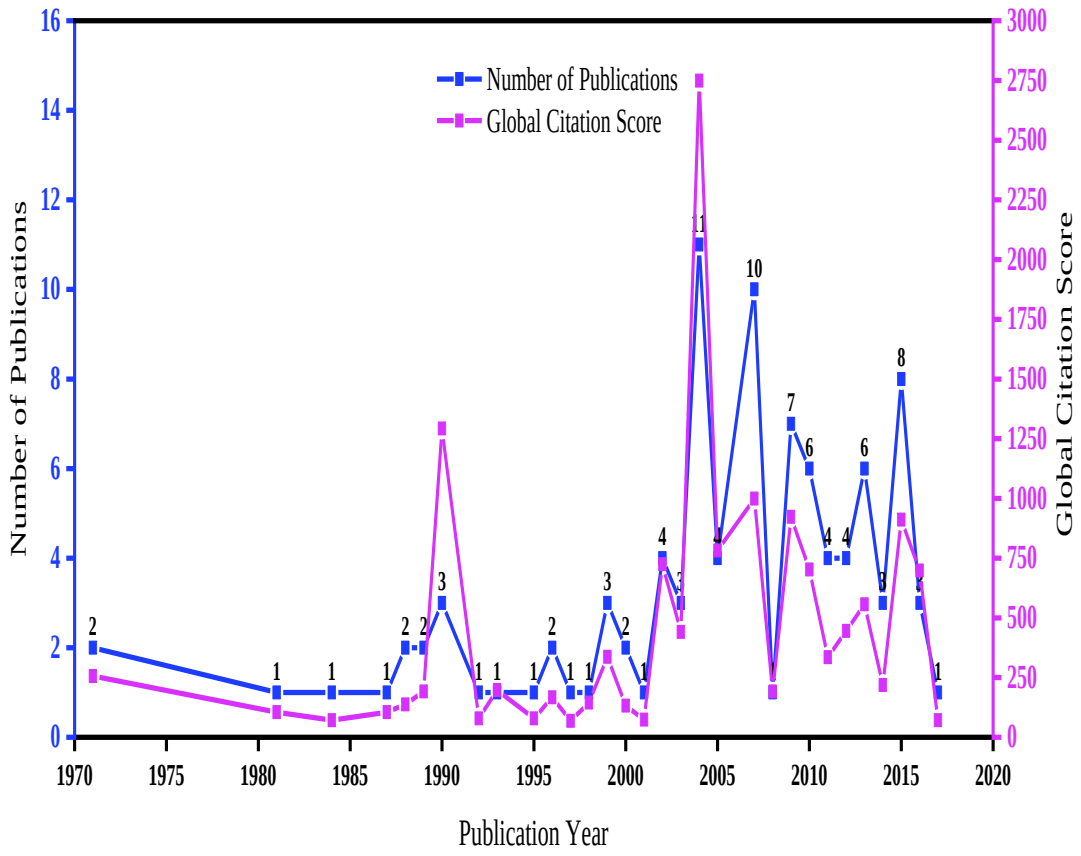

Figure 1: The annual number of publications and Global Citation Score of top 100 top-cited articles, 1971 to 2017

Table 2: Authors with more than 3 articles in the top 100 on Neem research

		Author positions					
Author (n = 398)	h_index	First	Co-author	Last	TC	NP	PY_start& End
Bhattacharyya KG	6	4	2	0	1491	6	2003~2005
Sharma A	5	2	2	1	1237	5	2004~2005
Verma VC	5	3	2	0	467	5	2007~2012
Nagini S	4	0	0	4	301	4	1999~2010
Chandrasekaran N	3	0	1	2	438	3	2009~2012
Dahl-Jensen D	3	0	0	3	314	3	2011~2013
Gond SK	3	0	2	1	275	3	2007~2009
Isman MB	3	1	2	0	510	3	1990~1995
Kharwar RN	3	1	0	2	275	3	2007~2009
Koul O	3	2	1	0	501	3	1990~2004
Kumar A	3	0	0	3	275	3	2007~2009
Mukherjee A	3	1	0	2	438	3	2009~2012
Murugan K	3	0	0	3	256	3	2005~2015

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Table 3: Top 100 cited articles on Neem

	Author	Title	Journal	DT	TC
1	Shankar, SS. et al.	Rapid synthesis of Au, Ag, and bimetallic Au core-Ag shell nanoparticles using Neem (*Azadirachta indica*) leaf broth	J COLLOID INTERF SCI	Article	1531
2	Schmutterer, H	Properties And Potential of Natural Pesticides From The Neem Tree, *Azadirachta indica*	ANNU REV ENTOMOL	Review	862
3	Bhattacharyya, KG; Sharma, A	Kinetics and thermodynamics of Methylene Blue adsorption on Neem (*Azadirachta indica*) leaf powder	DYES PIGMENTS	Article	544
4	Biswas, K. et al.	Biological activities and medicinal properties of Neem (*Azadirachta indica*)	CURR SCI INDIA	Review	473
5	Ahmed, S. et al.	Green synthesis of silver nanoparticles using *Azadirachta indica* aqueous leaf extract	J RADIAT RES APPL SC	Article	413
6	Bhattacharyya, KG; Sharma, A	*Azadirachta indica* leaf powder as an effective biosorbent for dyes: a case study with aqueous Congo Red solutions	J ENVIRON MANAGE	Article	336
7	Khattri, SD; Singh, MK	Removal of malachite green from dye wastewater using neem sawdust by adsorption	J HAZARD MATER	Article	309
8	Sultana, B. et al.	Antioxidant activity of phenolic components present in barks of *Azadirachta indica*, *Terminalia arjuna*, *Acacia nilotica*, and *Eugenia jambolana* Lam. Trees	FOOD CHEM	Article	279
9	ISMAN, MB. et al.	Insecticidal And Antifeedant Bioactivities of Neem Oils and Their Relationship To Azadirachtin Content	J AGR FOOD CHEM	Article	276
10	Bhattacharyya, KG; Sarma, A	Adsorption characteristics of the dye, Brilliant Green, on Neem leaf powder	DYES PIGMENTS	Article	254
11	Bhuyan, T. et al.	Biosynthesis of zinc oxide nanoparticles from *Azadirachta indica* for antibacterial and photocatalytic applications	MAT SCI SEMICON PROC	Article	231
12	Tripathy, A. et al.	Process variables in biomimetic synthesis of silver nanoparticles by aqueous extract of *Azadirachta indica* (Neem) leaves	J NANOPART RES	Article	219
13	ASCHER, KRS	Nonconventional Insecticidal Effects Of Pesticides Available From The Neem Tree, *Azadirachta indica*	ARCH INSECT BIOCHEM	Article	198
14	Mulla, MS; Su, TY	Activity and biological effects of Neem products against arthropods of medical and veterinary importance	J AM MOSQUITO CONTR	Review	196
15	Babu, BV; Gupta, S	Adsorption of Cr(VI) using activated Neem leaves: kinetic studies	ADSORPTION	Article	192
16	Naiya, TK. et al.	Saw dust and Neem bark as low-cost natural biosorbent for adsorptive removal of Zn(II) and Cd(II) ions from aqueous solutions	CHEM ENG J	Article	186
17	Elumalai, K; Velmurugan, S	Green synthesis, characterization and antimicrobial activities of zinc oxide nanoparticles from the leaf extract of *Azadirachta indica* (L.)	APPL SURF SCI	Article	180
18	Bhattacharyya, KG; Sharma, A	Adsorption of Pb(II) from aqueous solution by *Azadirachta indica* (Neem) leaf powder	J HAZARD MATER	Article	169
19	Verma, A; Mehata, MS	Controllable synthesis of silver nanoparticles using Neem leaves and their antimicrobial activity	J RADIAT RES APPL SC	Article	163
20	Butterworth, JH; Morgan, ED	Investigation of Locust Feeding Inhibition Of Seeds Of Neem Tree, *Azadirachta indica*	J INSECT PHYSIOL	Article	158
21	KOUL, O. et al.	Properties And Uses Of Neem, *Azadirachta indica*	CAN J BOT	Article	155
22	Su, TY; Mulla, MS	Ovicidal activity of neem products (azadirachtin) against *Culex tarsalis* and *Culex quinquefasciatus* (Diptera: Culicidae)	J AM MOSQUITO CONTR	Article	145

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ISSN 2616-0684 (Print)
ISSN 2616-0692 (Electronic)

23	Dhar, A. et al.	Production of biodiesel from high-FFA neem oil and its performance, emission and combustion characterization in a single cylinder DICI engine	FUEL PROCESS TECHNOL	Article	144
24	Sigl, M. et al.	A new bipolar ice core record of volcanism from WAIS Divide and NEEM and implications for climate forcing of the last 2000 years	J GEOPHYS RES-ATMOS	Article	133
25	Senthil-Nathan, S	Physiological and biochemical effect of Neem and other Meliaceae plants secondary metabolites against Lepidopteran insects	FRONT PHYSIOL	Review	132
26	Khalid, SA. et al.	Isolation And Characterization of An Antimalarial Agent Of The Neem Tree *Azadirachta indica*	J NAT PROD	Article	123
27	Alzohairy, MA	Therapeutics Role of *Azadirachta indica* (Neem) and Their Active Constituents in Diseases Prevention and Treatment	EVID-BASED COMPL ALT	Article	122
28	Sharma, A; Bhattacharyya, KG	Adsorption of chromium (VI) on *Azadirachta indica* (Neem) leaf powder	ADSORPTION	Article	121
29	Anjali, CH. et al.	Neem oil (*Azadirachta indica*) nanoemulsion as a potent larvicidal agent against *Culex quinquefasciatus*	PEST MANAG SCI	Article	118
30	Velusamy, P. et al.	Greener approach for synthesis of antibacterial silver nanoparticles using aqueous solution of Neem gum (*Azadirachta indica* L.)	IND CROP PROD	Article	117
31	Brahmachari, G	Neem - An omnipotent plant: A retrospection	CHEMBIOCHEM	Review	116
32	Verma, VC. et al.	Endophytic Actinomycetes from *Azadirachta indica A.* Juss.: Isolation, Diversity, and Anti-microbial Activity	MICROB ECOL	Article	114
33	Valek, L; Martinez, S	Copper corrosion inhibition by *Azadirachta indica* leaves extract in 0.5 M sulphuric acid	MATER LETT	Article	114
34	Chattopadhyay, RR	Possible mechanism of hepatoprotective activity of *Azadirachta indica* leaf extract: Part II	J ETHNOPHARMACOL	Article	112
35	Vinodhini, V; Das, N	Packed bed column studies on Cr (VI) removal from tannery wastewater by Neem sawdust	DESALINATION	Article	111
36	Boeke, SJ, et al.	Safety evaluation of Neem (*Azadirachta indica*) derived pesticides	J ETHNOPHARMACOL	Review	108
37	Martin, C. et al.	Fractional characterisation of jatropha, neem, moringa, trisperma, castor and candlenut seeds as potential feedstocks for biodiesel production in Cuba	BIOMASS BIOENERG	Article	108
38	OKPANYI, SN; EZEUKWU, GC	Anti-Inflammatory And Anti-Pyretic Activities Of *Azadirachta indica*	PLANTA MED	Article	105
39	KRAUS, W. et al.	Structure determination by NMR of Azadirachtin and related-compounds from *Azadirachta indica* juss,a. (meliaceae)	TETRAHEDRON	Article	105
40	Tripathi, A, et al.	Antibacterial Applications of Silver Nanoparticles Synthesized by Aqueous Extract of *Azadirachta indica* (Neem) Leaves	J BIOMED NANOTECHNOL	Article	101
41	Parida, MM. et al.	Inhibitory potential of Neem (*Azadirachta indica* Juss) leaves on Dengue virus type-2 replication	J ETHNOPHARMACOL	Article	101
42	Okafor, PC. et al.	*Azadirachta indica* Extracts as corrosion Inhibitor for Mild Steel in Acid Medium	INT J ELECTROCHEM SC	Article	100
43	LAVIE, D. et al.	Limonoids Of Biogenetic Interest From Melia-Azadirachta L	TETRAHEDRON	Article	98
44	Kusari, S, et al.	An endophytic fungus from *Azadirachta indica* A. Juss. that produces azadirachtin	WORLD J MICROB BIOT	Article	97
45	Verma, VC. et al.	Bio-control and plant growth promotion potential of siderophore producing endophytic Streptomyces from	J BASIC MICROB	Article	95

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ISSN 2616-0684 (Print)
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		Azadirachta indica A. Juss.			
46	Steen-Larsen, HC. et al.	Understanding the climatic signal in the water stable isotope records from the NEEM shallow firn/ice cores in northwest Greenland	J GEOPHYS RES-ATMOS	Article	94
47	Nathan, SS ., et al.	Effects of neem limonoids on the malaria vector *Anopheles stephensi Liston* (Diptera: Culicidae)	ACTA TROP	Article	91
48	Verma, VC ., et al.	The endophytic mycoflora of bark, leaf, and stem tissues of *Azadirachta indica* A. Juss (Neem) from Varanasi (India)	MICROB ECOL	Article	91
49	Betiku, E ., et al.	Mathematical modeling and process parameters optimization studies by artificial neural network and response surface methodology: A case of non-edible Neem (*Azadirachta indica*) seed oil biodiesel synthesis	ENERGY	Article	88
50	Rasmussen, SO ., et al.	A first chronology for the North Greenland Eemian Ice Drilling (NEEM) ice core	CLIM PAST	Article	87
51	Buizert, C ., et al.	Gas transport in firn: multiple-tracer characterisation and model intercomparison for Neem, Northern Greenland	ATMOS CHEM PHYS	Article	86
52	Benelli, G ., et al.	Old ingredients for a new recipe? Neem cake, a low-cost botanical by-product in the fight against mosquito-borne diseases	PARASITOL RES	Review	85
53	Visvanathan, R., et al.	Physical properties of Neem nut	J AGR ENG RES	Article	85
54	Sanuja, S., et al.	Synthesis and characterization of zinc oxide-neem oil-chitosan bionanocomposite for food packaging application	INT J BIOL MACROMOL	Article	85
55	Priyadarsini, RV ., et al.	The neem limonoids azadirachtin and nimbolide induce cell cycle arrest and mitochondria-mediated apoptosis in human cervical cancer (HeLa) cells	FREE RADICAL RES	Article	84
56	Roy, MK ., et al.	Antiproliferative effect on human cancer cell lines after treatment with nimbolide extracted from an edible part of the Neem tree (*Azadirachta indica*)	PHYTOTHER RES	Article	83
57	Cohen, E ., et al.	Cytotoxicity of nimbolide, epoxyazadiradione and other limonoids from neem insecticide	LIFE SCI	Article	82
58	Gupta, S ., et al.	Protective role of extracts of Neem seeds in diabetes caused by streptozotocin in rats	J ETHNOPHARMACOL	Article	82
59	Winkaler, EU ., et al.	Acute lethal and sublethal effects of neem leaf extract on the neotropical freshwater fish *Prochilodus lineatus*	COMP BIOCHEM PHYS C	Article	81
60	Nathan, SS ., et al.	The toxicity and physiological effect of neem limonoids on *Cnaphalocrocis medinalis* (Guenee) the rice leaffolder	PESTIC BIOCHEM PHYS	Article	80
61	Kumar, GH ., et al.	The Neem limonoids azadirachtin and nimbolide inhibit cell proliferation and induce apoptosis in an animal model of oral oncogenesis	INVEST NEW DRUG	Article	80
62	GOVINDACHARI, TR	Chemical And Biological Investigations on *Azadirachta indica* (The Neem Tree)	CURR SCI INDIA	Article	79
63	LOWERY, DT ., et al.	Toxicity Of Neem To Natural Enemies of Aphids	PHYTOPARASITICA	Article	79
64	Pai, MR ., et al.	Evaluation of antiplaque activity of *Azadirachta indica* leaf extract gel - a 6-week clinical study	J ETHNOPHARMACOL	Article	78
65	Abdel-Shafy, S; Zayed, AA	In vitro acaricidal effect of plant extract of neem seed oil (*Azadirachta indica*) on egg, immature, and adult	VET PARASITOL	Article	77

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ISSN 2616-0684 (Print)
ISSN 2616-0692 (Electronic)

		stages of *Hyalomma anatolicum excavatum* (Ixodoidea: Ixodidae)			
66	Okumu, FO., et al.	Larvicidal effects of a neem (*Azadirachta indica*) oil formulation on the malaria vector *Anopheles gambiae*	MALARIA J	Article	77
67	Liang, GM; Chen, W; Liu, TX	Effects of three Neem-based insecticides on diamondback moth (lepidoptera: plutellidae)	CROP PROT	Article	75
68	Singh, A., et al.	Assessment of genetic diversity in *Azadirachta indica* using AFLP markers	THEOR APPL GENET	Article	74
69	Tonthubthimthong, P., et al.	Supercritical CO2 extraction of nimbin from Neem seeds - an experimental study	J FOOD ENG	Article	74
70	Paul, R; ., et al.	Anticancer biology of *Azadirachta indica L* (Neem) A mini review	CANCER BIOL THER	Review	74
71	Bandyopadhyay, U ., et al.	Gastroprotective effect of Neem (*Azadirachta indica*) bark extract: Possible involvement of H+-K+-ATPase inhibition and scavenging of hydroxyl radical	LIFE SCI	Article	73
72	Takase, M ., et al.	An expatriate review of Neem, jatropha, rubber and karanja as multipurpose non-edible biodiesel resources and comparison of their fuel, engine and emission properties	RENEW SUST ENERG REV	Review	73
73	Banapurmath, NR ., et al.	Combustion characteristics of a 4-stroke CI engine operated on Honge oil, Neem and Rice Bran oils when directly injected and dual fuelled with producer gas induction	RENEW ENERG	Article	73
74	Kikuchi, T ., et al.	Cytotoxic and Apoptosis-Inducing Activities of Limonoids from the seeds of *Azadirachta indica* (Neem)	J NAT PROD	Article	72
75	Joshi, M ., et al.	Antibacterial finishing of Polyester/Cotton blend fabrics using Neem (*Azadirachta indica*): A natural bioactive agent	J APPL POLYM SCI	Article	72
76	Wandscheer, CB ., et al.	Larvicidal action of ethanolic extracts from fruit endocarps of Melia azedarach and *Azadirachta indica* against the dengue mosquito Aedes aegypti	TOXICON	Article	71
77	Gurunathan, B; Ravi, A	Process optimization and kinetics of biodiesel production from neem oil using copper doped zinc oxide heterogeneous nanocatalyst	BIORESOURCE TECHNOL	Article	71
78	Dhamodaran, G ., et al.	A comparative study of combustion, emission, and performance characteristics of rice-bran-, Neem -, and cottonseed-oil biodiesels with varying degree of unsaturation	FUEL	Article	71
79	ZEBITZ, CPW	Effect Of Some Crude And Azadirachtin-Enriched Neem (*Azadirachta-Indica*) Seed Kernel Extracts on Larvae Of Aedes-Aegypti	ENTOMOL EXP APPL	Article	71
80	Kumar, GH ., et al.	Nimbolide a limonoid from *Azadirachta indica* inhibits proliferation and induces apoptosis of human choriocarcinoma (BeWo) cells	INVEST NEW DRUG	Article	70
81	Koul, O ., et al.	Bioefficacy and mode-of-action of some limonoids of salannin group from *Azadirachta indica A.* Juss and their role in a multicomponent system against lepidopteran larvae	J BIOSCIENCES	Article	70
82	Kharwar, RN ., et al.	Javanicin, an Antibacterial Naphthaquinone from an Endophytic Fungus of Neem, Chloridium sp.	CURR MICROBIOL	Article	70
83	KIGODI, PGK ., et al.	Spectroscopic And Biological Investigation of Nimbolide And Deoxonimbolide-28 From *Azadirachta indica*	J NAT PROD	Article	69
84	Schmutterer, H	Side-effects of Neem (*Azadirachta indica*) products on insect pathogens and natural enemies of spider mites and insects	J APPL ENTOMOL	Article	69
85	Nayan, NK ., et al.	Production of the liquid fuel by thermal pyrolysis of Neem seed	FUEL	Article	69

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ISSN 2616-0684 (Print)
ISSN 2616-0692 (Electronic)

86	SIDDIQUI, S., et al.	Tetracyclic Triterpenoids and Their Derivatives From *Azadirachta indica*	J NAT PROD	Article	69
87	Thakurta, P ., et al.	Antibacterial, antisecretory and Antihemorrhagic activity of *Azadirachta indica* used to treat Cholera and diarrhea in India	J ETHNOPHARMACOL	Article	69
88	Benelli, G ., et al.	Larvicidal and Ovideterrent properties of neem oil and fractions against the filariasis vector Aedes Albopictus (Diptera: Culicidae): A bioactivity survey across production sites	PARASITOL RES	Article	69
89	JILANI, G., et al.	Repellent and Growth-Inhibiting Effects of Turmeric oil, Sweetflag Oil, Neem Oil, and Margosan-O on Red Flour Beetle (Coleoptera, Tenebrionidae)	J ECON ENTOMOL	Article	68
90	Chaudhari, AB., et al.	Polyurethane Prepared from Neem Oil Polyesteramides for Self-Healing Anticorrosive Coatings	IND ENG CHEM RES	Article	68
91	Dasgupta, T., et al.	Chemopreventive potential of *Azadirachta indica* (Neem) leaf extract in murine carcinogenesis model systems	J ETHNOPHARMACOL	Article	67
92	SaiRam, M., et al.	Anti-microbial activity of a new vaginal contraceptive NIM-76 from Neem oil (*Azadirachta indica*)	J ETHNOPHARMACOL	Article	67
93	Balasenthil, S ., et al.	Chemopreventive potential of Neem (*Azadirachta indica*) on 7,12-dimethylbenz[a] anthracene (DMBA) induced hamster buccal pouch carcinogenesis	J ETHNOPHARMACOL	Article	67
94	Satdive, RK ., et al.	Enhanced production of azadirachtin by hairy root cultures of *Azadirachta indica A.* Juss by elicitation and media optimization	J BIOTECHNOL	Article	67
95	Sharma, A; Bhattacharyya, KG	*Azadirachta indica* (Neem) leaf powder as a biosorbent for removal of Cd (II) from aqueous medium	J HAZARD MATER	Article	67
96	Talpur, AD; Ikhwanuddin, M	*Azadirachta indica* (Neem) leaf dietary effects on the immunity response and disease resistance of Asian seabass, Lates calcarifer challenged with Vibrio harveyi	FISH SHELLFISH IMMUN	Article	67
97	Nazeruddin, GM., et al.	Extracellular biosynthesis of silver nanoparticle using *Azadirachta indica* leaf extract and its anti-microbial activity	J ALLOY COMPD	Article	66
98	Gopal, M; ., et al.	Impact of Azadirachtin, an insecticidal Allelochemical from Neem on soil Microflora, enzyme and respiratory activities	BIORESOURCE TECHNOL	Article	66
99	Zennaro, P., et al.	Fire in ice: two millennia of boreal forest fire history from the Greenland NEEM ice core	CLIM PAST	Article	65
100	Amadioha, AC	Controlling rice blast in vitro and in vivo with extracts of *Azadirachta indica*	CROP PROT	Article	65

DT: Documents type; TC: Total Citation

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Table 4: Top 10 Journal Sources in Neem research

	Element (n = 72)	h_index	TC	NP	JIF (2020)
1	Journal of Ethnopharmacology	9	751	9	4.360
2	Journal of Natural Products	4	333	4	4.050
3	Journal of Hazardous Materials	3	545	3	10.588
4	Adsorption-Journal Of The International Adsorption Society	2	313	2	2.318
5	Bioresource Technology	2	137	2	9.642
6	Climate of the Past	2	152	2	4.295
7	Crop Protection	2	140	2	2.571
8	Current Science	2	552	2	1.102
9	Dyes and Pigments	2	798	2	4.889
10	Fuel	2	140	2	6.609
11	Investigational New Drugs	2	150	2	3.850
12	Journal of Geophysical Research-Atmospheres	2	227	2	4.260
13	Journal of Radiation Research And Applied Sciences	2	576	2	1.770
14	Journal of the American Mosquito Control Association	2	341	2	0.917
15	Life Sciences	2	155	2	5.037
16	Microbial Ecology	2	205	2	4.552
17	Parasitology Research	2	154	2	2.289
18	Tetrahedron	2	203	2	2.457

TC: Total Citations; NP: Number of Publications; IF: Journal Impact factor

Table 5: Country of origin of the 100 top-cited articles on Neem research

Country (n = 22)	Articles	Freq	SCP	MCP	MCP_Ratio	Total Citations
India	54	0.5870	48	6	0.111	8637
USA	5	0.0543	4	1	0.200	631
Nigeria	4	0.0435	3	1	0.250	358
Denmark	3	0.0326	0	3	1.000	267
Germany	3	0.0326	2	1	0.333	1028
Italy	3	0.0326	1	2	0.667	219
Brazil	2	0.0217	1	1	0.500	152
Japan	2	0.0217	2	0	0.000	155
Korea	2	0.0217	0	2	1.000	171
Pakistan	2	0.0217	1	1	0.500	348

SCP: Single Country publications, MCP: Multiple country Publications

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Table 6: Top Institutions with more than 3 articles in Neem research

	Institution (n=140)	Articles	Percent	Total citations	PY_start& End
1	Banaras Hindu University	6	6.0	776	2003~2005
2	Gauhati University	6	6.0	1491	2003~2005
3	Annamalai University	5	5.0	481	1999~2015
4	University Copenhagen	5	5.0	465	2011~2014
5	VIT University	4	4.0	549	2009~2012
6	Bharathiar University	3	3.0	256	2005~2015
7	Indian Inst Sci	3	3.0	390	2009~2010
8	Indian Inst Technol	3	3.0	300	2007~2012
9	University Bern	3	3.0	245	2011~2014

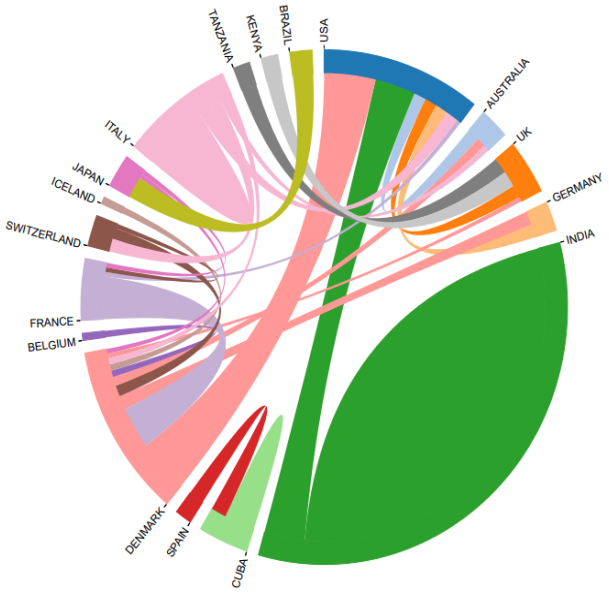

Figure 2: Inter State relations between countries of origin.

Furthermore, Guahati University had 1491 total citations from the (n=6) published articles, followed by Banaras Hindu University, and VIT University trailed behind.

Conceptual structure and collaborative countries analysis

Figure 5 depicts the keyword analysis, an essential component of this research topic. The analysis of 30 Keywords Plus terms was used to identify research trends in various scientific fields, as shown in Figure 3, by using multiple correspondence analysis for 30 Keywords Plus terms that can capture an article's content in Neem research with greater depth and variety. Furthermore, in Figure 4, the 30 occurrences of Author's Keywords which provided topic and information, include a list of terms that authors believe best represent the content of their research papers, as well as additional representative parameters for the content and scientific concepts (Figure 4). Besides, the article title was analyzed to capture the reader's attention and determine the extent to which topics are related to one another (Figure 5). Overall, Keywords Plus, Author Keywords, and Article keywords uncovered various research topics.

WorldCloud of keywords analysis

The visualization of the keywords Plus is shown in Figure 6. It was noticed that the most frequent keyword *Azadirachta-indica* occurred ten (10) times, followed by tree (6 times), activated carbon, biosynthesis, equilibrium, extracts, pesticides, sorption, toxicity, and wastewater each occurred (5 times), amongst others.

Discussion

This study carefully investigated the neem-based research trends using bibliometric tools to present a comprehensive synopsis of Neem studies to present a practical guide in assessing the most significant articles on neem-related topics. This evaluation was achieved by subjecting the data retrieved from Web of Sciences (WoS) to various up-to-date statistical packages such as VOSviewer 1.6.6, [29] "Bibliometrix app" using R.studio cloud, [27] Histcite [28], and Statistical Package for Social Sciences (SPSS). This current study also established the associations between study variables using Pearson's correlation. It was observed that the highest number of articles were published in the years 2004 and 2007, with NP=11 and NP=10 articles, respectively. More also, a downward drift in Neem publications was recorded from 2010. This decline needs to be addressed to mitigate research gaps and harness the outcome of such investigations.

This paper evaluated 100 top-cited articles on Neem, of which ninety-one (91) were research publications while the remaining nine (9) were reviewed papers as cataloged in the WoS. Bhattacharyya K.G. was the most cited author (TC:1491) with NP=6, followed by Sharma A. with TC=1237 and NP=5 being the first author in 3 of those papers and co-authored two papers. It was observed that Verma V.C. also had NP=5 and was the first author in 3 publications, and co-authored two papers just like Sharma A. However, unlike Sharma A, a lower total number of citations (TC=467) was recorded by Verma V.C. as against the total number of citations TC=1237 accrued to Sharma A. Additionally, it was observed that significant correlations exist between the number of citations and certain variables such as average year of publications, number of countries, number of articles per journal, and number of authors. These factors considerably influence the number of citations garnered by every article. Although many contributing authors' countries promote Neem research growth, India is the top country on Neem studies (NP=54). India has been noted to be the most prominent in this hub, with the highest total number of citations TC=8637. This increased representation in research productivity originating from a developing country such as India is worthy of emulation by other developing nations, particularly African countries, which record only two Single Country Publications from Nigeria. This pattern indicates that African countries need to boost their research machinery to contribute productively to the study of Neem.

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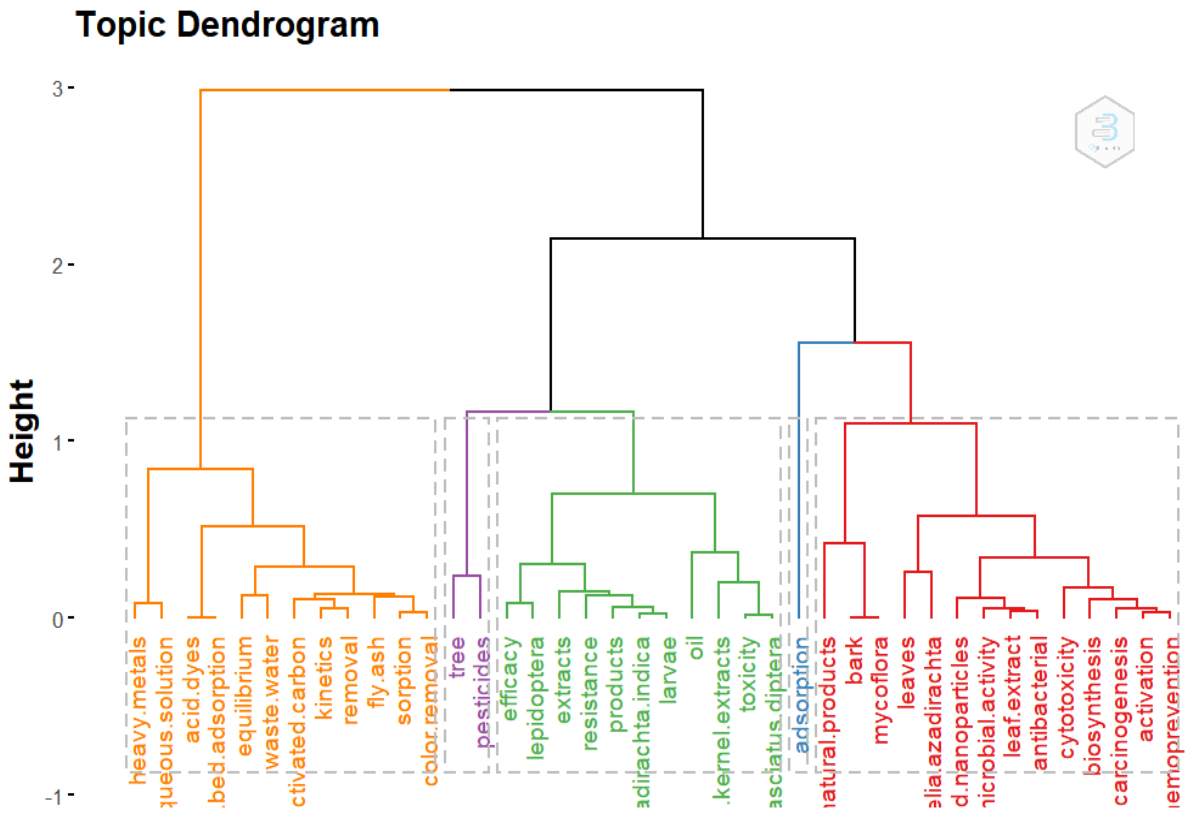

Figure 3: Factorial analysis using multiple correspondence analysis (MCA) method for 30 Keywords Plus in 5 clusters.

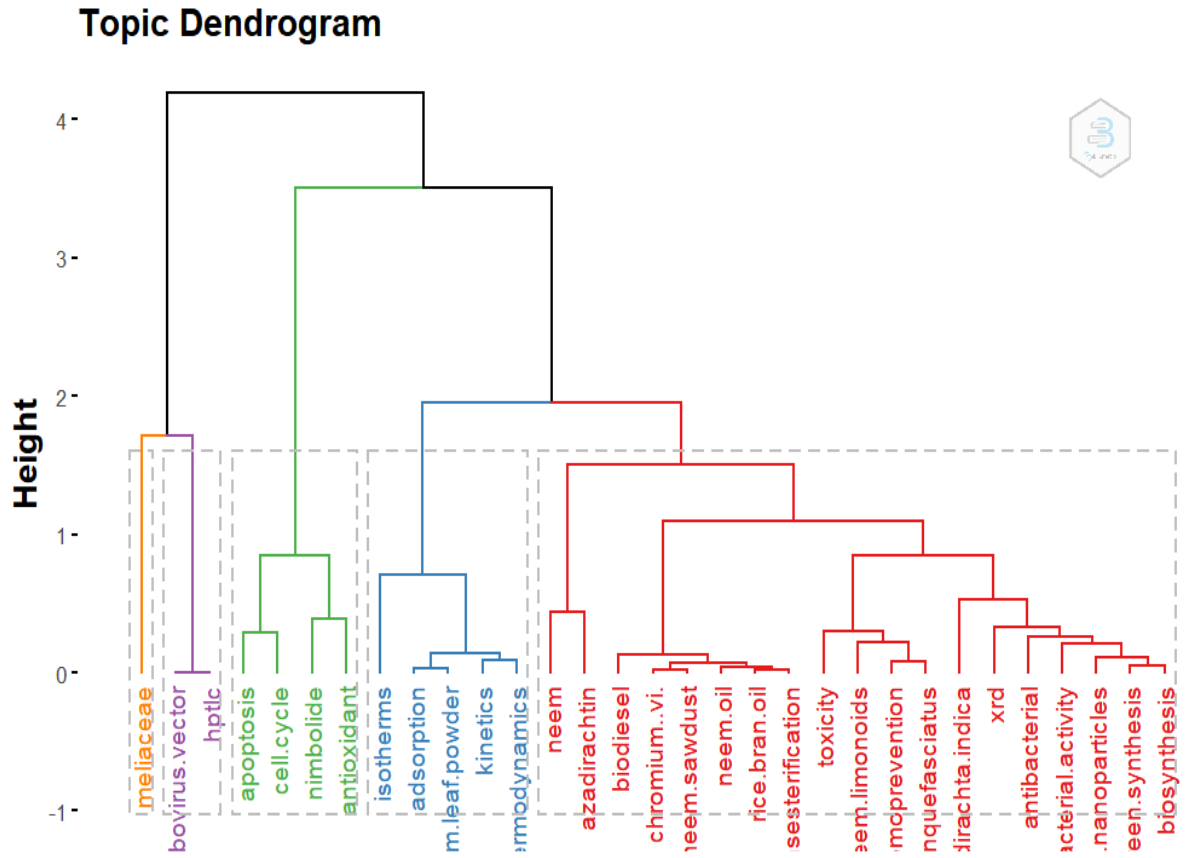

Figure 4: Factorial analysis using multiple correspondence analysis (MCA) method for 30 Author's Keywords in 5 clusters

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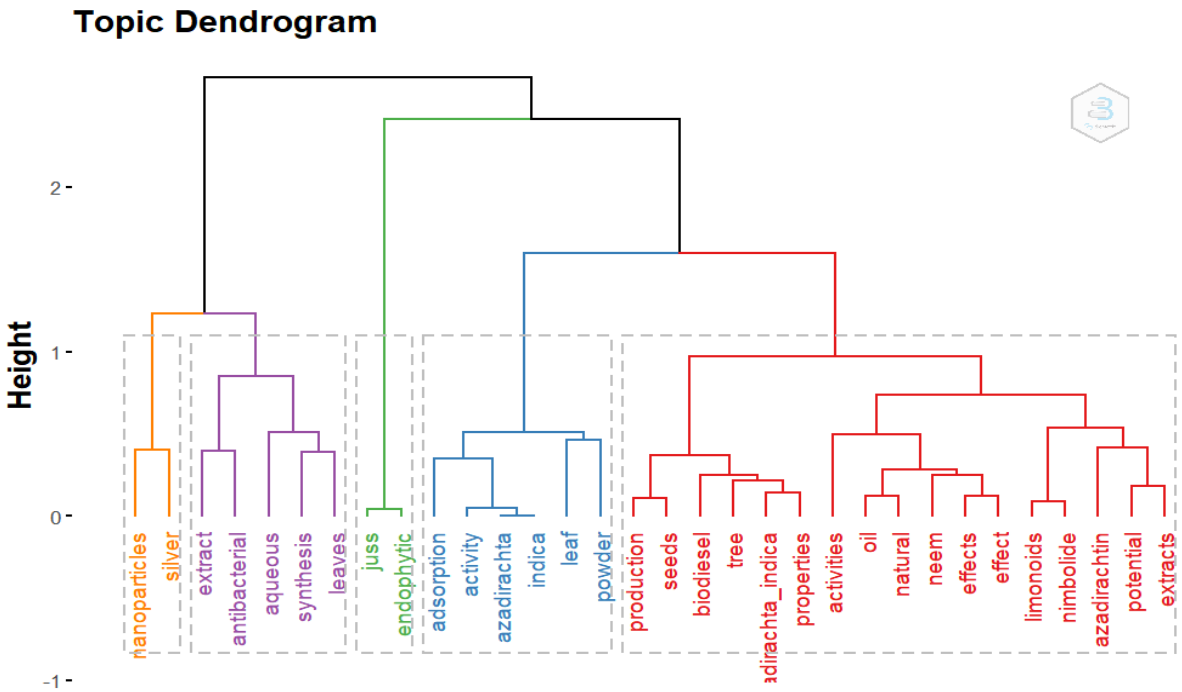

Figure 5: Factorial analysis using multiple correspondence analysis (MCA) method for 30 Article title in 5 clusters

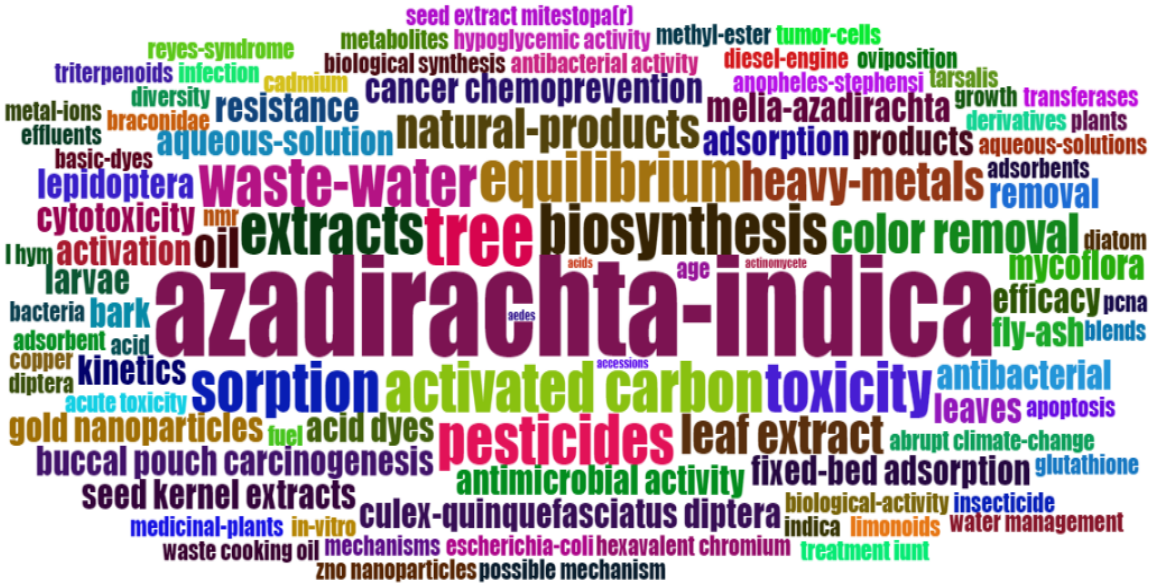

Figure 6: WorldCloud of keywords plus occurrences analysis

This evidence corroborates Djenontin *et al*.,[31] who submitted that Meliaceae species spread across African savanna and tropical forests. Hence, more commitments to studying Neem from African countries will enhance sustainable development foster contributions to the diversification of lipid sources.

Furthermore, our review of the most productive journal sources revealed that neem-based publications are found in a wide range of scientific journals, including Journal of Ethnopharmacology, Journal of Hazardous Materials, Journal of Natural Products, Adsorption-Journal of the International Adsorption Society, Current Science, Dyes and Pigments, Fuel, Investigational New Drugs, Journal of Geophysical Research-Atmospheres, Journal of Radiation Research and Applied Sciences, and Journal of Radiation Research. This result reflects the wide range of applications of Neem, making it suitable for publication in a variety of journals with high impact factors. Worldcloud Keyword analysis, on the other hand, discovered that the most commonly used keywords included *Azadirachta indica*, oil, sorption, pesticide, and heavy metals, which could be interpreted as a clear indication of the importance of neem research interest. Furthermore, thematic analysis of 100 top-cited neem articles provided us with various relevant themes in the study of Neem, resulting in a clear-cut evolution of Neem studies that can help scientists identify gaps and design appropriate experiments. Keyword analysis can also indirectly reveal various critical research topics and characteristics of a research field.

Finally, it is appropriate to acknowledge the limitations of this current study. This study relied solely on the Web of Science database; undoubtedly, essential details from other data sources would have been overlooked. It should also be noted that several factors influence the number of citations for any given article; thus, additional research should be conducted using other databases and including all document items.

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Conclusion

This research provided an insightful summary of the most historically important articles on Neem research works. This study's scope included publication year, collaborations, authorship, contributing countries, citations, and factors influencing them. In 2010, there was a decrease in Neem articles published. This evidence is regarded as a disadvantage that must be addressed urgently to avoid intellectual gaps in neem research. This research revealed that developing countries could also make significant contributions to Neem research. As a result, deliberate steps must be taken to increase the participation of local authors from developing countries and upgrade local journals to globally recognized standards. Given the importance of Neem in non-synthetic, environmentally friendly pest and disease control, neem research must be adequately funded to protect human health and the environment.

Conflict of Interest

The authors declare no conflict of interest.

Authors' Declaration

The authors hereby declare that the work presented in this article is original and that any liability for claims relating to the content of this article will be borne by them.

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