Bibliometrics of Alkaloid Chemistry Research in India

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This paper attempts at quantitative and qualitative assessment of alkaloid chemistry (a subgroup of organic chemistry) research in India as viewed through *Chemical Abstracts*. While focusing on World output *vis-a-vis* Indian output in terms of publications, this paper identifies the centers of excellence of alkaloid chemistry research, the research groups involved, and their channels of communication, besides studying the citedness of Indian work. Alkaloid chemistry research performed in India is found to be fairly collaborative and part of main stream science.

INTRODUCTION

Organic chemistry research in India has a long history. It is an intellectual activity leading to basic research and a scientific field that can be used to fulfill industrial needs. At present, most of the universities, institutions of higher learning, and government-funded R&D institutions have large organic chemistry laboratories. In a study carried out by Nagpaul and Pant[1] of cross-national assessment of specializations in chemistry, organic chemistry emerges as one of the strong areas of research in the chemical sciences in India. There are several scientometric studies[2] in organic chemistry both in international and national context, besides one study on Indian chemists.[3] Individual studies of subgroups of organic chemistry are, however, few.[4] Though these subfields are touched upon in the earlier studies[2] of organic chemistry, full justice could not be done to them in terms of detailed analysis. A quantitative assessment of the state of knowledge of such groups would throw light on India's performance in such small specialities. In fact, it is the current trend to study narrow specializations in order to get an in-depth state of knowledge.[5]

In two of the above mentioned organic chemistry studies,[2] "alkaloids" has emerged as one of the strongest areas of Indian organic chemistry research. This has prompted us to take up this speciality as a subject of our study.

Alkaloids are a nitrogenous base of plant, animal, or microbial origin, with typically characteristic physiological activity. This paper attempts at quantitative and qualitative assessment of alkaloid chemistry research in India with the primary focus on the following:

(a) World output *vis-a-vis* Indian output in terms of the number of publications for 1971−1989 with an interval of one year;
(b) Identification of the centers of excellence in India based on publications and citations;
(c) Identification of research groups around whom the research activity is concentrated;
(d) Identification of channels used for communication;
(e) Citedness of Indian work in international literature.

DATA AND METHODOLOGY

Being the only comprehensive international abstracting service in the field of chemical sciences, *Chemical Abstracts* (CA) has been chosen the source of data for this study. CA has divided its organic chemistry section into 14 subfields, of which "Alkaloids" is one. In 1986, CA covered 288 Indian journals and India accounted for 3.4% of the journal literature covered by CA and maintained its 7th position as a contribution of journal literature. Indian chemistry papers account for 3% of the CA files in 1981.[6] Moreover, previous studies have shown that most of the Indian scientists prefer to publish their work in foreign journals.[3,7] This supports the argument for considering the Indian literature reported in CA as representative of the Indian output in chemical sciences. The in-depth classification of chemical literature in CA also makes it convenient to study the growth of narrow specialities.

Under the subhead "Alkaloids" in CA, synthesis, reactions, physical organic studies, characterization, and structure studies of alkaloids, along with their analogues and intermediates, are included. Terpenoid and peptide alkaloids are also included in it.

In order to estimate the Indian contribution in alkaloid chemistry research one could directy have obtained the data on Indian publication output from the STN international on-line service. With the cost of an on-line search being quite high, a low-cost, manual scanning approach has been followed. Unfortunately CA has no corporate index, and one has to search entry by entry to identify papers from India. Therefore, each of these abstracts from all the issues from 1971 to 1989, taking alternate years, containing an organic chemistry section was carefully scanned and an index card was prepared for each Indian article. The following information was recorded, apart from the total number of abstracts:

i. authors and affiliation of first author;
ii. title (for finding out nature of work);
iii. documents with full bibliographic details;
iv. nature of the document, i.e., review, proceedings, report, patent, etc. and in case of patents, patent number, date, and year of acceptance.

After duly processing the information, data were subjected to a detailed analysis. For classification of papers according

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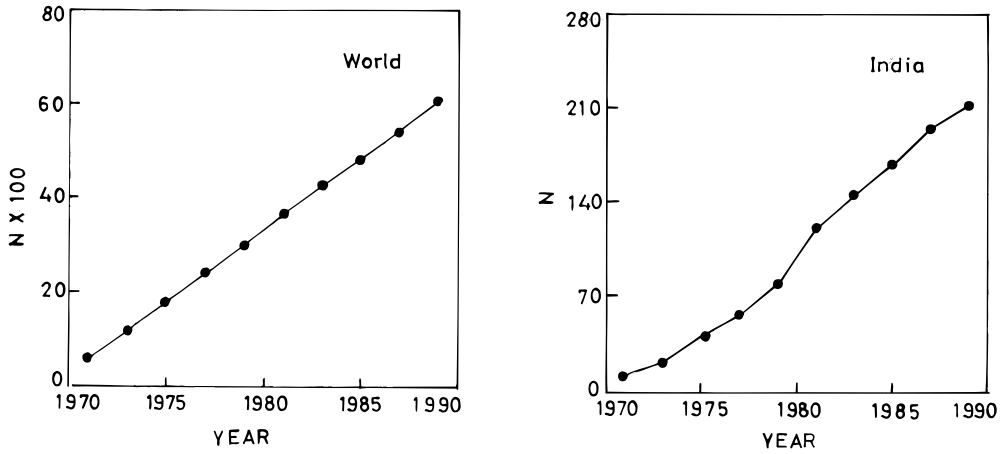

Figure 1. Growth of World and Indian Literature during 1970−1990.

to their subjects, generally the title of the paper was sufficient to ascertain it. In some cases we had to go through the abstracts.

A citation for each article was examined in annual Science Citation Index (SCI) for three years subsequent to the appearance of the source article. The three-year time lag was chosen to maximize the opportunity for an article to be cited because a typical article reaches its peak citation rate after approximately three years.[8] However, it would have been better to have a five year period as the citation window, because papers coming from developing countries or less known laboratories or authors need more time to get to their citation peak.

RESULTS AND DISCUSSION

World Output vs Indian Output. During 1971−1989 Indian scientists published 214 papers (3.5%) of the world ouput, slightly higher than the average Indian output in chemistry. To compare India's performance with the world's performance, we have used the Activity Index, first suggested by Frame[9] and used among others such as Bujdoso and Braun[10] and Garg and Sharma.[11]

The Activity Index (AI) characterizes the relative research effort of a country to a given subject field. It is defined as

$$\text{AI} = \frac{\text{given field's share in the country's publication output}}{\text{given field's share in the world's publication output}}$$

$$\text{mathematically AI} = \frac{n_{ij}/n_{io}}{n_{oj}/n_{oo}} \times 100$$

where n_{ij} is the Indian output of papers in a particular field; n_{io} is the total Indian output on all fields; n_{oj} is the world output of papers in a particular field; and n_{oo} is the total world output in all fields. AI = 1 indicates that the country's research effort in the given field corresponds precisely to the world's average. AI > 1 reflects higher activity than the world's average, and AI < 1 indicates lower than average effort dedicated to the field under study.

In the present context, AI for India has been calculated for different years to see how India's performance changed during different years by using the above formula but in a modified way. Here AI is given by the following:

$$\frac{\text{Indian output in a particular year/total Indian output}}{\text{world output in a particular year/total world output}} \times 100$$

Table 1. World Output vs Indian Output during 1971−1989 in "Alkaloids"

year	wold output	Indian output	activity index
1971	590	11	53.04
1973	584	10	48.72
1975	626	21	95.45
1977	607	15	70.92
1979	585	24	116.67
1981	680	41	171.47
1983	620	25	114.70
1985	533	22	117.43
1987	617	27	124.44
1989	653	18	78.42
total	6089	214	

The results of the AI are given in Table 1. It indicates that India's research effort in alkaloid chemistry is lower than the world during 1971, 1973, 1975, and 1977. But during the next five years, viz., 1979, 1981, 1983, 1985, and 1987 it has picked up and is higher than the world reaching its peak in 1981. The average AI for India for 1971−1989, however, is 99 which indicates that India's research effort in alkaloid chemistry corresponds precisely to the world's average.

Other features of output, as reflected by the plots of the cumulative output for world and India, indicate almost constant increase. Output for the world as well as for India peaks in the same year, i.e., 1981 (Figure 1).

Centers of Excellence. Two hundred fourteen publications have come from 35 institutions. Of these, 120 (56%) have been contributed by academic institutions including deemed universities, 83 (39%) by government-funded R&D institutions and the remaining 11 (5%) by private R&D institutions. Institution-wise output is given in Table 2. Institutions listed in Table 2 have contributed about 68% of the total Indian output. Table 2 indicates that except for the Central Drug Research Institute, Lucknow, all other institutions listed do not have much variation in the output as it varies between 5 and 8% of the total Indian output.

We calculated the Relative Citation Rate (RCR) for all of the institutions listed in Table 2 to overcome the bias in the communication channels used by different institutions.

Table 2. Institution Wise Distribution of Papers

Sl no.	institution	no. of Papers (%)	Citations			relative citation rate (RCR)
			self	others	total	
1.	Central Drug Research Institute (Lucknow)	33(15.4)	19	47	66	1.00
2.	Presidency College (Madras)	16(7.5)	5	36	41	1.64
3.	Punjab University (Chandigarh)	16(7.5)	9	31	40	0.81
4.	University of Pune (Pune)	16(7.5)	11	28	39	0.46
5.	University College of Sciences (Calcutta)	15(7.0)	6	17	23	0.62
6.	Bose Institute (Calcutta)	14(6.5)	7	13	20	0.77
7.	Allahabad University (Allahabad)	13(16.1)	8	17	25	1.04
8.	Regional Research Laboratory (Jammu)	12(5.6)	1	15	16	0.96
9.	University of Rajasthan (Jaipur)	10(4.7)	2	12	14	1.00

Table 3. Research Groups Active during 1971−1989

Sl. no.	group Leader and institution	papers	collaborative coeff (CC)	relative citation rate (RCR)
1.	Bhakuni, D. S. Central Drug Research Institute (Lucknow)	20	0.59	0.98
2.	Chakraborty, D. P. Bose Institute (Calcutta)	12	0.66	0.86
3.	Tewari, K. P. Allahabad University (Allahabad)	12	0.49	1.40
4.	Pai, B. R. Presidency College (Madras)	12	0.64	2.44
5.	Kessar, S. V. Punjab University (Chandigarh)	10	0.65	0.79
6.	Kapil, R. S. Central Drug Research Institute (Lucknow)	9	0.59	1.02
7.	Narasimhan, N. S. University of Pune (Pune)	9	0.60	0.51
8.	Atal, C. K. Regional Research Laboratory (Jammu)	8	0.68	0.94
9.	Govindachari, T. R. CIBA (Bombay)	8	0.51	0.75
10.	Parkashi, S. C. Indian Institute of Chemical Biology (Calcutta)	8	0.64	0.75
11.	Joshi, B. C. University of Rajasthan (Jaipur)	8	0.71	1.13
12.	Chatterjee, A. University College of Sciences (Calcutta)	7	0.49	0.42
13.	Mali, R. S. University of Pune (Pune)	6	0.58	1.14

RCR[12] is defined as the ratio of actual citation rate of the paper(s) to the average citation rate of the journal in which the paper(s) has been published. The value of RCR equal to 1 indicates that the paper(s) received as much citations as it was expected to get. RCR > 1 indicates that the paper(s) received more citations than expected, and RCR < 1 indicates fewer citations than expected.

Among the institutions listed in Table 2 only four institutions, viz., Central Drug Research Institute (Lucknow), Presidency College (Madras), Allahabad University (Allahabad), and University of Rajasthan (Jaipur), could obtain citations either more or equal to what these institutions were expected to get, and for the remaining five the value of RCR indicates that these institutions got fewer citations than what they were expected to get.

Research Groups around Whom the Research Activity Centers. Significant modern research and development is a collective activity generally conducted by a group rather than by a single individual. The research groups active in this field and around whom the research activity centers are given in Table 3. These research groups in all contributed 129 (60%) papers which is quite significant as compared to the total Indian research output in this field.

We also studied the pattern of collaboration of these research groups. To measure the extent of collaboration different authors have suggested different measures. For instance, Lawani[13] suggests the use of Collaborative Index (CI), while Subramanyam[14] suggests the use of the Degree of Collaboration (DC) to measure the strength of collaborativeness in a discipline. However, Ajiferuke[15] points out that these two measures are inadequate and suggests a single measure, which incorporates some of the merits of both and calls it Collaborative Coefficient (CC). Mathematically

$$\mathrm{CI} = \sum_{j=1}^{j=k} JF_j/N$$

$$\mathrm{DC} = 1 - f_1/N$$

where f_1 is the number of single author papers

$$\mathrm{CC} = 1 - \sum_{j=1}^{j=k} (1/J) f_j/N$$

where f_j is the number of J authored papers published in a discipline during a certain period of time, N is the total number of research papers published in a discipline during a certain period of time, and K is the greatest number of authors per paper in a discipline.

The value of the Collaborative Coefficient for different authors does not indicate much variation among different

Table 4. Most Commonly Used Journals for Publishing Research Papers in "Alkaloids"

Sl. no.	title of the journals	impact factor	no. of papers
1.	*Ind. J. Chem. Sect. B* (India)	0.281	64
2.	*Phytochemistry* (U.S.A.)	1.205	17
3.	*Tetrahedron Lett.* (U.S.A.)	2.080	15
4.	*Tetrahedron* (U.S.A.)	1.756	14
5.	*J. Ind. Chem. Soc.* (India)	0.108	11
6.	*Chem. Ind.* (U.K.)	0.329	9
7.	*Hetrocycles* (Japan)	0.873	7
8.	other 28 publications		77
	total		214

research groups (Table 3). However, for A. Chatterjee and R. S. Mali it is lowest (0.49) and for B. C. Joshi it is highest (0.71). This indicates that alkaloid chemistry research in India is fairly collaborative. The value of RCR for all these members indicates that B. R. Pai got twice as many citations as he was expected to get. The other four members, viz., K. P. Tewari, R. S. Kapil, B. C. Joshi, and R. S. Mali got more citations than expected. The remaining authors got fewer citations than expected.

Communication of Research Results. Publication in science serves as a means of communication among members of the scientific community. Scientists use different modes for communicating their research results. However, important among them being the articles in journals. Of the 214 publications, 192 (90%) appeared in journals and were scattered in 21 foreign and 11 Indian periodicals. The remaining 22 communications were spread among reviews and books, patents, reports, plenary lectures, and proceedings. The number of each was 15, 4.2, and 1, respectively.

The result of communication in various modes has been accepted as output indicators of scientific activity, although each of them is rated differently by the readers. For instance, literature appearing in international journals has a wider readership possibility and hence reflects higher potential connectivity compared to that appearing in Indian journals as the former has a larger circulation. Further, papers appearing in SCI covered journals indicate mainstream readership. Based on these indicators we analyzed publication data and found that of the 192 papers published from India in periodical literature 92 (48%) are in Indian journals and the remaining 100 (52%) are in journals published from abroad. Among the journals originating from abroad, 56 (56%) papers are in journals from the U.S.A., 17 (17%) are from the U.K. and 7 (7%) are from Japan. The remaining 20 (20%) papers are in journals published in Germany, Switzerland, Poland, Czechoslovakia, and Hungary. Table 4 lists Indian and foreign journals most commonly used by Indian scientists for publishing their research results.

Regarding the coverage of papers in SCI covered journals, of the 192 papers, 173 (90%) were in SCI covered journals, of which 93 (54%) papers were in SCI covered foreign journals and 80 (46%) were in SCI covered Indian journals. Thus, the number of papers in SCI covered journals is nine times the number of papers published in non-SCI covered journals. The number of papers published in SCI covered foreign journals is almost equal to the number of papers published in SCI covered Indian journals. This publication pattern indicates that information on a substantive part of the Indian alkaloid chemistry research is accessible to the international scientific community although the major portion of it is published in the *Indian Journal of Chemistry*.

Impact Factor of the Journals. The impact factor is an indicator of the quality of the journal and the work published in it. If a paper is published in a journal of higher impact factor, then the possibility of getting it noted by the scientists in the concerned field is greater. Out of the 192 papers which appeared in journals, 110 (57%) appeared in journals whose IFs were between 0 and 1; 42 (22%) appeared in journals with an IF $> 1 < 2$, and the remaining 21 (11%) were in journals whose IFs were >2. Although, data for international output in alkaloid chemistry in journals with IF > 2 is not available, however, from the number of papers appearing in high impact factor journals in organic chemistry, the percentage of Indian papers in high impact factor journals is low.

Citedness of Research Papers. While publication counts measure output, citation counts are considered to go one step further and address questions of quality, influence, and transfer of knowledge. However, as a subject, citation analysis remains controversial. It has been attacked on various grounds and has some inherent problems. The nature of citations (self or others) and the number of citations received by a paper in international literature is an indication of the international standing of the research work. Citation characteristics as to how quickly a paper will be cited, how long the citation rate will take to peak, and how long the paper will continue being cited vary significantly from one

Table 5. Highly Cited Authors

Sl. no.	authors and institution	journal	no. of citations
1.	Guha, K. P. et al. B. C. Royal Institute of Basic & Med. Sci. (Calcutta)	*J. Nat. Products* **1979**, *42*, 1−84	14
2.	Mohanraj, S. et al. Presidency College (Madras)	*J. Chem. Soc. Chem. Commun.* **1978**, *10*, 423	9
3.	Kessar, S. V. et al. Punjab University (Chandigarh)	*Tetrahedron* Lett. **1974**, *26*, 2269−70	9
4.	Kessar, S. V. et al. Punjab University (Chandigarh)	*Tetrahedron Lett.* **1977**, *17*, 1459−62	9
5.	Rajeshwari, S. et al. Presidency College (Madras)	*Collect Czech. Chem. Commun.* **1977**, *42*, 2270	9
6.	Govindachari, T. R. et al. CIBA (Bombay)	*Tetrahedron* **1973**, *29*, 891	6
7.	Suguna, H. et al. Presidency College (Madras)	*Ind. J. Chem. B* **1977**, *15B*, 416	6
8.	Pandey, G. et al. Allahabad University (Allahabad)	*Hetrocycles* **1981**, *16*, 449	6
9.	Bhattacharya, A. et al. Indian Institute of Chem. Bio (Calcutta)	*Tetrahedron Lett.* **1986**, *27*, 1215	6

field to another. The results of the citation analysis of the papers indicate that 31% of the papers did not receive any citation in the subsequent three years of the publication of the paper. Fifty-eight percent of the papers received between 1 and 4 citations, and the remaining 11% of the papers received either 5 or more citations. The list of papers receiving more than 5 citations is given in Table 5. When a whole set of papers was taken into consideration, the 214 communications were found to receive 409 citations with an average of 2.

In one study, the average citation rates for the six most prolific chemists is reported as being between 2.2 and 13.2.[16] In our study citations per paper of six prolific research groups range between 1.2 and 3.7.

Self-citation. Self-citation is sometimes seen as suspect, though there are many reasons for self-citations to be desirable or even necessary. The rise in self-citations indicates a fewer number of researchers in the field. Excess self-citations show the field is new.[17] In our study self-citations ranged from 6% to 35% which is slightly higher than the average of self-citation (30%) observed.[18]

Citation Lag. Citation lag is the time elapsed between the publication of the paper and its being cited. The lag in citation is an indication of the degree of current relevance of the research work to the specific field of knowledge.[19] By examining papers that become highly cited shortly after publication, one can often identify the so called "hot spots" in the subject areas of research that are currently of special interest.[19] Of the 214 communications published, 148 papers received 409 citations within three years of publication of the article. The quick rate of citations in international literature indicates that Indian research in alkaloids has been a part of main stream science.

CONCLUSIONS

1. Activity Index of Indian alkaloid research increased significantly during 1979 to 1987, reaching at its peak in 1981. Average activity index was, however, at par with world average.

2. The productivity of most of the research institutions varied between 5 and 8% of the total Indian research output. However, CDRI (Lucknow) was most productive among them with about 16% of the total Indian research output.

3. The Collaborative Coefficient of different research groups does not vary significantly, and the values of Collaborative Coefficient for different research groups indicate that alkaloid chemistry research is fairly collaborative.

4. As reflected by the pattern of publications and citations, Indian alkaloid chemistry research forms a part of main stream science; however, major portion of the research results have appeared in Indian and low impact factor journals.

5. The research centers as well as the research groups active in this area had fewer citations than was expected.

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