RESEARCH OUTPUT OF FACULTY MEMBERS OF CHEMISTRY DEPARTMENT OF TEZPUR UNIVERSITY AND NORTH-EASTERN HILL UNIVERSITY: A SCIENTOMETRIC STUDY

A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF PHILOSOPHY

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RESEARCH OUTPUT OF FACULTY MEMBERS OF CHEMISTRY DEPARTMENT OF TEZPUR UNIVERSITY AND NORTH-EASTERN HILL UNIVERSITY: A SCIENTOMETRIC STUDY

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Submitted

In partial fulfillment of the requirement of the Degree of Master of Philosophy in Library and Information Science of Mizoram University, Aizawl.

CERTIFICATE

This is to certify that **Nayana Borah** M.Phil. Scholar of the Department of Library and Information Science, Mizoram University has written her dissertation titled "**Research output of faculty members of Chemistry Department of Tezpur University and North-Eastern Hill University: A Scientometric Study**" under my supervision. To the best of my knowledge and belief, the work embodies her original investigation and findings and has not published anywhere.

I consider it worthy for the Degree of M. Phil. In Library and Information Science of the Mizoram University.

Dated: 20th September, 2021   Prof. S. N. Singh

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DECLARATION

Mizoram University

September, 2021

</div>

I, **Nayana Borah**, hereby declare that the subject matter of this dissertation is the record of work done by me, that the contents of this dissertation did not form basis of the award of any previous degree to me or to do the best of my knowledge to anybody else, and that the dissertation has not been submitted by me for any research degree in any other University/Institute.

This is being submitted to the Mizoram University for the degree of M. Phil.in Library and Information Science.

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PREFACE

Research plays an essential role in supporting a country's success and the well-being of its citizens. Universities, institutes, and other knowledge-transmitting organisations contribute significantly to the growth and development of society through research. Research productivity in higher education has become increasingly important in India and other countries during the last decade**.** There are several methods for determining the quantity and quality of a person's, institution's, set of institutions', or country's research output. Scientometrics is one of the tools for analysing research output. Evaluation of research output is an important criterion for finding out the academic performance of higher education institutions. As a result, accurate evaluation of these institutions' research output in terms of quantity and quality is essential for assessing their overall performance and ranking them at a national or international level. Therefore, the present study "**Research output of faculty members of Chemistry Department of Tezpur University and North-Eastern Hill University: A Scientometric Study**" was brought out**.**

The complete dissertation is arranged under the following five chapters to look into the problem:

Chapter-I presents a brief introduction of the research problem, objectives, scope of the study and research methodology.

Chapter-II gives a review of the literatures related to the present study. An attempt has been made to embrace only those studies which are directly related to the present study.

Chapter-III gives an overview of Research output, definition of Scientometrics, Origin of Scientometrics and Scopus database

Chapter-lV provides a comprehensive discussion on the collected data from the Scopus database and analysed the data to answer the objectives formulated for the study. It further gives the findings of the study.

Chapter-V provides the findings of the study according to the objectives formulated and further gives the overall conclusion of the study and suggestion

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1. INTRODUCTION

The objective of this chapter is to give a brief introduction about the research work, an overview of Tezpur University and North-Eastern Hill University, highlight the significance and scope of the study, research design, objectives and methodology of the study.

1.1. Background

Research is an imperative area that leads to any development. Educational Research is vital to get an in-depth analysis of the topic, to enhance knowledge in an efficient way. Without proper research, there cannot be any innovation and the importance of research has several facets. It is integrated into education at every level. The knowledge that one gain from research seek to serve diverse economic, cultural, and societal constituents. Through researches, higher educational institutions ensure continuing excellence in both learning and teaching resources. Educational research has resembled the nature of research as it is systematic, reliable, and valid the truth, investigates knowledge, and solves problems. However, educational research is more complex because it can use various approaches and strategies to provide solutions to the problems that take place within the field of education in an organized and methodical manner. The National Institutional Ranking Framework (NIRF) ranks the institutions of higher education in India. This research methodology was adopted by the Ministry of Human Resource Development (MHRD), Government of India encompassing parameters like Teaching, Learning and & Resources (TLR), Research and Professional Practice (RP), Graduation Outcomes (G,O), Outreach and Inclusivity (OI), Peer Perception, etc. Universities provide relevant research that can compete with the best in the world by providing interdisciplinary collaboration amongst the sciences, social sciences, and humanities. Higher education is the primary venue for examining and refining our national goals, developmental priorities, and civic ideals. Higher

education institution is responsible for the development of a modern economy, a knowledge society, and a dynamic political system.

In higher education, research productivity refers to the development and transmission of knowledge through various forms of research, teaching, and outreach activities. As a result, analysis of academic institutions' research productivity has become increasingly essential in ranking academic institutions.

Data on research performance assists in making strategic decisions about which research topics to support or expand. It also aids in determining the institution's status in context to global and domestic research output criteria. It addresses issues such as how research is conducted, its impact, the number of articles published in core journals by faculty members in their respective fields, the trend of publications (whether increasing or decreasing), patents awarded, technology transfer, and the study of research challenges on a subject and discipline level.

1.2. Research Output

Research is the creation of new knowledge or the innovative use of existing knowledge to create new ideas, methodologies, and understanding. This may involve synthesizing and analyzing previous research to the extent that it produces news and innovative results. Result output is a result of research that can take several different forms, such as books, artefact, book chapter, patent, conference paper, journal article etc. The distribution, publication, presentation, correspondence, or pathway by which research is made accessible to people other than the researcher is known as a research output. It is essential to evaluate research output in order to ranking institutions and gain access to individual researchers. It's also crucial to know if our country's funding pattern is on right track. There are many methods for determining the quantity and quality of a person's, institutions, group of institutions', or country's research output. Scientometric study is an important tool for analyzing research output.

Measurement of research activities is often used by policymakers and analysts to assess research success. It helps in the evaluation of a research institution's strengths and weaknesses, as well as the establishment of standards for other institutions. Setting

objectives, determining an institution's future plan or policy, and the criteria to meet those objectives are all greatly aided by the institution's net research success, which is heavily reliant on analysis of research output conducted by institutions from time to time.

1.3. Tezpur University:

Tezpur University is an Indian central university located in the state of Assam in the northeast region of the country. Tezpur University was founded in 1994 by an Act of Parliament with the primary goal of providing employment-oriented and multidisciplinary courses to meet Assam's development needs, in addition to delivering courses and fostering research in areas of direct and immediate interest to the region, as well as developing science and technology fields. Departments are categorized in four main schools and under those schools, 27 departments are there. Chemistry department is under School of Sciences. It is one of the most active department of Tezpur University. The department was started in the year 1997. Chemistry department is showing efficiency in high-quality chemical science and multidisciplinary research. Apart from several national collaboration projects, numerous worldwide collaborative projects are currently going on. A few members of the faculty are also involved in consulting initiatives. DST, UGC, CSIR, DBT, DAE, AICTE, and others providing external fund.

1.4. North Eastern Hill University

North Eastern Hill University (NEHU) is one of India's most prestigious universities, with its campus in Shillong, the capital of the north-eastern state of Meghalaya. It was founded in 1973 with the sole focus of distributing and advancing knowledge through the provision of educational and research facilities, as well as assisting in the improvement of the socioeconomic conditions and welfare of its citizens of the hilly region of the North-eastern area, particularly intellectual, educational, and cultural development. NEHU has shown its intellectual excellence in education and research in short period of time. In 2006, NEHU had been chosen as a 'university with potential for excellence' by the University Grant Commission (UGC).

NEHU has developed into a significant academic, social, and cultural organization with a defined positive vision, development, in just over 30 years.

Currently NEHU is having eight different schools and under those schools, 48 departments are there. Chemistry department is under the School of Physical Science. Department of Chemistry was established in the year 1976. The department is providing higher education in chemistry through M.Sc. and PhD program. Department of Chemistry is producing highly qualitative and quantitative research, so assessment of research output is necessary.

1.5. Chemistry

Oxford English Dictionary define Chemistry as the branch of science concerned with the substances of which matter is composed, the investigation of their properties and reactions, and the use of such reaction to form new substances. Medicines, food items, cosmetics, dyes, agrochemicals, polymers, liquid crystals, and agrochemicals have all been made possible by chemistry. Chemists have developed a wide range of new materials that are significantly better and more valuable than natural products, including high-tech polymers, liquid crystals, durable ceramics, nonlinear optical substances, novel electronics, designer pharmaceuticals, genetic materials, and alternative energy sources. Chemistry is a broad scientific field and its relevance is seen in almost every aspect of society, including medicine, cooking, environmental processes, cleaning and manufacturing goods etc. Chemistry plays a huge and important role in society, with relation to shelter and clothing. Different dyes, thermos-dynamical products, fabrics are also invention of chemistry. Chemistry is everywhere. As technology improves, the impact of chemistry on everyday life is increasing. For the first two thirds of the 20th century, chemistry was seen by many as the science of the future. The potential of chemical products for enriching society appeared to be unlimited. However, the negative aspect of chemistry has also come to the fore. Disposal of chemical by products at waste disposal sites of limited capacity has resulted in environmental and health problems of enormous concern. But the chemical products are essential if the world's population is to be clothed, housed and fed. The world's reserves of fossil fuels will eventually be exhausted, some new chemical

processes and materials will provide a crucial alternative energy source. Long term environmentally acceptable solutions to pollution problems are not attainable without chemical knowledge. Chemical enquiry will lead to a better understanding of both natural and synthetic materials and to the discovery of new substances that will help future generations better supply their needs and deal with their problems. Progress in chemistry can no longer be measured only in terms of economics and utility. The discovery and manufacture of new chemical goods must continue to be economically feasible but must be environmental acceptable. There are various organization and institution which are working and doing research in the field of chemistry all over the world.

Chemistry can be called as central science. Systematic study on chemistry will lead the world to better and developed one. The various new developments in technology and growth of literature help the scientists for their research and new discoveries.

1.6. Scientometrics: an overview

Scientometrics can be defined as the "quantitative study of science, communication in science and science policy" (Hess, 1977, 75). The focus of scientometrics is the measurement of science and is therefore concerned with the growth, structure, inter relationship and productivity of scientific disciplines (Jeyasekar and Saravanam, 2015). Scientrometrics is concerned with measuring and analyzing scientific literature. We can measure research performance/productivity of individuals, academic disciplines, different academic institutions, research fields etc. by applying various scientometric indicators, tools and techniques. Comparative research performance can be easily measured by using scientometric indicators.

Scientometric analysis sheds light on the growth pattern of literature, interrelationships between various fields of knowledge, productivity, authorship patterns, collaboration levels, and collaboration patterns, collection building and their use. Gradually, scientometric research is becoming more inter-disciplinary in nature.

1.7. SIGNIFICANCE OF THE STUDY

A number of studies has been conducted to analyze the research productivity of different discipline and different institutions. Very few studies have been found on this field with reference to North East India which deals with the research productivity of different institution and discipline whereas no scientrometric study is conducted so far which have the comparative study between two universities from the data available in Scopus database. So, present study will be an attempt to fill up the gap. Therefore the present study will attempt to analyze the Research publications of two central universities of North East India

The findings of the study will help in enhancing the visibility of institutions, trends of their research productivity, research collaboration etc. The individuals or the team of researchers also get appreciation and inducement for their work.

1.8. SCOPE OF THE STUDY

The scope of the present study covers the research publications of Chemistry department of Tezpur University and North-Eastern Hill University available in Scopus database for the period of 2000-2019. Research publications available in "all document types" will be covered in the study. According to the data of National Institutional Ranking Framework (NIRF), 2019, Tezpur University and North-Eastern Hill University are on the top among the other central universities of north east India. So, these two universities have been selected for the present study. Chemistry department has the highest contribution in both the universities among all the subjects available in Scopus database, so department of chemistry has been chosen for the study. The publications of Chemistry department, Tezpur University are available in SCOPUS from the year 2000. So, time span for the study is taken as 2000-2019 for both the universities.

1.9 Research Design

1.9.1. STATEMENT OF THE PROBLEM

The present study aims at examining the research output of Chemistry department of Tezpur University and North-Eastern Hill University. Universities conduct research to create, transfer and utilize knowledge to find solutions for different problems and for the development of the society. In academic and scientific works, publication is the chief means of communicating research, a primary means of recognition and reward. Therefore, it is through publication the researcher got professional recognition and esteem as well as promotion, advancement and funding for future research. Publication helps in the betterment of individuals.

Scientometric analysis is an important tool in analyzing any discipline. So an attempt has been made to study the "research productivity of chemistry department: a scientometric study in Tezpur University and North-Eastern Hill University".

1.9.2.OBJECTIVES OF THE STUDY

1. Analyze the distribution of publications year wise.
2. To determine the distribution of publications by document type
3. To compare the publications of both the universities on the basis of the number of publications and citation count.
4. Determine the research output's relative growth rate (RGR) and doubling time (DT).
5. Analyze the authorship pattern and assess the degree of collaboration
6. Analyze international collaborative efforts by the academics of both the universities

1.9.3. METHODOLOGY

The term research refers to the systematic method consisting of enunciating the problem, formulating a hypothesis, collecting the facts or data, analyzing the facts and reaching certain conclusions either in the form of solutions towards the concerned problem or in certain generalizations for some theoretical formulation (Kothari, 2004))

The study is designed to investigate the research productivity of two central universities in chemistry department indexed in Scopus database.

1.9.3.1 Parameters of the study

The Scientometric study includes various indicators to measure the research. The study will cover author wise research productivity, year wise distribution etc. as research productivity indicators.

1.9.3.2 Time Frame of Study

The study has covered twenty (20) years' time i.e. 2000-2019

1.9.4. Method of data collection and analysis

The raw data has been collected from the Scopus database and tabulated in MS-Excel file. Scopus is one of the leading scholarly databases which have the collection of many databases in different fields. It enables access to various databases, cross-disciplinary study, and in-depth exploration of particular subfields within a scientific or academic area. The bibliographic information of published work were gathered using the Scopus database's general search option. A list of faculty members of both the university has been prepared and the publications published by the faculty members of both the universities have been refined and retrieved for the study. For the analysis of collected data, suitable statistical and scientometric/bibliometric tools have been applied. For NEHU the following search query is used for retrieving data AF-ID ("North-Eastern Hill University"   60022264) AND SUBJAREA (chem) AND (EXCLUDE (PUBYEAR , 2021) OR EXCLUDE (PUBYEAR , 2020) OR EXCLUDE (PUBYEAR , 1999) OR EXCLUDE (PUBYEAR , 1998) OR EXCLUDE (PUBYEAR , 1997) OR EXCLUDE (PUBYEAR , 1996) OR EXCLUDE (PUBYEAR , 1995) OR EXCLUDE (PUBYEAR , 1994) OR EXCLUDE (PUBYEAR , 1993) OR EXCLUDE (PUBYEAR , 1992) OR EXCLUDE (PUBYEAR , 1991) OR EXCLUDE (PUBYEAR , 1990) OR EXCLUDE (PUBYEAR , 1989) OR EXCLUDE (PUBYEAR , 1988) OR EXCLUDE (PUBYEAR , 1987) OR EXCLUDE (PUBYEAR , 1986) OR EXCLUDE (PUBYEAR , 1985) OR EXCLUDE (PUBYEAR , 1984) OR

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And for Tezpur University, following query is used, AF-ID ("Tezpur University" 60007709) AND SUBJAREA (chem) AND (EXCLUDE (PUBYEAR, 2021) OR EXCLUDE (PUBYEAR, 2020)).

After collecting the data from Scopus, required data has been refined and analyzed.

1.10. Application of Scientometric tools and techniques

Different Scientometric tools and techniques are used in the research. Such as Degree of Collaboration, Collaborative Index, Annual Growth Rate, Relative Growth Rate, Doubling Time.

1.10.1 Degree of Collaboration

In order to calculate the degree of collaboration among the authors of research publication of Chemistry department, Tezpur University during 2000 to 2020, the formula given by Subramanyam (1983) is used.

Degree of collaboration

$$DC = \frac{Nm}{Nm+Ns}$$

Here N_m is the number of multi authored papers during a specific period in a discipline and N_s is the number of single authored papers during a specific period in a discipline.

1.10.2. Collaborative Index

It is one of the measure of degree of collaboration derived by Lawani (1986). Mathematically it can be expressed as

$$CI = \frac{\sum_{j=1}^{A} jfj}{N}$$

It is a measure of mean number of authors.

Where,

j = The number authors in an article i.e. 1, 2, 3,…….

f_{j} = The number of j authored articles

N= The total number of articles published in a year

A = The total number of authors per article

1.10.3 Annual Growth Rate

Based on the annual growth rate (AGR) given by (Kumar and Kaliyaperumal, 2015)

AGR= {(End Value – First Value)/ First Value} * 100

1.10.4. Relative Growth Rate

To identify the Relative Growth Rate of Publications a model developed by Mahapatra is used. The relative growth rate is the increase in the number of publications per unit of time.

$$RGR= \frac{W2-W1}{T2-T1}$$

Where,

W1 = log w1 (Natural log of initial number of publications)

W2 = log w2 (Natural log of initial number of publications)

T2-T1 = The unit difference between the initial time and final time.

1.10.5. Doubling Time

It is also calculated that there is a direct equivalence existing between the relative growth rates and doubling time. If the number of publications of a subject doubles during a given period, then the difference between the logarithms of the

numbers at the beginning and at the end of the period must be the logarithms of the number 2. If one uses natural logarithms, this difference has a value of 0.693.

Hence the Doubling time is calculated by the following formula

$$\text{Doubling Time} = \frac{0.693}{RGR}$$

1.11. Structure of the Dissertation

The present dissertation is structured in five parts.

Chapter 1 introduces the thesis, its need and practical significance, objectives and the methodology used.

Chapter 2 focuses on the review of the available literature in the context of the study and covers key sources. The literature review focusses on scientometric studies. The chapter concludes with finding the gaps which have formed a basis for the research.

Chapter 3 provides a broader context of research output, scientometrics, origin of scientometrics, Scopus database and application of scientometrics.

Chapter 4 illustrates the results of the study are published and discussed, and details of all the indicators and the outcome are presented.

Chapter 5 sums up findings based on the objectives set. Some suggestions are also given. The directions for possible avenues for future work are given before conclusion.

The bibliography is provided at the end. The bibliography and the in-text citations are given in APA citation style.

2. REVIEW OF LITERATURE

The objective of this chapter is to provide an overview of the research that has been done on various aspects of analysing research output. This chapter assisted the researcher in developing the conceptual understanding of the subject as well as in the research design.

2.1 Introduction

In any research project, a thorough review of the literature is important. An overview of a study of literature allows one to determine the research design and the scope of research. The literature review is an essential part of the study. By providing new ideas, principles, processes, strategies, and approaches, the literature review assists the researcher in framing the research thesis on the chosen subject. It also aims to examine past research patterns, new emerging area for research, growth of literature, researcher productivity, and research output of different research institution. The ultimate aim of the literature review is to find published material in the field.

A literature review may be as simple as a list of references, but it usually follows a structure which includes both summary and synthesis. But a formal literature review should provide a comprehensive view of the information, unbiased summary of the research work as well as established and contemporary thought.

An in-depth literature survey was conducted to trace out the previous studies for analysing research output of institutions, different subject fields and scientometrics. To gather information related to the topic different sources are being used, such as journals in online databases, theses, Scopus, seminar proceedings etc.

In this chapter an attempt has been made to review the related literature of the topic. The literatures are arranged chronologically.

Jeevan & Gupta (2002) analysed the research output from Indian Institute of Technology, Kharagpur using scientometrics. The time period taken for the study is 1994-95 to 1996-97, nine selected departments and their research publications in national and international journal have been selected for the study.1172 research paper were published during the time period. Maximum number of publications i.e., 757 were published in SCI- covered journals. Chemistry and Rubber Technology department published around 70% and above papers in SCI- covered journal. Chemistry department is getting highest rank based on the proportion of high-quality papers, i.e. 47.6 percent papers have received normalized impact factor above two. Based on Publication Effective Index, Chemistry, Physics &Meteorology, Rubber Technology and Electronics and Electrical Communication Engineering have received PEI value more than one. The departments having better qualitative performance also tends to collaborate more. Chemistry, Physics & Meteorology and Electronics and Electrical Communication Engineering have overall performed better in terms of quality than other departments.

Kumbar and his co-workers (2008) analyzed the research publications of University of Mysore in the time period of 1996 to 2006. From the study they found the AGR as 23.9%. Most of the publications are from chemistry, physics and astronomy, biochemistry, genetics and molecular biology and agriculture and biological sciences. Chemistry department leads in publications productivity with 379 papers during 1996-2006, followed by Physics department and zoology department. The university published nearly 14% of its papers through international collaboration with institutions from USA, Germany, Japan, Canada, South Korea and Denmark etc. It is also found that majority of authors from university of Mysore show low publication frequency.

Gupta and Bala (2011) analyzed the Indian research output in medicine during 1999 to 2008 using scientometrics. They studied Indian research output, its growth, rank, impact, collaboration, most prolific authors, pattern of research communication etc. Data has been collected from SCOPUS database for 10 years. From the study they found that during the study period India is in 12th position having 65,745 papers among the productive countries of the world in medicine. Maximum number of Indian

medicine research output is about cancer. Medical colleges contributed 55.13 percent of total publications followed by hospitals, research institutes, universities and research foundations etc.

Mooghali et al., (2011), analyzed the scientometric literature using scientometric indicators. The time period is limited to 1980 to 2009. The number of total articles found for the study is 691. The main objectives of the study were to find out the highest contributing authors of scientometrics during the time period, geoghraphical distribution, most productive institutions, language distribution, top journals of scientometrics etc. They found that USA was the leading contributor followed by Hungary and India in the field of scientometrics. Hungarian academy of science is the most productive institution in the particular field. Scientometrics is the most productive journal during the study period. Most of the literature were published in the field of library and information science. So scientometric analysis is performed mostly in library and information science subject.

Majhi and Maharana (2012), studied the research productivity of Physical science disciplines in Sambalpur University from the publications available in Scopus database. They analysed year wise growth of publications, most preferred journal, impact factor of the publishing journals, authorship pattern, subject wise distribution of papers etc. From the study it is found that Chemistry has the highest contribution, average growth rate increased gradually. Journal of Indian chemical society is found to be the most preferred journal having maximum number of contributions.

Baskarn (2013), studied the research productivity of Alagappa University during 1999 -2011. He analyzed the year wise distribution, relative growth rate, authorship pattern and degree of collaboration. From the study it is found that South Korea has high collaborative link with Alagappa University. They analyzed the Degree of collaboration as well as its mean value .Multi authored publications are more than the single author publications.

Dutt and Nikam (2014) studied collaboration in solar cell research in India as reflected by the publications indexed in Web of Science for a period of 20 years from 1991-2010. Almost half of the total output emerged out of domestic and international

collaboration. Academic institutions had almost equal proportion of output emerging from domestic as well international collaboration. Among the prolific institutions National Physical Laboratory-Delhi of the Council of Scientific and Industrial Research had the highest publications 36 emerging out of collaborative research. Indian researchers collaborated with their counterparts in 31 countries.

Gopikuttan and S (2014) studied the University of Kerala's publication production during a thirteen-year period from 2000 to 2012 using data from Web of Science. They evaluated the overall quality of science department faculty members using factors such as document type, year wise distribution, subject distribution, most prolific authors, and preferred journal, among others. They found that more number of papers were produced by the department of chemistry. Most preferred journals for publications are mostly Indian and UK is second in the list.

N K, Cherukodan and T K (2015) analyzed the growth and trends of research productivity of universities in Kerala using SCOPUS database during 1960 to 2015 and found the total number of publications is 11764. The study was limited to six state universities of Kerala. From the study it was observed that the academics mostly publish their article in foreign journals. Total 978 documents were produced by collaboration with foreign countries, which are France, Germany, Japan, UK and US. Sabu Thomas from Mahatma Gandhi University was the most prolific author with 566 publications and 13889 citations. Most productive area of research in Kerala were materials science, physics and astronomy, chemistry and engineering. It was observed that compared to other universities of India, the research productivity is found to be low in universities in Kerala.

Gautam and Mishra (2015) studied the scholarly research trend of Banaras Hindu University during the time period 2004-2013. Data are retrieved from Indian Citation Index online database and 1041 papers were selected for the study. From the study it is found that 88.09% of scientific publications are research article, highest papers were published in 2013, 2012, 2011 and 2010 and lowest number of papers were published in 2004 and from 2004 it increased gradually. Maximum numbers of publications were contributed by multi and two authored. From the study it is also

found the most productive authors are A.K. Singh, and Arvind Singh from Physics and Botany department respectively having 18 contributions each. Biological Science has the highest number of articles and Botany has the lowest number of contribution. The average rate of increasing publications is 104.1 per year, with SCIE indexed journals 404(39%) and non SCIE- indexed journal 637(61%).

Uddin, et al., (2015) analyzed Computer Science (CS) research output from Mexico during 1989 2014, indexed in Web of Science. The analytical characterization focuses on origins and growth patterns of CS research in Mexico. They analyzed TP, TC, ACPP, HiCP, H-index, ICP patterns etc., the major publication sources selected by Mexican computer scientists and the major funding agencies for CS research are also identified. The text-based analysis, on the other hand, focused on identifying major research themes pursued by Mexican computer scientists and their trends. Mexico, ranking 35th in the world CS research output during the mentioned period, is also unique in the sense that 75 % of the total CS publications are produced by top ten Mexican institutions alone.

Maurya, et al. (2018) analyzed the research performance of library and information science faculties of Mizoram University. From the study they found the total of 394 research publications by the department. The study looked at the distribution of publications by year and form, authorship patterns, collaboration levels, online research visibility via Google Scholar, research impact, research supervision, and research projects of LIS faculty members. According to the findings, there is an increase in the number of research publications, journal articles, and conference papers. The majority of research papers are co-authored by two people. Overall, there is a 0.6 degree of collaboration.

Siwach and Parmar (2018) analyzed the research contributions of CCS Haryana Agricultural University and they found that nearly equal number of publications appeared during 2001 to 2011 and a little more number of publications in 2012 to 2015. Average citation per paper is highest for the subject category Immunology and Microbiology. CCS Haryana Agricultural University has collaborative publication with different colleges and at the international level it has

maximum collaborative publications with United States. Total 2649 paper were published from 2001 to 2015 which received 15282 citation with an average citation per paper of 5.77. Out of total number of papers 13 have been cited more than 100 times.

Ahmed, Darmadji et al. (2018) Analysed the research productivity and international collaboration of top Indonesian university. The top ten Indonesian Universities were chosen for analysis and data were collected from SCOPUS database. They found that from earlier days, universities in Indonesia published articles in peer reviewed journal, but before 2000, the number of publication is less. After 2010 the number of documents are increasing, especially among the three largest Indonesian universities, i.e. Bandung Institute of Technology, University of Indonesia and Gadjah Mada University. The top Indonesian universities collaborated mostly with Japan, the United States, The Netherlands, Australia and Germany.

Ahmad, et al., (2018) analyzed research output of Webology journal during 2013 to 2017. They studied year wise distribution, authorship pattern, subject wise distribution, global distribution, citation analysis, degree of collaboration etc. They found that highest number of article are published in 2014, maximum papers are contributed by multiple authors, degree of collaboration is 0.71, maximum articles were contributed by authors from Iran followed by USA, Russia, India etc. Academic institution contributed highest number of publications.

Sharma (2018) analyzed research productivity of Library and Information science faculty members of selected universities of Punjab and Chandigarh using questionnaire as data collection source and time period up to 31st December, 2014 and found that the number of total publications is highest in Punjabi University, Patiala. She analysed the relative growth rate, authorship pattern, degree of collaboration etc.

Kpolovic and Dorgu (2019) studied the comparative determination of faculty's research productivity in Africa using h index and citation index from Google Scholar database. From the study they found that African h index and citation index are

significantly lower than the world averages of 17.50 1nd 971 respectively. The h index and citation index of the University of Cape Town, University of Pretora and Cairo University are significantly greater than those of other African universities. Southern Africa and North Africa each has h index and citation index that are significantly higher than those in the other African regions. South Africa and Egypt have h index and citation index that are not only greater significantly than those of other African countries but also significantly higher than the world averages.

Nandi and Bandopadhyay (2012) analyzed the research performance of botany and zoology department of the University of Burdwan during 1960-2000. In the study they found out year wise publication productivity, trend of doctoral research, authorship pattern, most prolific authors, citation scenario, most preferred journal, country wise distribution etc.

Kuri, et al. (2020) analyzed the research productivity of Indian School of Business, Hyderabad using scientometric indicators. The data were collected from SCOPUS database for the time period 2002 to 2020 and they found 561 number of publications. They found that number of publications are increasing gradually, 2015 and 2018 are the most productive years. Most of the publications are three authored. Average citation is highest in 2003, i.e. 91.80. The average growth rate is 1376.32. Maximum collaborations are with the United States. Most preferred source for publication is production and operation management. National Science Foundation was the top funding agency. They suggested the researcher to publish their research output in high impact factor journals to enhance the research impact.

Sudhier and Kumar (2020) analyzed the biochemistry research in India based on Web of Science database during 2004-2013. They studied the pattern of growth, major subject area of research, highly cited article, geographical distribution of literature, examine the validity of Lotka's law of productivity etc. The total number of publications during the study is 25,132. They discovered that the number of publications is gradually increasing, with the largest number of publications occurring in 2012. Annual average growth rate for the period is 36.84 percent. The most preferred medium of communication is journal article. Among different sub field of

biochemistry research, majority of the publications are in the topic biochemistry and molecular biology. 17.59 percent of total publication are international collaborative papers. PLOS One is having highest number of publications among all the preferred journal for publication. Tamil Nadu contributed the largest number of publications. The most productive research institute is Council of Scientific and Industrial Research.

2.2 Research gap

From the above literature review, we have seen that there are sufficient numbers of research conducted to analyze the research productivity of different disciplines and different institutions. But no study has been conducted to study the research productivity of the proposed area based on Scopus Database. So the present study will be an attempt to fill up the gap on the proposed topic.

3. RESEARCH PRODUCTIVITY: A SCIENTOMETRIC ANALYSIS

3.1. Role of Research in Universities:

Higher and technical educational institutes in India are the most essential source of technological competence and change input. In such organizations, research plays an essential role in supporting a country's success and the well-being of its citizens. Universities, institutes, and other knowledge-transmitting organizations contribute significantly to the growth and development of society through research. Research productivity in higher education has become increasingly important in India and other countries during the last decade. Faculty members in higher education institutions are primarily responsible for two functions: teaching and research. Aside from teaching program, one of the most essential activities is research and publishing. Faculty members and researcher publish their research findings in journals, books, book chapters, newspaper articles, reviews, conference papers, patents, and cases, among other formats. The institute is known around the world as a result of these works. Research publication of an institution make an overall impact in institutional output. The institution's research performance must be analyzed for self-evaluation as the institution grows. It assists institutes in determining the intellectual output of their research. The publication efficiency of an institution's faculty members is directly related to the institution's position or status in terms of research outcomes.

There are several methods for determining the quantity and quality of a person's, institutions, set of institutions', or country's research output. Scientometrics is one of the tools for analyzing research output. It also includes the examination of document usage and publication patterns using mathematical and statistical methodologies. It's worth noting that, in recent years, bibliometric and scientometric studies have become more widely utilized to assess faculty research performance, as well as the growth of many scientific disciplines and other disciplines.

3.2. Importance of Analyzing Research Productivity in Higher Education

Measurement of research activities is commonly used by policymakers and experts to evaluate research performance. Analysis of research productivity gives policymakers and administrators a better understanding of the complex nature of research operation, allowing them to have appropriate facilities and steer research in the right direction. Analysis of research performance helps in determining a institution's strengths and weakness, as well as establishing benchmarks for other institutions. Analysis of institution's research output helps in fulfilling the objectives, defining future policy and strategy to achieve the goal of the institutions.

Evaluation of research output is an important criterion for finding out the academic performance of higher education institutions. As a result, accurate evaluation of these institutions' research output in terms of quantity and quality is essential for assessing their overall performance and ranking them at a national or international level. Universities should attract companies by promoting research; they should see universities as repositories of useful information, and they should come to universities to solve their practical problems.

3.3 Origin of Scientometrics

The terms bibliometrics, scientometrics, informetrics, and librametrics are analogous and are directly related to measuring knowledge. The major scope and application involve different facets of library and information science, and they intend to ensure rapid collection of dissemination of the most important information for the generators of the knowledge. Sengupta analyzed the terms closely and found out that the terms overlap each other significantly. In the early 1900s, the only source of creative scientific work or a scholarly research was an individual, or sometimes a group of two or three persons. Before World War II, the active community was quite small, and every scientist was familiar with others in the area. Ideas and discoveries were even communicated amongst each via a post card or by word of mouth. Things changed post the World War II where in some experiments and scholarly work the researchers stared collaborating with each other, as a team. It would be difficult to list all the names, and editors started using the group name as the author. Slowly scholarly

knowledge started taking a turn in its reach, and the impact was considerable. The reasons why scientists collaborate, the process and types of collaboration, its opportunities, its strength and the outcome are key sociological concerns. Lawani even went to the extent of stating there is a good amount of evidence that researchers themselves are very much interested in the subject. "By scholarly communication, we mean the study of how scholars in any field use and disseminate information through formal and informal channels. The study of scholarly communication includes the growth of the scholarly communication, the relationships among research areas and disciplines, the information needs and uses of individual user groups, and the relationships among formal and informal methods of communication".

The origin of the term "bibliometrics" dates back to 1969 when Pritchard coined it. Till then this science was referred to as "statistical bibliography." In fact, Hood and Wilson found out that bibliometric methods have been applied in many forms for a century or more. Pritchard describes that the aim of a bibliography is: "to 27 shed light on the processes of written communication and of the nature and course of development of a discipline (in so far as this is displayed through written communication), by means of counting and analyzing the various facets of written communication.

In 1980, bibliometrics was added as one of the subject heading. Narin and Moll published a review article on bibliometrics, followed by White and McCain which restricted the scope of the term to bibliographies alone who defined it as "Bibliometrics is the quantitative study of literature as they are reflected in bibliographies. Its task, immodestly enough, is to provide evolutionary models of science, technology, and scholarship". Further overviews about bibliometrics and its examples which are not discussed above are Fairthrone, Pritchard, Sengupta, and Hertzel which provide various facts on the history of the development of bibliometrics.

Bibliometrics after its birth has been growing both in quantum and quality and has made way for the discovery of new branches as Informetrics and Scientometrics. "The origin of the term Scientometrics dates back to 1969 when two Russian scientists Namilov and Mulchenko coined the Russian term 'naukometriya,' the Russian

equivalent of the term Scientometrics". It is interesting to note that Price had already dwelled into this area in his book "Little Science, Big Science." The beginning of scientometrics as a discipline began in 1978 when a new journal Scientometrics was founded by Tibor Braun. "Scientometrics includes all quantitative aspects of the science of science, communication in science, and science policy". The emphasis of scientometrics is the measurement of science and is therefore concerned with the growth, structure, interrelationship, and productivity of scientific disciplines.

Tague-Sutcliffe defines "Scientometrics is the study of the quantitative aspects of science as a discipline or economic activity. It is part of the sociology of science and has application to science policy-making. It involves quantitative studies of scientific activities, including, among others, publication, and so overlaps bibliometrics to some extent". Use of scientific literature for studying and analyzing scientific activity has a long history and dates back to 1917 in which Cole and Eales analyzed publications in comparative anatomy published between 1543 and 1860 by counting 28 the number of titles, both books and journal articles, and grouped them by country. In 1923, Hulme published an analysis after he studied the scientific literature in the form of an international catalogue, for the years1901-1913. Following these works, Gross & Gross took a closer step in the analysis of scientific literature in 1927 when they tabulated citations received by the Journal of the American Chemical Society. Such an exponential growth of literature and rapid development of libraries for further reach generated several studies about the effectiveness and efficiency of information services. These studies led to the identification and application of appropriate quantitative measuring techniques known as scientometrics. Librarians and information scientists felt it would help them in various ways and started using scientometric studies to throw light on the growth pattern of literature, the collaborative research, ranking of journals, productivity and influence of authors, obsolescence studies, pattern of collection build up, their use, etc. However, the field developed rapidly after the introduction of Science Citation Index in 1963 by Eugene Garfield, launched by the Institute for Scientific Information, well-known as ISI (founded in the USA), and the development of computerized databases. During the past three-and-half decades the number of scientometric studies performed worldwide,

as reflected by the number of papers published in different journals which have increased considerably. A new international journal 'Scientometrics' started publishing from Hungary in 1978. This was the first periodical specialized on bibliometric topics. A regular biennial international conference also started taking place since 1987. Since 1987, many conferences held for the benefit of scientometric and informetric scholars across the world. The first bibliometric conference was organized by Leo Egghe and Ronald Rousseau in 1987 in Diepenbeek, Belgium. The primary aim of the conference was to bring the scientometricians, informetricians across the globe and sense the strength the subject has for future growth. "International Conference on Bibliometrics and Theoretical Aspects of Information Retrieval" was the first conference held. The deliberations covered a wide spectrum of scientometric research, which is beyond the scope of this thesis and needs a separate study. Till date a total of 14 such conferences were organized, the last one being in 2013. India also hosted one such conference under the leadership of I. K. Ravichandra Rao in 1991, which was held at DRTC (Documentation and Research Center), Bangalore which is a part of Indian Statistical Institute, whose headquarters is in Kolkata. There have been a lot of discussions regarding the uses of the three terms, bibliometrics, scientometrics, and informetrics.

During 1990s Brookes had the views that "I have no doubt that bibliometrics must now be conceded to library studies only. Its work is not yet ended as libraries continue to adapt to the changing world around them and bibliometrics itself needs the continued interest of outside experts, statisticians, and others, in developing and refining its techniques". Further, it is also stated that the main purpose of bibliometrics is to advance information and communication-related activities, scientific documentation by quantitative analysis of library collections and services. Whereas to contribute to an improved understanding of the process of scientific research as an important societal activity, a quantitative analysis of the use of scientific information is valuable through scientometrics techniques. In this context, Egghe stated that the concept of scientometric refers more to the general science of science or science policy research and hence is more linked (but not exclusively) with citation analysis studies.

Egghe also added that "one can also argue that scientometrics, using bibliometric techniques, is a part of bibliometrics."

These interpretations lead to the conclusion that the three terms, bibliometrics, scientometrics, and informetrics, are almost strongly interrelated with many common characteristics for which the researcher's choice of term is dependent on their familiarity with the phrase. Few more terms also have had a long history, one of them is Librarmetry which was coined by S. R. Ranganathan, Father of Library Science in India. Librametics attempts to study the library services with the help of statistics. S. R. Ranganathan coined the term librametry in 1948 at the ASLIB conference who felt there is a need to develop this subject in line with psychometry, econometry, biometry, etc. and apply the appropriate mathematical and statistical techniques for better library management and services. The researcher would like to use the definition by Price for the present thesis, which defines scientometrics as "the quantitative evaluation and inter-comparison of scientific activity, productivity, and progress". The research carried out here 30 involves applying various scientometric techniques to the mechanical engineering related literature. Irvine and Martin examined the values of all the measurement techniques and concluded that all the studies are focused towards quantitative measurements and not on qualitative evaluation. Brookes, on the other hand, feels that bibliometrics may be conceded to library studies only. Egghe and Rousseau also endorse the views of Brookes and feel that bibliometrics is restricted too narrowly to libraries and the documentary origin of the field. They, therefore, treat it as mathematical studies of libraries and bibliographies. Also, Hood and Wilson said that "each of these terms has a range of definitions that have been applied to them by the authors who are working in this field. These definitions indicate considerable overlap in a meaning of the terms, but they are not necessarily synonymous. Over time, the popularity (or usage) of the terms has changed, with the older term 'bibliometrics' fairly stable and the newer terms, 'informetrics' and 'scientometrics' gaining in usage."

3.4 Definition of Scientometrics:

Scientometrics is a branch of library and information science. Scientometric tools can be used to measure and compare the scientific activities at various levels of aggregation including institutions, sectors, provinces and countries. They can also be used to measure research collaborations, to map scientific networks and to monitor the evolution of scientific fields. Scientometrics empirically describes the constantly changing relationship between science, technology and the research productivity. This consequently sheds more light on the structure of subject literature and better organization of information resources which can ultimately be effectively used for various purposes including regeneration of information.

Scientometrics is concerned with the quantitative features and characteristics of science and scientific research. Emphasis is placed on investigations in which the development and mechanism of science are studied by statistical mathematical methods. Scientometrics is a discipline, which uses statistical and computational techniques in order to understand the structure and dynamics of science.

Nalimov and Mulchenko (1969) of USSR defined scientometrics as the quantitative methods which deals with the analysis of science viewed as an information process. According to Beck (1978) scientometrics is defined as the quantitative evaluation and inter-comparison of scientific activity, productivity and progress. Tague-Sutcliffe (1992) quantitative aspects of science as a discipline or economic activity. It is part of the sociology of science and has application to science policy making. It involves quantitative studies of scientific activities including, among others, publication, and so overlaps bibliometrics to some extent. Bookstein (1995) bibliometrics measurement for evaluation of scientific development, social relevance and impact of application of science and technology. Scientometrics is the science of measuring and analyzing science. In practice, scientometrics is often done using bibliometrics, which is a 4 measurement of the impact of (scientific) publications. Modern scientometrics is mostly based on the work of Derek J. de Solla Price and Eugene Garfield. The latter founded the Institute for Scientific Information, which is heavily used for scientometric analysis. Methods of research include qualitative,

quantitative and computational approaches. One significant finding in the field is a principle of cost escalation to the effect that achieving further findings at a given level of importance grow exponentially more costly in the expenditure of effort and resources. Related fields are the history of science and technology, philosophy of science and sociology of scientific knowledge.

Scientometrics the quantitative study of scientific communication--challenges science and technology studies by demonstrating that organized knowledge production and control is amenable to measurement. Scientometrics is the science of measuring and analysing science. In practice, scientometrics is often done using bibliometrics, which is a measurement of the impact of (scientific) publications. (Wikipedia) Scientometrics is the science of measuring and analyzing science. In practice, scientometrics is often done using bibliometrics that is measurement of (scientific) publications. Scientometrics means literally "measurement of science". In reality it means the application of statistical indicators (especially bibliometric indicators) as a mean for the evaluation of scientific productivity. "The term "scientometrics" (derived from the Russian "naukometria") used mainly in the East is defined as the study of the measurement of scientific and technological progress. This also explains the foundation in 1978 and the title of the journal Scientometrics in Hungary. For more information on the history and the contents of these names, we refer the reader to Egghe (1988) 10 Scientometrics deals mainly with science policy applications." (Egghe & Rousseau, 1990). Scientometrics are used to quantify scientific activities. Generally quantification of scientific activities is measurable by producing statistics on scientific publications indexed in indicator databases such as SCOPUS and Web of Science. Scientometric data can be useful to measure research collaborations among scientific environments and to monitor the evolution of special scientific subjects and fields. Also, decision and policy-makers are going to be interested in scientometric indicators.

3.5 Application of Scientometrics

Scientometric studies are mostly observational or verifiable in nature, and they are mostly done by representing and analyzing facts and data. It includes different

types of quantitative studies to determine the research productivity and impact of research, citation analysis, and distribution of scientific publications on the basis of language, geographic location etc., and obsolescence of literature, growth of literature, journal wise analysis, and institution wise analysis and so on. It has recently expanded into the field of informatics. It encompasses any quantitative study of knowledge transmission, irrespective of medium. Scientometrics provides methods for identifying important features of literature and monitoring its output. In fact, scientometrics has grown from the realization that the number of literature is increasing and evolving at a pace that no librarian, information manager, or scientist using conventional bibliographic methods and skills could keep up to date.

Scientometrics techniques are used for a number of purposes, including determining different scientific indicators, evaluating scientific research output, selecting journals for libraries, and even predicting future Nobel Laureates. The widespread use of scientometrics techniques in different fields has resulted in a massive increase in scientometrics and related literature. The techniques are now followed vigorously and because of that it has been found that one-fourth of all the articles published in Library and Information Science Periodicals are on scientometrics and allied topics. Many social science periodicals also publish significant number of articles and research paper on scientometrics.

3.6 SCOPUS

Scopus is the most comprehensive collection of abstracts and citations for peer-reviewed literature. Scopus provides a concise summary of research articles in science, technology, medicine, social sciences, and the arts and humanities from across the world. Scopus has various useful tools for tracking, analysing, and visualising research. We can find all the critical research around the world in Scopus. Across all research fields- science, mathematics, engineering, technology, health and medicine, social sciences and arts and humanities – Scopus delivers a brief summary of research works and global, interdisciplinary scientific information. Scopus features smart tools to track, analyse and visualize research.

Scopus contains publications from over 5000 publishers, 70 million items, 1.4 billion cited references dating back to 1970, 70000 main institutional profiles and 16 million author profiles. In the last 3 years, Scopus has added cited references from 1970 and thus increase the depth of the content.

4. DATA ANALYSIS AND INTERPRETATION

The act of gathering raw data and translating it into information that users can use to make decisions is known as data analysis. Data is gathered and examined to find out solution, test hypothesis, answer questions, and disprove theory.

North-Eastern Hill University (NEHU)

4.1. Year wise distribution

The data has been presented in table-1 to evaluate the year wise research productivity of Chemistry department, North Eastern Hill University. The table depicts the chronological distribution of research output of the department. Table 4.1 and Fig. 4.1 shows that North Eastern Hill University published a total of 649 papers on chemistry research between 2000 and 2019. The highest number of 53 (8.165%) publications were published in 2019 while lowest 9 (1.387%) publications were published in 2002. The average publications published per year was 32.45. The number of scientific publications by faculty members were less in the beginning but eventually it grew, however there were significant variations in some years.

Table 4.1. Year wise distribution

Year	No. of publications	Percentage
2000	11	1.695
2001	10	1.541
2002	9	1.387
2003	21	3.236
2004	20	3.087
2005	31	4.776
2006	42	6.471

Year	No. of publications	Percentage
2007	31	4.776
2008	27	4.160
2009	30	4.622
2010	38	5.855
2011	32	4.931
2012	36	5.545
2013	49	7.550
2014	37	5.701
2015	38	5.855
2016	39	6.009
2017	50	7.704
2018	45	6.934
2019	53	8.165
Total	**649**	**100**
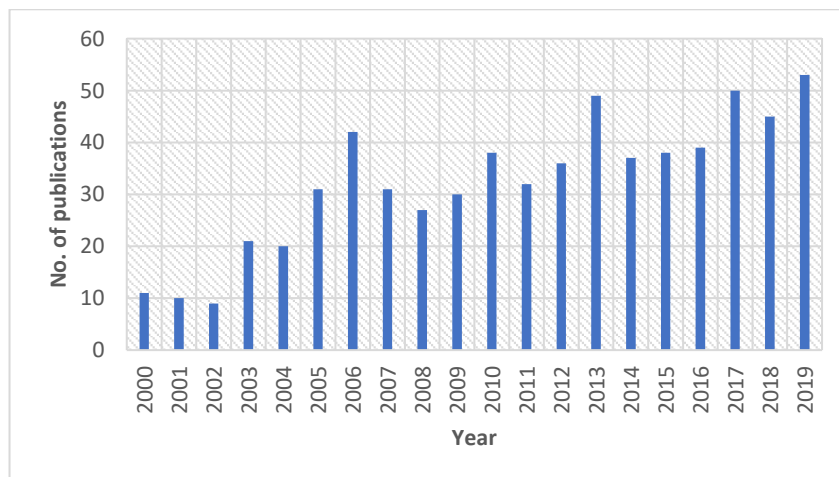
Figure 4.1: Year wise distribution

4.2. **Annual Growth Rate of Publications**

Table 4.2. Annual Growth Rate

Year	No. of publications	AGR
2000	11	0
2001	10	-9.090
2002	9	-10
2003	21	133.33
2004	20	4.76
2005	31	55
2006	42	35.48
2007	31	-26.19
2008	27	-124
2009	30	11.11
2010	38	26.67
2011	32	-15.79
2012	36	12.5
2013	49	36.11
2014	37	-24.49
2015	38	2.702
2016	39	2.63
2017	50	28.20
2018	45	-10
2019	53	17.78
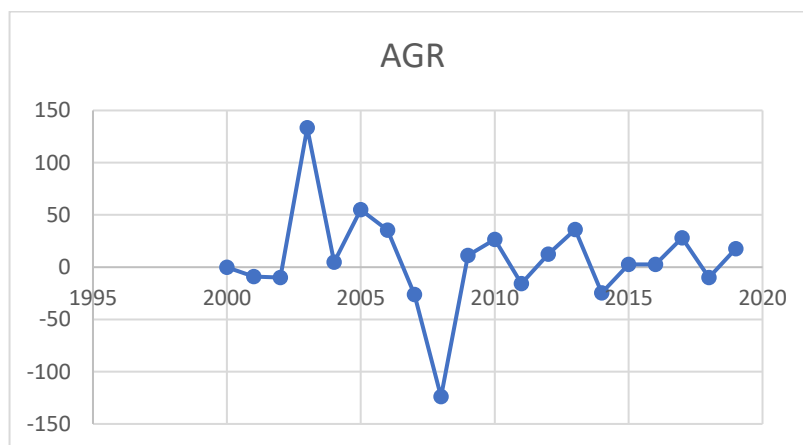
Figure 4.2: Annual growth rate

Table 4.2 and **Figure 4.2** presents the annual growth rate of chemistry department, NEHU during the study period. It showed a increasing growth rate with some variations. Maximum 133.33 AGR was recorded in the year 2003 followed by 55 in 2005, 36.11 in 2013, 35.48 in 2006, 28.20 in 2017, 26.67 in 2010, 17.78 in 2019, 12.5 in 2012, 11.11 in 2019, 4.76 in 2004 and in 2015 and 2016 AGR is found to be 2.702 and 2.63 respectively. In 2000 AGR is 0. For the years 2001, 2002, 2007, 2008, 2011, 2014, and 2018 AGRs are recorded in negative as -9.090, -10, -26.19, -124, -15.79, -24.49 and -10 respectively.

4.3. Relative Growth Rate and Doubling Time

Year	No. of publications	W1	W2	RGR	DT
2000	11		1.041	0	0
2001	10	1.041	1	.041	16.902
2002	9	1	0.954	.046	15.065
2003	21	0.954	1.322	.030	23.1
2004	20	1.322	1.301	.021	33
2005	31	1.301	1.491	.017	40.764
2006	42	1.491	1.623	.012	57.75
2007	31	1.623	1.491	.012	57.75

2008	27	1.491	1.431	.015	46.2
2009	30	1.431	1.477	.0153	45.294
2010	38	1.477	1.579	.0127	54.566
2011	32	1.579	1.505	.0123	56.341
2012	36	1.505	1.556	.0127	54.566
2013	49	1.556	1.690	.0103	67.281
2014	37	1.690	1.568	1.427	0.471
2015	38	1.568	1.579	.011	63
2016	39	1.579	1.591	.012	57.75
2017	50	1.591	1.698	.009	77
2018	45	1.698	1.653	.009	77
2019	53	1.653	1.724	.008	86.625

Table 4.3 represents the relative growth rate and doubling time of the research output of faculty members of chemistry department, NEHU for the duration 2000-2019. RGR is calculated to evaluate the increase in the number of research productivity on time and DT is directly associated with RGR. The maximum 1.427 RGR was recorded in the year 2014 followed by .046 in the year 2002. The minimum RGR .008 is observed in the year 2019.

From the **table 4.3**, it has been observed that the values of RGR gradually decreased over the years with some fluctuations. Values of Doubling Time are increasing from top to bottom with some fluctuations.
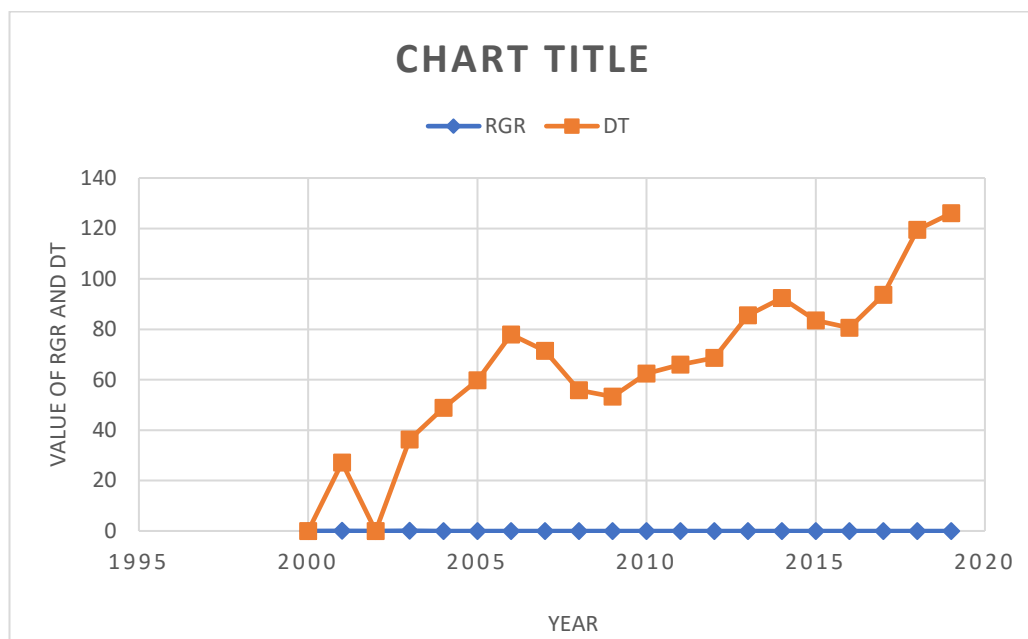
Figure 4.3: Relative Growth Rate and Doubling Time

From **table 4.3** and **figure 4.3** it is observed that maximum doubling time 86.625 was recorded in year 2019 followed by 77 in 2018 and 2017, 67.281 in 2013, 63 in 2015, 57.75 in 2006, 2007 and 2016, 56.341 in 2011, 54.566 in 2010 and 2012, 46.2 in 2008, 45.294 in 2009, 40.764 in 2005, 33 in 2004, 23.1 in 2003, 16.902 in 2001, 15.065 in 2002. The minimum doubling time 0.471 was recorded in 2014.

4.4. Authorship Pattern

The study of authorship pattern is an important aspect in Scientometric analysis. Authorship of a work has grown increasingly significant for scientists and researchers, and a lot of studies has been conducted on this area in recent years. Its goal is to assess at the performance of researcher in contributing research output either individually or jointly.

Table 4.4.: Authorship Pattern

Years	Single	Two	Three	Four	Five	More than five	Total
2000	0	5	5	1	0	0	11
2001	0	4	4	0	1	1	10

Year							Total
2002	0	2	4	2	1	0	9
2003	0	6	9	4	1	1	21
2004	0	7	6	4	0	3	20
2005	0	10	7	7	3	4	31
2006	0	25	7	0	2	8	42
2007	0	13	5	6	2	5	31
2008	1	9	7	5	2	3	27
2009	0	15	8	3	2	2	30
2010	1	9	10	7	2	9	38
2011	0	16	3	5	3	5	32
2012	1	10	7	10	5	3	36
2013	1	14	9	13	5	7	49
2014	0	4	12	9	8	4	37
2015	0	5	17	1	4	11	38
2016	1	5	11	4	4	14	39
2017	0	4	10	12	7	17	50
2018	1	4	8	11	6	15	45
2019	0	11	8	12	6	16	53
Total	**6**	**178**	**157**	**119**	**62**	**128**	**649**

Table 4.4 depicts the authorship pattern of Chemistry department, NEHU during 2000 to 2019. It is found that two author contributed papers occupies the first position (178) in respect to total number of papers published during the period of analysis.

Three author collaborated papers comes next (157) in order of sharing the research output during the period of study.

More than five author collaborated research output takes the third position (128) among total number of papers published during the time period of study.

Fourth position is taken by more than four author collaborated papers (119) in sharing chemistry research output during the period of study. Five author collaborated output take the fifth position (62).

Among all the research publications of Chemistry department NEHU, the number of single authors collaborated paper take the last position with 6 papers.

From the above discussion we observed that researcher of Chemistry department, NEHU mostly preferred to work with joint authorship. Single authored publications are so less in comparison to collaborated publications.

4.5. Collaborative Index and Degree of Collaboration

Table 4.5. Collaborative Index and Degree of Collaboration

Year	CI	DC
2000	2.63	1
2001	3.1	1
2002	3.22	1
2003	3.14	1
2004	3.3	1
2005	3.48	1
2006	3.07	1
2007	3.38	1
2008	2.69	0.96
2009	2.93	1
2010	3.81	0.97
2011	3.31	1
2012	3.57	0.97
2013	3.64	0.97

2014	3.89	1
2015	3.97	1
2016	4.31	0.97
2017	4.46	1
2018	4.47	0.97
2019	4.15	1
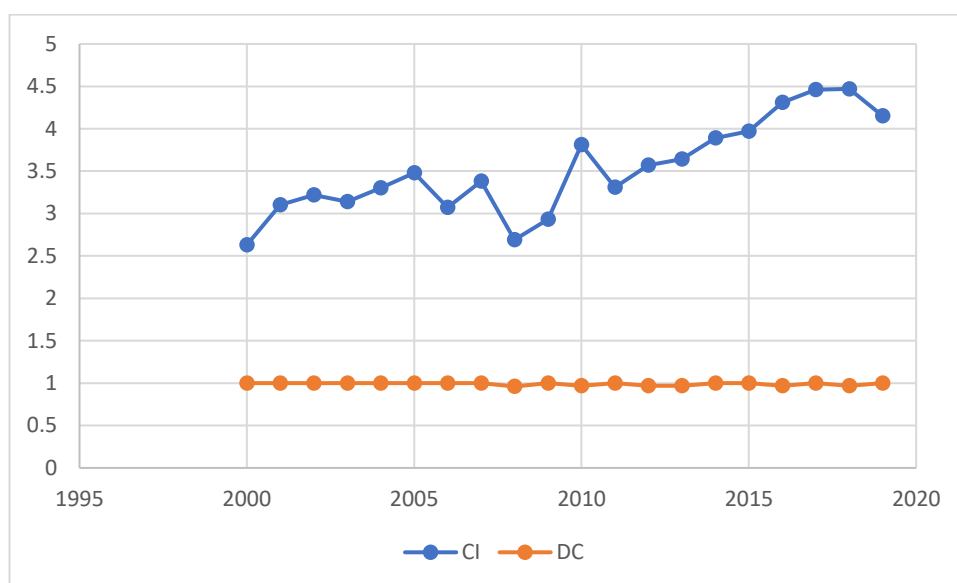
Figure 4.4: Collaborative Index and Degree of Collaboration

Table 4.5 and **Figure 4.4** shows the degree of collaboration and Collaborative Index (CI) in chemistry, throughout a 20-year study period, the (2000-2019). Degree of collaboration ranges from 1 to 0.97. In 2000, the collaboration index was 2.63, while in 2018, it was 4.47. During the study, the average CI was 3.52.

4.6. Form wise distribution

The research output of Chemistry department, NEHU spreads over 6 different types of publication media, such as journal article, review, conference paper, letter, erratum, and book chapter.

The analysis shows that journal articles are the most common type of bibliographic publication, accounting for 633 (97.535%) of all publications.

Conference paper occupies the second position with 8(1.233%) publications followed by Review with 5(0.770%) contributions, book chapter, Erratum and Letter with 1(1.154%) contribution each.

Table 4.6. Document type wise distribution

Document type	Record count	Percent
Research article	633	97.535
Conference paper	8	1.233
Review	5	0.770
Book chapter	1	0.154
Erratum	1	0.154
Letter	1	0.154
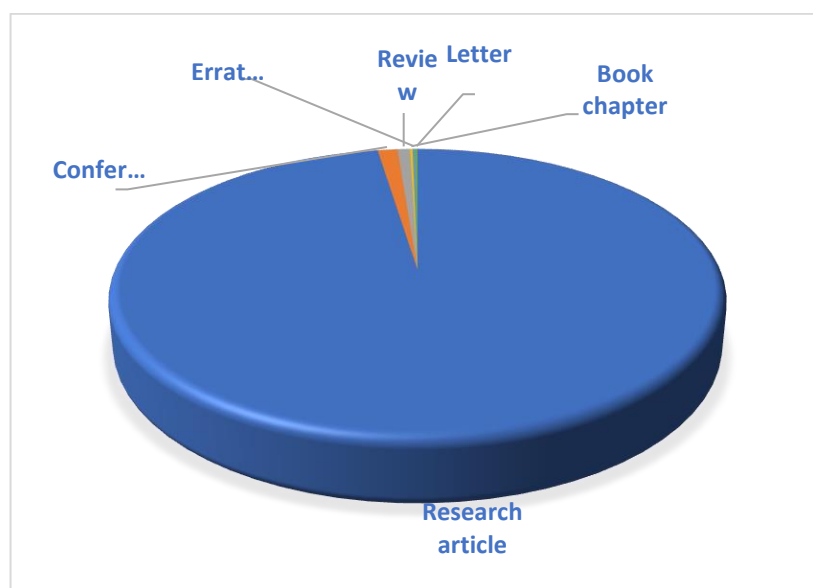
Figure 4.5: Form wise distribution

`   It may be concluded from the above discussion that the Journal form of research output has highest level, Conference paper and Review have the medium level, book chapter, Erratum and letter were having low level (less than 1 percentage) research output in the Chemistry research in NEHU.

4.7. International Collaboration of publications

Table 4.7. International Collaboration

Name of country	Number of collaborations	Percent
United States	43	6.626
Switzerland	42	6.471
Trinidad and Tobago	39	6.009
Belgium	33	5.085
Italy	22	3.389
Taiwan	18	2.773
Czech Republic	18	2.773
Malaysia	18	2.773
Australia	16	2.465
Germany	12	1.849
Maxico	12	1.849
Portugal	10	1.541
Netherlands	8	1.233
Canada	7	1.079
China	5	0.770
Japan	4	0.616
Qatar, Viet Nam	4	0.616
Saudi Arabia, Sweden, United Kingdom	3	0.462
France, Israel, Poland, Thailand, Romania Ukraine	1	0.154

Table 4.7 indicates the country wise distribution of collaboration in Chemistry department, NEHU. At the international front as shown in the table, Chemistry

department NEHU has maximum collaborative publications with United States and collaborated 93 publications, followed by Switzerland with 49 publications, Trinidad and Tobago with 39 publications, Belgium with 33 publications, Italy with 22 publications, Taiwan with 20 publications, Czech Republic, Germany, Malaysia with 18 publications, Australia with 17 publications, Canada with 15 publications, Maximo with 13 publications, United Kingdom with 12 publications, Portugal with11 publications, China with 9 publications, Netherlands with 7 publications, Japan with 6 publications, Qatar, Viet Nam with 4 publications, Saudi Arabia, Sweden with 3 publications, France and Poland with 2 publications and Brazil, Egypt, Hong Kong, Israel, Romania, South Africa, South Korea, Spain, Thailand, Ukraine with 1 publication.

4.8. Citations count of publications

Table 4.8. Citation count

Year	No. of publications	Citations received	Cumulative citations
2000	11	121	121
2001	10	127	348
2002	9	210	458
2003	21	302	760
2004	20	271	1031
2005	31	425	1456
2006	42	401	1857
2007	31	502	2359
2008	27	606	2965
2009	30	359	3324
2010	38	462	3786
2011	32	770	4556
2012	36	462	5018

2013	49	672	5690
2014	37	466	6156
2015	38	337	6493
2016	39	385	6878
2017	50	500	7378
2018	45	312	7790
2019	53	253	7943
Total	**649**	**7943**	**7943**

During the study period, research publications of faculty members of Chemistry department, NEHU received a total of 7943 citations. The average citation per paper is 12.238. The number of highest citations received in 2011 is 770 with 32 publications.

Tezpur University (TU)

4.9. Year wise distribution of TU

The data has been presented in table-1 to evaluate the year wise research productivity of faculty members of Chemistry department, Tezpur University. The table depicts the chronological distribution of research output of the department. **Table 4.9** and **Figure 4.6** shows that Tezpur University published a total of 641 papers in chemistry research between 2000 and 2019. The highest number of publications 92 (14.353%) were published in 2014 while lowest 1 (0.156%) publication was published in 2000.There were 32.05 publications every year on average. The number of publications were growing gradually. From the year 2000 to 2014 research output of the department is increasing and from 2015 onwards number of publications are increasing with some fluctuations and growth rate is decreased.

Table 4.9. Year wise distribution of TU

Year	Number of Publications	Percentage
2000	1	0.156
2001	2	0.312
2002	2	0.312
2003	4`	0.624
2004	8	1.248
2005	8	1.248
2006	8	1.248
2007	14	2.185
2008	18	2.808
2009	22	3.432
2010	31	4.836
2011	35	5.460
2012	40	6.240
2013	70	10.920
2014	92	14.353
2015	58	9.048
2016	53	8.268
2017	69	10.765
2018	56	8.737
2019	50	7.800
Total	641	100
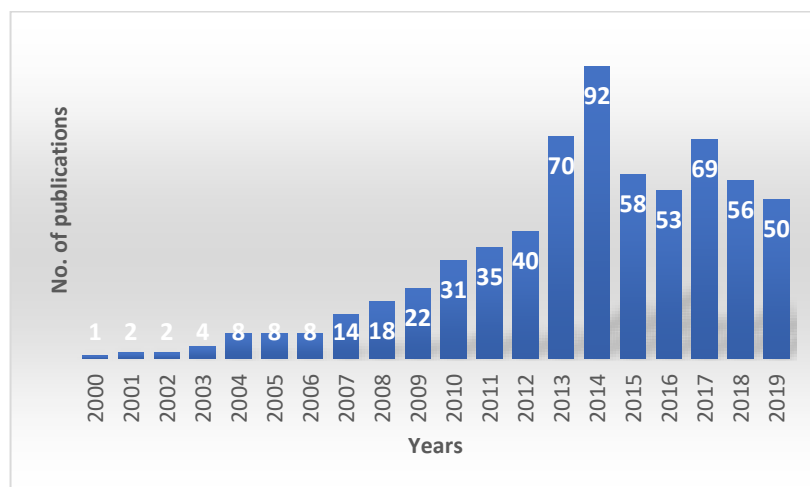
Figure 4.6: Year wise distribution of TU

4.10. Annual Growth Rate of Publications of TU

Table 4.10. Annual Growth Rate of Publications of TU

Year	Number of Publications	AGR
2000	1	0
2001	2	100
2002	2	0
2003	4`	100
2004	8	100
2005	8	0
2006	8	0
2007	14	75
2008	18	14.286
2009	22	22.222
2010	31	40.909
2011	35	12.903
2012	40	14.285

2013	70	75
2014	92	31.428
2015	58	-36.956
2016	53	-8.621
2017	69	30.187
2018	56	-23.214
2019	50	-10.714

Table 4.10 and **Figure 4.7** depicts the annual growth rate of chemistry department, TU during the study period. Maximum 100 AGR was recorded in the years 2001, 2003 and 2004 followed by 75 in 2007 and 2013, 40.909 in 2010, 31.428 in 2014, 30.187 in 2013, 22.222 in 2009, 14.286 in 2008, 14.285 in 2012 and 12.903 in 2011. In 2000, 2002, 2005 and 2006 AGR is 0. For the years 2015, 2016, 2018 and 2019 AGRs are recorded in negative as -36.956, -8.621, -23.214 and -10.714 respectively.
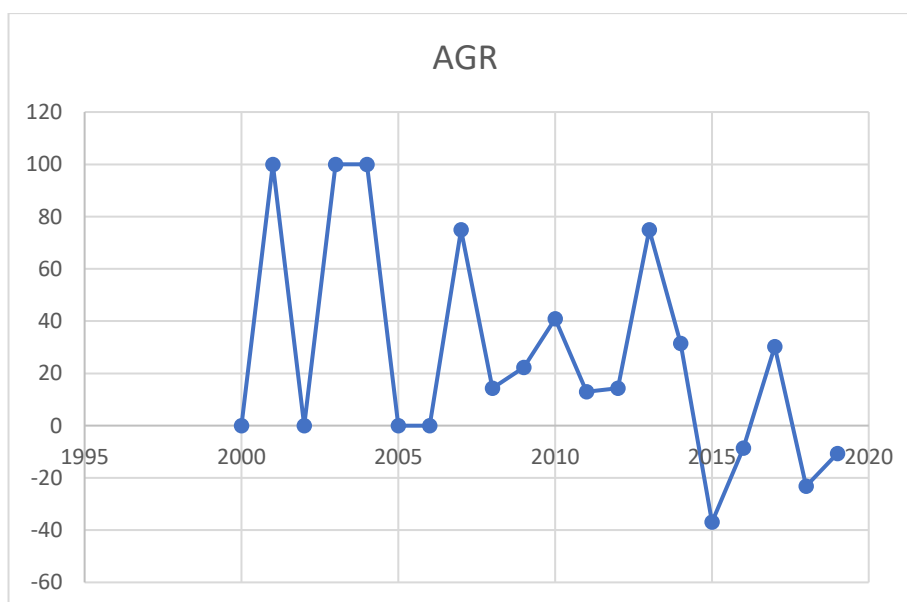

Figure 4.7: Annual growth rate of TU

4.11. Relative Growth Rate and Doubling Time of Publications of TU

Table 4.11. Relative Growth Rate and Doubling Time of TU

Year	Number of Publications	W1	W2	RGR	DT
2000	1		0	0	0
2001	2	0	.3010	0.301	2.30
2002	2	.3010	.3010	0	0
2003	4`	.3010	.6020	.1505	4.60
2004	8	.6020	.9030	.0752	9.21
2005	8	.9030	.9030	0	0
2006	8	.9030	.9030	0	0
2007	14	.9030	1.1461	.0405	17.11
2008	18	1.1461	1.2552	.0272	25.47
2009	22	1.2552	1.3424	.0218	31.78
2010	31	1.3424	1.4913	.0165	42
2011	35	1.4913	1.5440	.0131	52.90
2012	40	1.5440	1.6020	.0116	59.74
2013	70	1.6020	1.8450	.0081	85.55
2014	92	1.8450	1.9637	.0053	130.75
2015	58	1.9637	1.7634	.0058	119.48
2016	53	1.7634	1.7242	.0078	88.84
2017	69	1.7242	1.8388	.0071	97.60
2018	56	1.8388	1.7481	.0069	100.434
2019	50	1.7481	1.6989	.0082	84.51

Table 4.11 represents the research output's relative growth rate and doubling time of chemistry department, TU for the duration 2000-2019. RGR is used to assess

the rate of increase in research productivity over time, and DT is directly related to RGR. In 2001, a maximum of.301 was recorded, followed by a minimum of.1505 in 2003. In the year 2015, the RGR was at its lowest point of.0053.

From the table it has been observed that the values of RGR gradually decreased over the years with some fluctuations. Values of Doubling Time are increasing from top to bottom with some fluctuations.
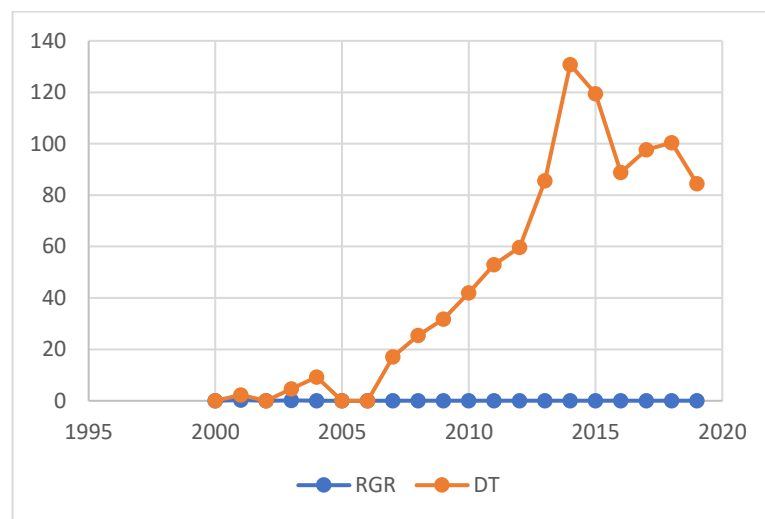

Figure 4.8: Relative Growth Rate and Doubling Time of TU

From table **4.11** and **figure 4.8** it is observed that maximum doubling time 130.75 was recorded in year 2014 followed by 119.48 in 2015, 100.434 in 2018, 97.60 in 2017, 85.55 in 2013, 88.84 in 2016, 84.51 in 2019, 59.74 in 2013, 52.90 in 2011, 42 in 2010, 31.78 in 2009, 25.47 in 2008, 17.11 in 2007, 9.21 in 2004 and 4.60 in 2003. The minimum doubling time 2.30 was recorded in 2001. In 2000, 2002, 2005 and 2006 doubling time was 0.

4.12. Year wise authorship distribution of TU

Table **4.12.** Year wise authorship pattern of TU

Years	Single	Two	Three	Four	Five	More than five	Total
2000	0	0	1	0	0	0	1

2001	0	1	1	0	0	0	2
2002	0	0	1	0	1	0	2
2003	0	0	3	0	1	0	4
2004	0	4	3	0	1	0	8
2005	0	4	1	1	0	2	8
2006	0	4	3	1	0	0	8
2007	0	9	3	1	1	0	14
2008	0	5	6	6	0	1	18
2009	0	11	8	1	1	1	22
2010	0	13	12	3	1	2	31
2011	0	13	10	4	6	2	35
2012	1	15	6	12	4	2	40
2013	0	21	16	17	8	8	70
2014	0	26	19	26	8	13	92
2015	0	13	12	14	13	6	58
2016	0	7	9	21	8	8	53
2017	1	15	12	15	13	13	69
2018	1	13	13	13	7	9	56
2019	0	16	8	9	7	10	50
Total	**3**	**190**	**147**	**144**	**80**	**77**	**641**

Table **4.12** indicates the authorship pattern of Chemistry department, TU during 2000 to 2019. It is found that two author contributed papers occupies the first position (190) in respect to total number of papers published during the period of analysis.

Three author collaborated papers comes next (147) in order of sharing the research output during the period of study.

Four author collaborated research output takes the third position (144) among total number of papers published during the time period of study.

Fourth position is taken by more than five author collaborated papers (80) I sharing chemistry research output during the period of study. Five author collaborated output take the fifth position (77).

Among all the research publications of Chemistry department TU, the number of single author collaborated paper take the last position with 3 papers.

From the above discussion we observed that researcher of Chemistry department, TU mostly preferred to work with joint authorship. Single authored publications are so less in comparison to collaborated publications.

4.13. Year wise Collaborative index and Degree of Collaboration of TU

Table 4.13. Collaborative Index and degree of Collaboration of TU

Year	CI	DC
2000	3	1
2001	2.5	1
2002	4	1
2003	3.75	1
2004	2.75	1
2005	3.37	1
2006	2.62	1
2007	2.57	1
2008	3.22	1
2009	2.77	1
2010	2.93	1
2011	3.25	1

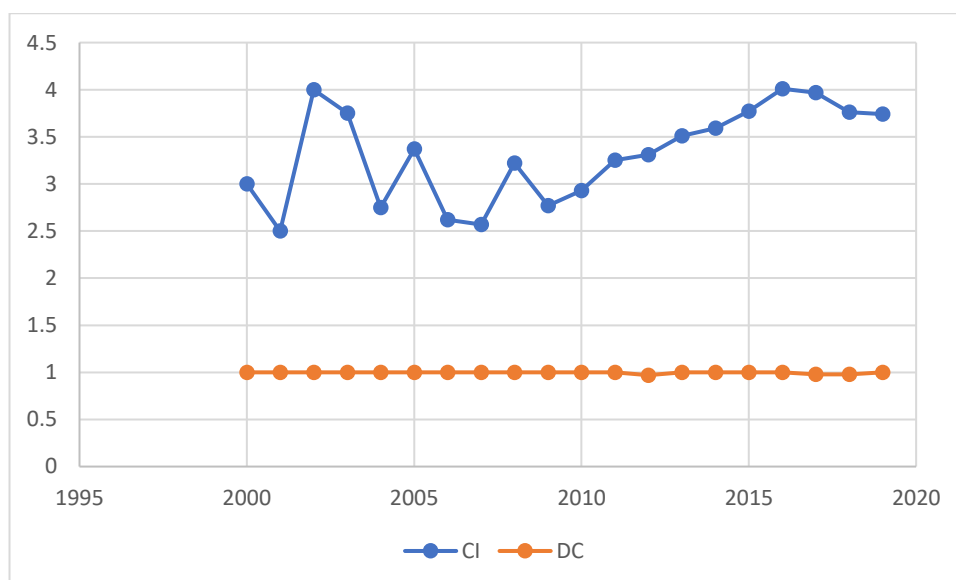| 2012	3.31	0.97
2013	3.51	1
2014	3.59	1
2015	3.77	1
2016	4.01	1
2017	3.97	0.98
2018	3.76	0.98
2019	3.74	1

Figure 4.9: Collaborative Index and Degree of Collaboration of TU

It could be depicted from the above discussion that the number of single authored paper is less than that of multi authored papers. The formula suggested by K. Subramanyam is used to determine the degree of collaboration. The details of this formula has been mentioned in the Chapter 1.

The table **4.13** revealed the degree of collaboration during 2000 to 2019 lies from 0.98 to 1.

In chemistry, Table 4.13 demonstrates the authorship pattern and Collaborative Index (CI) across a 20-year study period (2000-2019). In 2000, the collaboration index was 3; in 2016, it was 4.01. During the research, the average CI was 3.31.

4.14. Document type wise distribution of TU

The research output of Chemistry department, TU spreads over 6 different types of publication media, such as journal article, review, conference paper, letter, erratum, and book chapter.

The analysis shows that journal articles are the most common type of bibliographic publication, accounting for 95.55 % (615) of all publications. Review occupies the second position with 2.18% (23) publications followed by Conference paper with 0.95% (10) contributions, book chapter with 0.66% (7) contributions, Erratum with 0.47% (5) contributions and followed by Letter and short survey with .095% (1) contribution each.

Table 4.14. Document type wise distribution of TU

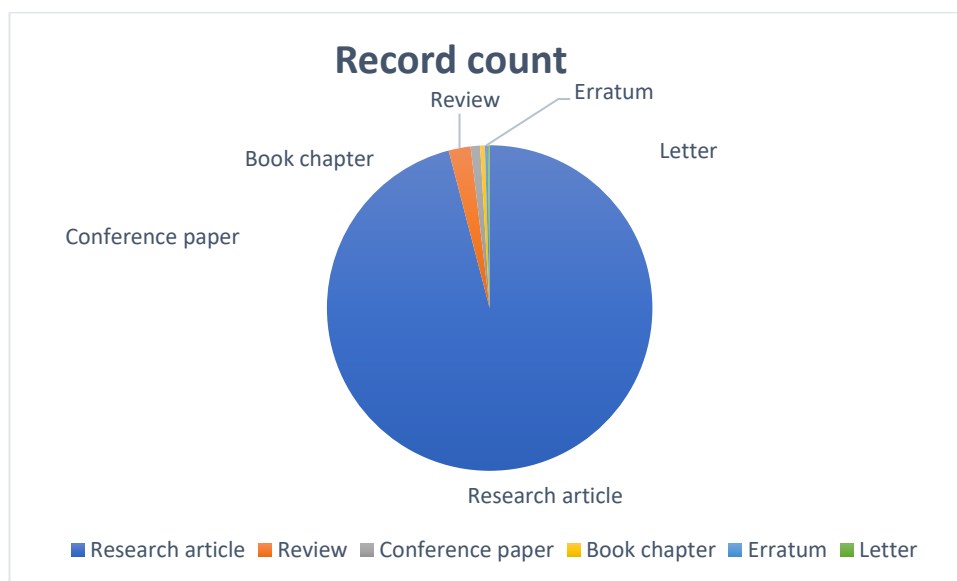| Document type	Record count	Percent
Research article	615	95.55
Review	14	2.18
Conference paper	6	0.95
Book chapter	3	.66
Erratum	2	.47
Letter	1	.095

Figure 4.10: Form wise distribution of TU

It may be concluded from the above discussion that the Journal form of research output has highest level, Review has the medium level, conference paper, book chapter, Erratum, letter and survey were having low level (less than 1 percentage) research output in the Chemistry research in Tezpur University.

4.15. International collaboration of publications of TU

Table 4.15. International Collaboration of TU

Name of country	Number of collaborations	Percent (%)
Japan	10	1.56
South Korea	9	1.40
Germany, Russian Federation	6	0.936
Sweden, Finland	5	0.780
France	4	0.624
United States, Hungary	3	0.468
Australia, Canada, Ethiopia	2	0.312

Bulgaria, Denmark, Italy, China, United Kingdom	1	0.156

Table **4.15** indicates the country wise distribution of collaboration in Chemistry department, TU. At the international front as shown in the table, Chemistry department TU has maximum collaborative publications with Japan having 10 collaborative publications, followed by South Korea with 9 publications, Germany and Russian Federation with 6 publications, Sweden and Finland with 5 publications, France with 4 publications, United States and Hungary with 3 publications and Australia, Canada, Ethiopia collaborated 2 papers with each the country. Chemistry department, TU has collaborated 1 paper with each the country of Bulgaria, Denmark, Italy, China, United Kingdom.

4.16. Citation count of Publications of TU

Table 4.16. Citation count of TU

Year	Number of Publications	Citations received	Cumulative Citations
2000	1	68	
2001	2	15	83
2002	2	61	144
2003	4	72	216
2004	8	393	609
2005	8	243	852
2006	8	214	1066
2007	14	223	1289
2008	18	598	1887
2009	22	750	2637
2010	31	784	3421
2011	35	705	4126

2012	40	1502	5628
2013	70	2741	8369
2014	92	2391	10760
2015	58	1178	11938
2016	53	841	12779
2017	69	1088	13867
2018	56	504	14379
2019	50	322	14693

During the study period, research publications of faculty members of Chemistry department, Tezpur University received a total of 14693 citations. The average citation per paper is 22.921. The number of highest citations received in 2013 is 2741 with 70 publications.

5. FINDINGS, CONCLUSION AND SUGGESTIONS

5.1 Introduction

This chapter highlights the important findings, conclusions and suggestions as the outcome of the study. It gives an objective outlook of the research carried out by faculty members in Tezpur University and North-Eastern Hill University, Chemistry in the time span of 2000 to 2019 as per data indexed in SCOPUS database, a reputed international database. The records were downloaded, organized, sorted and analysed using MS-Excel. The major findings as per the objectives are summarized in this chapter.

5.2 Major findings

The investigation was started with the intention to analyse and evaluate the research output of chemistry department, North-Eastern Hill University and Tezpur University accordingly objectives of the study were designed. Based on the data analysis the following findings are drawn.

5.2.1 To examine the year wise distribution of the publications

Analysis of the data shows that a total of 649 publications were published by North Eastern Hill University and 641 publications were published by Tezpur University during the period of 2000–2019 on Chemistry research. In case of North Eastern Hill University, the highest number of 53 (8.165%) publications were published in 2019 while lowest 9 (1.387%) publications were published in 2002. In case of Tezpur University, The largest number of papers published in 2014 was 92 (14.353 %), while the lowest number of publications was 1 (0.09 %) in 2000.

5.2.2　To find out Annual Growth Rate of Publications

In case of NEHU analysis of data showed an increasing growth rate. In NEHU maximum 133.33 AGR was recorded in the year 2003 followed by 55 in 2005, 36.11

in 2013, 35.48 in 2006, 28.20 in 2017, 26.67 in 2010, 17.78 in 2019, 12.5 in 2012, 11.11 in 2019, 4.76 in 2004 and in 2015 and 2016 AGR is found to be 2.702 and 2.63 respectively. In 2000 AGR is 0. For the years 2001, 2002, 2007, 2008, 2011, 2014, and 2018 AGRs are recorded in negative as -9.090, -10, -26.19, -124, -15.79, -24.49 and -10 respectively.

In TU, maximum 100 AGR was recorded in the years 2001, 2003 and 2004 followed by 75 in 2007 and 2013, 40.909 in 2010, 31.428 in 2014, 30.187 in 2013, 22.222 in 2009, 14.286 in 2008, 14.285 in 2012 and 12.903 in 2011. In 2000, 2002, 2005 and 2006 AGR is 0. For the years 2015, 2016, 2018 and 2019 AGRs are recorded in negative as -36.956, -8.621, -23.214 and -10.714 respectively.

5.2.3. To analyze the relative growth rate and doubling time of the research productivity

Analysis indicates that, in NEHU, the maximum 1.427 RGR was observed in the year 2014 followed by .046 in the year 2002. The minimum RGR .008 is observed in the year 2019. From the study it has been observed that the values of RGR gradually decreased over the years with some fluctuations. Values of Doubling Time are increasing from top to bottom with some fluctuations. It is observed that maximum doubling time 86.625 was recorded in year 2019 followed by 77 in 2018 and 2017, 67.281 in 2013, 63 in 2015, 57.75 in 2006, 2007 and 2016, 56.341 in 2011, 54.566 in 2010 and 2012, 46.2 in 2008, 45.294 in 2009, 40.764 in 2005, 33 in 2004, 23.1 in 2003, 16.902 in 2001, 15.065 in 2002. The minimum doubling time 0.471 was recorded in 2014.

In Tezpur University, the maximum .301 was found in the year 2001 and after that .1505 in the year 2003. The minimum RGR .0053 is observed in the year 2015. It is also observed that the values of RGR gradually decreased over the years with some fluctuations. Values of Doubling Time are increasing from top to bottom with some fluctuations. It is observed that maximum doubling time 130.75 was recorded in year 2014 followed by 119.48 in 2015, 100.434 in 2018, 97.60 in 2017, 85.55 in 2013, 88.84 in 2016, 84.51 in 2019, 59.74 in 2013, 52.90 in 2011, 42 in 2010, 31.78 in 2009,

25.47 in 2008, 17.11 in 2007, 9.21 in 2004 and 4.60 in 2003. The minimum doubling time 2.30 was recorded in 2001. In 2000, 2002, 2005 and 2006 doubling time was 0.

5.2.4 To find out the form wise distribution of the publications

The research output of Chemistry department, NEHU and TU spreads over 6 different types of publication media, such as journal article, review, conference paper, letter, erratum and book chapter. The analysis shows that journal articles are the most common type of bibliographic publication in both the universities. In NEHU, journal article accounting for 633 (97.535%) of all publications and in TU, journal article accounting for 95.55 % (615) of all publications.

5.2.5 To compare the publications of both the universities on the basis of the number of publications and number of citations received.

The study shows that publication output of both the universities are in a positive growth track. Number of publications are higher in North-Eastern Hill University as compared to Tezpur University. The total number of publications of TU is 641 and NEHU is 649. In case of TU, the average publications published per year was 32.05 and in NEHU the average publications published per year was 32.45.

During the study period, there are large differences in citation count between both the universities. Research publications of faculty members of Chemistry department, Tezpur University received a total of 14693 citations. The average citation per paper is 22.921. The number of highest citations received in 2013 is 2741 with 70 publications.

In case of North- Eastern Hill University, research publications of faculty members of Chemistry department received a total of 7943 citations. The average citation per paper is 12.238. The number of highest citations received in 2011 is 770 with 32 publications.

Clearly the number of citations received by Tezpur University is almost the twice of the citations received by North -Eastern Hill University.

5.2.6. To find out the single author vs. multi authored papers with degree of collaboration and Collaborative Index

From the analysis of authorship pattern of Chemistry department, NEHU during 2000 to 2019 it is found that two authors contributed papers occupies the first position (178) in respect to total number of papers published during the period of analysis. Among all the research publications of Chemistry department NEHU, the number of single author collaborated paper take the last position with 6 papers. In case of Tezpur University two author contributed papers occupies the first position (190) in respect to total number of papers published during the period of analysis. Among all the research publications of Chemistry department TU, the number of single author collaborated paper take the last position with 3 papers. From the analysis we observed that researcher of Chemistry department, in both the universities mostly preferred to work with joint authorship. Single authored publications are so less in comparison to collaborated publications.

Analysis revealed that in NEHU, Degree of collaboration ranges from 1 to 0.97. In 2000, the collaboration index was 2.63, while in 2018, it was 4.47. During the study, the average CI was 3.52. In case of Tezpur University the degree of collaboration during 2000 to 2019 lies from 0.98 to 1. In 2000, the collaboration index was 3, while in 2016, it was 4.01. Throughout the study, the average CI was 3.31.

5.2.7. To study the international collaborative efforts by the academics of both the universities

Analysis indicates that, Chemistry department NEHU has maximum collaborative publications with United States and collaborated 93 publications, followed by Switzerland with 49 publications, Trinidad and Tobago having 39 publications, Belgium having 33 publications, Italy with 22 publications, Taiwan having 20 publications, Czech Republic, Germany, Malaysia having 18 publications, Australia having 17 publications, Canada with 15 publications, Maximo with 13 publications, United Kingdom with 12 publications, Portugal with11 publications, China with 9 publications, Netherlands with 7 publications, Japan with 6 publications, Qatar, Viet Nam with 4 publications, Saudi Arabia, Sweden with 3 publications,

France and Poland with 2 publications and Brazil, Egypt, Hong Kong, Israel, Romania, South Africa, South Korea, Spain, Thailand, Ukraine with 1 publication.

Chemistry department TU has maximum collaborative publications with Japan having 10 collaborative publications, followed by South Korea with 9 publications, Germany and Russian Federation with 6 publications, Sweden and Finland with 5 publications, France with 4 publications, United States and Hungary with 3 publications and Australia, Canada, Ethiopia collaborated 2 papers with each the country. Chemistry department, TU has collaborated 1 paper with each the country of Bulgaria, Denmark, Italy, China, United Kingdom.

5.3. Conclusion

Scientometric studies helps to find out the most productive organizations and authors from an academic or educational institution, country, and also the most influential journals in which they publish. Day by day several new methods have been evolving to find out the impact of research output. The results of such studies bring out several features in varied dimensions like how better an institution is, who are the prolific contributors to a subject field etc, and in turn help for the development of an institution and help to attract more funds for the institution.

In this study the research output of faculty members of Chemistry department of Tezpur University and North-Eastern Hill University has been studied. The study shows that publication output of both the universities are in a positive growth track. Number of publications and growth rate of publications are higher in North Eastern Hill University as compared to Tezpur University but the citation count is more in Tezpur University. Major segment of research output in both the universities are in the form of journal articles. The faculty members prefer joint authorship in writing articles; which indicates the extent of interdisciplinary research in the institution. Hefty quantity of articles has been published in International Journals. Authorship style in both the universities are multi-authored. Both the universities are having international collaborative publications.

5.4. Suggestions

Measuring an institution's research impact is crucial for policymakers to evaluate and plan the organization's research strategy. Suggestions and recommendations for improving research output visibility are

1. Universities may conduct periodic evaluations of research output. This will aid in the improvement of the weaker subject area.

2. Based on the findings, scientists should focus their efforts on the areas that have been ignored, with the goal of conducting more research activities. From the conclusion of this present study, the competence of both the institution could be recognized. Therefore, the individual institution may be inspired to issue more number of contributions.

3. More prospects for international collaboration in research may be generated. As a result, more international collaboration papers will be produced.

4. The funding agencies, universities and other research institutions/organizations are to be provided with more financial assistance in the form of research grants and equipment to enhance the quality of research.

5.5. Scope for further research

Further study can be carried out in the area by collecting data from different database with application of advance statistical tools, different scientometric tools, techniques and indicators. It will give the real picture of Chemistry research in both the universities

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6. EDUCATIONAL QUALIFICATIONS

Examination passed	Year of Passing	Board/ University	Class/ Division	% of Marks	Subjects
High School Leaving Certificate Examination	2010	Board of Secondary Education, Assam	I	71.33	Maths, Eng, Sci, S. sci, MIL, Adv. Maths
Higher Secondary School Leaving Certificate Examination	2012	Assam Higher Secondary Education Council	I	69.6	Chem, Phy, Maths, Biolg, Maths, Eng, MIL
B. Sc.	2015	Dibrugarh University (Assam)	First class with distinction	73.93	Chem(M), Phy, Maths, Eng, Env Sci
MLIS	2018	Gauhati University	I	67.2	Library and Information Science

LIST OF PUBLICATIONS

1. Research Productivity of Chemistry department, Tezpur University: A Scientometric Study, **Nayana Borah**, December 2020, *Library, Philosophy and Practice.*

2. Research Output Analysis of the Highest Productive Department of Mizoram University: A Study Based on SCOPUS Database, **Nayana Borah**, S. N. Singh, 2021, *Library, Philosophy and Practice.*

CONFERENCES AND SYMPOSIUM

1. Paper presented in international conference on "Recent Advances in Social Sciences, Humanities, Management and Scientific Research" RAMAS- 2021, entitled: "**Scientometric Profile of the Highest Productive Department of Mizoram University: A Study Based on SCOPUS Database"**, organised by Eudoxia Research Centre, India, 5th-6th, June, 2021.

2. Paper presented in National Seminar in "Social media and Librarianship: Connecting the Communities", entitled: "**Marketing of Library and Information Products and Services through Social Media**", organized by deparment of Library and Information Science, Mizoram University, 26th-28th February, 2020.

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DEPARTMENT : Library and Information Science

TITLE OF DISSERTATION : Research output of faculty members of Chemistry Department of Tezpur University and North-Eastern Hill University: A Scientometric Study.

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ABSTRACT

RESEARCH OUTPUT OF FACULTY MEMBERS OF CHEMISTRY DEPARTMENT OF TEZPUR UNIVERSITY AND NORTH-EASTERN HILL UNIVERSITY: A SCIENTOMETRIC STUDY

A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF PHILOSOPHY

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DEPARTMENT OF LIBRARY AND INFORMATION SCIENCE
SCHOOL OF ECONOMICS, MANAGEMENT AND INFORMATION SCIENCE
SEPTEMBER, 2021

RESEARCH OUTPUT OF FACULTY MEMBERS OF CHEMISTRY DEPARTMENT OF TEZPUR UNIVERSITY AND NORTH-EASTERN HILL UNIVERSITY: A SCIENTOMETRIC STUDY

BY

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Under the supervision of

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Submitted

In partial fulfillment of the requirement of the Degree of Master of Philosophy in Library and Information Science of Mizoram University, Aizawl.

1.INTRODUCTION

Research is an imperative area that leads to any development. Educational Research is vital to get an in-depth analysis of the topic, to enhance knowledge in an efficient way. Without proper research, there cannot be any innovation and the importance of research has several facets. It is integrated into education at every level. The knowledge that one gain from research seek to serve diverse economic, cultural, and societal constituents. Through researches, higher educational institutions ensure continuing excellence in both learning and teaching resources. Educational research has resembled the nature of research as it is systematic, reliable, and valid the truth, investigates knowledge, and solves problems. However, educational research is more complex because it can use various approaches and strategies to provide solutions to the problems that take place within the field of education in an organized and methodical manner. The National Institutional Ranking Framework (NIRF) ranks the institutions of higher education in India. This research methodology was adopted by the Ministry of Human Resource Development (MHRD), Government of India encompassing parameters like Teaching, Learning and & Resources (TLR), Research and Professional Practice (RP), Graduation Outcomes (G,O), Outreach and Inclusivity (OI), Peer Perception, etc. Universities provide relevant research that can compete with the best in the world by providing interdisciplinary collaboration amongst the sciences, social sciences, and humanities. Higher education is the primary venue for examining and refining our national goals, developmental priorities, and civic ideals. Higher education institution is responsible for the development of a modern economy, a knowledge society, and a dynamic political system.

In higher education, research productivity refers to the development and transmission of knowledge through various forms of research, teaching, and outreach activities. As a result, analysis of academic institutions' research productivity has become increasingly essential in ranking academic institutions.

Data on research performance assists in making strategic decisions about which research topics to support or expand. It also aids in determining the institution's status in context to global and domestic research output criteria. It addresses issues such as how research is conducted, its impact, the number of articles published in core journals by faculty members in their respective fields, the trend of publications (whether increasing or decreasing), patents

awarded, technology transfer, and the study of research challenges on a subject and discipline level.

2. Research Output

Research is the creation of new knowledge or the innovative use of existing knowledge to create new ideas, methodologies, and understanding. This may involve synthesizing and analyzing previous research to the extent that it produces news and innovative results. Result output is a result of research that can take several different forms, such as books, artefact, book chapter, patent, conference paper, journal article etc. The distribution, publication, presentation, correspondence, or pathway by which research is made accessible to people other than the researcher is known as a research output. It is essential to evaluate research output in order to ranking institutions and gain access to individual researchers. It's also crucial to know if our country's funding pattern is on right track. There are many methods for determining the quantity and quality of a person's, institutions, group of institutions', or country's research output. Scientometric study is an important tool for analyzing research output.

Measurement of research activities is often used by policymakers and analysts to assess research success. It helps in the evaluation of a research institution's strengths and weaknesses, as well as the establishment of standards for other institutions. Setting objectives, determining an institution's future plan or policy, and the criteria to meet those objectives are all greatly aided by the institution's net research success, which is heavily reliant on analysis of research output conducted by institutions from time to time.

3.Tezpur University:

Tezpur University is an Indian central university located in the state of Assam in the northeast region of the country. Tezpur University was founded in 1994 by an Act of Parliament with the primary goal of providing employment-oriented and multidisciplinary courses to meet Assam's development needs, in addition to delivering courses and fostering research in areas of direct and immediate interest to the region, as well as developing science and technology fields. Departments are categorized in four main schools and under those schools, 27 departments are there. Chemistry department is under School of Sciences. It is one of the most active department of Tezpur University. The department was started in the year 1997. Chemistry department is showing efficiency in high-quality chemical science and multidisciplinary research. Apart from several national collaboration projects, numerous worldwide collaborative projects are currently going on. A few members of the faculty are also

involved in consulting initiatives. DST, UGC, CSIR, DBT, DAE, AICTE, and others providing external fund.

4.SIGNIFICANCE OF THE STUDY

A number of studies has been conducted to analyze the research productivity of different discipline and different institutions. Very few studies have been found on this field with reference to North East India which deals with the research productivity of different institution and discipline whereas no scientrometric study is conducted so far which have the comparative study between two universities from the data available in Scopus database. So, present study will be an attempt to fill up the gap. Therefore, the present study will attempt to analyze the Research publications of two central universities of North East India

The findings of the study will help in enhancing the visibility of institutions, trends of their research productivity, research collaboration etc. The individuals or the team of researchers also get appreciation and inducement for their work.

5.SCOPE OF THE STUDY

The scope of the present study covers the research publications of Chemistry department of Tezpur University and North-Eastern Hill University available in Scopus database for the period of 2000-2019. Research publications available in "all document types" will be covered in the study. According to the data of National Institutional Ranking Framework (NIRF), 2019, Tezpur University and North-Eastern Hill University are on the top among the other central universities of north east India. So, these two universities have been selected for the present study. Chemistry department has the highest contribution in both the universities among all the subjects available in Scopus database, so department of chemistry has been chosen for the study. The publications of Chemistry department, Tezpur University are available in SCOPUS from the year 2000. So, time span for the study is taken as 2000-2019 for both the universities.

6. STATEMENT OF THE PROBLEM

The present study aims at examining the research output of Chemistry department of Tezpur University and North-Eastern Hill University. Universities conduct research to create, transfer and utilize knowledge to find solutions for different problems and for the development of the society. In academic and scientific works, publication is the chief means of communicating research, a primary means of recognition and reward. Therefore, it is through

publication the researcher got professional recognition and esteem as well as promotion, advancement and funding for future research. Publication helps in the betterment of individuals.

Scientometric analysis is an important tool in analyzing any discipline. So an attempt has been made to study the "research productivity of chemistry department: a scientometric study in Tezpur University and North-Eastern Hill University".

7.OBJECTIVES OF THE STUDY

1. Analyze the distribution of publications year wise.
2. To determine the distribution of publications by document type
3. To compare the publications of both the universities on the basis of the number of publications and citation count.
4. Determine the research output's relative growth rate (RGR) and doubling time (DT).
5. Analyze the authorship pattern and assess the degree of collaboration
6. Analyze international collaborative efforts by the academics of both the universities
7. The study is designed to investigate the research productivity of two central universities in chemistry department indexed in Scopus database.

8.Methodology

The study has covered author wise research productivity, year wise distribution etc. as research productivity indicators.The study has covered twenty (20) years' time i.e. 2000-2019.The raw data has been collected from the Scopus database and tabulated in MS-Excel file. Scopus is one of the leading scholarly databases which have the collection of many databases in different fields. It enables access to various databases, cross-disciplinary study, and in-depth exploration of particular subfields within a scientific or academic area. The bibliographic information of published work were gathered using the Scopus database's general search option. A list of faculty members of both the university has been prepared and the publications published by the faculty members of both the universities have been refined and retrieved for the study. For the analysis of collected data, suitable statistical and scientometric/bibliometric tools have been applied.

9.REVIEW OF LITERATURE

The review of literature gives the glimpses of studies of scientometric analysis of different discipline and institutions. The study is arranged in chronological order. However, this chapter help the researcher with a better understanding of the previous studies that happened on this topic and how this study could be improved. On the analysis of the literature review, it has been observed that there are sufficient numbers of research conducted to analyse the research productivity of different disciplines and different institutions. But no study has been conducted to study the research productivity of the proposed area based on Scopus Database. So the present study will be an attempt to fill up the gap on the proposed topic.

10.FINDINGS OF THE STUDY

i. **To find out Annual Growth Rate of Publications**

In case of NEHU analysis of data showed an increasing growth rate. In NEHU maximum 133.33 AGR was recorded in the year 2003 followed by 55 in 2005, 36.11 in 2013, 35.48 in 2006, 28.20 in 2017, 26.67 in 2010, 17.78 in 2019, 12.5 in 2012, 11.11 in 2019, 4.76 in 2004 and in 2015 and 2016 AGR is found to be 2.702 and 2.63 respectively. In 2000 AGR is 0. For the years 2001, 2002, 2007, 2008, 2011, 2014, and 2018 AGRs are recorded in negative as -9.090, -10, -26.19, -124, -15.79, -24.49 and -10 respectively.

In TU, maximum 100 AGR was recorded in the years 2001, 2003 and 2004 followed by 75 in 2007 and 2013, 40.909 in 2010, 31.428 in 2014, 30.187 in 2013, 22.222 in 2009, 14.286 in 2008, 14.285 in 2012 and 12.903 in 2011. In 2000, 2002, 2005 and 2006 AGR is 0. For the years 2015, 2016, 2018 and 2019 AGRs are recorded in negative as -36.956, -8.621, -23.214 and -10.714 respectively.

ii. **To analyze the relative growth rate and doubling time of the research productivity**

Analysis indicates that, in NEHU, the maximum 1.427 RGR was observed in the year 2014 followed by .046 in the year 2002. The minimum RGR .008 is observed in the year 2019. From the study it has been observed that the values of RGR gradually decreased over the years with some fluctuations. Values of Doubling Time are increasing from top to bottom with some fluctuations. It is observed that maximum doubling time 86.625 was recorded in year 2019 followed by 77 in 2018 and 2017, 67.281 in 2013, 63 in 2015, 57.75 in 2006, 2007 and 2016,

56.341 in 2011, 54.566 in 2010 and 2012, 46.2 in 2008, 45.294 in 2009, 40.764 in 2005, 33 in 2004, 23.1 in 2003, 16.902 in 2001, 15.065 in 2002. The minimum doubling time 0.471 was recorded in 2014.

In Tezpur University, the maximum .301 was found in the year 2001 and after that .1505 in the year 2003. The minimum RGR .0053 is observed in the year 2015. It is also observed that the values of RGR gradually decreased over the years with some fluctuations. Values of Doubling Time are increasing from top to bottom with some fluctuations. It is observed that maximum doubling time 130.75 was recorded in year 2014 followed by 119.48 in 2015, 100.434 in 2018, 97.60 in 2017, 85.55 in 2013, 88.84 in 2016, 84.51 in 2019, 59.74 in 2013, 52.90 in 2011, 42 in 2010, 31.78 in 2009, 25.47 in 2008, 17.11 in 2007, 9.21 in 2004 and 4.60 in 2003. The minimum doubling time 2.30 was recorded in 2001. In 2000, 2002, 2005 and 2006 doubling time was 0.

iii. To find out the form wise distribution of the publications

The research output of Chemistry department, NEHU and TU spreads over 6 different types of publication media, such as journal article, review, conference paper, letter, erratum and book chapter. The analysis shows that journal articles are the most common type of bibliographic publication in both the universities. In NEHU, journal article accounting for 633 (97.535%) of all publications and in TU, journal article accounting for 95.55 % (615) of all publications.

iv. To compare the publications of both the universities on the basis of the number of publications and number of citations received.

The study shows that publication output of both the universities are in a positive growth track. Number of publications are higher in North-Eastern Hill University as compared to Tezpur University. The total number of publications of TU is 641 and NEHU is 649. In case of TU, the average publications published per year was 32.05 and in NEHU the average publications published per year was 32.45.

During the study period, there are large differences in citation count between both the universities. Research publications of faculty members of Chemistry department, Tezpur University received a total of 14693 citations. The average citation per paper is 22.921. The number of highest citations received in 2013 is 2741 with 70 publications.

In case of North- Eastern Hill University, research publications of faculty members of Chemistry department received a total of 7943 citations. The average citation per paper is 12.238. The number of highest citations received in 2011 is 770 with 32 publications.

Clearly the number of citations received by Tezpur University is almost the twice of the citations received by North -Eastern Hill University.

v. To find out the single author vs. multi authored papers with degree of collaboration and Collaborative Index

From the analysis of authorship pattern of Chemistry department, NEHU during 2000 to 2019 it is found that two authors contributed papers occupies the first position (178) in respect to total number of papers published during the period of analysis. Among all the research publications of Chemistry department NEHU, the number of single author collaborated paper take the last position with 6 papers. In case of Tezpur University two author contributed papers occupies the first position (190) in respect to total number of papers published during the period of analysis. Among all the research publications of Chemistry department TU, the number of single author collaborated paper take the last position with 3 papers. From the analysis we observed that researcher of Chemistry department, in both the universities mostly preferred to work with joint authorship. Single authored publications are so less in comparison to collaborated publications.

Analysis revealed that in NEHU, Degree of collaboration ranges from 1 to 0.97. In 2000, the collaboration index was 2.63, while in 2018, it was 4.47. During the study, the average CI was 3.52. In case of Tezpur University the degree of collaboration during 2000 to 2019 lies from 0.98 to 1. In 2000, the collaboration index was 3, while in 2016, it was 4.01. Throughout the study, the average CI was 3.31.

vi. To study the international collaborative efforts by the academics of both the universities

Analysis indicates that, Chemistry department NEHU has maximum collaborative publications with United States and collaborated 93 publications, followed by Switzerland with 49 publications, Trinidad and Tobago having 39 publications, Belgium having 33 publications, Italy with 22 publications, Taiwan having 20 publications, Czech Republic, Germany, Malaysia having 18 publications, Australia having 17 publications, Canada with 15 publications, Maximo with 13 publications, United Kingdom with 12 publications, Portugal

with11 publications, China with 9 publications, Netherlands with 7 publications, Japan with 6 publications, Qatar, Viet Nam with 4 publications, Saudi Arabia, Sweden with 3 publications, France and Poland with 2 publications and Brazil, Egypt, Hong Kong, Israel, Romania, South Africa, South Korea, Spain, Thailand, Ukraine with 1 publication.

Chemistry department TU has maximum collaborative publications with Japan having 10 collaborative publications, followed by South Korea with 9 publications, Germany and Russian Federation with 6 publications, Sweden and Finland with 5 publications, France with 4 publications, United States and Hungary with 3 publications and Australia, Canada, Ethiopia collaborated 2 papers with each the country. Chemistry department, TU has collaborated 1 paper with each the country of Bulgaria, Denmark, Italy, China, United Kingdom.

11. Conclusion

Scientometric studies helps to find out the most productive organizations and authors from an academic or educational institution, country, and also the most influential journals in which they publish. Day by day several new methods have been evolving to find out the impact of research output. The results of such studies bring out several features in varied dimensions like how better an institution is, who are the prolific contributors to a subject field etc, and in turn help for the development of an institution and help to attract more funds for the institution.

In this study the research output of faculty members of Chemistry department of Tezpur University and North-Eastern Hill University has been studied. The study shows that publication output of both the universities are in a positive growth track. Number of publications and growth rate of publications are higher in North Eastern Hill University as compared to Tezpur University but the citation count is more in Tezpur University. Major segment of research output in both the universities are in the form of journal articles. The faculty members prefer joint authorship in writing articles; which indicates the extent of interdisciplinary research in the institution. Hefty quantity of articles has been published in International Journals. Authorship style in both the universities are multi-authored. Both the universities are having international collaborative publications.

12. Suggestions

Measuring an institution's research impact is crucial for policymakers to evaluate and plan the organization's research strategy. Suggestions and recommendations for improving research output visibility are

1. Universities may conduct periodic evaluations of research output. This will aid in the improvement of the weaker subject area.

2. Based on the findings, scientists should focus their efforts on the areas that have been ignored, with the goal of conducting more research activities. From the conclusion of this present study, the competence of both the institution could be recognized. Therefore, the individual institution may be inspired to issue more number of contributions.

3. More prospects for international collaboration in research may be generated. As a result, more international collaboration papers will be produced.

4. The funding agencies, universities and other research institutions/organizations are to be provided with more financial assistance in the form of research grants and equipment to enhance the quality of research.