Characteristics of Highly Cited Publications of Gauhati University (1989-2018): Curious Cases

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ABSTRACT: *Citation received by a research publication is regarded as the primary credit to the author(s) as well as the organization of the author(s) affiliated to. A good number of metrics are there to measure the impact and prestige of a given set of research publications as well as the productivity of the researchers. This study is carried out on a sample data of 312 highest cited research publications credited to Gauhati University, Guwahati, Assam, India for a publication window of 30 years (i.e. 1989-2018). The sample drawn for the study is 10 percent of total of 3115 publications available in the Scopus citation database. Test of significance of correlation of the number of citations with the corresponding Field Weighted Citation Impact is carried out on 17 highly cited authors and found to be not significant in seven cases. Except in three cases, where the number of publications is significantly high, the significance of the correlation of the two mentioned variables is not predictable based on the number citations. Consistency of the author's citation impact measured by z index reveals a high consistency in the citation window of the authors, but cases are obverted where authors credited with relatively fewer publications recorded very high consistency and ranked high as per z-index. The ANOVA test to see if there is any kind of association in the type of research collaboration and the citation received by the publications returned insignificantly. Correlation of the citation across three databases viz. Google Scholar, Scopus and Web of Science have been studied and observed to be significant in all cases. Keyword occurrences of high frequency along with their link strength have been studied and portrayed using VOSviewer application, while the subjects with citation peak have been ranked as per Citation Per Paper.*

Keywords: Research Productivity, Gauhati University, Significance Of Correlation, Field Weighted Citation Impact, Z-index, Author Productivity

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1. Introduction

Analysis of the research productivity of an institution of teaching and research has received unprecedented emphasis due to a number of factors. The requirements for reviewing and framing certain tailor made policy decisions towards academic excellences; the stringent parameters adopted by different assessment agencies pertaining to higher education and research, and subsequently to meet the competitive edge over counterparts, have pushed the institutions to obvert into quantitative and qualitative analysis of the research productivity with serious attention. This study is carried out to visualize the research productivity of Gauhati University Guwahati, Assam, India on a sample dataset of 312 highly cited publications, being 10% of the total of 3115 as available in the Scopus citation database published over a publication window of 30 years (i.e. 1989-2018). The number of publications and the citations accrued over the citation window has been taken as the primary data for analysis. Consistency of

the citation distribution of the highly cited authors has been studied based on z-index proposed by Prathap (Prathap, 2011a; Prathap, 2011b, Prathap, 2014). Corollary to this, it is also examined if the correlation of the citation received by the publications with higher citations is significant in different citation databases viz. Google Scholar, Web of Science (WoS) and Scopus.

2. Literature Review

There are a good number of studies that has been conducted on research productivity of institution at national and international level. Swarna, Kalyane & Kumar (2002) carried out a scientometric study on technical reports of Bhaba Atomic Research Centre (BARC). Inter institutional collaboration found to be low and nuclear science and technology was found to be the most prominent area of research. Ghosh (2014) found that the major collaborator in CSIR-IICB research is University of Calcutta at national level and University of Texas Health Science Centre, San Antonio in international platform. Chaurasia & Chavan (2014) carried out a study on IIT Delhi faculties and researcher publication and found that the publication rate is growing with an AGR of 10.37 and the degree of collaboration is 0.96. Nagarkar & Kengar (2017) in their study on the research contribution of the faculty members of Department of Physics of Sabitribai Phule University, Pune found that the university collaborated with the research scholars of USA, UK, Germany and Japan and at the national level, Bhaba Atomic Research Centre topped the list. A keyword analysis also has been done. Pradhan & Ramesh (2017) analyzed research publication of six IITs in terms of Total Number of Publications (TNP), Total Number of Citations (TNC), Citation Per Paper (CPP) and Relative Citation Impact (RCI). Saberi & Ekhtiyari (2019) studied the characteristics of classic papers of Library and Information Science as indexed in the Google Scholar. Author's affiliations of the classic papers are from European universities except one from China. A positive correlation was also found between the citation of Google Scholar, Scopus and WoS. It indicates that when the citation increases in Google scholar; Scopus and WoS citations are also increases.

Gupta & Dhawan (2003) carried out a study of Indians authors' collaboration with Peoples Republic of China in S&T field. Physics found to be the major research area of collaboration and a total 34 bilateral papers are found from the collaboration of 22 Indian and 24 Chinese contribution. The study reveals that most of the collaborations between the two countries are through multilateral channels. Gupta & Bala (2012) carried out a study on research output of South Asian countries namely Bangladesh, Pakistan, Nepal and Sri Lanka for the period 2001-2010. Individual collaboration of each country at international level, most productive country etc. has been analyzed to pen down an overall picture of the productivity in these countries. Bouabid, Paul-Hus & Lariviere (2015) observed that the collaboration between BRICS and G-7 countries was increasing in a large extent but the intra BRICS scientific collaboration found to be very low during the study period.

Meho & Young (2007) found that 30.8% of citation is overlapping between the Google Scholar and union of WoS and Scopus. The Spearman's rank order of correlation coefficient between the Google Scholar and WoS found to be 0.874 and between Google Scholar and Scopus it was 0.970, thus indicating a strong correlation between the databases. Google Scholar citation found to be not significantly changing the relative ranking of the authors as compared to the WoS and Scopus databases. In another study, Kulkarni, Aziz, Shams & Busse (2009) found that Google Scholar and Scopus retrieved more citation per article than WoS. They conducted a study on 328 high profile articles of 3 medical science journals and have done a regression analysis of characteristics of the articles and database interaction. Group authorship found to be the most significant term and compared to WoS, Google Scholar has fewer citations to group authors even though the database had more no of citation.

3. Objectives

Research publications credited to Gauhati University as available in Scopus database during the publication window of 30 years (1989-2018) has been analyzed with the following objectives.

1. Identification of the highly cited publications and their primary attributes;

2. To examine if the authors credited to the highly cited publications have high consistency in the citation;

3. To examine if the correlation among the citations across citation databases is significant;

4. To investigate if there is any association in the number of citation received by a research publications with the level of author's collaboration;

5. To document the keyword occurrences of the research publications.

4. Methodology and the Dataset

Research publications credited to Gauhati University during the period 1989-2018 (i.e. 30 years) has been downloaded from Scopus database and filtered for English language only, all type of documents excluding "Erratum". Publications have been arranged in their descending number of citations and top 312, being 10 percent of total 3115 filtered out for the study. Authors affiliated to the publications have been scanned and only those having affiliated to Gauhati University been considered for analysis. MS Excel and the R software has been used to carry out the statistical tests. VOSviewer application is used for portraying the link strength of the keywords of highest frequencies. Number of citation accrued to a publication, Field Weighted Citation Impact (FWCI), citations in WoS and Google Scholar has been gathered to carry out the necessary analysis apropos to the objectives and the hypotheses set for the study. Table 1 giving the records available for the authors (at least one) affiliated to Gauhati University for the stated period in two widely used citation databases.

Citation database	Search Expression	Records after filtering	Sample10%
Scopus	AFFIL (gauhati AND university) AND (EXCLUDE (DOCTYPE , "er")) AND (LIMIT-TO (PUBYEAR , 2018) OR LIMIT-TO (PUBYEAR , 2017) OR…… LIMIT-TO (PUBYEAR , 1989)	3115	312
WoS*	(OG = Gauhati University) AND LANGUAGE**:** (English) Refined by: [excluding] PUBLICATION YEARS**:** (2019) Timespan**:** All years. Indexes**:** SCI-EXPANDED, SSCI, A&HCI.	2119	-

*Gauhati University has access to WoS database for the years 1989- only

Table 1. Search Expressions, time window and the records of data for Gauhati University

Records available in Scopus is higher over the WoS, and hence been selected as the primary source of data for this study. A list of top 40 publications having at least 100 citations has been appended in annexure 1.

4.1. FWCI and z-index

Field Weighted Citation Impact (FWCI) is an article level index developed by Scopus. It is a ratio of the number of citations received by a publication to the total citation received by all publications devoted to the subject in question over last three years. FWCI>1 means the publication has received higher citations to the global average of citations received by all the publications in the same subject field. Accordingly FWCI<1 means a lesser citations to the global average. For example, a FWCI of 1.15 and 0.85 respectively has received 15% higher and 15% lesser citations to the global average of all other publications in the subject field. Scopus updated the data on weekly basis (Scopus, 2019).

The 3D evaluation metrics proposed by Prathap (2011a, 2011b) has been used to evaluate the research productivity of the authors. The total number of publications (P) represents the quantity, and the impact (i) is C/P (C- number of citations). He showed that it is possible to define second-order, energy-like terms $E = \sum c_i^2$ and $X = iC$, where X represents a second dimension which Prathap introduced as Exergy and, a third dimension of quality s is introduced to calculate the consistency.

Mathematically, Exergy (X), Energy (E) and z- index can be described as follows:

If P is the total number of publication and C is the total number of citation received by P publications then, Exergy, X may be calculated as $i^2P = iC \quad | i = C/P|$.

Energy, $E = \sum C_K^2$ (The complete citation sequence of each publication of K in the citation window of the author in a given dataset). The consistency term, $\eta = X/E$, Z (Zynergy) = $\eta X = \eta^2 E$ and $z = Z^{1/3}$.

5. Hypotheses

Following three hypotheses have been formulated apropos to the objectives lined up for the study:

Hypothesis 1:
H_0: The correlation between total citations received by a publication with the FWCI is not significant
Ha: The correlation between total citations received by a publication with the FWCI is significant

Hypothesis 2:
H_0: Correlation of citation received by a publication across citation databases is not significant
Ha: Correlation of citation received by a publication across citation databases is significant.

Hypothesis 3:
H_0: There is no any association in the number of citation received by a research publication with the level of authors' collaboration

Ha: There is some association in the number of citation received by a research publication with the level of authors' collaboration

6. Result and Discussion

6.1. Citation Consistency and Significance of Correlation with FWCI

In order to test if the highly cited authors depict a high consistency of their citation credits, the z-index of highly productive authors with at least five highly cited publications have been studied. The benchmark for the number of publications has been set to at least three. Table 2 giving the author affiliated to Gauhati University, the citation range and the FWCI of the 17 highly cited authors derived from the dataset for the study. A test of significance of the correlation between citations received by all the

ID	Authors	No of Public-ation	Cited highest	FWCI highest	Cited lowest	FWCI lowest	*Corr	t value	**t value (critical)	Accept Reject Ho
1	Bhattacharyya K.G.	55	803	14.47	21	0.2	0.67	6.55	2.00	Rejected
2	Bhattacharjee B.	65	431	25.46	21	1.35	0.83	11.74	2.09	Rejected
3	Phukan P.	22	174	4.73	21	0.64	0.61	3.41	2.09	Rejected
4	Kalita M.C.	11	40	1.82	21	0.55	0.27	0.83	2.26	Accepted
5	Das H.L.	5	113	0.66	21	0.13	0.40	0.75	3.18	Accepted
6	Sarma B.K.	8	113	0.66	21	0.13	-0.05	-0.12	2.45	Accepted
7	Borgohain C.	5	100	3.58	25	0.85	0.94	4.67	3.18	Rejected
8	Senapati K.K.	5	100	3.58	25	0.65	0.94	4.67	3.18	Rejected
9	Sarma H.P.	9	80	4.01	23	0.65	0.91	5.97	2.37	Rejected
10	Das B.K.	6	79	0.87	26	0.87	-0.11	-0.23	0.23	Accepted
11	Talukdar A.K.	5	75	1.54	21	0.23	-0.91	-3.70	3.18	Accepted
12	Sarma K.C.	7	61	1.09	32	1.2	0.24	1.26	2.57	Rejected
13	Deka M.	5	55	2.59	22	1.72	0.16	0.27	3.18	Accepted
14	Bhadra J.	5	52	5.19	22	0.55	0.94	4.59	2.57	Rejected
15	Sarkar D.	7	52	5.19	22	0.55	0.84	3.46	2.57	Rejected
16	Das D.K.	6	51	4.41	22	0.44	0.46	1.05	2.78	Rejected
17	Ahmed G.	5	50	1.81	21	1.12	0.28	0.90	3.18	Accepted

*Corr =Pearson's Correlation **p= 0.05, two tailed t - test

Table 2. Consistency of the citation and FWCI of the highest productive authors in GU

publications by a given author and the respective FWCI has been carried out to test the hypothesis 1 above. A two tailed t-test has been conducted in each case and the critical value is compared at ñ = 0.05. Out of the 17 observations, the null hypothesis is accepted in seven cases. It is observed that except three cases, where the number of publication is significantly high, the significance of correlation of the two mentioned variables don't related to the number of publications, rather to the consistency of the citations accrued by each of the publications and corresponding FWCI. It is hence inferred that except the relatively highly cited publications, correlation between number of citations and corresponding FWCIs is unpredictable for significance.

6.2. Consistency of the Citation Window of Authors as per z-index

On further analysis of the consistency of the research impact in the form of citations received by a given author throughout the citation window, the z-index proposed by Prathap (Prathap, 2011a; Prathap, 2011b) has been used. The z-index normalizes the impact of research by a given researcher taking into account the whole citation window irrespective of the number of publications the author credited with. Accordingly, z index for all 62 authors having affiliated to GU have been calculated and a ranked list for top 37 is presented in table 3. It is observed that Bhattacharjee, B. with highest 177 publications and 4364 citations (ranked 2nd in citation) relegated to rank 3rd in z score while Bhattacharyya K.G., ranked 3rd in publication and 1st in citation occupied the top rank in z-score. Surprisingly, Ghosh D. with only three publications and 583 citations, elevated to the 2nd rank in z score. It is further observed that, Sharma K.C. with 9th and 8th rank in publication and citations relegated to the 20th position as per z-score. The analysis above leads to infer that z-index may be a better metrics to rank authors by the consistency of citation accrued over a given citation window.

S. No	Author	Pub	Citation	$E=\Sigma C_k^2$	$I=C/P$	$X=IC$	$\eta=X/E$	$Z=\eta X$	$z=Z^{1/3}$
1	Bhattacharyya K.G.	126	6446	1754154	51.16	329769.17	0.188	61994.39	39.58
2	Ghosh, D	3	583	326145	194.33	113296.33	0.347	39356.91	34.02
3	Bhattacharjee, B	177	4364	317014	24.66	107596.02	0.339	36518.59	33.18
4	Das, D.K	153	2028	23978	13.25	26880.94	1.121	30135.33	31.12
5	Phukan, P	123	2242	125976	18.23	40866.37	0.324	13256.97	23.67
6	Pal, B	10	440	37938	44.00	19360.00	0.510	9879.53	21.46
7	Das, B.K	51	913	31177	17.90	16344.49	0.524	8568.57	20.46
8	Bhattacharyya, P.N	8	663	379005	82.88	54946.13	0.145	7965.80	19.97
9	Devi, N	16	367	13113	22.94	8418.06	0.642	5404.09	17.55
10	Senapati, K.K	17	441	25469	25.94	11440.06	0.449	5138.60	17.26
11	Borgohain, C	17	426	25256	25.06	10675.06	0.423	4512.07	16.52
12	Debanath, M. K.	1	64	4096	64.00	4096.00	1.000	4096.00	16.00
13	Khan, M.I	17	327	11795	19.24	6289.94	0.533	3354.25	14.97
14	Kakati, M.	6	202	14290	33.67	6800.67	0.476	3236.46	14.79
15	Chakraborty, P	5	155	7151	31.00	4805.00	0.672	3228.64	14.78
16	Sarma, B.K	29	506	24824	17.45	8828.83	0.356	3140.03	14.64
17	Das, P	1	56	3136	56.00	3136.00	1.000	3136.00	14.64
18	Patgiri, AD	1	54	2916	54.00	2916.00	1.000	2916.00	14.29
19	Narzary, D	11	251	11665	22.82	5727.36	0.491	2812.06	14.11
20	Sarma, K.C	47	600	22188	12.77	7659.57	0.345	2644.18	13.83
21	Mahanta, M.J	1	50	2500	50.00	2500.00	1.000	2500.00	13.57

22	Goswami, M	5	135	5465	27.00	3645.00	0.667	2431.11	13.45
23	Baruah, P.K	37	516	22372	13.95	7196.11	0.322	2314.68	13.23
24	Kataki, D	7	171	7563	24.43	4177.29	0.552	2307.25	13.21
25	Singha, K	4	121	6629	30.25	3660.25	0.552	2021.03	12.64
26	Sarkar, D	42	476	15284	11.33	5394.67	0.353	1904.11	12.39
27	Talukdar, A.K	28	392	16502	14.00	5488.00	0.333	1825.12	12.22
28	Sarma, G.K	6	141	6145	23.50	3313.50	0.539	1786.70	12.13
29	Bhadra, J	23	295	8287	12.83	3783.70	0.457	1727.57	12.00
30	Sarma, M.J.	12	203	6949	16.92	3434.08	0.494	1697.07	11.93
31	Das, U.N	13	341	56129	26.23	8944.69	0.159	1425.42	11.25
32	Ahmed, G.U	37	339	6795	9.16	3105.97	0.457	1419.73	11.24
33	Nath, P	29	480	46850	16.55	7944.83	0.170	1347.28	11.04
34	Deka, M	53	462	12486	8.72	4027.25	0.323	1298.95	10.91
35	Jha, D.K	33	850	386720	25.76	21893.94	0.057	1239.51	10.74
36	Kalita, H.R	4	97	4729	24.25	2352.25	0.497	1170.03	10.54
37	Kumar, J	15	182	4484	12.13	2208.27	0.492	1087.52	10.28

Pub= Number of Publications

Table 3. z- index of the highly cited authors of Gauhati University

6.3. Correlation Coefficient of the Citations across Different Databases

Citations received by the research publications across three databases namely Scopus, WoS and the Google Scholar have been presented in table 4. As many as 81 publications in WoS and 15 in Google Scholar are not indexed due to obvious criteria of the databases. Citations received in Google Scholar are observed to be in the higher side in most of the cases. Hence, correlations of the citation data of other two databases have been carried out with Google Scholar. Correlation Coefficient and the results of the test of significance of the correlations are presented in table 4. It is observed that the correlation of Google Scholar and Scopus, and between Google Scholar and WoS is found to be significant. This lead to reject the null hypothesis of the second hypothesis and the alternative one is accepted. The finding of the study is similar to that of the Saberi and Ekhtiyari (2019).

		Scopus	**WoS**
Google Scholar	Pearson Correlation	0.925	0.930
	t-value (calculated)	42.917	44.407

Critical value of t (2 tailed) at df 310 = 1.962, $\rho = 0.05$

Table 4. Correlation and test of significance of Google Scholar, Scopus and WoS Citation

6.4. Type of Authors Collaboration and Citation

Publications in the dataset were assigned three tags according to the levels of the collaboration of authors at International, National and Regional and arranged with the number of citations received. Publications with single authors were excluded from this categorization. The result of the ANOVA test conducted in R software is given in the table 5 leads to accept the null hypothesis in the hypothesis 3 above. Accordingly, it is concluded that there is no any association in the number of citation received by a research publication with the level of author's collaboration.

6.5. Type of Authors Collaboration and Citation

Publications in the dataset were assigned three tags according to the levels of the collaboration of authors at International, National and Regional and arranged with the number of citations received. Publications with single authors were excluded from this categorization. The result of the ANOVA test conducted in R software is given in the table 5 leads to accept the null hypothesis in the hypothesis 3 above. Accordingly, it is concluded that there is no any association in the number of citation received by a research publication with the level of author's collaboration.

df	F Value	Pr>F
2	2.383	0.094
	Sig. p = 0.05	

Table 5. Association of the type of Collaboration with Citation received by the publications

6.6. Keyword Occurrence Link Strength

Occurrence of keywords and the strength of links have been studied using VOSviewer. Table 6 giving the top 54 keywords along with the link strength of at least 5 and graphically presented in figure 1.

Sl No.	Keyword	Occur	Link	Sl No.	Keyword	Occur	Link
1	Adsorption	23	74	28	Fe(Iii)-Mcm41	2	8
2	Montmorillonite	17	67	29	Ni(Ii)-Mcm41	2	8
3	Kaolinite	16	64	30	Tetrabutyl-Ammonium Clay	2	8
4	Kinetics	12	49	31	Cadmium	3	7
5	Thermodynamics	5	20	32	Nanocrystalline	3	7
6	Isotherm	5	19	33	Co(Ii) And Ni(Ii)	2	7
7	Temperature	3	19	34	Fe(Iii)	2	7
8	Adsorption Kinetics	4	18	35	Aldehyde	4	6
9	Adsorption Isotherm	3	18	36	Photoluminescence	3	6
10	Enthalpy	3	17	37	Rhamnolipid	3	6
11	Poly(Oxo Zirconium) Clay	3	16	38	Sem	3	6
12	Neem Leaf Powder	6	13	39	Speciation	3	6
13	Wet Oxidation	5	13	40	Bacillus Pumilus Ks2	2	6
14	Acid-Activation	3	12	41	Bioremediation	2	6
15	Acid Activated Clay	2	12	42	Olefin	2	6
16	Arsenic	5	11	43	Styrene	2	6
17	Biosurfactant	4	11	44	Xrd	2	6
18	Crude Oil	4	11	45	Biosorption	3	5
19	Metal Ions	3	11	46	Iodine	3	5
20	Tetrabutylammonium Clay	2	11	47	X-Ray Diffraction	3	5
21	Isotherms	2	10	48	Brilliant Green	2	5
22	Methylene Blue	4	9	49	Catalysis	2	5
23	Lead	3	9	50	Ferromagnetism	2	5

24	Thin Film	3	9	51	Magnetic Nanocomposite	2	5
25	azadirachta indica	3	8	52	Manganese	2	5
26	PAHs	3	8	53	Photocatalyst	2	5
27	Co(Ii)-Mcm41	2	8	54	Soil	2	5

Occur = Occurrence of Keywords

Table 6. Keyword occurrence and link strength of the publications

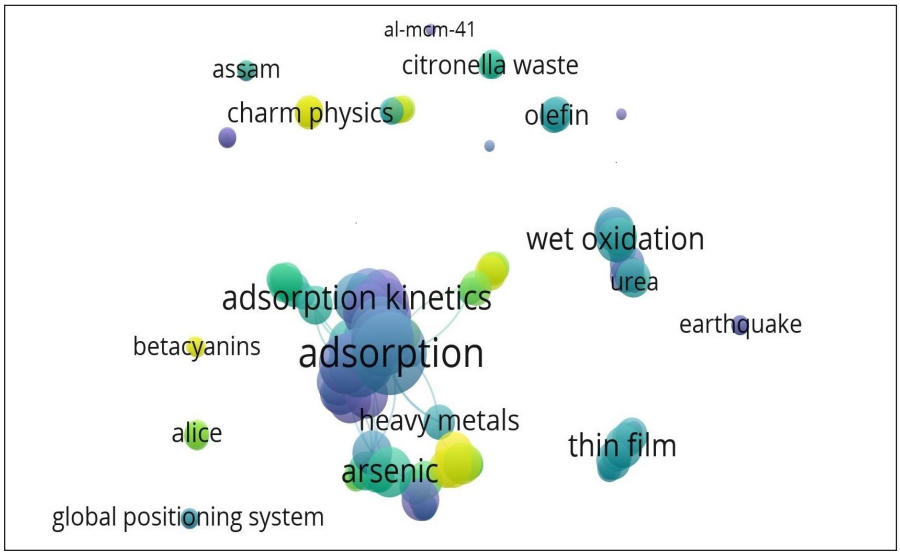

Figure 1. Link strength of the keywords of highest occurrence

6.7. Subject wise Citation Peak

Research publications in the data set have been analyzed for the index keyword as assigned by Scopus followed by clubbing into respective major subjects. The summed up publications under subjects is ranked as per Citation Per Paper (CPP) as presented in the table 7. It is interesting to note that Botany, with only 5 publications topped the list as per CPP bypassing Chemistry and Physics, which otherwise is dominant with relatively higher number of publications and citations. The same observation is evident for other subjects in the table. It is inferred that researchers in Gauhati University have excelled not only in Chemistry and Physics, but in other subjects, as well. However, this fact is inviting more intensive analysis taking in to account certain more inherent parameters related to citation distribution of the publication.

SlNo	Discipline	Publication	Citation	CPP
1.	Botany	5	784	156.80
2.	Chemistry	111	9190	82.79
3.	Physics	108	6115	56.62
4.	Geological Science	4	225	56.25
5.	Business Administration	1	51	51.00
6.	Anthropology	1	50	50.00
7.	Mechanical Engineering	4	172	43.00

8.	Information Technology	1	42	42.00
9.	Zoology	8	330	41.25
10.	Environmental Science	10	410	41.00
11.	Bioengineering and Technology	6	233	38.83
12.	Biotechnology	36	1377	38.25
13.	Instrumentation and USIC	6	217	36.17
14.	Statistics	7	240	34.29
15.	Mathematics	2	52	26.00
16.	Electronic and Communication	2	50	25.00
CPP = Citation Per Paper				

Table 7. Subject wise Citation Peak of the publications of Gauhati University

7. Conclusion

Research publications available in Scopus database affiliated to Gauhati University studied using metrics and statistical principles revealed certain insights in this study. The test of significance of the correlation between citations received by a researcher with the FWCIs for the publications over a given period is found to be significant only for the authors having relatively high number of publications. An author receiving relatively higher citation in a small set of publication may influence the average citation (i.e. Citation Per Paper), but to rank a researcher among others in a homogeneous set of publications, the z-index gives a better normalization of the measure how consistently he/she has received citations against all the works published during a particular period. It is observed in this study that researcher with relatively very less number of publications have elevated to higher rank as per z-index due to high consistency of citations received. The high positive correlation between Google Scholar and Scopus, and Google Scholar and WoS is evident in the study. However, as many as 15 publications in Google Scholar and 81 in WoS belonging to the dataset for this study is not present. This is undoubtedly a matter of consideration for the library managers towards promoting citation databases among the users. Subject wise distribution of the CPP reveals a very interesting fact that a cluster of small set of publications belonging to a given subject ranked significantly high over subjects with relatively very high number of publications. An intensive study involving various parameter viz. type of publication, channel of publication, distribution of the citing sources, etc. seems to be promising fascinating facts.

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