

Recent advances and future trends in phosphorus recycling with biochar: A bibliometric analysis

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1. Introduction

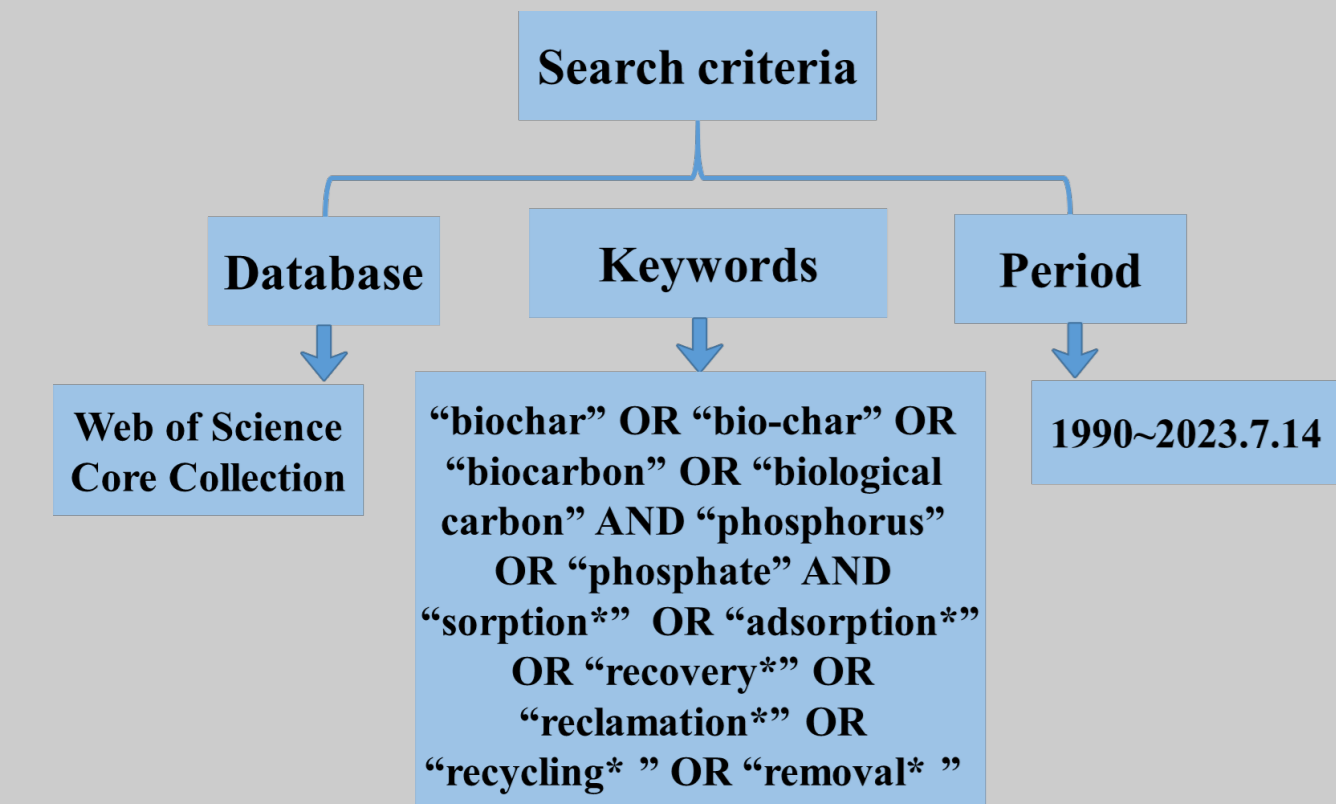
As a non-renewable resource, phosphorus enjoys the dual characteristics of polluting and resource. Specifically, polluting refers to excessive phosphorus discharged into the waterbody will lead to eutrophication of the waterbody, thus affecting the water quality, while resource refers to the application of appropriate amount of phosphorus can promote plant growth and improve crop yield. Therefore, how to effectively remove phosphorus from bodies of water and recycle it as a soil conditioner or fertilizer for agricultural land applications has been a hot issue in global research.

2. Phosphorus crisis and the wide range of uses of phosphorus as a resource

- ◆ Many scholars have modeled the depletion of phosphorus resources and discovered that the global phosphorus resource will be in a shortage within 50–100 years at the current rate of phosphorus mining and consumption.
- ◆ Phosphorus as a resource is widely used in feed, detergents, preservatives, food additives, household chemicals, pesticides, fertilizers, and electronics.

3. Recent advances analysis by bibliometrics

Two types of document (article and review article) published up to July 14, 2023 were collected and analyzed from the Web of Science core databases and a bibliometric survey was conducted using VOSviewer and Bibliometrix software.



3.2 Top 15 research areas, institutions, countries/regions, journals

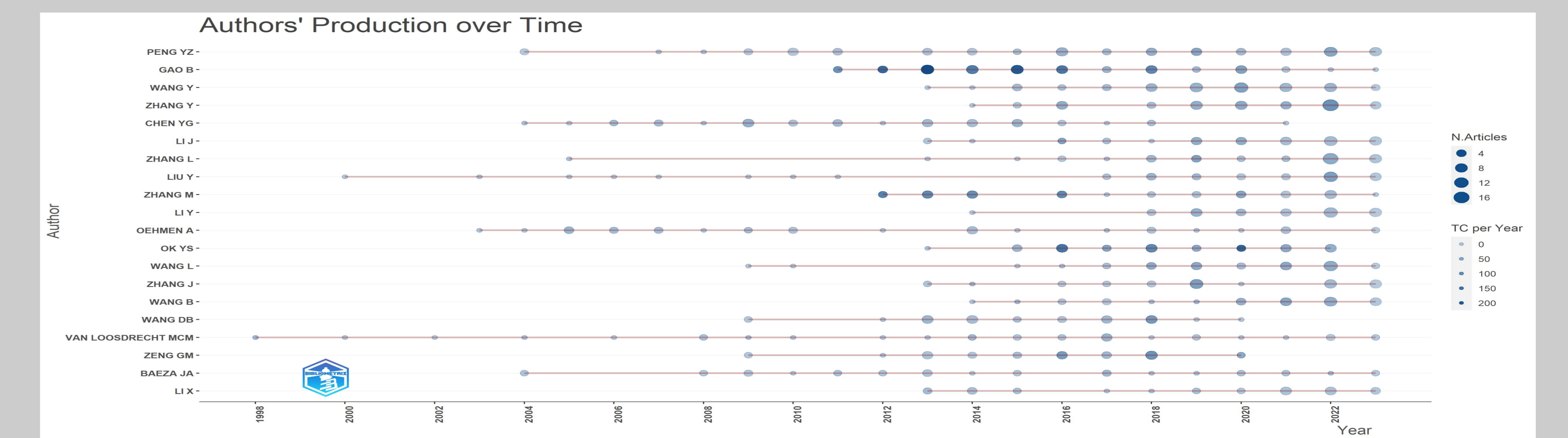
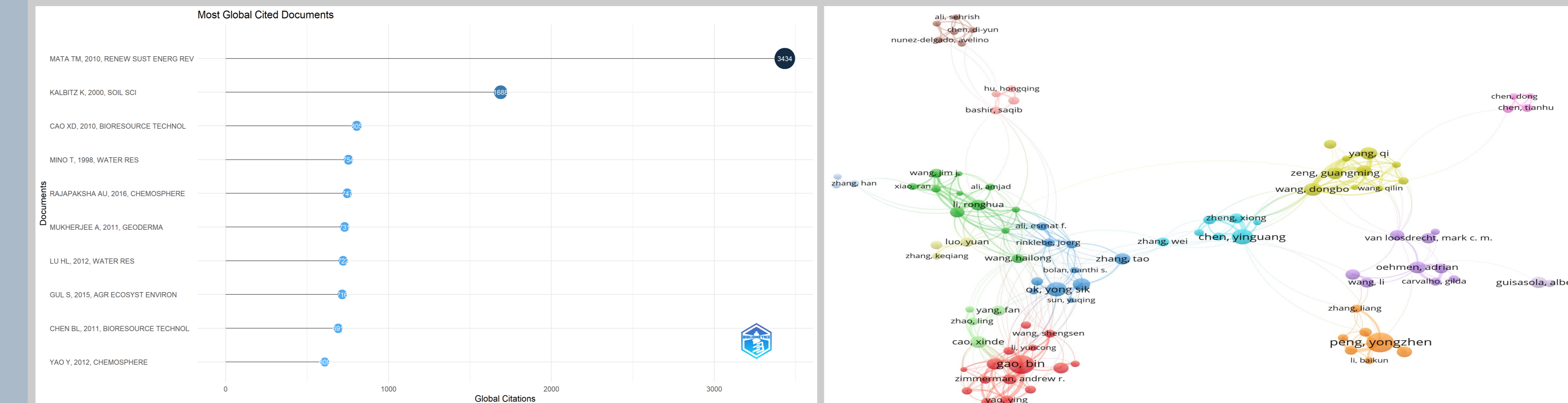
No.	Research Areas	Record Count	%
1	Environmental Sciences	2,554	52.714%
2	Engineering Environmental	1,324	27.327%
3	Water Resources	875	18.060%
4	Engineering Chemical	656	13.540%
5	Biotechnology Applied Microbiology	523	10.795%
6	Energy Fuels	338	6.976%
7	Soil Science	280	5.779%
8	Agricultural Engineering	259	5.346%
9	Chemistry Multidisciplinary	237	4.892%
10	Green Sustainable Science Technology	234	4.830%
11	Ecology	148	3.055%
12	Agronomy	142	2.931%
13	Chemistry Physical	116	2.394%
14	Microbiology	111	2.291%
15	Plant Sciences	109	2.250%

No.	Journal	Record Count	%
1	SCIENCE OF THE TOTAL ENVIRONMENT	295	6.089%
2	BIORESOURCE TECHNOLOGY	227	4.685%
3	WATER SCIENCE AND TECHNOLOGY	224	4.623%
4	CHEMOSPHERE	218	4.499%
5	WATER RESEARCH	208	4.293%
6	ENVIRONMENTAL SCIENCE AND POLLUTION RESEARCH	135	2.786%
7	CHEMICAL ENGINEERING JOURNAL	128	2.642%
8	JOURNAL OF ENVIRONMENTAL MANAGEMENT	119	2.456%
9	JOURNAL OF CLEANER PRODUCTION	116	2.394%
10	ENVIRONMENTAL TECHNOLOGY	82	1.692%
11	DESALINATION AND WATER TREATMENT	81	1.672%
12	JOURNAL OF HAZARDOUS MATERIALS	79	1.631%
13	JOURNAL OF ENVIRONMENTAL CHEMICAL ENGINEERING	64	1.321%
14	WATER ENVIRONMENT RESEARCH	60	1.238%
15	JOURNAL OF WATER PROCESS ENGINEERING	59	1.218%

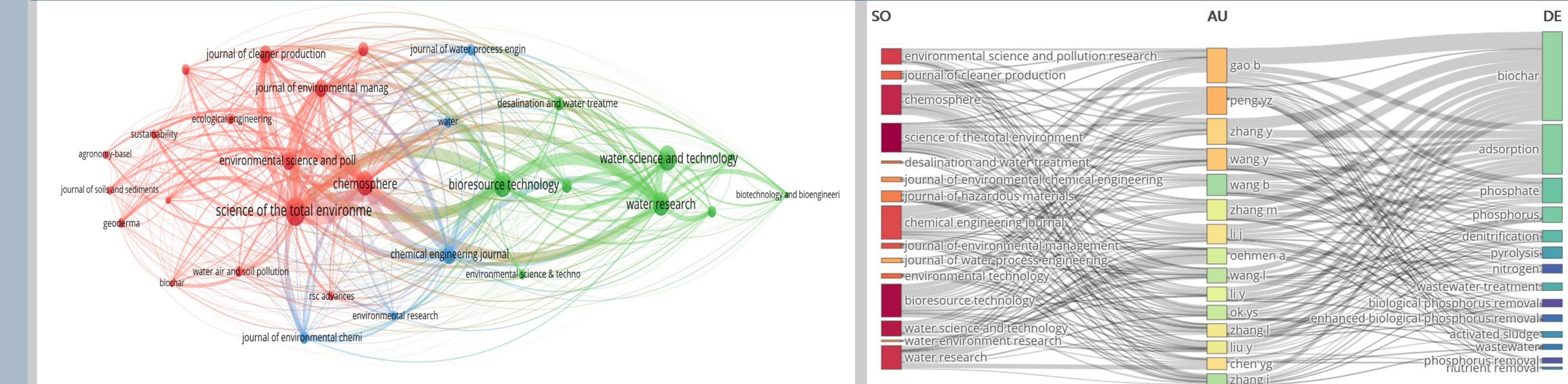
No.	Affiliations	Record Count	%
1	CHINESE ACADEMY OF SCIENCES	267	5.511%
2	TONGJI UNIVERSITY	120	2.477%
3	MINISTRY OF AGRICULTURE RURAL AFFAIRS	118	2.436%
4	STATE UNIVERSITY SYSTEM OF FLORIDA	118	2.436%
5	UNIVERSITY OF CHINESE ACADEMY OF SCIENCES CAS	96	1.981%
6	UNIVERSITY OF FLORIDA	96	1.981%
7	HARBIN INSTITUTE OF TECHNOLOGY	88	1.816%
8	BEIJING UNIVERSITY OF TECHNOLOGY	87	1.796%
9	UNIVERSITY OF QUEENSLAND	85	1.754%
10	CHINESE ACADEMY OF AGRICULTURAL SCIENCES	80	1.651%
11	EGYPTIAN KNOWLEDGE BANK EKB	69	1.424%
12	UNIVERSITY OF CALIFORNIA SYSTEM	65	1.342%
13	ZHEJIANG UNIVERSITY	64	1.321%
14	NORTHWEST A F UNIVERSITY CHINA	60	1.238%
15	TSINGHUA UNIVERSITY	59	1.218%

No.	Countries/Regions	Record Count	%
1	PEOPLES R CHINA	2,178	44.954%
2	USA	730	15.067%
3	AUSTRALIA	336	6.935%
4	INDIA	228	4.706%
5	CANADA	226	4.665%
6	SOUTH KOREA	215	4.438%
7	SPAIN	166	3.426%
8	GERMANY	161	3.323%
9	BRAZIL	141	2.910%
10	ENGLAND	134	2.766%
11	IRAN	120	2.477%
12	FRANCE	109	2.250%
13	DENMARK	95	1.961%
14	JAPAN	95	1.961%
15	PAKISTAN	95	1.961%

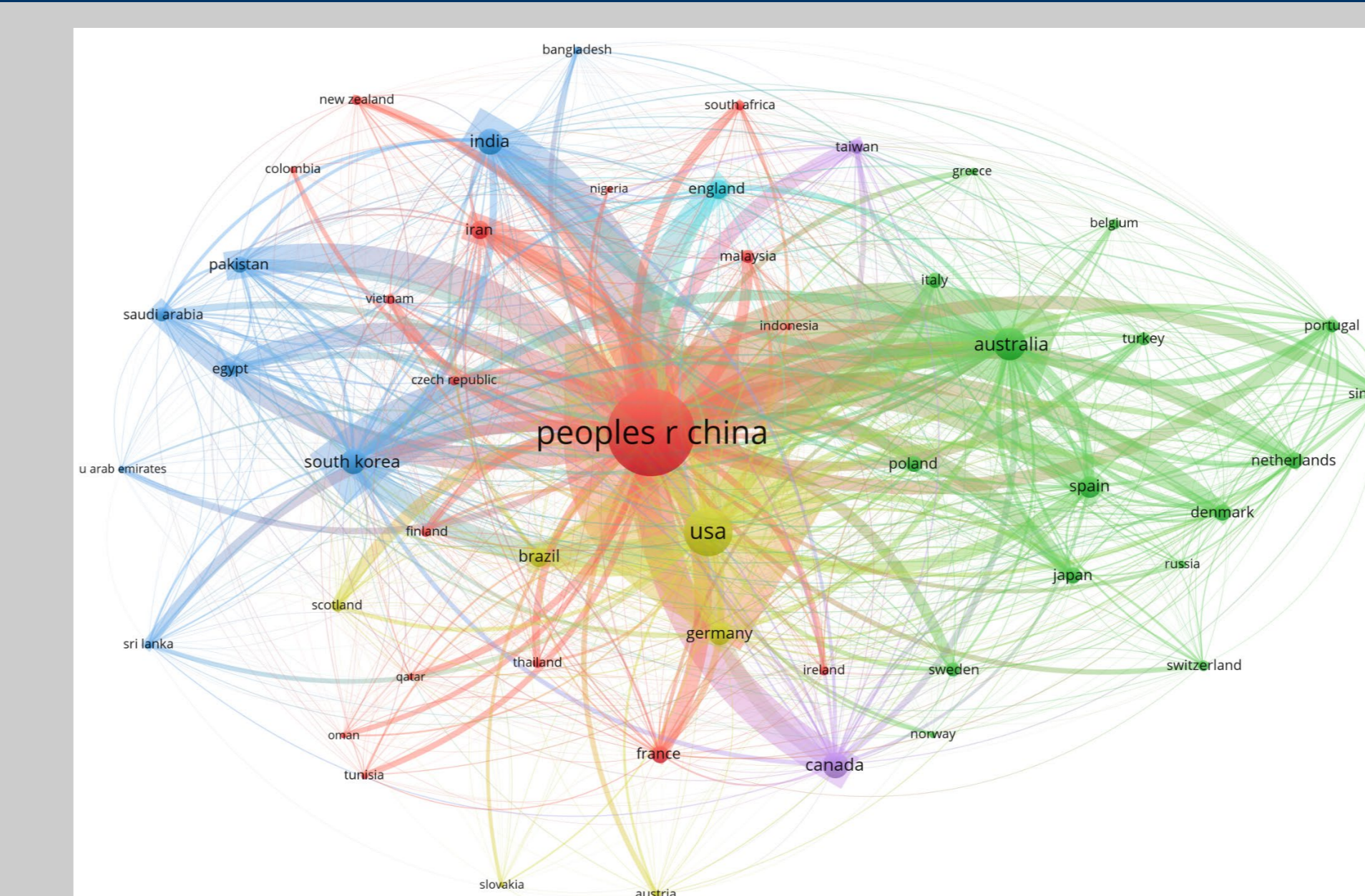
3.4 Highly cited papers, author networks, production over the last six years of most relevant authors



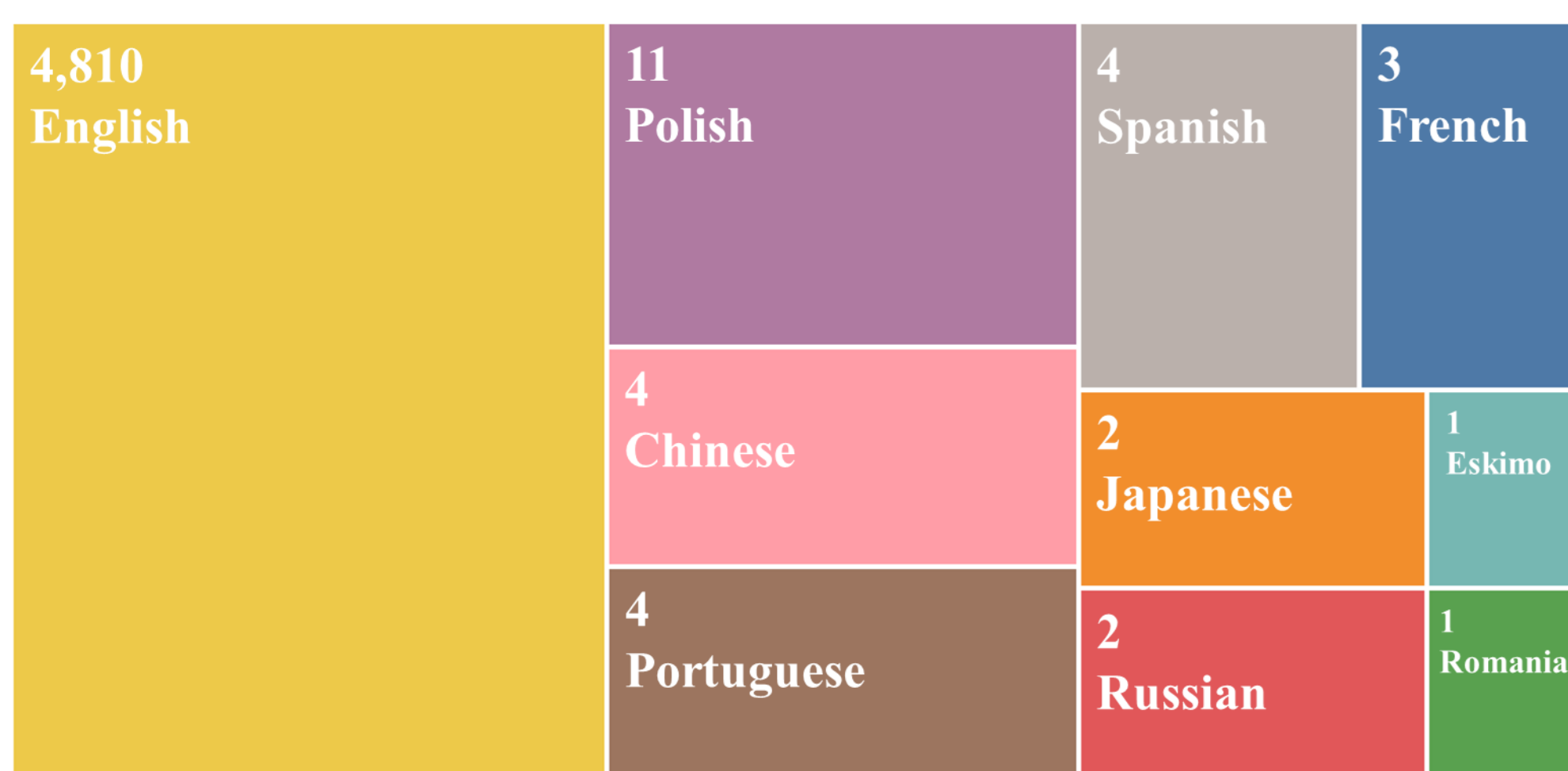
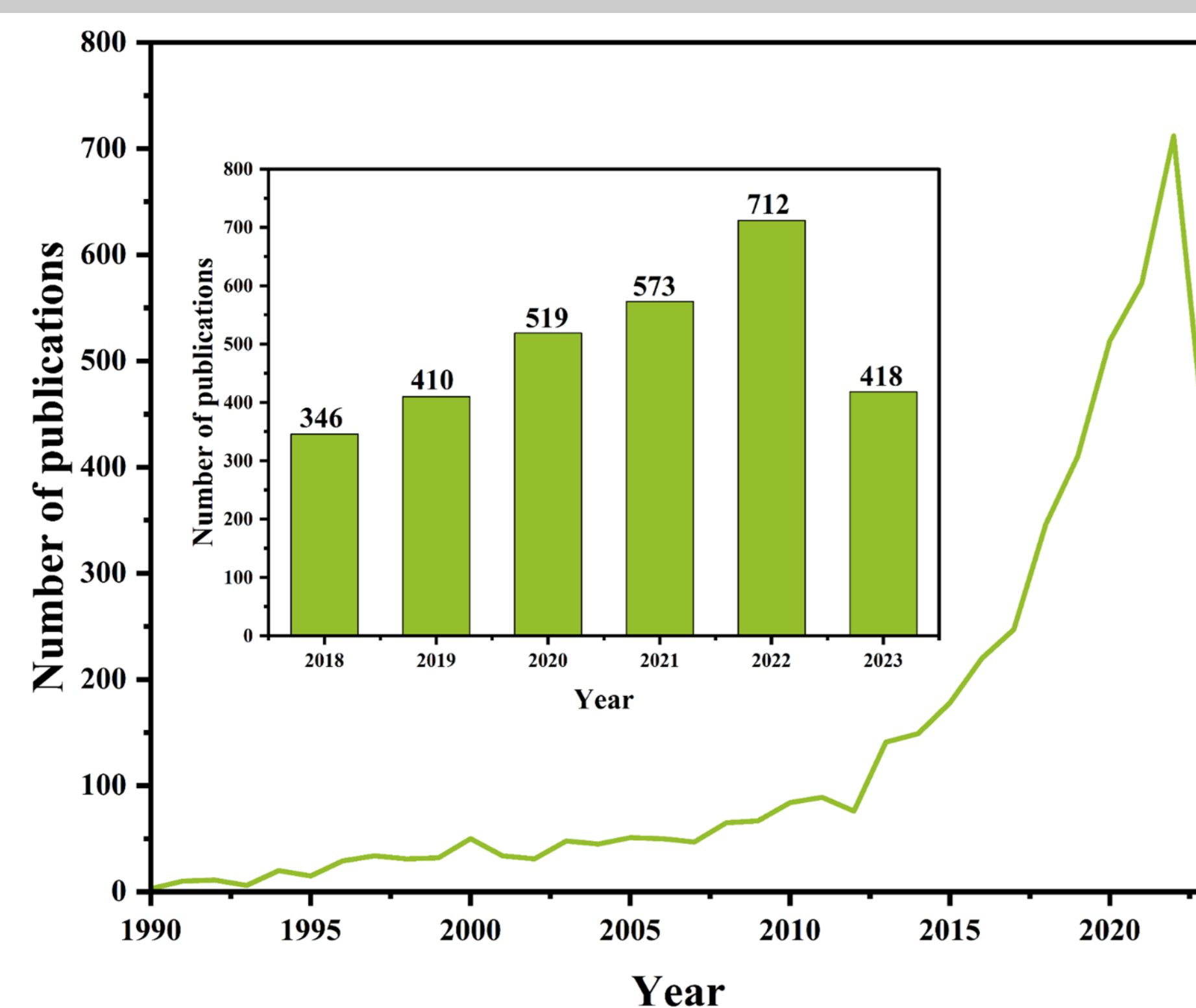
3.5 The 30 most expressive journals of publications and the three-fields plot correlating the top 15 journals, authors and authors' keywords



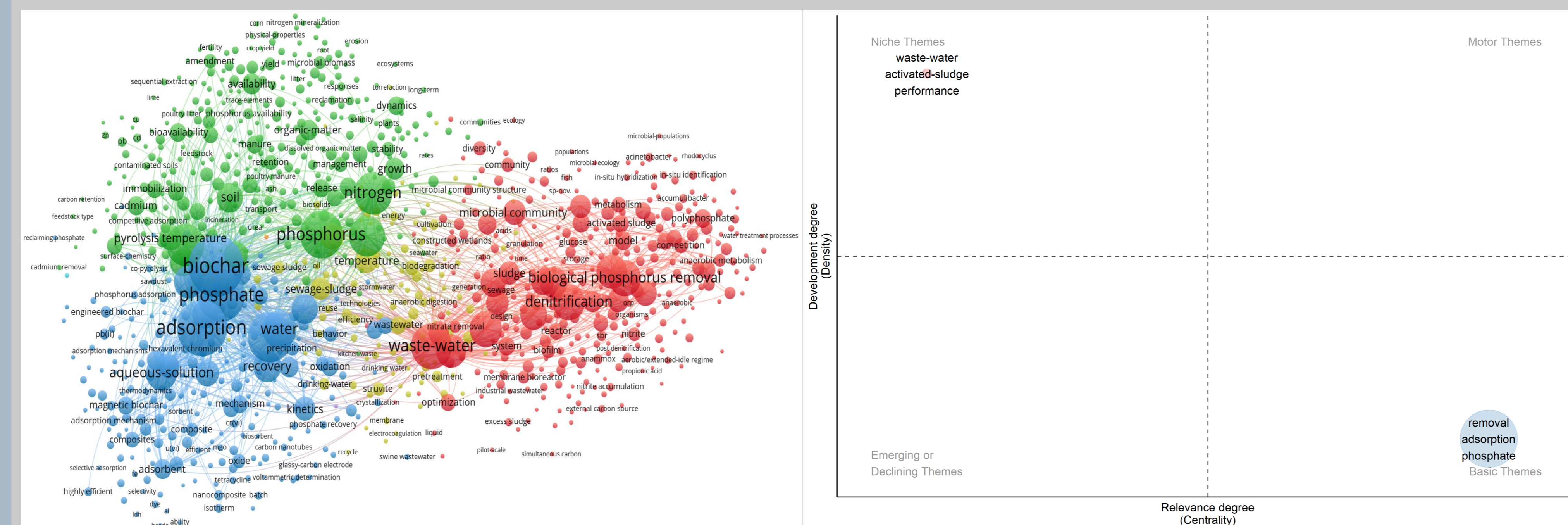
3.6 Collaboration network strength between the countries/regions according to co-authorship



3.1 Publication evolution, top 10 languages



3.3 Keyword co-occurrence network, thematic map



References

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4. Conclusions, future trends and perspectives

- (1) The number of papers in the field of phosphorus recovery with biochar has been growing rapidly, which proves that the field has attracted the interest of scholars worldwide.
- (2) Most of these studies are focused on the field of environmental sciences, with journals such as Science of The Total Environment, Bioresource Technology and Water Science and Technology are the main sources of these studies.
- (3) Peoples R China publishes the largest number of articles, has the greatest influence, and maintains the closest ties with the rest of the world.
- (4) Chinese Academy of Sciences is the most published organization followed by Tongji University and Ministry of Agriculture and Rural Affairs.
- (5) The thematic map analysis shows that removal, adsorption, and phosphate may become the hotspot of research and the direction of future development.
- (6) Future research should focus more on improving phosphorus recycling efficiency, exploring the agronomic efficiency and mechanism of action of phosphorus recycling products, and assessing the economic and ecological benefits of the phosphorus recycling process.