

## A SCIENTOMETRIC STUDY ON NEUTRINO RESEARCH: CONTINENT LEVEL ANALYSIS

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### ABSTRACT

*In this paper, we have made a quantitative evaluation of the research output in the field of Neutrino based on a scientometric investigation of as many as 8,993 records published in journals and through other channels as contained in the Scientific Citation Index (SCI) and Social Science Citation Index (SSCI) and on the bibliographic databases of Web of Science during the period of 2011-2016. It is inferred that the records have been published in five languages and have been contributed by 30,742 authors in 322 journals during the study period. Most number of the records is in the form of Articles (7984), and a total number of 588 major institutions belonging to 91 different countries have produced them. 8993 records were segregated among the six continents, of which the European continent occupies the first and Asian continent occupies the second position on the basis of the publication of records. The Australian continent has only two countries which have published 445 documents and have got 22,151 Global Citation Scores. Only a meager number of 317 documents have been published by seven countries in the African continent and they got 12,661 GCS.*

**Keywords:** Neutrino, Scientometrics, Continent analysis.

### 1. INTRODUCTION

Neutrinos are tiny particles of massless kind traveling close to the lightspeed. They are born from the violent astrophysical events like star explosions and burst of gamma rays. These Neutrino particles are found in massive abundance in the universe, and they are capable of moving

At the same time, the importance of these neutrino particles cannot be overlooked, as they constitute one of the essential elements of the universe and have been instrumental for the scientists to better understand the physical aspects. Neutrino particles have been discovered to be present in three types: electron neutrinos, muon neutrinos, and tau neutrinos. All these

from place to place seamlessly, because of which it is highly difficult to pin them down. Neutrinos are described by the leading scientists to be strange particles devoid of mass or electric charge, in fact they are almost nothing, and hence called "Ghost Particles".

neutrino particles are created from the radioactive decay, as a natural byproduct of nuclear fusion. Enrico Fermi was the scientist who developed a complete theory of neutrino interactions and coined the term neutrino for these particles. A group of researchers discovered the neutrino in 1956, a finding which later earned them the 1995 Nobel Prize in Physics.

### 2. LITERATURE REVIEW

Rao and Arivunithi (2012) have pointed out citing Scopus database that there are increasing number of journal articles in

the field of neutrino research in India, indicating the trend of collaborative research. The study reveals that the Indian

scientists have a strong base in neutrino research. In a similar study, **Velmurugan and Radhakrishnan (2017)** have made a scientometric investigation of the Phytochemistry research in India using the Web of Science (WoS) core collection database in the time span of last 21 years. This study deals with articles, reviews, proceedings, correction and editorial pieces in terms of authorship, publication, International and institutional collaboration, subject based categories, most cited

references, ranking of core journals, highly cited authors etc. A recent study in this line is by **N.Amsaveni and M.Manikandan (2014)**, in which a quantitative analysis of the research trends in Management Information System in a time span of 25 years has been attempted using scientific publications reflected in the core collection of web of science database. This study also presents the productivity, characteristics and various aspects of global publications, authorship pattern and prolific journals.

### 3. METHODOLOGY

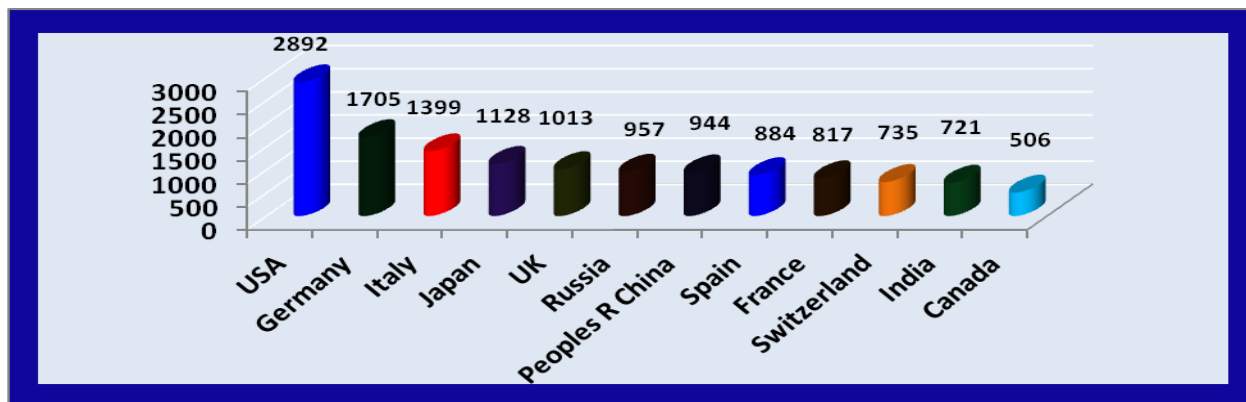
The present study is based on the references and aims to analyze quantitatively the growth and development of neutrino research in global level in terms of publication output, as reflected in the international multidisciplinary bibliographical database of Web of Science during the years 2011-2016. Web of Science is the largest abstract and citation database of research literature and quality web only

journals. It has been designed to enable not only the researchers for accessing scientific information, but also to provide the information scientists to study the literature for different information analyses purposes. A total of 8993 records were downloaded and analyzed using the Histcite software application and the downloaded data has been tabulated using MS-EXCEL.

### 4. ANALYSIS AND INTERPRETATION

**Table 4.1: Highly productive countries on Neutrino research**

S. No	Country	Records	TLCS	TGCS	Continent
1	USA	2892	5208	85192	North America
2	Germany	1705	4588	54823	Europe
3	Italy	1399	3134	42980	Europe
4	Japan	1128	2338	33858	Asia
5	UK	1013	2496	50280	Europe
6	Russia	957	2098	32406	Asia
7	Peoples R China	944	1445	26305	Asia
8	Spain	884	1759	35688	Europe
9	France	817	1579	33149	Europe
10	Switzerland	735	1886	34855	Europe
11	India	721	966	17668	Asia
12	Canada	506	1138	40318	North America



In total, 91 countries are found to be producing scholarly articles in the field of neutrino research. Of these, the top 12 countries account for more than 500 publication records. The remaining countries contribute only below 500 publication records to their credit. The above table

Out of the top 12 countries, The United States of America ranks first with as many as 2892 publication records, 5208 local citations and 85192 global citation scores. Germany, Italy and Japan make out for the second, third and fourth places, with

presents a clear picture of the top 12 countries from where more than 500 publication records have been produced in the particular field. It is hence evident that these countries accord more importance to the research in neutrino research in the global scenario.

1705, 1399 and 1128 publications respectively. India turns out to be the 11<sup>th</sup> contributor among the top most countries with 721 publication records, 966 local citations and 17668 global citation scores.

**Table 4.2: Continent Wise Research Output on Neutrino research**

Rank	Continents	Contributing Countries	No. of Records	%	TLCS	TLCS
1	Europe	34	10018	47.01	21926	432003
2	Asia	33	5698	26.74	10956	189089
3	North America	7	3678	17.26	6868	139825
4	South America	8	885	4.15	838	31736
5	Australia	2	445	2.09	1240	22151
6	Africa	7	317	1.49	424	12661
7	Unknown	-	271	1.27	577	1589
<b>Total</b>		<b>91</b>	<b>21312</b>	<b>100.00</b>	<b>42829</b>	<b>829054</b>

Table 4.2 presents the list of continents contributing to the neutrino research in the world. Among all the continents, European countries (a total of 34

countries) are inferred to have contributed to the field of study with highest number of research publications. These 34 countries together have produced 10018 publications.

Followed by Europe in the list is Asia with the contribution of 33 countries, 5698 publication records. Out of the total records, as much as 73 percent has been produced

from these two continents (Europe and Asia). It is to be noted that the other four continents together have produced only 27 percent of records.

**Table 4.3: Neutrino Research Output in European Countries**

S. No	Country	Records	TLCS	TGCS	% of 10018
1	Germany	1705	4588	54823	17.02
2	Italy	1399	3134	42980	13.96
3	UK	1013	2496	50280	10.11
4	Spain	884	1759	35688	8.82
5	France	817	1579	33149	8.16
6	Switzerland	735	1886	34855	7.34
7	Poland	359	659	16181	3.58
8	Belgium	293	828	20592	2.92
9	Netherlands	284	729	22347	2.83
10	Greece	240	432	4509	2.40
11	Portugal	225	369	8018	2.25
12	Denmark	191	164	15114	1.91
13	Czech Republic	180	251	4243	1.80
14	Finland	170	329	18898	1.70
15	Romania	163	401	9453	1.63
16	Turkey	156	195	6917	1.56
17	Austria	138	248	6814	1.38
18	Hungary	117	200	2004	1.17
19	Bulgaria	106	258	11080	1.06
20	Croatia	99	236	1880	0.99
21	Slovakia	96	150	1766	0.96
22	Serbia	85	144	1520	0.85
23	Norway	84	113	8701	0.84
24	Rep of Georgia	81	177	1613	0.81
25	Belarus	80	155	1463	0.80
26	Slovenia	78	47	1549	0.78
27	Ireland	67	67	12339	0.67
28	Estonia	59	123	1408	0.59
29	Cyprus	50	101	883	0.50
30	Lithuania	48	99	732	0.48
31	Latvia	6	3	26	0.06
32	Macedonia	4	2	4	0.04

33	Bosnia & Herzog	4	4	161	0.04
34	Iceland	2	0	13	0.02
<b>Total</b>		<b>10018</b>	<b>21926</b>	<b>432003</b>	<b>100.00</b>

The above table offers a clear picture of each country's contribution in the continent of Europe for the neutrino research. Out of the 34 contributing countries, Germany, Italy and United

Kingdom occupy the first three positions with more than 1000 records. It is clear that these nations fund lavishly and concentrate more on the research works in this field.

**Table 4.4: Neutrino Research Output in Asian Countries**

S. No	Country	Records	TLCS	TGCS	% of 5698
1	Japan	1128	2338	33858	19.80
2	Russia	957	2098	32406	16.80
3	Peoples R China	944	1445	26305	16.57
4	India	721	966	17668	12.65
5	South Korea	480	1133	19993	8.42
6	Taiwan	337	674	13391	5.91
7	Sweden	271	869	17291	4.76
8	Israel	155	231	12168	2.72
9	Ukraine	116	359	2420	2.04
10	Iran	98	127	1660	1.72
11	Armenia	87	138	1538	1.53
12	Pakistan	64	102	783	1.12
13	Vietnam	64	81	708	1.12
14	Malaysia	41	43	741	0.72
15	Azerbaijan	41	46	698	0.72
16	Thailand	34	87	606	0.60
17	U Arab Emirates	29	71	395	0.51
18	Sri Lanka	24	38	406	0.42
19	Qatar	23	38	336	0.40
20	Saudi Arabia	20	35	5252	0.35
21	Singapore	12	28	121	0.21
22	Indonesia	10	1	36	0.18
23	Kazakhstan	9	1	68	0.16
24	Uzbekistan	8	2	6	0.14
25	Syria	6	0	40	0.11
26	Oman	5	0	47	0.09
27	Jordan	3	0	28	0.05

28	Lebanon	3	0	29	0.05
29	Iraq	2	0	2	0.04
30	Myanmar	2	0	28	0.04
31	North Korea	2	5	50	0.04
32	Bangladesh	1	0	3	0.02
33	Mongol Peo. Rep	1	0	8	0.02
<b>Total</b>		<b>5698</b>	<b>10956</b>	<b>189089</b>	<b>100.00</b>

It can be inferred from the above table that India ranks fourth among the total number of 33 countries producing research outputs in the field of neutrino research. First three places are held by Japan, Russia and China with 1128, 957 and 944 records

respectively. Compared to them, the research outputs emerging from India appear to be far less with only 721 total records. It is apparently revealed from the table that India needs to improve the research output on large scale in this field.

**Table 4.5: Neutrino Research Output in North American Countries**

S. No	Country	Records	TLCS	TGCS	% of 3678
1	USA	2892	5208	85192	78.63
2	Canada	506	1138	40318	13.76
3	Mexico	242	280	12969	6.58
4	Barbados	31	242	1326	0.84
6	Cuba	5	0	8	0.14
5	Costa Rica	1	0	3	0.03
7	Dominican Rep	1	0	9	0.03
<b>Total</b>		<b>3678</b>	<b>6868</b>	<b>139825</b>	<b>100.00</b>

The above table on the contribution of North American countries reveals that USA accounts for as much as 78 percent, vividly indicating its position as an advanced country in this field. It is also to be

noted that USA ranks first in the country wise list of contributors on the global level. Canada and Mexico occupy the subsequent places in the North American continent.

**Table 4.6: Neutrino Research Output in South American Countries**

S. No	Country	Records	TLCS	TGCS	% of 885
1	Brazil	394	388	7341	44.52
3	Chile	198	164	11014	22.37
2	Argentina	133	102	10967	15.03
4	Colombia	133	168	1994	15.03
7	Ecuador	16	16	153	1.81
6	Venezuela	6	0	244	0.68

5	Uruguay	3	0	14	0.34
8	Paraguay	2	0	9	0.23
<b>Total</b>		<b>885</b>	<b>838</b>	<b>31736</b>	<b>100.00</b>

Table 6 given above offers a glimpse into the research output to have emerged from the continent of South America. Brazil, Chile and Argentina occupy the first three places in this continent with 394, 198 and 133 records respectively. It is evident that

Brazil's contribution is far ahead of the other countries in terms of records with limited funding agencies and research facilities, these countries have been able to produce only a relatively small amount of research output.

**Table 4.7: Neutrino Research Output in Australian Countries**

S. No	Country	Records	TLCS	TGCS	% of 445
1	Australia	305	642	16843	68.54
2	New Zealand	140	598	5308	31.46
<b>Total</b>		<b>445</b>	<b>1240</b>	<b>22151</b>	<b>100.00</b>

The above table details out the contribution of Australia and New Zealand, only two countries in the continent of

Australia. Australia is followed by New Zealand in the continent with 305 and 140 records respectively.

**Table 4.8: Neutrino Research Output in African Countries**

S. No	Country	Records	TLCS	TGCS	% of 317
1	South Africa	94	113	9257	29.65
2	Egypt	83	141	1138	26.18
3	Morocco	74	39	1230	23.34
4	Peru	27	47	405	8.52
5	Algeria	25	73	310	7.89
6	Madagascar	10	11	224	3.15
7	Tunisia	4	0	97	1.26
<b>Total</b>		<b>317</b>	<b>424</b>	<b>12661</b>	<b>100.00</b>

It can be inferred from the above table that South Africa, Egypt and Morocco occupy the top three places in the field of neutrino research. While the number of records and citation records are far below in

the case of countries belonging to the African continent, it is pertinent that they have been able to produce even this much of research with their extremely limited resources. The field of neutrino research is a

highly time consuming and work requiring a huge expenditure, and the less amount of

contribution from the third world African countries is hence understandable.

## 5. CONCLUSION

This paper has attempted a scientometric study of the research works produced in the field of neutrino research from various countries and different continents of the world. It can be inferred from the above analyses that USA tops the list of countries and Europe tops the list of continents with as much as 47% of the total research work. The developed status of USA and European nations is evident from the focus they offer to this field. Among the Asian countries, Japan alone crosses the 1000 records mark; even Russia, China and

India have produced only a less number of studies. It is further evident that South America and Africa have contributed very less in this field, evidently due to their economic constrains. The field of neutrino research is a rapidly progressing branch of physical science. More and more number of countries and agencies are in the process of carrying out huge research projects in this field. In this context, more studies, both in terms of quality and quantity, can be expected to emerge in near future from the countries like India.

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