Publications of Banaras Hindu University during 1989-2016: A Three-dimensional Bibliometric Study

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ABSTRACT

A3-D bibliometric evaluation of Banaras Hindu University (BHU), Varanasi is reported in this study. Data was retrieved from Web of Science, Science Citation Index-Expanded for the period 1989-2016. A total 16556 records are included in this study. Exponential growth of publications is seen since 2005. Chemistry has maximum publications, followed by Physics. Current Science published maximum research publications of BHU. Council of Scientific & Industrial Research is the main collaborator of BHU with 443 publications, followed by Defence Research and Development Organisation with 280 publications. BHU's main collaborator country is USA with 607 publications, followed by Germany with 471 publications. Maximum consistency (0.40) in international collaboration is seen with Nepal, whereas minimum consistency observed with England. Maximum consistency of publications is seen 1995. Highest consistency (0.37) is seen in sub-field electrochemistry. Sepectrochimica acta Part A has highest consistency (0.53), while Astrophysics and Space Science has lowest (0.19) consistency.

Keywords: Three-dimensional study; Banaras Hindu University; BHU; Collaboration

1. INTRODUCTION

The institutions belonging to the higher education sector taken together are the biggest contributors to India's academic research output. University rankings are now taken seriously. The first global university rankings became available in 2003 by Shanghai Jiao Tong University, now known as the Academic Ranking of World Universities (ARWU). Three Indian institutions appeared in the world rankings in 2003 were Indian Institute of Science (IISc), Bengaluru in the 251–300 bracket and the Indian Institutes of Technology (IITs) at Delhi and Kharagpur in the 451–500 bracket. The Shanghai ARWU rankings are based mainly on research indicators, as are many other similar rankings, e.g. the Leiden rankings, the Taiwan Higher Education Accreditation Evaluation Council University Ranking, and the EU Assessment of University-Based Research. The European University Association report confirms that most international rankings focus predominantly on indicators related to the research function of universities. It is therefore meaningful in the present exercise to focus on the research contributions of higher educational institutions (HEIs) in India[1-2].

These research-intensive institutions belonging to the higher education sector are the biggest contributor to India's academic research output. Measuring scientific research competence of institutions has always been considered a challenging but useful exercise. It is now generally accepted that institutions of higher education and research need to be subjected to some benchmarking process or performance

evaluation time to time which highlighted the strength and inspire to hold rank nationally and globally[3-4].

In India the National Institutional Ranking Framework (NIRF) approved by Ministry of Human Resource and Development ranked the universities across the country based on 'Teaching, Learning and Resources,' 'Research and Professional Practices,' 'Graduation Outcomes,' 'Outreach and Inclusivity,' and 'Perception'. Banaras Hindu University ranked third among top universities in the NIRF.

In recent years, three dimensional (3-D) bibliometric analysis has been used by Prathap[5] to identify the leading countries, organisations and authors and the most influential journals in the area of monsoon research. A bibliometric profiling of Current Science based on quantitative indicators identified the most productive authors, cities and states that have published articles and notes in Current Science in the recent past[6]. Dwivedi[7] evaluated Indian dengue research and global dengue research[8] through the primary 3-D measures of quality, quantity, consistency and two secondary indicators, the h index and z index. In the present paper. Author made an attempt to evaluate research performance of the Banaras Hindu University using a 3-D method. The data for the study was retrieved from Web of Science database for the period 1989 to 2016.

Research performance is modelled by a simple heuristic 'thermodynamic' model[9-11] that complemented the quantity and quality dimensions with a third dimension, consistency, η, to allow a better 3-D evaluation of the information-production process. The parallel used was the '3Vs' metaphor of Laney[12] on 3-D data management, in which the number of papers, P,

indicated volume; the quality (or impact i), as measured by the ratio C/P, where C is the total number of citations received by P papers, indicated the velocity with which the ideas in P papers are communicated through citations C, and consistency η indicated the variety (variability) in the quality of the individual papers in the publication set or, in other words, the shape of the distribution curve. By using all three components together, a z-index can be computed from an energy-like term ($Z = \eta$ X $= \eta^{2E}$) as $z = Z^{1/3}$, which has the same dimensions as the number of publications. X is energy and E is energy[5-6], so it is possible to imagine a phantom indicator named *zynergy* for $Z = \eta$ X $= \eta^{2E}$. This phantom index combines quantity, quality, and consistency (or efficiency) in the true spirit of 3D evaluation. The accurate calculation of consistency (η) requires the complete citation sequence, (i.e. the distribution curve) for country, organisation, author or journal.

2. THREE-DIMENSIONAL EVALUATION TOOLS

Several indicators have been used to express performance of scientific output of an individual, institution, or an entity. Scientific performance of individual or an entity can be measured by using different parameters.

2.1 Quantity

Number of papers/articles 'P' published during a prescribed window will be called publication window (for this study the window is from 1989 to 2016). A five-year citation window is considered for each year.

2.2 Quality and Consistency

Quality denotes citation per paper, calculated as C/P where C is the number of citations during a prescribed citation window. The quality measurement needed two separate windows, the publication window and the citation window. In 3-D evaluation of performance measurement after computing quantity P and quality i parameters, it is possible to derive other indicators by following these sequences. $P = i^0 P$ (zeroth-order indicator), $C = i^1 P$ (first-order indicator), $X = i^2 P = iC$ (second-order indicator), where $C = \Sigma c_j$, $j = 1$ to P.

C is derived from complete citation sequence, c_j of the citation of each paper in a publication portfolio of P papers as the total number of citations, $C = \sum c_j$, for $j=1$ to P. Both P and C serve as indicators of performance in their respective ways. If $C=iP$ may be assumed as the first-order indicator for performance, the exergy indicator $X = i^2 P$, is an energy like quantity which serves as a second order indicator of performance. This model leads to a trinity of energy- like terms[5, 13-14]

$$X = i^2 P, E = \Sigma c_j^2, S = \Sigma (c_j - i)^2 = E - X.$$

The h-index is observed by ordering the citation in a decreasing sequence[15]. Highly cited papers are seen to be concentrated in a small region, possibility of huge variation in the quality of papers in the publication set. According to Prathap[11], in case of high skews, the product $X = iC = i^2 P$, which is a second-order indicator is a better proxy for performance than C itself. Apart from X, an additional indicator E also appears

as a second-order indicator as seen above. The existence of both proxies X and E allows to introduce third proxy named as consistency (variability) $\eta = X/E$. When $X = E$, i.e., $\eta = 1$, the condition indicates for the perfect consistency means uniform performance (all papers have the same number of citations, $c_j = c$). The inverse of consistency gives the concentration of best work in few papers of extraordinary impact. Thus, for a complete 3-D evaluation of publication activity, one needs P, i, and η. These are the three primary components of a quantity-quality-consistency landscape.

3. METHODOLOGY

Data is retrieved from Science Citation Index-Expanded for Organisation=(Banaras Hindu University) for the period 1989-2016. Data downloaded in Excel sheets on various parameters that needed to unfold the data three-dimensionally. From all the related articles P and Citation C are computed for this study. Then all the indicators quality, quantity, consistency for various year, various subject field and collaborative countries are counted on excel sheets. By using all the three indicators together, z index can be calculated from an energy like term ($Z=\eta X= \eta^2 E$). This z index is the combination of quantity, quality and consistency (or efficiency), provide truly 3D evaluation of scholarly publications. It may be assumed P, i and η as primary indicators and h and z index are secondary, composite indicators.

4. RESULTS AND DISCUSSIONS

A total of 17367 records are retrieved. These records included all types of documents like articles, article proceedings, article book chapter, biographical item, book review, corrections, discussions, editorial materials, letter, meeting abstract, news items, notes, reprints, review. The total 16556 records covering articles, article proceedings, letter, and reviews are taken in this assessment. The strategy was extended with refine selection for various particular disciplines, collaborative institutions and collaborative countries.

4.1 Growth

Figure 1 shows the yearly publication of BHU. Maximum (1000) publications are observed in 2013, whereas minimum (200) publications are seen in 1995.Figure also shows that publications were nearly constant for the period 1989 to 2005 except the year 1995 where dip was observed. Exponential growth is seen since the year 2005. The many vacant seats of faculty members were filled at that time (2004-05) might be
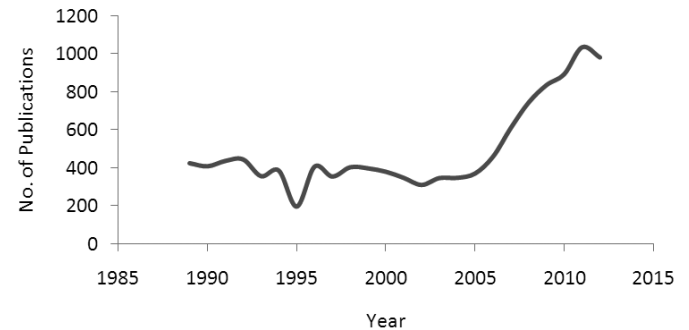

Figure 1. Yearly growth of BHU.

the reason for exponential growth after 2005.

Table 1 describes the yearly distribution of three primary bibliometric components viz, quantity (P), quality (i) and consistency (η) with two sub indices h and z-index. Maximum consistency is seen in the year 1995. The value of h-index is highest in 2011 while the value of z-index is highest in 2012. The list with the year 2012, as articles, articles proceedings, reviews, letter and notes of more recent origin would not have had enough time to collect a reasonable number of citations. For this reason, the list has been terminated with the year 2012. A five-year citation window is considered to be reasonable from this point of view. For each year in Table 1, a five year citation window is used for calculations of different parameters.

Table 1. Yearly distribution of values of three primary bibliometric components and the h- and z- indices for BHU

Years	P	C	i	η	h	z
1989	428	725	1.69	0.24	10	6.69
1990	412	777	1.89	0.23	11	6.94
1991	440	952	2.16	0.20	13	7.48
1992	448	978	2.18	0.35	10	9.09
1993	360	781	2.17	0.29	11	7.89
1994	389	968	2.49	0.26	12	8.51
1995	200	990	4.95	0.45	13	13.01
1996	410	1005	2.45	0.37	11	9.71
1997	358	921	2.57	0.30	12	8.91
1998	407	1554	3.82	0.13	15	9.12
1999	401	1222	3.05	0.19	14	8.94
2000	383	1191	3.11	0.34	13	10.81
2001	351	1653	4.71	0.12	16	9.82
2002	314	2180	6.94	0.06	17	9.69
2003	350	2998	8.57	0.04	19	10.20
2004	351	2325	6.62	0.11	19	11.98
2005	374	3268	8.74	0.06	23	11.85
2006	462	3824	8.28	0.15	26	16.70
2007	613	5741	9.37	0.20	32	21.91
2008	747	5842	7.82	0.22	32	21.55
2009	839	7622	9.08	0.33	40	28.28
2010	897	10209	11.38	0.12	38	23.94
2011	1038	10424	10.04	0.23	42	28.67
2012	985	10322	10.48	0.32	39	32.74

4.2 Authorship Pattern

Authorship pattern of BHU is shown in Fig. 2. From Fig. 2 it is clear that multi author published maximum papers in most years. The two author papers decreases with year, whereas mega author papers increases with year. In the present study,3 and 4 author is considered as multi author, whereas if number of author is more than 4 in a paper then it was considered as mega author.

The value of collaboration coefficient (CC) is shown in Fig. 3. For calculating the value of CC author follow the procedure given by Price and Beaver[16] and Garg and Dwivedi[17].
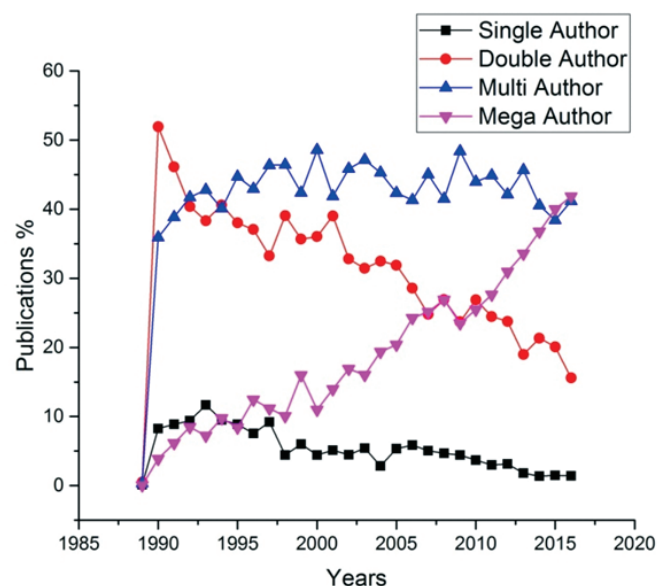

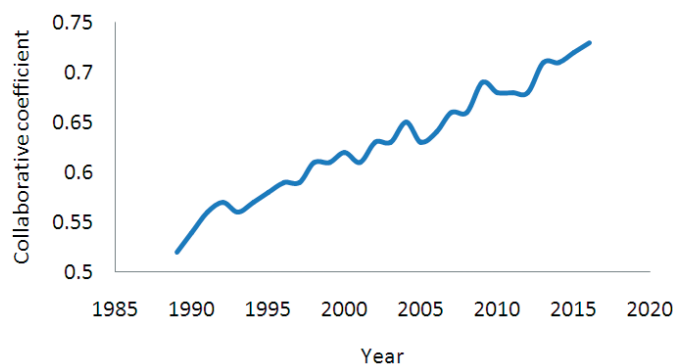**Figure 2. Distribution of authorship pattern with year.**

Figure 3. Distribution of Collaboration Coefficient with years.

The Fig. 3 shows that the value of CC above 0.5 in every year and it is exponentially increasing. According to Ajiferuke[18], CC tends to zero as single authored papers dominate and higher the value of CC, higher the probability of multi and mega authored papers. This implies that papers published by BHU are more in collaboration and collaboration pattern is continually increasing with years.

4.3 International collaboration

Table 2 lists values of three primary bibliometric components and the h- and z- indices for BHU collaborating with leading countries. Table 2 indicates that BHU's main collaborator country is USA with 607 publications, followed by Germany with 471 publications. Maximum consistency (0.40) in international collaboration is seen with Nepal, whereas minimum consistency (0.10) observed with England. Here, the maximum value of consistency is very less than 1, this indicate that none country has consistent collaborator with BHU. USA has a highest value (60) of h-index. While Israel has maximum (60.5) value of z-index. Highest quality (impact) (70.01) observed with Russia. This shows that quality of papers with collaboration with Russia is best in comparison to other papers.

Table 2. Values of three primary bibliometric components and the h- and z- indices for BHU collaborating with leading countries

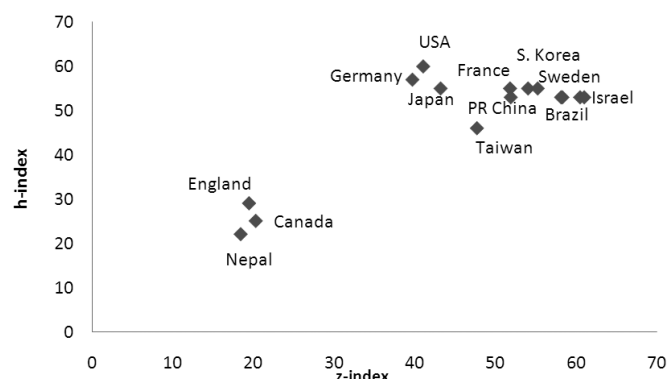| Countries	P	C	i	η	h	z
USA	607	15496	25.53	0.18	60	41.07
Germany	471	12949	27.49	0.18	57	39.73
Japan	278	10467	37.65	0.20	55	43.22
France	209	10430	49.9	0.27	55	51.83
South Korea	186	10325	55.51	0.28	55	54.07
P.R. China	182	9690	53.24	0.27	53	51.92
Sweden	175	10716	61.23	0.26	55	55.26
England	166	3562	21.46	0.10	29	19.48
Brazil	147	9499	64.62	0.32	53	58.32
Hungary	143	9344	65.34	0.32	53	58.16
Israel	135	9356	69.30	0.34	53	60.51
Russia	134	9381	70.01	0.35	53	47.73
Taiwan	128	7327	57.24	0.26	46	20.32
Canada	104	2863	27.53	0.11	25	18.45
Nepal	88	1169	13.28	0.40	22	52.36

Figure 4 summarise leading countries collaborating with BHU in z-h map. From figure it is clear that England, Canada and Nepal have lower value of z-h indices.

4.4 Institutional Collaboration

Values of three primary bibliometric components along with the h- and z- indices for BHU collaborating with leading institutes are listed in Table 3. It is clearly seen from Table 3 that CSIR is the main collaborator of BHU with 443 publications,

Table 3. Values of three primary bibliometric components and the h- and z- indices for BHU collaborating with leading institutes

Organisations	P	C	i	η	h	z
Council of Scientific & Industrial Research, India	443	3426	7.73	0.39	27	21.71
Defence Research and Development Organisation, India	280	10098	36.06	0.17	53	39.84
Indian Institute of Technology, India	255	1224	4.8	0.33	17	12.51
Centre national de la recherché scientifique, France	169	9706	57.43	0.29	55	54.71
Bhabha Atomic Research Centre, India	166	8017	48.3	0.23	49	44.78
State University System of Florida, USA	162	9545	58.92	0.30	53	55.06
University of California System, USA	152	9639	63.41	0.32	55	58.06
US Department of Energy	143	9783	68.41	0.33	55	60.26
Tokyo Institute of Technology, Japan	141	9418	66.79	0.33	53	59.29
University of Tokyo, Japan	138	9473	68.64	0.34	55	60.53
State University of Newyork Suny System, USA	133	9313	70.02	0.34	53	60.77
Oak Ridge National Laboratory, USA	133	9688	72.84	0.35	55	62.47
Columbia University, USA	130	9379	72.15	0.36	55	62.22
Yonsei University, South Korea	130	9307	71.59	0.35	53	61.64
University System of Geargia, USA	130	9318	71.68	0.35	53	61.74

Figure 4. A 2-D z-h map of leading countries in collaboration with BHU.

followed by DRDO with 280 publications. CNRS of France has 169 publications in collaboration with BHU. CSIR has maximum (0.39) consistency, whereas DRDO has minimum (0.17) consistency in collaboration with BHU. Here, the maximum value of consistency is very less than 1, this indicate that none institution has consistent collaborator with BHU. Highest quality (impact) (72.84) observed with Oak Ridge National Laboratory, USA. This shows that quality of papers with collaboration with Oak Ridge National Laboratory, USA is best in comparison to other papers written with collaboration to other institutes.

Figure 5 summarise leading institutions collaborating with BHU in z-h map. From figure it is clear that IIT and CSIR have lower value of z-h indices.

CSIR-Council of Scientific & Industrial Research (India); DRDO-Defence Research and Development Organisation (India); IIT-Indian Institute of Technology (India); CNRS-Centre national de la recherché scientifique (France); BARC- Bhabha Atomic Research Centre; USDOE-US Department of Energy (USA), UC- University of California System (USA); UT- University of Tokyo (Japan); ORNL- Oak Ride National Laboratory (USA); SUSF- State University system of Florida (USA); TIT- Tokyo Institute of Technology (Japan);
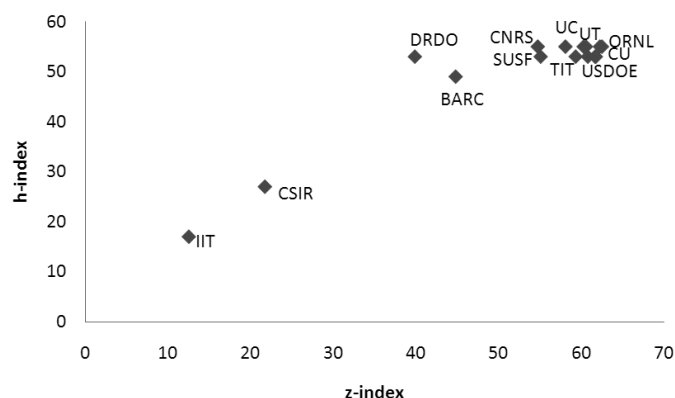
4.5 Sub-fields of the Study

Sub-field wise distribution of consistency, h-index and z-index are given in Table 4. Chemistry has maximum (2118) publications, followed by Physics with 1884 publications. Maximum consistency (0.37) is seen in sub-field electrochemistry, whereas minimum (0.09) consistency is observed in sub-field of Physics. The value (57) of h-index is highest for Physics. The quality (impact) 10.23 is maximum for Physics.

The number of papers and citations in Table 1 are more than the number of papers and citations mentioned in this table, because here we have considered only major 14 publishing sub-field.

Table 4. Values of three primary bibliometric components and the h- and z- indices for BHU in different sub-fields

Sub-fields	P	C	i	η	h	z
Chemistry	2118	15180	7.17	0.2	42	27.88
Physics	1884	19268	10.23	0.09	57	25.99
Material Science	1367	9064	6.63	0.15	40	20.61
Engineering	1137	5782	5.09	0.16	30	16.92
Biochemistry and Molecular Biology	699	4445	6.36	0.33	27	21.01
Pharmacology & Pharmacy	586	4276	7.3	0.24	26	19.49
Metallurgy Metallurgical Engineering	485	2809	5.79	0.17	20	14.00
Plant Sciences	480	2639	5.5	0.36	22	17.38
Environmental Sciences Ecology	443	3471	7.84	0.33	26	20.68
Biotechnology Applied Microbiology	410	3474	8.47	0.32	29	21.09
Agriculture	382	2497	6.54	0.31	23	17.22
Geology	378	1174	3.11	0.22	15	9.36
Mathematics	317	1087	3.43	0.18	15	8.83
Electrochemistry	300	2640	8.8	0.37	23	20.47

Figure 5. A 2-D z-h map of leading institution in collaboration with BHU.

4.6 Leading Journals

List of leading journals used by BHU for publication are shown in Table 5. Current Science published maximum research publications of BHU, followed by Spectrochimica Acta Part A and Indian Journal of Chemistry Section A. Sepectrochimica Acta Part A has highest consistency (0.53), while Astrophysics and Space Science has lowest (0.19) consistency. The maximum value of consistency indicates that paper published by BHU faculty in journal Spectrochemica Acta Part A is nearly continuous. The value of impact factor (3.17), h (26) and z-indices (24.65) are maximum for Physical Review C. The highest quality (impact) (28) for papers published in Physical Review C. The paper published in Physical Review C is better in comparison to paper published in other journals.

4.7 Prolific and Highly Cited Papers

Table 6 lists the prolific authors of BHU having publications more than 200. Maximum 346 publications are written by ON Shrivastava of Department of Physics, whereas maximum citations are received by C.P. Singh of the same department.

Table 6. Prolific Authors having publications more than 200

Name	Departments	Publications	Citations
Shrivastav O.N.	Dept of Physics	346	4578
Sundar, Shyam	Institute of Medical Sciences	338	11844
Rai, S.B.	Dept of Physics	242	4254
Singh C. P.	Dept of Physics	217	18528

Table 5. Values of three primary bibliometric components and the h- and z- indices for leading journals of BHU research

Journals	IF	P	C	i	η	h	z
Current Science	0.905	255	504	1.98	0.29	10	6.62
Indian Journal of Chemistry Section A	0.787	122	216	1.77	0.43	6	5.48
Spectrochimica Acta Part A- Molecular and Biomoloecular Spectroscopy	1.977	115	620	5.39	0.53	12	12.09
Synthesis and Reactivity in Inorganic and Metal- Organic Chemistry	0.144	103	168	1.63	0.45	6	4.97
Indian Journal of Chemistry Section B	0.689	102	241	2.36	0.4	7	6.12
Journal of theIndian Chemical Society	0.251	98	62	0.63	0.24	4	2.1
Journal of Material Science	2.163	97	375	3.87	0.44	11	8.64
International Journal of Hydrogen Energy	3.548	96	761	7.93	0.4	15	13.36
Journal of the Geological Society of India	0.567	84	145	1.73	0.25	6	3.95
Physical Review C	3.715	83	2160	26.02	0.27	26	24.65
Bulletin of Material Science		82	155	1.89	0.36	6	4.73
Microwave and Optical Technology Letters	0.585	81	222	2.74	0.33	8	5.83
Astrophysics and Space Science	2.064	80	147	1.84	0.19	9	3.73
Journal of Alloys and Compounds	2.39	60	453	7.55	0.60	12	12.73
Indian Journal of Agricultural Sciences	0.177	58	41	0.71	0.24	4	1.9

Table 7. Ten highly cited papers

Publication details	TNC
Adcox, K. *et al.*, Formation of dense partonic matter in relativistic nucleus-nucleus collisions at RHIC: Experimental evaluation by the PHENIX Collaboration, *Nuclear Physics A* 757 (2005) 184-283	1703
Kumarasamy, K.K. *et al.* Emergence of a new antibiotic resistance mechanism in India, Pakistan, and the UK: a molecular, biological, and epidemiological study, *Lancet Infectious Disease* 10 (9) (2010) 597-602	1094
Adler, S.S. *et al.* Elliptic flow of identified hadrons in Au+Au collisions at root s(NN)=200 GeV, *Physical Review Letters 91(18) (2003) 182301*	952
Adler, S.S. *et al.* Scaling properties of proton and antiproton production in root s(NN)=200 GeV Au+Au collisions, *Physical Review Letters* 91 (17:17230) (2003)	952
Adler, S.S. *et al.* Suppressed pi(0) production at large transverse momentum in central Au plus Au collisions at root s(NN)=200 GeV, *Physical Review Letters* 91 (7:072301) (2003)	952
Adcox, K. *et al.* Suppression of hadrons with large transverse momentum in central Au+Au collisions at root s(NN)=130 GeV, *Physical Review Letters* 88 (2: 022301) (2002)	809
Croft, S.L.; Sundar, S.; Fairlamb, A.H. Drug resistance in leishmaniasis, Clinical Microbiological Review 19(1) (2006) 111-126	718
Adler, S.S. Identified charged particle spectra and yields in Au plus Au collisions at root(SNN)=200 GeV, *Physical Review C* 69 (3: 034909) (2004)	586
Yo , J.J. *et al.* Ultrathin Planar Graphene Supercapacitors, *Nano Letters* 11(4) (2011) 1423-1427	501
Sharma, Y.C.; Singh, B.; Upadhyay, S.N. Advancements in development and characterization of biodiesel: A review, *Fuel* 87(12) (2008) 2355-2373	470

Table 7 lists the top ten highly cited papers of BHU. All of them are mega-authored and in international collaboration with other countries. Author from BHU are not in first authorship.

5. CONCLUSIONS

An attempt of 3-D evaluation on a renowned institution Banaras Hindu University research output published in scholarly journal listed by Web of Science database for the period 1989 to 2016 is made. Exponential growth of publications is seen since the year 2005. Maximum consistency of publications is seen in the year 1995. The papers published by BHU are more in collaboration and collaboration pattern is continually increasing with years. BHU's main collaborator country is USA with 607 publications, followed by Germany with 471 publications. Maximum consistency (0.40) in international collaboration is seen with Nepal, whereas minimum consistency observed with England. The maximum value of consistency is very less than 1, this indicate that none country has consistent collaborator with BHU. Highest quality (impact) (70.01) observed with Russia, which indicates quality of papers with collaboration with Russia is best in comparison to other papers. CSIR is the main collaborator of BHU with 443 publications, followed by DRDO with 280 publications. Chemistry has maximum (2118) publications, followed by Physics with 1884 publications. Highest consistency (0.37) is seen in sub-field electrochemistry. Current Science published maximum research publications of BHU. Sepectrochimica Acta Part A has highest consistency (0.53), while Astrophysics and Space Science has lowest (0.19) consistency. Maximum 346 publications are written by ON Shrivastava of Department of Physics, whereas maximum citations are received by C.P. Singh of same department.

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