Available online at www.sciencedirect.com

ScienceDirect

www.elsevier.com/locate/jes

JES JOURNAL OF ENVIRONMENTAL SCIENCES

www.jesc.ac.cn

Commentary

Progress of environmental research in China from 2000 to 2019: Case studies of JES and ES&T

China's tremendous economic and cultural progress since the initiation of the reforms and opening up process has been accompanied by the steady expansion of its scientific research capabilities. We selected *Journal of Environmental Sciences* and *Environmental Science & Technology* (hereinafter referred to as JES and ES&T, respectively) as two representative journals for assessing the progress and impact of research in the field of environmental science in China. The developmental trajectory of JES, which is a prestigious Chinese journal, reflects China's expanding global influence within the environmental field. ES&T is a top journal in the field of environmental science, and the ES&T publication records of Chinese researchers reflect the strength and progress of scientific research within China. We performed a biblio metric analysis of research articles and reviews published in these two journals using the online Science Citation Index (SCI) Expanded database included in the Web of Science Core Collection.

The number of published papers in leading journals is an important indicator of a country's scientific research capabilities (Fig. 1). The ES&T Asia Office, headed by Prof. Guibin Jiang, was officially instated at the Research Center for Eco-Environmental Sciences (RCEES), Chinese Academy of Sciences on January 2006, and has been actively expanding ES&T's reach within Asia, and especially in China. From 2000 to 2019, ES&T published 25,852 research articles and reviews, and Chinese authors participated 4623 papers (17.9% of the total published papers). During this period, the first authors of 3776 papers were from China, accounting for 81.7% of the total number of papers associated with China. Whereas there was a slight increase in the number of papers from China during the initial part of this period, more recently, the number of papers has increased exponentially, reflecting the rapid increase in China's impact on environmental research. Prior to 2000, it was very difficult for Chinese researchers to publish papers in ES&T. In 2000, only 13 papers contributed by Chinese researchers were published, but by 2019 this number had increased to 606. Thus, a 45.6-fold increase in papers from China occurred during this period, with a compound annual growth rate of 22.4%, which was far higher than the global average. The global share of Chinese publications increased steadily from 1.6% in 2000 to 40.8% in 2019, and China now ranks second for environmental science publications in ES&T after the United States, followed by Canada, Germany, and the UK.

JES published 4797 research articles and reviews between 2001 and 2019, with the number of papers published in this journal rising from 92 in 2001 to 331 in 2019. JES is also becoming increasingly internationalized. One of the journal's current editor-in-chiefs, Prof. X. Chris Le, an internationally renowned expert in field of environmental science, actively promotes internationalization of the journal. Authors from 84 countries or world regions have contributed 1602 papers published by JES (33.4% of the total number of published papers), and the United States, Japan, Canada, India, and South Korea were the top five countries. Whereas JES published only 21 papers contributed by international authors in 2001, this figure had risen to 122 by 2019. The proportion of international papers showed a fluctuating but rising trend from approximately 20% in 2001 to approximately 40% during the latter part of this period, approaching 50% in 2017. In addition, the impact factor (IF) of JES, which reflects the extent of its internationalization and international influence, evidenced a rapid increase during the study period. In 2003, JES had an IF of 0.255, which rose to 1.412 in 2009, subsequently rising exponentially to 5.565 in 2020, which indicates the status of JES as a leading international journal in the environmental field. JES currently ranked globally as JCR-Q1 in the environmental sciences.

During the period 2000–2019, China's scientific research institutions also made substantial progress. We analyzed and compared the number of papers contributed by the top 10 independent author-affiliated institutions that generated the largest numbers of papers published in ES&T during two separate periods: 2000–2019 and 2015–2019. Between 2000 and 2019, five of these top institutions were from the United States, two were from Switzerland, and two were from China. Of the two Chinese institutions, RCEES ranked fourth and Peking University ranked tenth. However, when we limited our analysis to papers published by ES&T over the last 5 years, RCEES ranked first and Nanjing University, Tsinghua University, and Peking University ranked third, fourth, and sixth, respectively. Over the past 20 years, researchers affiliated with RCEES have published 493 papers, in total, in ES&T, accounting for 10.7% of all of the journal's papers authored by researchers in China.

https://doi.org/10.1016/j.jes.2021.07.032

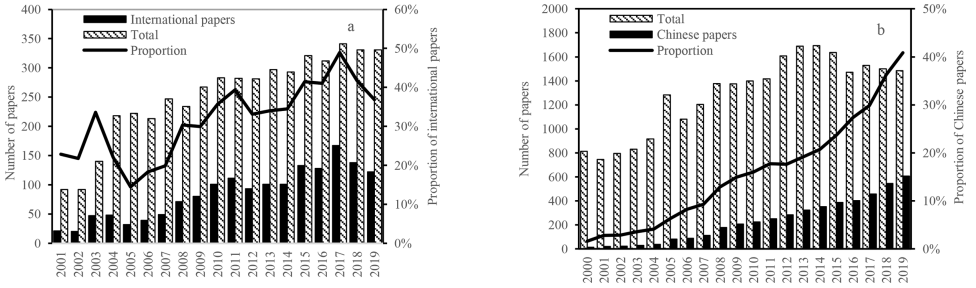

Fig. 1 – Trends relating to papers published in JES (a) and ES&T (b).

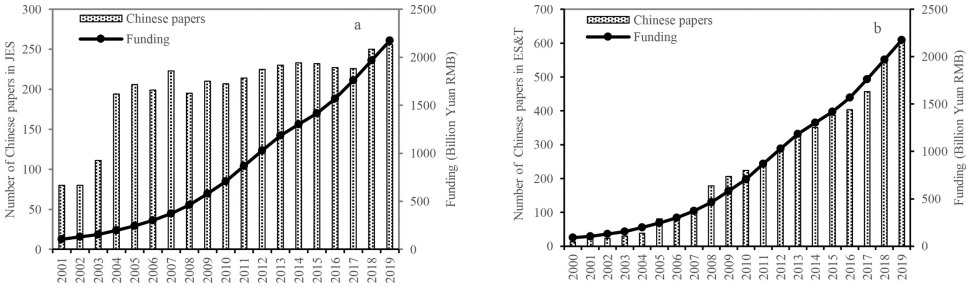

Fig. 2 – The relationship between funding and the number of papers in JES (a) and ES&T (b).

The number of papers from RCEES increased from 1 in 2000 to 59 in 2019, with a compound annual growth rate of 24.0%.

The Journal Normalized Citation Impact (JNCI) of a single publication is the ratio of the actual number of citing items to the average citation rate of publications in the same journal in the same year and with the same category of papers. The JNCI of ES&T papers published by researchers in China was 1.31, whereas the JNCI of JES papers published by Chinese researchers were 1.02 during the period 2000–2019. Both of these ratios were slightly higher than the overall JNCIs for the two journals' papers. These data show that the citation impacts of papers from China were above the mean, and, on average, they have had more impact than other papers published in ES&T and JES.

The development of scientific research and article output are affected by many factors. Scientific research inputs, which support the continuing progress of research institutes and universities, are among the main driving forces behind their article outputs. We analyzed the relationship between funding and the number of papers published. The results of our analysis are shown in Fig. 2.

According to data sourced from the Statistical Bulletin of China's Science and Technology Investment, over the past 20 years, China's scientific research funding increased from 89.6 billion Yuan RMB in 2000 to 2173.7 billion Yuan RMB in 2019, indicating a 24.3-fold increase with a compound annual growth rate of 18.27%. We applied the Pearson correlation coefficient in an analysis of the association between research funding and the number of papers published in ES&T by Chinese researchers and found a strong positive correlation ($r = 0.994$, $p = 0.01$). We also found a positive correlation ($r = 0.712$, $p = 0.01$) between research funding and the number of papers from China published in JES. Our analysis of specific funders revealed that the research reported in 2910 papers published in ES&T was funded by China's Natural Science Foundation (NSF), accounting for 62.9% of the 4623 papers from China published in this journal. Comparable figures for JES were 1733 papers funded by NSF, accounting for 45.6% of the 3798 papers from China published in this journal.

Another driving force behind article publication is collaborative research conducted across different institutions. From 2001 to 2019, researchers in China published a total of 2981 papers in ES&T and JES in collaboration with researchers from nearly 100 countries and world regions. The number of co-authored papers published in ES&T increased 67.2-fold from 5 in 2000 to 336 in 2019 at a compound annual growth rate of 24.79%. Moreover, the total number of papers from China published in ES&T and the number of jointly authored international papers evidenced a strongly positive correlation ($r = 0.996$, $p = 0.01$). The number of jointly authored papers published in JES increased 5.2-fold from 9 in 2001 to 47 in 2019 at a compound annual growth rate of 9.6%. The total number of papers from China and the number of jointly authored international papers published in JES were also positively correlated ($r = 0.794$, $p = 0.01$).

To assess the role of collaboration, we used the UCINET software (version 6) to analyze the number of papers coauthored by Chinese and international researchers (Fig. 3). The US, Canada, Australia, Japan, Germany, and the UK were the countries that collaborated most frequently with China. Collaborative projects leading to co-authored papers published in ES&T and JES have mostly involved Chinese and American researchers, with such papers comprising nearly 20% of all of the papers with Chinese co-authors. Furthermore, the number of collaborations has expanded over time.

The situation regarding jointly authored papers differs slightly for the two journals. The top five countries, as the researchers' countries of origin, with the highest number of joint

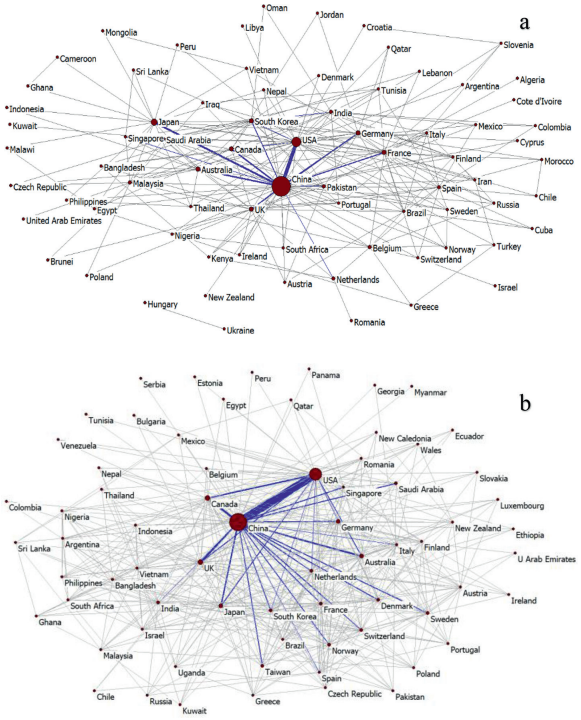

Fig. 3 – Network of joint papers published in JES (a) and ES&T (b).

publications with Chinese authors in ES&T were the United States (1464), Canada (268), the UK (211), Australia (192), and Japan (149). The top five countries, as the researchers' countries of origin, with the highest number of joint publications with Chinese authors in JES were the United States (194), Japan (77), Australia (59), Canada (50), and Germany (46). International collaboration has greatly contributed to the progress of research in the field of environmental science in China and should be further strengthened through efforts aimed at addressing global environmental problems.

The KeyWords Plus was used to identify research trends in ES&T and JES. The most frequent KeyWords Plus were *water, adsorption, oxidation*, and *degradation* in ES&T in the past 20 years. Water was the most prominent research topic among Chinese researchers. The exposure, toxicity, adsorption, degradation, and removal of pollutants, such as organic compounds and heavy metals, in wastewater and drinking water are serious environmental concerns.

Over the study period, water and soil research has been a focus in JES, which accords with the research areas prioritized by ES&T. The adsorption, accumulation, degradation, and removal of pollutants, such as heavy metals, in water and soil were central concerns in papers published in JES, and their proportion continues to grow. Other pollutants, such as polycyclic aromatic hydrocarbons, were also foregrounded from 2005 to 2014, but the proportion of papers focusing on this research area has declined in recent years. Moreover, the frequency of appearance of new keywords, such as *nanoparticles* and *activated carbon*, has increased significantly, thus indicating a strong research focus on new technologies and materials for removing pollutants.

In general, the number and quality of papers published by researchers in China has markedly increased in the last 20 years. The rising number of papers published by Chinese researchers in ES&T and the increasing internationalization of JES indicate that China has made remarkable progress in the field of environmental science research and that the international influence of JES is expanding. The overall level of China's science and technology has greatly improved. Some important fields have entered the world's advanced ranks, and others reflect a shift from a background position to a central one. The advance of science and technology in China thus demonstrates a major leap forward.

Rongrong Lei
Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing 100085, China
University of Chinese Academy of Sciences, Beijing 100049, China

Ying Xing*
Institutes of Science and Development, Chinese Academy of Sciences, Beijing 100190, China

Wenbin Liu*
Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing 100085, China
Hangzhou Institute For Advanced Study, UCAS, Hangzhou 310024, China
University of Chinese Academy of Sciences, Beijing 100049, China

*Corresponding authors.
E-mails: xingying@casisd.cn (Y. Xing), liuwb@rcees.ac.cn (W. Liu)