MICROPLASTICS IN AQUACULTURE: A BIBLIOMETRIC ANALYSIS BASED ON WEB OF SCIENCE DATA

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ABSTRACT

This study aims to analyze bibliometric repertoire on the topic microplastics in aquaculture with an understanding that occurrence of microplastics contribute to aquaculture pollution resulting in environmental hazards. Rising concerns on the theme is in relation to hazardous biotic as well as a biotic build-up of microplastics from off shore, on-shore anthropogenic activities in aquaculture practices, distressing ecosystem balance and global health. Bibliometric analysis on the search string 'microplastics in aquaculture' was obtained from Web of Science database dating publications 2011 onwards, signifying the recent and surging discourse on the issue. Country and organization based bibliographic outcomes depict larger participation of China with other regions in expanding its research initiatives. Besides the main theme, drawing relations to greater co-occurrence of key terms identifies with words such as fish, pollution, toxicity, sustainability and ingestion. Association to attainment of seven Sustainable Development Goals (SDGs) can also be deduced from analyzed records.

KEYWORDS: *Aquaculture; Microplastics; Sustainability; Hazard; Pollution; Bibliometric Analysis.*

1. INTRODUCTION

Adequate and quality protein supply in human diet is linked to food security(Coles et al., 2016). 20% of animal protein requirement to three-billion world population is fulfilled from fish diet, with 52% share of fish coming from aquaculture productions(FAO, 2018). Aquaculture products are nutritious source of proteins, essential amino acids, vitamins and minerals fulfilling global food demands. Rising dependance on seafood with increasing world population deems aquaculture productions to cater future nutrimental demands.

Microplastic pollution is an alarming problem in aquaculture as it thwarts environmental safety as well as food safety(Wu et al., 2023). Microplastics (MPs) are fragments of plastics below 5mm length entering the environment directly as primary MPs, or indirectly by breakdown'secondary MPs'. Microplastic pollution is considered as an environmental hazard of appalling global concern. Growing findings indicate leakage of microplastics into aquaculture settings by abiotic and biotic factors as well as by humanactivity.Major pathways of aquaculture entry of MPsinclude cultured fish,fish feed, wastewater, fishing and farming equipment(Iheanacho et al., 2023). Fish are biological indicators of MP ingestions; with uptakes in the gastrointestinal tract of fish reflecting level of MP pollution at the site (Bray et al., 2019). Microscopic plastics are directly ingested by pelagic and bottom dwelling (demersal) organisms from surface waters or aquatic sediments in search for food. G20 countries, as a matter of trepidation generate nearly two-third of global plastic waste(Fadeeva and Berkel, 2021).Highest MP contaminated fish species (nearly 44.2 %) has been found from Asian regions (Kibria, 2022). MPs have toxic effects on fish physiology, related to neural toxicity, oxidative damage, depleted food intake, behavioural abnormalities, impeding growth and survival (Bubu-Davies and Anwuri, 2022; Bhuyan, 2022). MPs adsorbtoxic chemical pollutant such as polycyclic aromatic hydrocarbons, heavy metalsandharmfulmicrobes hitchhiking unnecessary translocation to biotic tissues of aquatic species (fish, crustaceans, bivalves, phytoplanktons and zooplanktons) as well as humans(Wang et al., 2016; Kirstein, et al., 2016). Chemical additives used in preparation of plastic such as bisphenol A and persistent organicpollutantscan easily leach in water posingneurotoxic, immunotoxic health impacts to terrestrial and aquatic forms.Direct and indirect exposure to MPs is related to cellular and tissue toxicity with likely health risks to humans(Wright and Kelly, 2017). MPs have problem of bioaccumulation and biomagnification across food webs. Because of their ease of mobility and pervasiveexistence in aquafarmingecologies MPs are speculated to be slow form of disasters(Bergmann, 2022). Assessment and ensuing management of plastic loads from aquaculture is an impending and demanding issue for aquaculture sustainability as well an imminent concern for monitoring and management of aquatic and terrestrial ecosystems (Tian et al., 2022). Present analysis explores available bibliometric data to draw relationships amonggrowth of publications and citations over time; commonco-occurring terms concerning the topic; co-authorship links of research groups among regions, organizations; and strength of these collaborative linkages for building better understanding on the pressing theme.

2. MATERIALS AND METHODS

2.1 Collection of bibliometric data

Bibliometric data pertaining to the search term ‘Microplastics in Aquaculture’ was obtained from Web of Science (WoS) database. Bibliometric analysis attempts to provide improved understanding of the research setting, organization, and interrelationships(NOAA, 2024).Web of Science (WoS) earlier known as Web of Knowledge, is a popular, structured database for retrieval, analysis and distribution of comprehensiveinformation about the research data. Since2016, WoS is maintained by Clarivate Analytics(Pranckute, 2021). WoS core collection supports *ten* citation indexesincluding*four*Journal citation indexes (Science Citation Index Expanded, Social Sciences Citation Index, Arts and Humanities Citation Index, Emerging Sources Citation Index); *two*Conference Proceedings Citation Index in Science (CPCI-S),Social Science and humanities (CPCI-SSH);*two*Chemical indexes (Current Chemical Reactions- CCR expanded, Index Chemicus);*two*Books Citation Index in Science (BKCI-S), Social Science and humanities (BKCI-SSH).

Individual fields selected for analysis in WoS were ‘Author’, ‘Title’, ‘Times Cited Count’ (under ‘Author, Title, Source’); ‘Abstract’,‘Document Type’,‘Keywords’, ‘WoS Categories’, ‘Research Areas’ (under “Abstract, Keyword, Addresses”); ‘Highly Cited’ (under ‘Cited References and Use’). Citation report with cumulative h-index of publications was generated.

2.2 Analysis of bibliometric data

Analysis of bibliometric data is supported by VOSviewer,a data mining software for construction and elucidation of bibliometric links. Obtained clustersincluded bibliometric network visualization of a) co-authorship as per countries andorganizations,with weightage determined through total link strength,b) co-occurrence ofkeywords, with criteria set tofilter 5 co-occurring keyword entries inpublications.

3. Results and Discussion

A total of 655 publications were retrieved pertaining to the topic ‘Microplastics in Aquaculture’ from search results,having cumulative h-index of ‘72’. ‘Articles’ with record count of 578 accounted 87.976% of total document types followed by ‘Review article’ (record count of 75, percent contribution 11.416%), early access (12, 1.826%); editorial material (3, 0.457%); bibliography and proceeding paper both 1 each at 0.152%.

Publications earlier since 2011 are documented. Ahead 2014, an empirical rise in citations has followed by subsequent growth in publications (Fig.1). An escalating trend in number of publications and citations is indicative of increased participation in contribution to investigation on the pressing issue. Out of 11,737 citing articles 11,211 were without self-citations. Total times cited were at 21,076 out of which 19,003 were without self-citations with an average 32.18 citations per publication a number depicting high referencing of research topic.

3.1 Analysis of bibliographic network

Bibliographic network analysis investigates and envisions relationships created amid publications on the basis of authorship, citations, or common words(NOAA, 2024),detailing on collaboration; semantic; as well as citation networks.

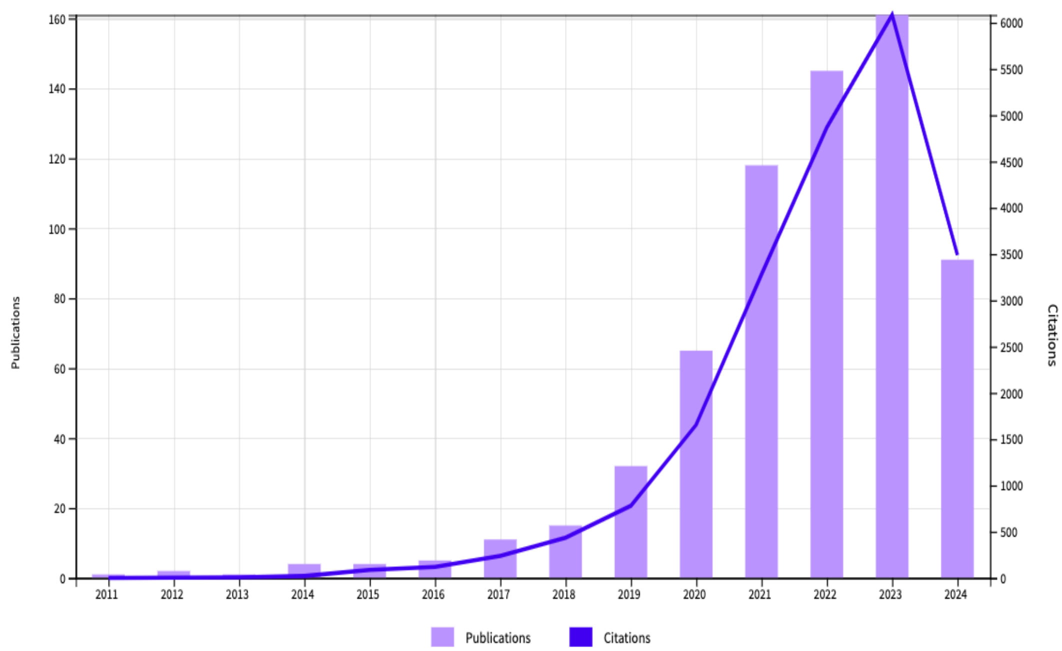

Fig. 1:Publications and citations over time on the topic ‘Microplastics in Aquaculture’.

Source – Author, 2024 (WoS, 2024)

3.1.1 Co-authorship according to countries

Visualization of bibliographic networkon the theme generated 91 entries with co-authorships according to countries. Links were drawn based on 90 countries, since 1 record contained no data in the field being analysed.Stronger connections of top 10 countries based on their link strength of co-authorships with other regions in brackets,involve countries such as Spain (*link strength* 105), People's Republic of China (PRC) *link strength* 98, Germany *link strength* 98, Italy *link strength* 98, France *link strength* 86 ; followed by England (*link strength* 82), Portugal (*link strength* 79), US, (*link strength* 77), India (*link strength* 68)and Greece (*link strength* 63) explicable from Fig. 2.

Collective resolute for effective participation in attaining sustainable development goals SDGs as G20 agenda among nations including PRC, Germany, Italy, France, England, US, India, Brazil, Canada, Australia, Saudi Arabia, European Union can be the reason for greater collaborations in terms of linkages(Zhao and You, 2024).Markedly, China among East Asian countries is a major user of plastic with overbearing concerns pertaining to microplastics due to higher MP uptakes from dietary contaminations (Zhao and You, 2024).

Maximum publication records are communicated from People's Republic of China with highest citations (Table1) indicating higher referencing of their research communications. Interestingly all publications retrieved are in English; globally, most shared language of scientific communication (Eberhard, Simons and Fennig, 2024).

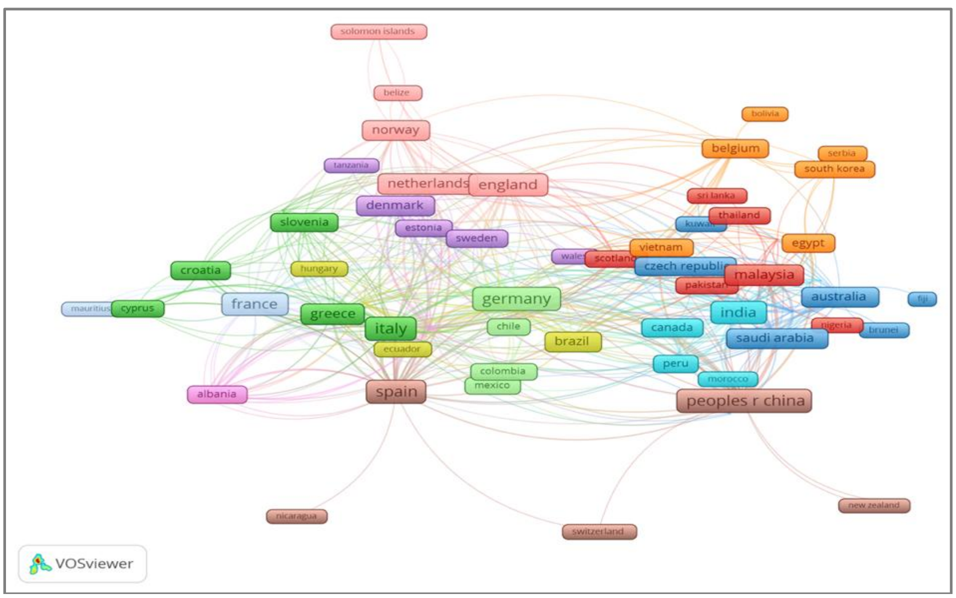

Fig. 2:Bibliometric network visualization of co-authorship as per countries, on the topic 'Microplastics in Aquaculture'.

Source – Author, 2024(WoS, 2024)

Table 1:Top 25 countries with publications on the topic 'Microplastics in Aquaculture'.

Countries/Regions	Record Count	% of 655	No. of citations
Peoples R China	232	35.42	6387
England	55	8.397	4255
India	48	7.328	686
USA	48	7.328	1623
Italy	46	7.023	2304
Spain	46	7.023	1937
Malaysia	38	5.802	1498
France	37	5.649	1694
Germany	31	4.733	1262
Portugal	30	4.58	1375
Brazil	27	4.122	626
Bangladesh	26	3.969	403
Australia	24	3.664	1081
Iran	23	3.511	706
Norway	22	3.359	669
Canada	20	3.053	1667
Netherlands	17	2.595	1200
Greece	15	2.29	508
South Korea	15	2.29	802
Saudi Arabia	14	2.137	130
Vietnam	14	2.137	188
Denmark	13	1.985	887
Thailand	13	1.985	294
Belgium	12	1.832	950
Czech Republic	12	1.832	177

Source - Author, 2024(WoS, 2024)

3.1.2 Organisation wise co-authorships

As per 1151 organisations identified, 888 show co-authorships weighted through total link strength. Chinese Academy of Science, PRC has close clustering with several organisations co-authorship wise,indicating at stronger, astute collaborativelinks, defined from Fig.3. Expansion of researchthrough concerted collaborations offer higher publication visibility (seen insection 3.1.1 as increase in publication counts) and growing citations. Distant clusters of Kerala University of Fisheries and Ocean Studies, India; University of Cadiz, Spain indicate limited research collaborations. Unique cluster, exist between Alfred Wegener Institute,Germany; University of Austral de Chile University of Catolica del Norte, Chile; Sorbonne University,France elaborating on close collaborations.

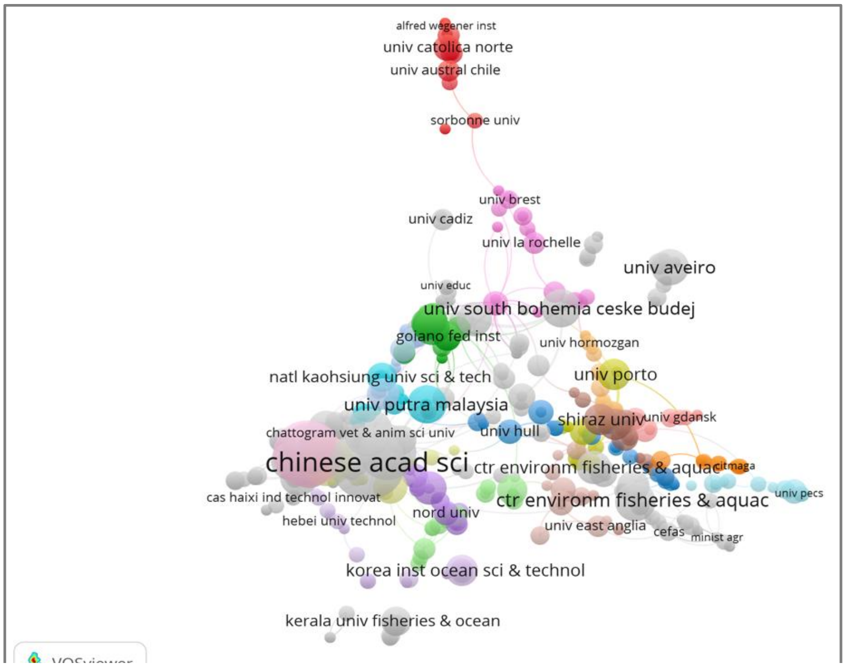

Fig. 3: Co-authorship as per organisations.

Source – Author, 2024 (WoS, 2024)

3.1.3Keyword co-occurrence

Outlining importance of the topic in documented works can be perceived through intense clusteringaround original search terms 'microplastics','aquaculture'; (Fig.4).

Six clusters with closely linked co-occurring terms areidentified as;

*Cluster 1*including words-microplastics, aquaculture, environment, plastics, fresh-water, soil, sustainability, antibiotics, carbon, hitchhikers, microplastic pollution, biodegradation, adsorption, antibiotic resistant genes, heavy metals, pahs, biofilm, biofilm formation, wastewater, sorption, bioremediation,metals, nanoplastics;

Cluster 2consisting of co-occurring words-fish, bioavailability,performance, diet, toxicity, polystyrene microplastics, oxidative stress, virgin microplastics, zebrafish, aquatic organisms, daphnia magna, aquatic, environment, fishes, tissue, reproduction, rainbow trout, micro, mytilus coruscus,gene expression, apopotosis, inflammation, damage, gut microbiota, liver, aquatic organisms, microplastic, oyster, expression, nanoplastics, gut, survival,health;

Cluster 3 of terms such as- sediments, sediment, surface water, source, fate, sandy beaches, marine litter, distribution, yellow sea, china, mariculture,ftir, guangzhou city, pearl river;

Cluster 4ingestion, sea, contamination, coastal waters, extraction, protocol, bivalves, wild, oysters, fibers, food safety, atlantic, coastal, mytilus-edulls, mussels, seafood, demersal fish; *Cluster* 5plastic debris,mediterranean sea, larvae, spatial distribution,india, beach, marine litter, pollution, litter, monitoring, polypropylene;

Cluster 6 nile red, bioindicators, 1st observations,ocean,model, zooplankton.

Concentration of clusters over the keywords - ‘toxicity’; ‘pollution’; ‘fish’, ‘environment’; ‘sustainability’, ‘ingestion’ gives sound backing to interrelationships among related issues. It is known that microplastics in aquaculture have toxic impacts in aquaculture settings causing pollution. Presence of microplastics in fish feeds and meal from fish is threat to aquaculture sustainability and consumer health (Mahamud et al., 2022). Linkage to terms ‘fish’, ‘ingestion’, highlights seafood and dietary transfers of microplastics.

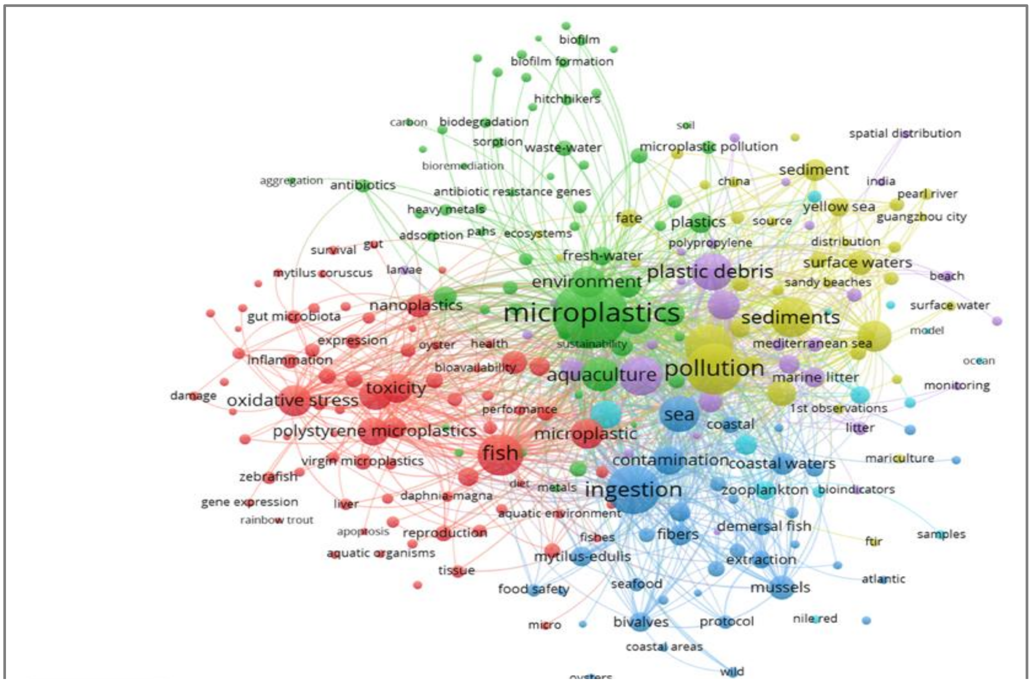

Fig. 4:Co-occurrence of keywords.

Source - Author, 2024 (WoS, 2024)

Correlation of data to seven SDGs given in table 2, corresponds to UN 2030 agenda of sustainability for prosperity of people and planet at large(United Nations, 2015). Goal 14 - *life below wate*r has largest count 592 out of 655 publications seconded by goal 15-*life on land* (11 counts) underlining considerable impact of microplastics in aquaculture on aquatic life as well as terrestrial life forms;goal 3- *good health and well being*, goal 6 *clean water and sanitation* each with 10 records; goal 13- *climate action* (8), goal 12- *responsible consumption and production* (2), goal 2- *zero hunger* (1).

Most numerous documents under the WoS category were from environmental science carrying 73.28% of total publications. 29.47% research was represented from Marine freshwater ecology, Engineering Environmental 10.23%, Toxicology 9.47%, Fisheries 7.79%, Water Resources 4.89%, Multidisciplinary Science 3.05%, Ecology 2.75% accounting top 8 categories specified from Fig.5.

Table 2:Publications covering Sustainable Development Goals

Sustainable Development Goals	**Record Count**	**% of 655**
14 Life Below Water	592	90.382
15 Life On Land	11	1.679
03 Good Health And Well Being	10	1.527
06 Clean Water And Sanitation	10	1.527
13 Climate Action	8	1.221
12 Responsible Consumption And Production	2	0.305
02 Zero Hunger	1	0.153

Source - Author, 2024 (WoS, 2024)

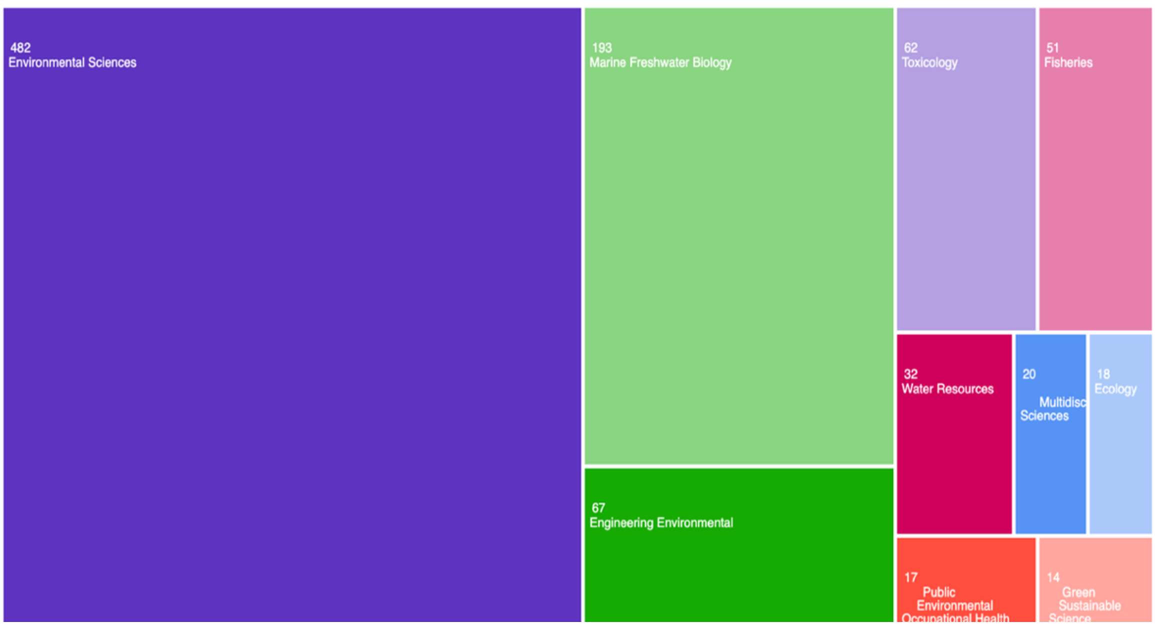

Fig. 5:Publications as per Web of Science categories on the topic 'Microplastics in Aquaculture'.

Source – Author, 2024 (WoS, 2024)

138 publication titles addressed the theme. Table 3 provides documents in publication titles. Among top 10 publication titles a larger share is endorsed by *Marine Pollution Bulletin* (14.351%) following *Science of the Total Environment*(12.824%), *Environmental Pollution*(6.718%), *Journal of Hazardous Materials*(4.733%), *Chemosphere (4.275%), Frontiers In Marine Science*(3.969%),*Environmental Science and Pollution Research*(2.901%), *Aquatic Toxicology*(2.137%), *Ecotoxicology and Environmental Safety*(2.137%), *Environmental Research*(1.832%).In top 10 Elsevier titles account 49.007% of the total.

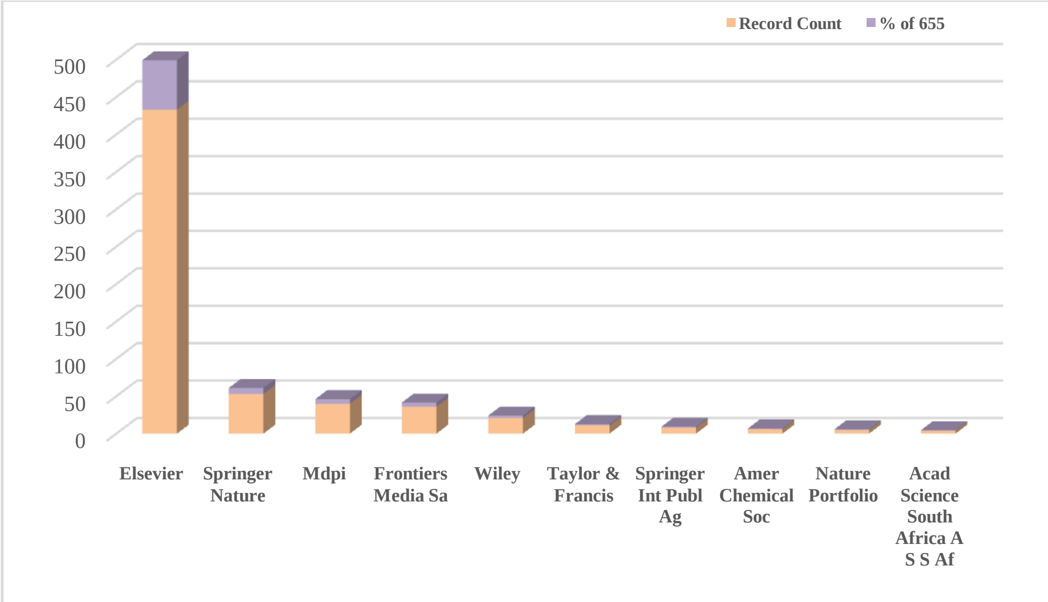

Fig. 6:Top 10 publishers on the topic

Source – Author, 2024 (WoS, 2024)

Table 3: Top 10 publication titles on the theme

Publication Titles (Publisher)	Record Count	% of 655
Marine Pollution Bulletin (Elsevier)	94	14.351
Science Of The Total Environment (Elsevier)	84	12.824
Environmental Pollution (Elsevier)	44	6.718
Journal Of Hazardous Materials (Elsevier)	31	4.733
Chemosphere (Elsevier)	28	4.275
Frontiers In Marine Science (Frontiers)	26	3.969
Environmental Science And Pollution Research (SpringerNature)	19	2.901
Aquatic Toxicology (Elsevier)	14	2.137
Ecotoxicology And Environmental Safety (Elsevier)	14	2.137
Environmental Research (Elsevier)	12	1.832

Source – Author, 2024 (WoS, 2024)

Thirty-eight publication entries had research works on the topic. Among top10 publishers Elsevier's has highest record count of 433and proportions 66.107%, followed by Springer Nature (53, 8.092%),Mdpi (40, 6.107%), Frontiers Media S.A. (36, 5.496%), Wiley (21, 3.206%) , Taylor and Francis (11, 1.697%), Springer International Publisher AG (8, 1.221%), American Chemical Society (6, 0.916%), Nature Portfolio (5, 0.763%), Academy of Science South Africa ASAAf (4, 0.611%), as listed in Fig.6.

CONCLUSION

Microplastics are side effects of globally escalating plastic production and ensuing usage.Their rising proportions in aquaculture environment and biomagnification through aquaculture productions has hazardous health impactsencompassing aquatic and terrestrial food webs. From the bibliometric analysis it is evident that the subject is relatively recent with publications beginning 2011, and pertinent to addressalof global apprehension on the theme,with noticeablesurge in publicationssince 2014.The topic is a meeting point of severalSDGsstating concerns of environment sustainability. Representation of theme in publication titles related to pollution, hazard, toxicity, marine sciences and environment safety,specifiesinterlinkagesof the issue.It is obvious that build-up of microscopic forms of plastics in environment and in organisms can pose serious threat to ecological and biotic survivals. Careful investigation of aquaculture systems is a prerequisite for development and deployment of future strategies to avert microplastic hazard covet into a slow budding disaster.

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