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The Non-Cited Scientific Research Papers of the Pioneer Indian Scientists: The "Invisibile Impact" Of Uncitedness Phenomena

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Abstract

The present paper deals with the non-cited papers of some pioneer Indian scientists namely JC Bose, KC Kar and PN Bose. Quite a number of scientometric studies looking at the Indian scientific contribution built upon the journals indexed by Science Citation Index (Web of Science, online verson of SCI) and Scopus databases have been brought out in the literature. Such quantitative studies focused on the scientific progress and effect of the scientific research activities of India came out over the years. Even so a very few number of studies have been made on the uncitedness of the India's scientific research papers by the leading Indain scientists. This paper gives an overview of the non-cited papers of the pioneer Indian scientists and impact of some uncitedness phenomena on those scientific contributions over time. The article intends to show the non-cited papers are not the less important component of the usual citation activity. This paper also attempts to find the probable reasons of the non-citation of papers by the scientists under study. Non-citation can perpetuate stereotypes that Indian scientists are not producing high-quality or core research, corroborating existing favouritism and prejudices. The lack of recognition for Indian scientists' contribution can discourage future generations of scientists from pursuing research and contributing to their fields. This paper intends to address these uncitedness issues by actively seeking out and recognizing the value of the contributions of the Indian scientists under study as we know the consistent non-citation can contribute to the obliteration or gloom of Indian scientists' works from the historical record, making it challenging to trace the development of original ideas and discoveries.

Keyword(s): Non-citation, uncitedness, weightage, omission, skip, worthy

Abbreviation(s): SCI (Science Citation Index), JCB (JC Bose), KCK (KC Kar), PNB (PN Bose), RNI (Relative Non-citation Indicator)

1. Introduction

Citation analytical study has been considered to be a reliable measure to assess the scientists or contributors and their works in various domains in science. The number of core citations i.e. the intensity of citation of a paper largely depends on the research workers in the subject area. Quite a number of scientometric studies looking at the Indian scientific contribution built upon the journals indexed by Science Citation Index (Web of Science, online verson of SCI) and Scopus databases have been brought out in the literature. Such quantitative studies focused on the scientific progress and effect of the scientific research activities of India came out over the years. Even so a very few number of studies have been made on the uncitedness of the India's scientific research papers by the leading Indain scientists.

The present paper deals with the non-cited papers of some pioneer Indian scientists namely JC Bose, KC Kar and PN Bose. Jagadish Chandra Bose (1858-1937) was one of the pioneers of modern science in India. His landmark contributions to the investigation of radio and microwave optics. His discoveries affected the advanced scientific research in India in various fields of millimetre-wave physics, plant physiology, botany and biophysics. Jagadish Chandra was a trailblazer in Indian science, his scientific contributions had a lasting impact on our understanding of the natural world. He developed the several inventions, including the crescograph and conducted extensive research on plant physiology and established the existence of a nervous system in plants. In 1917, he founded the Bose Institute (Basu Bijnan Mandir) in Kolkata for higher research. Bose was the director of the Institute until his death on 23th November 1937.

Kulesh Chandra Kar (1899-1975), popularly known as KC Kar was a renowned Indian theoretical physicist who made significant contributions to our understanding of the universe. Kar worked on various aspects of theoretical physics, including atomic structure, wave statistics, relativity, acoustical physics and quantum mechanics. He also contributed to the development of physics education in India. For his outstanding research work, he obtained D.Sc. degree from the University of Calcutta in 1925. He was appointed as a Professor in Physics in Presidency College (now University), Kolkata and then lifelong Emeritus Professor of Physics at the College. He established the Institute of Theoretical Physics, Kolkata and started the Indian Journal of Theoretical Physics.

Pramatha Nath Bose (1855-1934), popularly known as PN Bose was a pioneer geologist of India, whose contributions and discoveries of great significance largely impacted on the progress of scientific research in the domain of geology. He was born at Gaipur of Kushdaha Pargana under Gobardanga Municipality in the district of North 24 Parganas of the present day state of West Bengal (India) on 12th May 1855. He was one of those Indians who commenced his study of science early in life. He set out for London as a Gilchrist Scholar and returned as a B Sc. of London University. Bose was the Fellow of the Geological Society (FGS). Pramatha Nath was the first Indian to whom British appointed as a graded post (Assistant Superintendent) in the Geological Survey of India (GSI), Kolkata on 13th May 1880 and there he continued to serve till 1st December 1903. The landmark contributions in geological science done by him led to the foundation of the great iron and steel factory of the Tatas in

Jamshetpur in 1908 and several iron & steel works in independent India. He breathed his last on 27th April 1934 at Ranchi.

Non-citation can perpetuate stereotypes that Indian scientists are not producing high-quality or core research, corroborating existing favouritism and prejudices. The lack of recognition for Indian scientists' contribution can discourage future generations of scientists from pursuing research and contributing to their fields. This paper intends to address these uncitedness issues by actively seeking out and recognizing the value of the contributions of the Indian scientists under study as we know the consistent non-citation can contribute to the obliteration or gloom of Indian scientists' works from the historical record, making it challenging to trace the development of original ideas and discoveries.

2. Objectives

The main objectives of this study are:

i. to give an overview of the non-cited papers of the pioneer Indian scientists under study;
ii. to show the non-cited papers are not the less important component of the usual citation activity and
iii. to find the probable reasons of the non-citation of papers by the scientists.

3. Methodology

The bibliographic details of research publications of JC Bose have been collected from the biography on JC Bose written by Meher H. Engineer and Prantosh Bhattacharya[1]. The short biography and research papers of KC Kar were collected from the obituary written by SD Chatterjee brought out by *Indian Journal of Theoretical Physics*, 23(2), 1975 formed the basic tool for this work[2]. Google Scholar, ResearchGate etc. (online) have been consulted to find citations to the scientific papers as far as possible.

The bibliographical data relating to PN Bose's papers have been collected from the GSI library. Different tools like Science Citation Index (SCI: five yearly cumulated hardcopy volumes) from 1945 onwards in the National Library of India in Kolkata. Memoirs and Records of GSI (hardcopy), Google Scholar, ResearchGate etc. (online) have been consulted to find citations to his scientific research papers as far as possible.

Different potential source materials or tools such as biographical memoirs of the fellows of the different societies and academies, websites including citation databases, collected papers of the scientist, if any, books written by the scientist, obituaries published in different sources after their death and unpublished writings as may be found out.

One of the major sources of data for the present scientometric study was Clarivate Analytics (commonly used as Web of Science) which annually indexes different scientific articles brought out from India and abroad. From these records, data have been culled out for papers that remained non-cited during 1900–2013.

4. Review of Literature

During this study on uncitedness of scientific contributions it has been found out a very few number of papers on non-citations. In 2005, HP Sharma and SK Sen [10] showed some classic cases of non-recognition and non-citation. They mentioned three Indian scientists namely JN Mukherjee (colloid and soil chemist), GC Bhattacharya (a self-made biologist, a D.Sc *honoris causa* of the Universtity of Calcutta who worked in the Bose Institute) and ECG Sudarshan (the theoretical physicist) as the instances of such non-citational cases. They also reported a case of non-citation in the history of superconductivity research. In 1968, N Kumar and KP Sinha (the theoretical physicists) produced a paper on possibility of photoinduced superconductivity in semiconducting or insulating state [11]. Sharma and Sen showed five experimental papers [12-16] published in different journals (between 1989 and 1992) regarding "transient or metastable photoinduced superconductivity in cuprate systems" which confirmed the predictions made by Kumar and Sinha. Interestingly, none of these five papers has cited the paper of Kumar and Sinha whereas other four papers have all cited the paper by Yu *et al*.

In 2021, Golosovsky and Lariviere [18] measured the uncitedness ratio which is the fraction of uncited papers in their collected data sets and suggested that uncitedness is a predictable result of the Poisson statistics. They studied the citation dynamics of the papers published in three scientific disciplines (Physics, Economics, and Mathematics) and four broad scientific categories (Medical, Natural, Social Sciences, and Arts & Humanities).

5. Non-cited papers of the scientists:

5.1 Subject-wise distribution of non-cited papers of JC Bose

Sl. Nos.	Subjects	Total Publication Productivity (TPP)	% of TPP	No. of Non-cited Papers	% of Non-cited Papers	Relative Non-citation Indicator (Ratio of Non-cited Paper% to TPP %)
1	Physics	13	10	06	05	0.5
2	Biophysics	22	16	09	08	0.5
3	Plant Physiology	93	69	93	83	1.2
4	Others	06	05	04	04	0.8
	Total	134	100	112	100	1.0

Table 5.1 shows the Relative Non-citation Indicator (also called Relative Uncitedness Index [11]) of the non-cited scientific papers of JC Bose. The table represents total papers percentage and total non-cited papers percentage by discipline. This is a relative measure of non-citation of papers which is a ratio of non-cited papers percent to the percentage of total publication productivity (i.e. the total number of paper pblications) by the scientist under study. The lower value of this relative indicator means greater impact and higher value indicates less impact. It can be zero or more.

The table shows that the largest value (1.2) of RNI was for Plant Physiology and is replicated a greater distribution of non-cited papers for this discipline. The distribution of non-cited papers for Plant Physiology was 100% of the total publication productivity in the same discipline. For Physics and Biophysics, the distribution of non-cited papers was 46% and 41% respectively, of their total publication productivity.

5.2 Subject-wise distribution of non-cited papers of KC Kar

Sl. Nos.	Subjects	Total Publication Productivity (TPP)	% of TPP	No. of Non-cited Papers	% of Non-cited Papers	Relative Non-citation Indicator (Ratio of Non-cited Paper% to TPP %)
1	Acoustical Physics	16	13	1	1	0.08
2	Nuclear and Particle Physics	59	48	47	59	1.2
3	Quantum Statistical Mechanics	12	10	11	14	1.4
4	Wave Mechanics or Wave Statistics	19	15	10	13	0.87
5	Mathematics	2	2	2	3	1.5
6	Theory of Relativity	15	12	8	10	0.83
	Total	123	100	79	100	1.0

Table 5.2 shows that the largest value (1.5) of RNI was for Mathematics and is replicated a greater distribution of non-cited papers by KC Kar for this discipline. The distribution of non-cited papers for Mathematics was 100% of the total publication productivity in the same discipline. For Quantum Statistical Mechanics and Nuclear & Particle Physics, the distribution of non-cited papers was 92% and 80% respectively, of their total publication productivity. For Acoustical Physics, Wave Mechanics and Theory of Relativity, the share of non-cited papers were 6%, 53% and 53% respectively of their total publication productivity.

5.3 Subject-wise distribution of non-cited papers of PN Bose

Sl. Nos.	Subjects	Total Publication Productivity (TPP)	% of TPP	No. of Non-cited Papers	% of Non-cited Papers	Relative Non-citation Indicator (Ratio of Non-cited Paper% to TPP %)
1	Geology	7	29	-	-	-
2	Paleontology	3	13	1	12.5	0.96
3	Mineralogy	9	38	2	25	0.66

4	Petrology	2	8	2	25	3.1
5.	Archaeology	2	8	2	25	3.1
6.	Ethnology	1	4	1	12.5	3.1
	Total	24	100	8	100	1.0

Table 5.3 shows that the largest value (3.1) of RNI was for Petrology, Archaeology, Ethnology and is reflected a greater distribution of non-cited papers by PN Bose for these disciplines. The distribution of non-cited papers for those disciplines was 100% of the total publication productivity in the respective disciplines. For Paleontology and Mineralogy, the distribution of non-cited papers was 33% and 22% respectively, of their total publication productivity. One of the possible reasons for this might be that the scientist publish their experimental findings in domestic journals, which are not given due recognition by the foreign researchers and their scholarly literature as well.

6. Models that explain uncitedness phenomena

The uncitedness phenomenon implies the the phenomenon of scientific works not being cited by other peer researchers, even though their prospective pertinence and applicability to the field. The uncitedness phenomenon has been considered in several research publications. Here are some models that attempt to explain this phenomenon, namely:

i) Golosovsky and Lariviere[18] developed a model of citation dynamics that studies acquiring citations as inhomogeneous Poisson stattistics. The model considers for the phenomenon of uncitedness, suggesting that it is an inevitable consequence of the Poisson process. The models accounts for the following factors:

a. Direct Citations: A direct citation is a direct reference to the original source (scientific journals, online database or any news portals /recommendations by fellow scientists) and original author's name is usually included in the text. An author of a new publication may cite a paper directly after searching it in databases, scientific journals, or following recommendations.
b. Indirect Citations: An author of another new publication can find the paper in the reference lists of already selected papers and cite it.
c. Reference list length: The average reference list length and its growth rate are considered.
d. Fitness distribution: The model describes a log-normal reduced fitness distribution, which affects the citation rates of papers.

The model explains the uncitedness ratio, citation trajectories of papers in various scientific disciplines and categories. The uncitedness ratio, also known as the “uncitedness fraction” or “uncitation rate” is a metric used to measure the the proportion of papers that remain non-cited over a certain period of time. Generally, it is defined as the number of papers that have obtained no citations divided by the total number of papers published in a given research domain or journal. The uncitation rate is usually formulated as a percentage or a fraction and it can vary depending on the

journal, time span or area of study considered. Golosovsky and Lariviere showed that the uncitedness ratio for papers in the natural sciences and mathematics ranged from 10% to 30% while another inquiry made by Seglen reported an uncitedness ratio of nearly 50% for papers in the social sciences.
Specifically, Golosovsky assumed that the receiving of citations by a paper follows an inhomogeneous Poisson statistics, which is a random or stochastic process that models the arrivals of citations over time.
The Poisson distribution is characterised by a rate parameter **λ** (lambda) that represents the average number of citations received by a paper per unit time. The probability of receiving 'c' citations in a given time interval is then given by the Poisson distribution:

$$\mathbf{P(c) = (\lambda^k * e^{(-\lambda)}) / c!}$$

Golosovsky showed this model to develop the framework of citation dynamics, including the uncitedness phenomenon, and to estimate the parameters of the model from real data. It is assumed in this model that each citation to be an independent event. The rate parameter **(λ)** is assumed to be constant over time and the use of the Poisson distribution to model the number of citations received by a paper.

ii) Sugimoto and Lariviere's law [19] stated that a large proportion of papers are not cited, and that this proportion is relatively constant across fields and time. The law expains the phenomenon of uncitedness, where a significant proportion of research papers do not recieve any citations in the short term, indicating a potential gap in knowlege transfer and scholarly communication.

iii) Leydesdorff & Rousseau[20] collaborated a research studies that the uncitedness ratio, or the fraction of papers in a collection, is the number of uncited papers in a given field is equal to the total number of papers in that field, multiplied by the fraction of papers in that field that are not cited by any other paper in that field. This ratio remains non-cited after a certain period, depends strongly on the length of that period. This can be expressed as:

$$U = P * (1 – C/P)$$

Here, U indicates the number of uncited papers, P indicates total number of papers in the field and C is the number of citation in the field.
The model explains that the number of non-cited papers in a field is a function of the total number of papers and the citation density of the field. This model has been influential in understanding citation patterns and the dynamics of scholarly communication, suggesting that a significant portion of research papers may not be cited by other papers.

iv) Wallace, Lariviere and Gingras[21] studied a research work that the uncitedness ratio is strongly affected by the annual growth in the number of publications and their reference list length. They also demonstrated that the proportion of cited papers is a fraction of the number of articles published, the number of citing papers, and the number of references they contain.

v) Seglen's Law[22] demonstrated that the number of citations received by a paper is inversely proportional to the number of papers published. This denotes that as the number of papers increases, the number of citations per paper decreases, leading to a higher fraction of non-cited papers. Seglen contended that this is because of the mismatch between the number of publications and the number of references, resulting in a highly skewed citation distribution. The significant points of this law are firstly, the distribution of citations is highly skewed, with a few papers receiving many citations and many papers receiving few or no citations and secondly, the number of papers published exceeds the number of references available, leading to a surplus of non-cited papers and the third one is the scientific publication network displays a strong hierarchy, with breakthrogh papers receiving most of the citations.

vi) MacRoberts and MacRoberts[23] model assumed that the number of non-cited papers in a field follows an exponential decay function, with a constant rate of citation. The model can be represented by the following equation:

$$U = P * e^{(-kt)}$$

Where, U indicates number of uncited papers, P is the total number of papers in the field, k denotes the citation rate (constant) and t is time.
This model proposed that the number of non-cited papers decreses exponentially over time, with a constant rate of citation.

vii) Garfield[24] showed the different reasons why papers may not be cited, ranging from quality issues to a paper being so well known that citation is deemed unnecessary. He proposed three reasons for uncitedness:
First reason is the mediocre, unintelligible, irrelevant or eccentric; secodly, meritorious but undiscovered or forgotten and the third one is well-known to the point of being considered common knowledge, making citation unnecessary.

viii) Price's Square Root Law[25] suggested that the half of the publications come from the square root of all contributors. For example, in a research project with 16 researchers, 4 of them will prepare 50% of the work. Price's formula for uncitedness states that:

$$U = P - \sqrt{P} = \sqrt{P}$$

Where, U indicates number of uncited papers and P is the total number of papers. This indicator is used to estimate the number of core papers or authors in a field, and is often used in conncection with Price's law to understand the distribution of citations and papers among authors.

ix) Bradford Law[26 & 27] divides papers into three zones: a core of highly cited papers, a middle zone of moderately cited papers and a periphery of non-cited papers.The Bradford law is based on the idea that the distribution of citations follows a Bradford distribution, which is a statistical distribution that describes the scattering of articles across an increasing number of journals or sources. The model summarizes that the number of non-cited papers in a field is

inversely proportional to the square of the number of journals or sources. The majority of uncited papers are found in a small number of journals or sources. A smaller number of highly cited papers are found in a large number of journals or sources. But this is a rough estimate and may not always accurately calculate the number of non-cited papers. It is aimed to provide a general idea of the distribution of citations in a field. This can be expressed as:

$$U = P / S^2$$

Where, U is the number of uncited papers, P is the total number of papers and S indicates the number of sources (journals, articles, online databases etc.)
For example, if there are 50 papers in a field and 5 sources, the Bradford formula assumes that:

$$U = 50/5^2 = 50/25 = 2$$

x) Zipf's Law[28] proposed that the frequency of a word is inversely proportional to its rank. In other words, the most common word will occur approximately twice as often as the next most common, three times as often as the third most common, and so on. According to Zipf's law, the number of citations received by a paper is inversely proportional to its rank in the citaion distribution. In other words, most cited paper will have approximately twice as many citations as the next most cited paper, three times as many as the third most cited paper, and so on. Mathematically, this can be expressed as:

$$c(n) = k/n$$

Where, c(n) is the number of citations received by the nth most cited paper, k is a constant and n is the rank of paper (1,2,3, so on)
This law actually explains the skewed nature of citaion distributions, where a small number of papers receive a disproportionate number of citations.

xi) Lotka's Law[29] suggests that the number of authors with at least a certain number of publications is inversely proportional to the square of the number of publications. It can be assumed that distribution of citations among papers, with a few papers recieving many citations and many papers receiving few or no citations. It can be formulated as:

$$N(a) = K / a^n$$

Where, N(a) is the number of authors with at least 'a' publications, K is a constant, 'n' is an exponent between 1 and 3 that depends on the field of study. Following the formula of Lotka, it can be predicted as:

$$U = K / c^2$$

Where, U is the number of uncited papers, K is a constant and c is the number of citations recived by a paper. Lotka's law is a variant of the Lotka's law of citation distribution and used to analyse the distribution of citations and uncited papers in scientific literature.

6.1 Categories of uncitedness phenomena

The uncitedness phenomena emphasize the various practices or courses of action in which creativities or research works can go uncited, and the importance of exploring beyond citation counts to understand the true impact of research.

Here are the expamples of various ways the research ideas remain uncited:

i) Overlooked classics[30]: Uncited work that is envisaged as classic in its field but is no longer received citations.
ii) Invisible impact[31]: Uncited work that has a significant impact but is not acknowledged or cited.
iii) Hidden gems[32]: Uncited work that has significant value but remains undiscovered.
iv) Unknown unknowns[33]: Uncited work that is not widely recognised or acknowledged.
v) Sleeping beauties[34]: Uncited work that lies dormant for a period before being rediscovered and cited.
vi) Lost knowledge[35]: Uncited work that was once known but has been forgotten over time.
vii) Uncited but influencial[36]: Uncited work that influences research or innovation without being explicitly acknowledged.
viii) Underrated contributions[37]: Uncited work that makes significant contributions but is unappreciated.
ix) Neglected pioneers[38]: Uncited work that is pioneering but fails to receive recognition.
x) Unrecognized innovation[39]: Uncited work that introduces new ideas or methods but is not recognized.

7. Probable reasons of non-citation of Indian scientific contributions

There are quite a number of probable reasons for the rare or non-citation of Indian scientific contributions by leading scientists:

i) Lack of accessibility: Indian research papers may not be extensively distributed or indexed in well-known international databases, making them less reachable to the worldwide all-inclusive scientific research community.
ii) Language coverage: Publications in Indian languages or in local journals may not have readability or cited by the foreign peer researchers.
iii) Quality and impact factor: Indian research contributions may not be brought out in the high impact factor journals, which can curb citation counts.
iv) Not giving weightage in citing local papers: Indian research workers might prioritize collaborating with foreign research colleagues over citing local papers. Contributors may be more likely to cite papers from leading global institutions or researchers.
v) Limited formats: Some Indian research publications might not be easily accessible online or in digital format, making them harder to view/consult and cite.
vi) Limitations in accessing cutting-edge research: Indian scientists might face limitations in accessing cutting edge research due to lack of digital

infrastructure and funding supports, leading to fewer citations.

vii) Citation practices vary across disciplines: Sometimes interdisciplinary differences in the coverage of the topics, subject scope and depth might affect the visibility of Indian publications and consequently fail to receive optimum citations.

viii) Coverage of the SCI (Web of Science): Coverage of SCI or any other citation index database does not remain constant over time new journals are added others i.e. ceased publications are dropped. Thus serious errors of interpretation can occur from use of bibliometric data. Again, the coverage of limited number of citing journals could be a considerable underestimate of the total citations obtained.

ix) Depth of backfiles: How far backfiles are tracked by citation index might be a considerable fator for gaining core citations.

In many cases, written records, obituaries, personal accounts or biographies have poor survival opportunities. Usually, cited articles appear in the citation index only under the name of first author listed in each article. To receive all citations to an author, one must determine the collaborators first and this is a difficult and tedious process. Even more difficult is the problem of eliminating self-citations.

8. Is Non-Cited Work Worthless?

According to MacRoberts and MacRoberts[23] "the equation: cited=used, may be correct with many caveats, exceptions, corrections, and qualifications, but the equation: not cited=not used, is simply false". Usually, number of citations obtained by a paper indicates the measurement of impact of that paper. But uncited papers are not useless according to Golosovsky and Lariviere [18]. Seglen **[22]** also opined that even uncited papers have a definite probability of constant scientific advancement as a part of a continuous probability distribution. He contended that uncitedness is the consequence of the mismatch between number of papers and the number of references. Not only the distribution of citations are highly skewed but also the culling out of total number of references to all papers is quite difficult task. All papers might not have appended sufficient number of references that may further cite the original. Non-cited papers are often not considered in scientometric analysis. It has been seen that those non-cited or rarely cited articles still form an integral segment of such kind of quantitative research studies. The huge numbers of scientific publications that the citation database enters as non-cited have likely been cited elsewhere by somebody. Even non-citation may be a case of 'omission'. And it may the situation where the uncitedness implies a skip of something worthy. Many a time, being an earlier version of database, it excluded or just missed the actual citations to add its final list whereas updated version counts them properly. Sometimes it may be the cause of unavailability of full-text bibliographical details of the publications. So, somehow uncitedness also effects on the engrossment or culling out of citations and plays a role as a form of the exchange of scientific information.

9. Findings

JC Bose's pioneering work in plant physiology is indeed a significant contribution to the field. However, the fact that his papers were published in the *Transactions of the Bose Research Institute*, which was not indexed in the Science Citation Index (SCI), likely limited their visibility and citation counts. Journals not indexed in SCI or other major citation databases may not receive the same level of international recognition. This highlights the importance of publication venue and indexing in citation databases for disseminating research and tracking its impact.

Charles Susskind (1921-2004), a historian of technology and a professor emeritus of electrical engineering, Berkeley, USA cited a number of papers written by J.C. Bose. Notably, what Susskind did was that he made citations to the papers of JCB in his papers related to early history of electronics or prehistory of radiotelegraphy but he didn't cite his papers in any of the experimental physics research paper as a core paper. So, it can be said that Susskind's citations do not prove the actual importance of Bose's physical papers which were much advanced of his time. It is further interesting to note that the many important papers of JCB obtained no citations at all. Eleven research papers (including ten biophysical) of JCB received only 1 citation each. Most of his papers including his first physical paper which was published in Asiatic Society of Bengal lack citations.

KC Kar's work in theoretical physics is indeed valuable, but the *Indian Journal of Theoretical Physics*, where a greater number of his papers were published, might not have been widely recognised or indexed in prominent international citation databases during that time. Kar's papers might not have been easily discoverable by the global research community. This could have limited the visibility and citation counts of his papers. Moreover, the journal might have been primarily focused on the Indian research community, which could have restricted its international reach and citations. Consequently, Kar was not able to gain enough popularity among the world fraternity of scientists of his own research areas. Probably, for this reason, his papers were not much discussed and recommended for reading by the scientists in their own circle, i.e. in their own *invisible college*. Besides, citation patterns can vary across disciplies, and some disciplines might have lower citation rates overall. Likewise, theoretical physics might have different citation norms than other fields. It has been noted that many of Kar's significant papers in acoustical and particle physics were not cited at all. Among them, some papers are very brief. Out of his 79 non-cited papers, 14 papers are very brief i.e. they contain only two pages. It seems that the rare citation to those papers of K.C. Kar may be for the cause of not having any bibliography of his collected physical papers in full text format. It is thus, the availability and traceability to his papers is not so easy to a research worker on related areas in theoretical physics. Perhaps it causes a greater number of his papers consisting interpretations of new approaches to acoustical physics, wave statistics, theory of relativity and gravitation remained non-cited by others. It may also be said that as possibly, India did not get much of strong footing in the world science at that period, the prominent scientists of the western world preferred to give his papers a miss. Kar's less travel to the foreign countries prominent for cutting-edge research on his field of research in those times to attend conferences or related did not work much in his favour either. He was not able

to cultivate a network with his fellow foreign scientists who will talk or discuss about his works amongst themselves and thus cite his works in their papers (Hu & Wu, 2019[41]). There was likely to have been an apparent darkness of Kar's scientific publications among the then western scientific communities.

PN Bose published his geological papers during the British colonial era in India. His work might have been overlooked or undervalued by Western scientists. Some of his papers were published in Indian journals or in languages like Bengali, making them inaccessible to the researchers abroad. In the early twentieth century, international collaboration and communication were limited, making it difficult for his work to reach a larger audience. PN Bose's research publications spanned geology, paleontology, petrology, and ethnology. His papers might have been brought out in specialised journals, limiting their visibility to researchers in other fields. Citation habits or norms have evolved over time. Earlier researchers might not have consistently cited previous work, especially from non-Western sources. Many older papers, including his own geological explorations might not be indexed in recent databases or citation indexes, making them much more difficult to trace.

9. Discussion and Conclusion:

Citation norms might have been affected by the pattern of the formation of research schools and institution building among the scientists. JC Bose didn't attempt to build up a school of research. Though he established an institute which he would like to call it a mandir or temple. Kar has founded up a school of research, named Institute of Theoretical Physics (also called Calcutta School of Theoretical Physics). Collaborative work, if taken into account to indicate the formation of school, is more prominent to Kar who worked in the areas of theoretical research but exceptionally not attained higher positions early in his professional career in research-cum-academic environments or R & D.

During PN Bose's geological explorations in the Vindhya regions, he encountered a type of carbonetites which are also known to occur in many other places such as Australia, Africa etc. He proclaimed them as igneous rocks to have been produced from ancient volcanic activities. It was against the then general accepted notion. These rocks were considered as metamorphic. His interpretations were completely ignored by most other GSI scientists. However, in 1960s evidences were found in volcanic activities in Tanzania in Africa in favour of his theorization (Bhattacharya, C.R., Professor of Geology, University of Calcutta, private communication [5-6]). This proves his pioneering and correct geological acumen, much advanced of his time. But unfortunately the time gap of his work and evidences in support of his interpretation is so wide that core citations to him could not be traced.

PN Bose was the first person in India to introduce microsection analysis in petrology. This pioneering work is noted and mentioned in historical publications of GSI, Kolkata but is not properly acknowledged by his fellow geologists. Some of the authorities now think that the three major iron and steel factories of India viz. Jamshedpur, Rourkela and Vilai owe their existence to geological discoveries of PN Bose. Indeed the consultant geologists (C.P. Perin and C.M. Weld) thought PNB did not take his pioneering in Central Province to its fullness (Harris, 1958)[4].

In the past, the research contributions of the scientists might not have been readily available online, making it harder for other researchers to access and cite their work. The research domain might be highly competitive, with many esteemed journals and authors, making it harder for a particular research work to get cited.

Despite several factors (eg. cultutal, historical and academic) contributed to uncitation of papers, JCB and KCK's contributions to modern physics and theoretical physics respectively remain significant, and their works continues to be important in the same fields. PN Bose served as a mentor and inspiration to many young geologists and paleontologists in India. His extensive investigations on the Gondwana system and the Himalayan foothills helped shape our understanding of India's rich geological heritage and the way of future geologists and paleontologists.

Non-citation can create a knowledge gap, as other researchers in the same fields may miss crucial findings, insights, or methodologies developed by Indian scientists under study. Uncitedness can lead to missed opportunities for collaboration, building upon existing research, and advancing scientific progress. Misreckoning of Indian scientists in citations can perpetuate biases and energize prevailing dominance in the scientific community.

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