CHAPTER-1

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1 INTRODUCTION

Research publication is one of the most important activities of any Research and Development Laboratory, besides its contribution to the field of basic and applied research, and innovation. Research communication reflects the performance, status and societal importance as well as its' existence in the present global scenario. The National Metallurgical Laboratory is one of the leading R&D organisations functioning under the banner of the Council of Scientific and Industrial Research (CSIR). NML was inaugurated in 1950 at Jamshedpur, Jharkhand (Erstwhile Bihar) and is striving hard to contribute R&D to Minerals based industries in India and abroad since its inception.

The focus area of this globally reputed R&D laboratory is to innovate, develop, transfer, standardise and provide specialised services such as R&D, Technology Transfer, Consultancy, Standards and Quality control so as to support the scientific and industrial growth and success in the areas of Minerals, Metals and advanced Materials by an experienced team of scientists and engineers and wealth of state-of-the art technology is well established. The expert team of scientists contribute, on an average, 75 number of research papers annually (1950-2007) and organising several national and international seminars, workshops and disseminating knowledge to society. However, the average growth of literature per year for last two decades (1991-2010) reached more than
102 papers. Similarly, the year 2006-2007 became the milestone in the publication history of NML, as it broke the record of previous years with a record publication of 239 papers and received more than 572 citations.

1.1 STATEMENT OF THE PROBLEM OF INVESTIGATION

Scientific research is not like any product from an industrial enterprise. Some areas of it required technique of evaluation, quantitative or qualitative. Publications are not the ends of research. However, the number of innovations developed by research efforts has to be related to the allotment of resources in terms of men and materials. When research was merely an academic pursuit of a few men and women in large universities, evaluations were not attempted as rigorously as it is today. But in recent decades, scientific and technological research has become part of industrial programme and the flow of funds has been manifold increasing. A major part of the funds allotted is spent in applied research in every R&D institution, which aims at the development of new processes to reduce the costs, improve the quality of products already in production, or create new devices, which can replace the old with added advantage and to help economic growth. Scientific research, unlike in the past, has become a social and economic necessity. Under these conditions, evaluation of research activity today becomes as much a necessity as in any other field of social activity.

Scientific research and publications are the backbone of any country, more so for a developing country like India. Considering its importance in modern industries, this study has chosen the subject area. The major assignment of any Research and Development organisation/institution is to execute basic Research, Applied Research,
performing R&D services, providing expertise and consultancy services to various Industries. On the other hand, communication of their research findings and published papers in journals, proceedings, reports are another major task of any R&D organisation, which can be applied as a parameter to evaluate their performance. A number of studies have been performed on scientometric profile of different R&D Institutions, Subject areas, Country, Journals and even their comparative study so as to monitor what is happening, in which direction they are moving, and, what are the trends of publications. However, the present Productometric Analysis on NML undertaken by the investigator is a solo attempt. Publication trends are always in demand for application in various purposes like, drafting five-year plan proposals, audit reply, SWOT analysis, performance indicators, collection development for NML library, etc. Therefore, in the light of above facts, this topic was chosen to identify and analyse the publication profile of NML.

The publication account of NML like any R&D organisation will work as an effective Management Information Tool and will be useful in framing S&T policy and acts as the performance indicator to measure both strength and weakness of the respective R&D organisation.

The present research study has concentrated primarily on the Publication pattern vis-à-vis the subject coverage and Research Trends by analysing the total number of publications appeared in SCI / Non-SCI journals, National Proceedings, International Proceedings, Books, and Monographs. This study has thoroughly examined the entire spectrum of its collection of research to assess the state of innovation and research reflected in different period of time (1950-2007) by analysing through
value added method. The output of the above Productometric study can effectively function as Management Information Tool and can be applied to determine research collaboration at National Metallurgical Laboratory.

1.2 AIMS AND OBJECTIVES OF THE STUDY

The objective of the case study is to evaluate the publications output and research trends of NML. The final output of the research studies will work as Management Information Tool. As information generation is the major activities, it can be repackaged and presented in the form of graphs and tables that will reflect the publication executed by NML during 1950-2007. The study will also reflect the Research trends, publication pattern, total numbers of publications appeared in different types of information sources viz. primary, secondary and tertiary source. In order to have publication account for any R&D organisation, the same will work, as an effective Management Information Tool and the same will be useful for framing S&T policy and work as an indicator to measure strength and weakness in the respective R&D area.

Thus, the present study set froths the following objectives to achieve:

a) To ascertain the research trends, publication pattern and the quantum of publications in different the field of Metallurgy and Materials Science contributed by NML during last 58 years;

b) To discover the share of each of the three major sources of information, namely, primary, secondary and tertiary in which these publications dominate;
c) To serve as an effective management information tool, so as to facilitate the management of R&D institution for framing appropriate S&T policy tailored to the need of the current age;

d) To serve as an indicator to measure both strength and weakness of the respective publications in the R&D area of Metallurgy and Materials Science; and

e) To discover quality and quantity of publications through citation analysis and impact factor.

1.3 SCOPE AND LIMITATIONS

Scope is intimately related to generalization. A scope statement sets empirical and theoretical limit on the extent to which an inference can be generalised (Goertz and Mahoney, 2006, p.1). The field of social science research is virtually unlimited, and the materials of research endless. Every group of social phenomena, every phase of human life, and every stage of past and present development are materials for social scientists.

However, Research in social science has certain limitations and problems like, language, geography, complexity of the matter, human problems, personal values, selection of sampling techniques and statistical methods, etc that are inherent with scope of research. Therefore, scope and a limitation of the research needs to be clearly addressed from the very outset of the investigation.

Owing to paucity of time, fiscal constraints, limited access to data and vastness of sample, the present study has the following limitations:
1.3.1 The evaluation of publication activities of this Productometric Study has been confined to NML research publications covering the period from 1950-2007 (58 years), but not of any other period (i.e. limitation by time);

1.3.2 This study evaluates the publications of NML only, but not of any other R&D institutions (i.e. limitation by number and nature of the R&D institute covered in the investigation);

1.3.3 The R&D publications of NML scientists for the period 1950-2007 have been analysed through well established bibliometrics principles and method, but do not apply any other techniques and methods (i.e. limitation by principles of analysis and evaluation);

1.3.4 This study covers those publications of NML published between 1950-2007 only (i.e. limitation by the period being covered);

1.3.5 It includes those publications, which have been covered under the domain of Metallurgy and Materials and allied Sciences only (i.e. limitation by discipline and/or subject area);

1.3.6 It considers the publications contributed by National Metallurgical Laboratory located at Jamshedpur and its field station located at Chennai (CSIR complex), but not any other NML or analogous R&D institution functioning anywhere (i.e. limitation by geography of the institutions); and
1.37 This study evaluates the publications of NML through citation analysis from 1972-2007 (36 years) through Science Citation Index on-line version retrieved at www.isiknowledge.com only; (i.e. limitation of citation analysis by periods and database).

1.4 SIZE OF THE SAMPLE

The objectivity of the findings pertain to the method of collection of data and securing the responses. It should present and permit the use of methods which is fairly objective in which every observer or judge seeing a performance arrives at precisely. This ensures the objectivity of the collected data, which has been used for analysis, inferences and generalization. While in a statistical approach vis-à-vis Bibliometrics approach, the ‘individual’ disappears from the analysis, in a case study the “individual” representing the ‘wholeness’ is preserved, as it is an approach which view any social unit as a whole. Thus, a case study gives us a total view of unit or clear insight into a situation, or processes in its total setting. The perspective of a case study is both quantitative and organic. It gives an overall generic picture of the case, under investigation.

The sample for the present study has been taken from Annual Reports that represented and incorporates the total number of research articles published by National Metallurgical Laboratory since its inception (1950). The technical project reports are also has been incorporated separately. The research articles have further been categorised into SCI/Non-SCI, National/International Proceedings. The International database - METADEX, Science Citation Index (on-line version) also been referred to for determining the appearance of research communication in.
the international databases. In order to derive the relevant Key Words, the BS: 1000 M-1993 (British Standards) has been referred to and for getting the consistency, research areas grouped by key Words. The thesaurus for metallurgical terms, published from Cambridge Science Abstract, has been consulted for framing related area of Research and Development together. The internationally reputed DIALOG Inc. Database available on CD-ROM (1966-2004) and on-line (2005) have been taken into consideration for research study. To achieve the survey objective, the present work would proceed on the following samples:

- Annual Reports of NML (1957-2007);
- The Technical Project Reports (1950-2007);
- National and International proceedings published by NML;
- International databases-Metadex, Science Citation Index retrieved through Web of Science, Science Direct (Elsevier Pub.), Springer Link on-line e-journals; and
- Research publications’ carrying different sources and forms.

1.5 LITERATURE REVIEWED

To carry out the study, the information resource published in primary, secondary and tertiary sources were reviewed so as to assess the quantum literature unfolded on the subject. The on-line articles available at Science Direct and Springerlink Home page were downloaded and reviewed. The most prominent journal that contains the article on Bibliometric study, R&D evaluation and other articles, which fall in topic domain were studied and taken into account. Since the present study is a
case study of a single R&D institution, namely NML, the study required the review of the literature brought out by NML since 1950.

The basic purpose of any literature review is to demonstrate the quantum of literature unfolded on a particular subject. For the present study, the following literatures relevant to this study are reviewed so as to have the experience and trends of the previous researches on the subject.

1.5.1 Godin (1996, pp.587-606) attempted in his study on “Research and the Practice of Publication in Industries”. The work tries to access the usefulness of bibliometrics for measuring industrial scientific activities. A total of 11814 papers and 84658 patents originating from 199 multinationals are statistically analyzed in order to understand (a) the importance of industrial application; (b) the field of science privileged; (c) the level of science useful to industry; and (d) the science and technology relationships.

1.5.2 Kostoff (1999, pp.539-604) in his study on, “Science and Technology Innovation” described the two novel complementary approaches for systematically enhancing the process of innovation and discovery. One approach is workshop-based and the other approach is literature-based. Both approaches insight and understanding from one or more disparate technical areas to another. The said study highly recommended that, the approaches be combined into a single process. The integrated approach has the potential to be a major breakthrough for the systematic promotion of innovation and discovery.
1.5.3 Karki, et. al. (2000, pp.279-288) studied on “Activity and Growth of Organic Chemistry research in India during 1971-1989”. The said work investigates Indian Organic Chemistry research activity during 1971-1989 using Chemical Abstracts. It attempts at quantification of national contribution to world efforts, and identifies areas of relative strengths and weakness. Also, the growths of Indian Organic Chemistry output as a whole and in sub-field where the activity index for the world and India are similar.

1.5.4 Moed (2000, pp.323-346) studied in detail on “Bibliometric Indicators Reflect Publication and Management Strategies”. The said study covered nine research departments in the field of biotechnology and molecular biology, indicators of research capacity, output and productivity. In a quantitative approach, ranking of departments based on a number of different research performance indicators were compared with one another. The result was discussed with members from all nine departments involved. Two publication strategies were identified, one denoted as quantity of publication and the other as quality of publication strategy, and two strategies with respect to scientific collaboration were outlined, one focusing on multi-lateral and second on bi-lateral collaborations. The findings suggest that, rankings of departments may be influenced by specific publication and management strategies, which in turn may depend upon the phase of development of the departments or their personnel structure. Consequently, differences in rankings cannot be interpreted merely in terms of quality or significance of research. It is suggested, that the problem of assigning papers resulting from multi-lateral collaboration to the contributing research group has not yet been solved properly and that more research is needed into the influence of department’s state of development and personnel structure upon the
values of bibliometric indicators. A possible implication at the science policy level is that different requirements should hold for departments of different age or personnel structure.

1.5.5 Jacob and Ingwersen (2000, pp.75-93) in their survey on, "A Bibliometric Study of the Publication Pattern in the Sciences of South African scholars (1981-96). Studied on the subjects like Physics, Chemistry, Plant and Animal Science, Biochemistry/Microbiology. So as to find out the standard of education, quality of publication, development, and overall progress. The said study reveals that, with exception to Physics, the results demonstrate the world share of South African, in particular reference to publications in the field of Plant and Animal Science and an equal decline of citations noticed in 1986-87. Further, the international embargo period, (1994-96) reaches almost the same level as observed in 1985-89. Also the study shows further that, there is a direct relation between academic positions, research experience and productivity among South African scientists in the four scientific disciplines.

1.5.6 Jacob (2001, pp.1-17) studied on "A Bibliometric Study of the Publication Patterns of Scientist in South Africa 1992-96, with particular reference to status and funding”. This paper is a bibliometric study of the publication patterns of a selected group of academic and research scientists of ten universities of South Africa for a period of five years, 1992-96. The study collected two sets of data through a scientometrics analysis of science citation index and a questionnaire. The said study demonstrates that, there is a direct relationship between status and publication productivity. The study further shows that, there are significant differences in productivity between areas of sciences but that
there is no direct relationship between institutional funding and productivity.

1.5.7 Basu and Aggarwal (2001, pp. 379-394) conducted a study on “International Collaborations in Science in India and its impact on Institutional Performance”. The work was based on a case study of major Indian institutions, where cluster analysis was used to distinguish between intrinsically high performance institution and those that gain disproportionately in terms of perceived quality of their output as a result of international collaborations.

1.5.8 Hartemink et. al. (2001, pp.217-268) studied on “Developments and trends in soil science: 100 volumes of Geoderma (1967-2001). Geoderma (1967-2001) published 100 volumes containing 2079 papers covering 31,637 pages and filling 191 cm of self-space. The contents of the 100 volumes are presented including an overview of the geographic origin of the research and authors, and an analysis of soil science subjects over time. The findings of the work reveals that more than half of the research reported in Geoderma was conducted in the temperate regions, whereas the tropics and sub-tropics account for about 30% of the papers. In the 1980s, 53% of the papers were descriptive but it decreased to 31% in the 1990s with a higher percentage of papers focusing on methodology. One of the intriguing trends is that 29% of the papers in the 1970s were based on field studies whereas only 18% of the papers in the 1990s were field based. Laboratory studies deceased from 60% in the 1970s to 49% in the 1990s. Over the same period, desk studies increased from 11% to 33% of the published papers. The majority of the papers in Geoderma have had no strong focus and only in recent years, papers had an increased focus (i.e. agriculture, environment etc.) There has been a strong increase in
soil physics papers whereas the share of soil chemistry steadily declined over time. Typical pedagogical papers cover about 30% of the journal and little change was found with time, except for the advent of papers in pedometrics. Papers on Soil Mineralogy have sharply declined from 25% in the 1980s to less than 10% in 1990s. Over the same period, a doubling in the number of papers on soil and environment occurred. Papers containing information on soil classification increased from 30% in the early 1970s to around 50% in the late 1990s. Papers are based on a larger amount of soil samples and in recent years, an increasing number of papers are based on existing data. The impact factor of Geoderma has steadily increased since the mid 1970s and in particular in the late 1990s. This review has shown important trends in Geoderma papers that likely reflect some of the major changes that have occurred in soil science as a whole.

1.5.9 Powell et al. (2002, pp.49-72) studied on “Library and Information Science Practitioners and Research”. An analysis of 615 responses revealed the following: almost 90% of the LIS practitioners in the USA and Canada regularly read at least one research journal, nearly 62% read research based articles, approximately 50% occasionally apply research result to professional practices and 42% occasionally or frequently perform research related to their job or to the LIS professional. The data analysis also identified factors related to practitioner’s involvement in research and determined how practitioners assess their research training and skills.

investigated how five Japanese R&D programmes promote inter-sectoral and inter-institutional networks. The result of the said study shows that, the projects of the Next Generation Programme for pre-competitive research formed few but multiple university-industry-government linkages within each project by designing the complementary relationship among the participants. Linkages between private companies were not much formed except for the projects of the Exploratory Research for Advanced Technology Programme (ERATO), in which researchers temporarily leave their own institutes. The funds for research that is more basic was found to have little effect on the formation of networks within projects but do form the linkages outside the projects.

1.5.11 Kumar and Kumar (2004, pp.11-21) in their study on “Productometric Study of Scientists of ICAR’s National Research Canter for Soybean (NRCS)”. Which was based on a chronological documentation list prepared for the purpose along with another and subject’s indexes. This study analyses the average number of papers along with names of the journals, subject and language distribution. Authorship pattern is also studied in this paper. It also gives method of calculating score of individual authors, calculates their scores and rank order. The said study concludes with strengths and weakness of soybean research in India.

1.5.12 Kumar and Garg (2004, pp.121-132) studied on “Scientometrics of Computer Science Research in India and China”. The work encompasses an analysis of 2058 papers published by Chinese author and 2678 papers published by Indian authors in the field of computer science during 1971-2000 indicate that India’s output is significantly higher than the Chinese output. However, China is catching up fast. Chinese research result in domestic journals, while Indian researchers prefer to publish their
research result in journals published in the advanced countries of the West. In addition, the share of papers in journals covered by SCI for India was higher than from China. However, no significant effect has been observed on the impact of the research output of the two countries as seen by different impact indicators. Team research was more common in India as compared to China.

1.5.13 Palmer et. al. (2005, pp.167-178) in their study on “Tourism and Statistic: Bibliometric study 1998-2002” which was based on the use of statistics in any scientific discipline considered the key elements in evaluating its degree of maturity and demonstrates the generation of nonspeculative knowledge. The aim of this study was to carry out bibliometric analysis of the use of statistical methods in tourism research. To accomplish this, a group of 12 tourism journals published within 5-year period (1998-2002) were chosen and 1,790 articles were reviewed by means of taxonomy with 24 statistical categories. The main results show the percentage of articles they apply statistical techniques as compared to those that do not, and ranking of the techniques must often used and their distribution according to journal.

1.5.14 Further Schwartz et al. (2005,pp.25-36) in their study examined the issues of impact and innovation in ground water research by using bibliometric data pertaining to 3120 papers from the Journal Water Resource Research with full contents and their citation data from the ISI Web of Science. The result of this study reinforce the importance of being a pioneer in a research strand, strategically shifting research strands, adopting strategies that can facilitate the true major research breakthroughs.
1.5.15 Garg et al. (2006, pp.151-156) attempted to study on “Scientometric Profile of Indian Agricultural Research as Seen through Science Citation Index Expanded” This work analysed 16891 publications published by Indian scientists during 1993-2002 and indexed by Science Citation Index Expanded (Web of Science) indicates that the publication output in the agricultural sciences is on the decline since 1998 onwards. 'Dairy and animal sciences' followed by 'veterinary sciences' constitute the largest component of the Indian agricultural research output. Agricultural universities and institutes under the aegis of Indian Council of Agricultural Research (ICAR) are the major producers of research output. Most of the papers have been published in domestic journals and in low normalized impact factor journals with a low rate of citation per paper. Most of the highly productive institutions are either agricultural universities or the institutes under the aegis of ICAR. Most of the prolific authors are from the highly productive institutions. However, only a few highly cited authors are from highly productive institutions.

1.5.16 Kademani et al. (2006, pp.23-48) analyses quantitatively the growth and development of Nuclear Science and Technology research in India in terms of publication output as reflected in International Nuclear Information System (INIS) (1970-2002) database. During 1970-2002 55313 papers were published by the Indian Nuclear scientists in various domains: Physics (23033), Chemistry (16368), Life and Environmental Sciences (7203), Engineering and Technology (6960), Other Aspects of Nuclear and Non Nuclear Energy (981) and Isotopes and Radiation Application (768). Year-wise growth of publications and input of records to INIS database by India and other countries were analysed. The total number of records input to INIS database by India was 30356 (54.88%) and by other countries and international organizations 24957 (45.12%).
The average number of papers published per year was 1676.15. The average Indian contribution to the world literature was 2.25%. Authorship and collaboration trend was towards multi-authored papers. Intensive international collaboration was found during the period and bilateral collaboration accounted for 80.06% of the total collaborative papers. More than 99% of publications were published in English. More than 60% of publications were published in journals. Most preferred journals by the scientists were Pramana 1327 (3.95%), Indian Journal of Pure and Applied Physics 1104 (3.29%), Physical Review-D 925 (2.75%), Journal of the Indian Chemical Society 783 (2.33%) and Indian Journal of Chemistry-A 734 (2.19%). High frequency Indexer Assigned Descriptors were: Gamma-radiation (4076), Temperature–dependence (3220), Experimental – data (2749), Radiation – doses (2306) and India (2000).

1.5.17 Kademani (2007, pp. 347-364) this paper attempts to highlight quantitatively the growth and development of world literature on thorium in terms of publication output as per Science Citation Index (1982-2004). During 1982-2004, the scientists in the field ‘thorium’ published 3987 papers. The average numbers of publications published per year were 173. The highest numbers of papers 249 were published in 2001. The spurt in the literature output was reported during 1991-2004. There were 94 countries involved in the research in this field. USA is the top producing country with 1000 authorships (21.11%) followed by India with 498 authorships (10.51%). Authorship and collaboration trend was towards multi-authored papers. Intensive collaboration was found during 1990-2004. One paper 'Nuclear Instruments and Methods in Physics Research - A 406 (3) (1998) 411-426' had 64 collaborators. There were 586 international collaborative papers. Bilateral collaboration accounted for 80.55 percent of total collaborative papers. Bhabha Atomic
Research Centre (India) topped the list with 153 authorships followed by Los Alamos National Laboratory (USA) with 105 authorships. The most preferred journals by the scientists were: *Journal of Radio analytical Nuclear Chemistry* with 181 papers, *Radiochimica Acta* with 139 papers, *Journal of Radioanalytical Nuclear Chemistry -Articles* with 127 papers, *Geochimica Cosmochimica Acta* with 96 papers, *Health Physics* with 91 papers, *Applied Radiation and Isotopes* with 88 papers, *Journal of Alloys and Compounds* with 65 papers, *Earth and Planetary Science letters* with 59 papers and *Chemical Geology, Indian Journal of Chemistry -A, Radiation Protection Dosimetry* with 55 papers each. English was the most predominant language used by the scientists for communication. The high frequency keywords were: Thorium (500), Uranium (284), Separation (94), Thorium Isotopes (90), Thorium (IV) (86), Seawater (73), Solvent Extraction (70), and Rare Earth Elements (68).

1.5.18 *Nwagwu (2006, pp.259-269)* Studied on “A bibliometric analysis of productivity patterns of biomedical authors of Nigeria during 1967-2002”. He compiled Bibliographic data on biomedical literature of Nigeria drawn from articles listed in Medline covering the period 1967-2002, and numbering 6820 were analysed to study the pattern of productivity of various author categories using Lotka's law. The 2184 authors who wrote the papers were divided into four different files, namely all authors, first authors, non-collaborative authors and co-authors. We hypothesized that the productivity patterns of each of the categories of authors differed from Lotka's inverse power law. The results showed that only the co-author category differed from the inverse power version of the law, while the other categories did not, although they yielded various exponents.
Albert et al. (2007, pp.41-51) studied on "Scientific and technological performance evaluation of the Spanish Council for Scientific Research (CSIC) in the field of Biotechnology". An evaluation of the Spanish CSIC performance in Biotechnology, as compared with those of the French CNRS and the Italian CNR, has been carried out to determine the balance between the generation of scientific knowledge and the transfer of technology. This study shows a high scientific productivity mostly in journals with moderate impact factor, a low generation of patents and an insufficient transfer of knowledge to the Spanish companies. Other indicators confirm the existence of competitive human resources in biotechnological research producing scientific knowledge of interest for the development of patents and that cooperates successfully at European level.

Glanzel and Schlemmer (2007, pp.267-275) worked on "National research profiles in a changing Europe (1983–2003) an exploratory study of sectoral characteristics in the Triple Helix". In this paper, bibliometric methods are used to analyse the integration of these countries into the EU was accompanied by corresponding changes in their sectoral research profiles. In addition, the authors discuss changes in the national profiles of three accession countries and three EU15 member states during the last two decades. The results confirm that a process of European homogenisation and convergence is taking place, but also show that this process is slow and that member countries have maintained their individual peculiarities and preferences during this evolution.

Though numerous studies have been conducted by different researchers in the field of Productometric, Scientometric, or bibliometric studies covering different research output along with their citation trend and impact factor, but none of these studies seem to have a direct
bearing on the output of NML, though have relevance in some form or the other with Metallurgy, Materials and allied Sciences. Therefore, the present study has not only become imminent, but its significance cannot be ignored.

1.6 SIGNIFICANCE AND ORIGINALITY OF WORK

Any government, public, private funded organisation require the reports (as data) on their major assignment as already performed, which can be used as performance indicators. There are several parameters like, invention, rendered R&D services, handling major R&D projects, consultancy services and publications. The communication of research finding is usually considered as an image and reputation the same is always required by the decision makers of any institutions/organisations to take judicious decision for framing strategy according to their needs.

By considering the above facts, Productometric Analysis of National Metallurgical Laboratory has been made, for consideration as a management information tool. This study on scientometric profile is unique work and any scholar and R&D workers in any parts of the globe have never done the same. The Productometric analysis embodied the maximum parameters on NML publications by which one can judge the quality through citation, and impact factor provides the authenticity, validity and quality. The study on research trend can be applied to find out the area in which major chunk of research has been carried out, and the trend in which more efforts are required and fund can judiciously allocated in future. Government R&D organisations frequently evaluate the performance and its CBA which acts as the, Management Information tool required periodically for up-dation.
1.7 HYPOTHESES FORMULATED FOR THE STUDY

Goode and Hatt (1952, p.56) define hypothesis as “a proposition which can be put to a test to determine its validity”, and Johnson (1956, p.192) adds that, keen observation, creative importance in setting up reasonable hypotheses.

To make scientific progress of the work, the following hypotheses have been formulated:

- Since the current infrastructure in the field of Materials Science and Technology (MST) in NML is much more better compared to other area of R&D, major chunk of research contributions made by NML must have been in the field of Materials Science and Technology;

- Since quality being the sole motive of the NML and the impact of foreign publication in the above disciplines is more effective, majority of research publications made by NML must have been contributed to foreign journals with high impact factor;

- Since most of the contributions in the disciplines are interdisciplinary in nature, majority of research contributions made by NML are by collaborative efforts of a team of scientists, rather than individual contributions;

- Since, the research at NML is concentrated with latest development and innovations in the respective fields, majority of such publication must have been published in journals compared to other form of information sources;
• Since NML is a premier R&D laboratory in the field of Minerals, Metals, Metallurgy, Materials Sciences, and Working under the banner of Council of Scientific and Industrials Research, Government of India, so quality and quantity in terms of Citation and impact Factor should be highly impressive; and

• Since the core journals, determined by the majority of the Scientometric Studies, reflects that they carry maximum number of papers and citation of reputed scientists, the present Productometric Study may establish the same trend.

1.8 METHODOLOGY FOLLOWED

Methodology describes how one would investigate the topic by specifying the methods of both data collection and data analysis, identify the variable(s) of interest define them and their relationship (if any), and specify how they would be measured. Moreover, he identifies two broad categories of methods in social science research, viz, Qualitative methods, and Quantitative methods.

By considering the above facts, the study has been divided into two parts 1) Bibliometric study, and 2) Analytical study with reference to finding the Research trends. Each article has been examined with respect to bibliometric details. The evaluation criteria have been focussed on the following parameters.
1.8.1 Bibliometric Study

The definition and purpose of publications is to shed light on the process of written communication and of the nature and course of a discipline by means of country, analyzing the various facts of written communication. The simple method of explaining bibliometric is that 'it is the statistical or quantitative description of a literature.' Here, 'literature' implies a group of related documents. Bibliometric furnishes possible methods by which significant features of a literature may be described and its working monitored. In fact, bibliometric has grown out of the realization that, literature is growing and changing at a rate with no librarian or information worker equipped with traditional bibliometric methods and skills could keep abreast.

In the process of employing bibliometric method for collection, distribution, and evaluation of data, the following methodical steps are followed, not only to make scientific progress in the work, but also to achieve the survey objectives:

i) Yearwise distribution of research papers (Journals, Proceedings, Books, and Reports);
ii) Yearwise distribution of papers appeared in National Proceedings;
iii) Yearwise distribution of papers appeared in International Proceedings;
iv) Yearwise distribution of papers appeared in SCI Journals;
v) Yearwise distribution of papers appeared in Non-SCI Journals;
vi) Authorship pattern;
vii) Research collaboration;
   a) Intra institutional;
   b) Inter institutional;
c) National collaboration
d) International collaboration;
e) Solo research (no collaboration);
viii) Journal wise distribution of papers;
ix) Distribution of papers as per impact factor;
x) Yearwise distribution of project reports;
xi) Yearwise distribution of patents filed;
xii) Yearwise distribution of patents sealed;
xiii) Impact factor of papers; and
xiv) Total number of papers appeared in Journals, Proceedings and Books, Monographs, and Reports.

The yearwise data further condensed into decadewise, this has been done for easily and conveniently analysis and interpretation of the 58 years data to present complete history of NML publications.

1.8.2 Research Trends

It will be helpful in determining research direction by classification and analysis of publication data since 1950-2007. The trend of research has been the quantum of research papers available or published in respective R&D domain. The R&D area has been broadly categorised under the following ten broad divisions. The 10-division has further been categorised in sub-divisions and so on, for example.

Broad Area(s)
i) Mineral Processing;
ii) Ferrous Metallurgy;
iii) Non-Ferrous Metallurgy;
iv) Minerals Characterisation and Evaluation;
vi) Refectories and Advanced Ceramics;
vi) Process Modelling and Simulation;
vii) Corrosion Protection;
viii) Environmental Protection and Control;
ix) Powder Metallurgy; and
x) R&D Management and S&T Policy

The above-mentioned areas have been further narrowed down into depth area of the specific division. The R&D area has been classified into minute / depth area prepared by UDC classification schedule i.e. BS 1000M: 1993 and necessary suggestions from the peer has been incorporated. The first round study reflects that more than 4000 articles have been contributed by NML on Minerals, Metals, Materials Science and allied areas.

For determining the research trend, the following steps are followed:
i. Classification of Research articles;
ii. Grouping of Research area as per classification;
iii. Year wise grouping of works under different R&D area;
iv. Statistical Analysis and the computation of research data; and
v. Final analysis, discussion and recommendations.

1.8.3 Citation Analyses

Citation analysis constitutes an important tool in quantitative studies of science and technology. To assess the quality of a given
publications, the number of times it has been cited in the literature can be counted. The use of citation analysis in research on the history of science is based on a literary model of the scientific process. In this model, the papers written in published to report it and the relationship between discrete pieces of work are represented by the reference in the papers represent scientific work.

The main objective of the study is to highlight the citation impact of publications contributed by the National Metallurgical Laboratory during 1972-2007 (as per availability of data) through on-line Science Citation Index database retrieved through Web of Science specifically to highlight the following:

- To identify the extent of citations received to the publications of NML;
- To find out the yearwise growth of citations;
- To find out the time lag between publication of a paper and its getting first citation;
- To identify highly cited papers of NML and their citation life cycle;
- To identify the institutions in the citing papers of NML publications;
- To find out the distribution of citing papers of NML publications according to country of publishing publications;
- To find out types of documents citing NML publications;
- To examine the scattering of citations among journals;
- To find out the distribution of the citing journals according to impact factors; and
1.8.4 Application of Bibliometric law

The application of **Bradford Law** has been applied on the data generated from Productometric analysis of NML publications for the last fifty-eight years. The laws have been helpful in identifying core journals in the Minerals, Metals, Metallurgy and Materials science and the same can be applied for adopting procurement of journal for the NML in particular and R&D Library of the said subject area in general.

1.9 SCHEME OF WORK

For the sake of convenience and clarity, the entire gamut of research has been divided in the following five broad chapters:

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Description</th>
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<tr>
<td>Chapter I</td>
<td>Introduction</td>
</tr>
<tr>
<td>Chapter II</td>
<td>Genesis and Growth of Metallurgy, Materials Science and National Metallurgical Laboratory.</td>
</tr>
<tr>
<td>Chapter IV</td>
<td>Analysis and Interpretation of Data.</td>
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<td>Chapter V</td>
<td>Conclusion, Suggestions and Area for Future Study</td>
</tr>
</tbody>
</table>

1.10 CONCLUSION

The following goals have been achieved through this study:

1. Ascertained the research trends, publication pattern and the quantum of publications in different the field of Metallurgy and Materials Science contributed by NML during last 58 years;
2. Discovered the share of each of the three major sources of information, namely, primary, secondary and tertiary in which these publications dominate;

3. It will serve as an effective management information tool, to facilitate the management of R&D institutions for framing appropriate S&T policy tailored to the needs of the current age; and

4. It will serve as an indicator to measure both strength and weakness of the respective publications in the R&D area of Metallurgy and Materials Sciences by NML Scientists and R&D personnel.

The final output of the above research has reflected the panoramic bird’s eye-view of the whole spectrum of publication executed by the globally reputed laboratory, NML. The output also meaningfully established a system that may be further updated to keep in track of valuable research publications profile of the National Metallurgical Laboratory (Council of Scientific and Industrial Research, Jamshedpur) included in this investigation.

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