

BIBLIOMETRIC ANALYSIS OF PUBLICATIONS ON NUCLEAR SCIENCE AND TECHNOLOGY OF THE PHILIPPINES FROM 1956 TO 2020

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ABSTRACT: This paper aimed to analyze the publication outputs in nuclear science and technology of the Philippines from 1956 to 2020 using bibliometric analysis. The researcher reviewed 4, 620 publications written about the Philippine's nuclear science and technology using the INIS Database. Findings showed that majority of the publications are merely general information and annual reports and there are very few empirical studies conducted. Publication is fluctuating per year in the 21st century although a 5-year trend analysis shows increasing number of publications since 1956. The International Atomic Energy Agency has topped the number of worldwide distribution of publications on the Philippine's NST while United States topped all other countries. The Philippines ranked only 4th with the highest number of publications about its very own nuclear science and technology next to France. The Philippines responds to the need to disseminate information on its NST through the publication of the Philippine Nuclear Journal. Current response of Philippines shows focus on Food and Agriculture, Human Health and Medicine, Environmental Protection and Management, and Applications of High Technology Materials. Research on the country's NST deserves the attention of Filipinos now more than ever for a competitive future.

KEYWORDS: Bibliometric, Nuclear Science and Technology, Philippines, Scientometric, Research Publications, Science Education

I. INTRODUCTION

Nuclear Science and Technology (NST) in the Philippines

Nuclear energy in the Philippines appears to be a forgotten treasure. Since the closing of the Bataan Power Plant which began construction in 1976 and completed in 1984, the Philippines' behavior towards nuclear energy, thereby the direct application of nuclear science, has been obviously cold, and no government since then has ever attempted to venture on nuclear power. However, according to Bernido (2007), there is a possibility for the introduction of nuclear power in the country's projected energy sources by the year 2025. Could this really happen especially so that no universities in the Philippines is presently offering nuclear engineering?

Historically speaking, by virtue of Presidential Decree No. 606 signed into law on December 13, 1974 by the then President Marcos, the Philippine Energy Atomic Commission (est. 1958 by RA No. 2067, 'Science Act of 1958') was transferred from the National Science Development Board to the Office of the President because of the, at the time, increased utilization of atomic energy and that the nuclear power development program in the country have resulted in highly demanding responsibilities and expanded functions. This was done to ensure that the Office of the President was directly informed by the Commission on the accelerating pace of international nuclear activities, in the interest of national security and public safety.

Realizing that science and technology efforts should have priority for national development, by virtue of Executive Order No. 784 signed into law by then President Marcos on March 17, 1982, the National Science Development Board and its attached agencies were reorganized to form the National Science and Technology Authority which had the general responsibility to formulate and implement policies, plans and programs for the development of science and technology capabilities for the promotion of scientific and technological activities, to ensure that the

results of scientific and technological activities are properly applied and utilized to accelerate economic and social development, and to continually review the state and needs of science and technology in the light of the country's development goals.

However, by virtue of Executive Order No. 128 by the then President Aquino, the Philippine Atomic Energy Commission, or PAEC, was reorganized to form an institute, now known as the Philippine Nuclear Research Institute, or PNRI. The PNRI was mandated to perform the following functions: (a) conduct research and development on the application of radiation and nuclear materials, processes and techniques in agriculture, health, nutrition and medicine and in industrial or commercial enterprises; (b) undertake the transfer of research results to end-users, including technical extension and training services; (c) operate and maintain nuclear research reactors and other radiation facilities; and, (d) license and regulate activities relative to production, transfer, and utilization of nuclear and radioactive substances.

Since the passing of the 'Science Act of 1958' in 1958 up to this year 2020, after almost 62 years – how has the field of nuclear science evolved? There were very limited studies on nuclear science and technology in the Philippines, and this study is the first real attempt to trace nuclear science and technology researches since 1956 as a bibliometric study.

Bibliometric Studies on NST of Different Countries

In Mexico, Garrido (2007) studied research outputs in nuclear science and technology between 1986 and 1994 (yielding 920 nuclear science papers) by combining bibliographic references from several sources including the INIS Database and analyzed the documents by various parameters including subject, publication year, among others. In Iran, Akbari and Bozorgi (2009) surveyed the INIS Database from 2002 to 2006 and studied the citation behavior of the authors through the survey and citation analysis method. Further in Iran, Davarpanah (2012) conducted a study on the status of nuclear science and technology in Iran using the Science Citation Index Expanded from 1990 to 2010, and not using the INIS Database like the other studies reviewed herein.

An old study which did not use the INIS Database is the study of Van Leeuwen and Tussen (1995), in Denmark, which consulted the Institute for Scientific Information (ISI) and non-ISI databases, which noted the value of combining bibliometric indicators of publication output, international visibility and international co-operation in a study of nuclear energy research. A new study, in Pakistan, Gupta (2012) performed a scientometric analysis from 2001 to 2010 of Pakistan's science and technology output using the Scopus database, and not the INIS Database, and concluded that Pakistan would need to increase its output and improve on the quality of its research efforts. In Ghana, Agyeman and Bilson (2015) performed descriptive bibliometric technique to analyze publications on nuclear science and technology in Ghana that were listed in the INIS Database from 1964 to 2014.

In India, Kademani et al. (2007) performed a scientometric analysis of science and technology activities using the Science Citation Index covering the period 1990-2004, and studied various parameters including growth characteristics, language, and pattern of collaboration. In Bangladesh, Gupta (2013) did a scientometric analysis of national publications of Bangladesh in their outputs in Science and Technology covering the period 2001 to 2010 and analyzed parameters including growth and country publications share in the world's research output, using the Scopus Citation Database.

International Impact of this Study

Using the terms 'nuclear research', 'nuclear science and technology', 'bibliometric analysis', 'scientometric analysis' combined with 'Philippines', no study has ever been conducted on the topic and available as published article in google scholar, Science Citation Index, Web of Science and even in other miscellaneous repositories. In the INIS (International Nuclear Information System) Database, the use of these terms showed 19 entries from the following countries and/or organizations: International Atomic Energy Agency (13), France (2), European Commission (1), Japan (1), Malaysia (1), and United States (1). No study on the subject was ever published from the Philippines since 1958.

II. STATEMENT OF THE PROBLEM

This study aimed to perform bibliometric analysis in nuclear science and technology publications in the Philippines by from 1956 to 2020. This study specifically sought answers to the following:

1. What are the characteristics of the Philippines' Nuclear Science and Technology (NST) publications in terms of:

- a. Main subject area studied;
 - b. Type of Publications;
 - c. Year of publication; and
 - d. Worldwide publication trend.
2. What implications on the government’s response to NST could be derived from available data?
 3. What is the modern response of the Philippines to NST?

III. RESEARCH METHODOLOGY

Technique Employed. The main data-collection technique employed in the study is the descriptive bibliometric technique to analyze Philippine publications available in government, as well as journal articles available and indexed in google scholar and are found in the International Nuclear System (INIS Database).

Procedure Implemented. With over 380 million articles indexed, the Google Scholar could be the widest article repository that could provide any article which the researcher needed to establish the absence of a similar study. In the google scholar, the following words and phrases were encoded and were used to search: Philippines (1, 950, 000 related articles), Philippines and Nuclear Science and Technology, (116, 000 articles), and Philippines, Nuclear Science and Technology, and Bibliometric Study (537 articles). Analysis of the 537 articles with the 3 terms did not yield similar study. Advanced Search was, then, made. The following restrictions were applied: found in the title, at least one of the following words (bibliometric, scientometric, nuclear science, nuclear technology), there were zero results. Advanced Search was, the made again, this time for the ‘entire web’, and there were zero results. The study is the pioneering method type in this field of study in the Philippines, and could be the recent bibliometric study study in the entire web as of this writing.

Further, with over 4.3 million bibliographic records as of 2019, the International Atomic Energy Agency website was also searched. ‘Philippines’ was first used as a term and the repository showed 9, 598 search results. ‘Nuclear Science and Technology’ was added and there were 4, 620 results. ‘Bibliometric’ was added and there were zero results. The same methodology was employed by Agyeman and Bilson (2015) in the bibliometric study on nuclear science and technology researchers in Ghana, by Kademani *et al.* (2006) in their scientometric study on nuclear science and technology in India. No bibliometric study on the researches related to nuclear science and technology has ever been conducted in the Philippines since 1956.

Parameters Studied. This bibliometric study considered the following parameters: Main Subject Area Studied, Type of Publication, Year of Publication (1956 to 2020, and per 5-year interval), Country of Publication, Language of Publication, and High-indexed Terms.

IV. DISCUSSION OF FINDINGS

Main Subject Area Studied and Implications

Table 1. Frequency and Percentage of Philippine Nuclear Science and Technology Publications Along Main Subject Area Studied

Rank	Main Subject Area	f	%
1	Gen. Info. and Annual Reports	927	20.06
2	Applied Life Sciences	665	14.39
3	Environmental Sciences	324	7.01
4	Specific Nuclear Reactors And Associated Plants	287	6.21
5	Energy Planning, Policy and Economy	285	6.17

6	Mngt of Radioactive Wastes, and Non-Radioactive Wastes From Nuclear Facilities	241	5.22
7	Rad. Protection and Dosimetry	195	4.22
8	Gen. Studies of Nuc. Reactors	164	3.55
9	Geosciences	143	3.10
10	Instrumentation Related to Nuclear Science and Tech.	141	3.05
	Others/Hundreds more	1,248	27.02
	Total	4,620	100.00

Table 2 Frequency and Percentage of Philippine NST Publications Along Year of Publication with 100+ Publications

Year of Publication	f	%
2015	108	2.34
2014	108	2.34
2013	133	2.88
2012	103	2.23
2011	101	2.19
2009	100	2.16
2007	119	2.58
2001	105	2.27
2000	103	2.23
1999	132	2.86
1998	111	2.40
1997	122	2.64
1996	108	2.34
1992	106	2.29
1956	11	0.24

Findings on Main Subject Area Studied as shown in Table 1 indicate that majority of the publications (927 of 4,620 publications, 20.06%) in nuclear science and technology in the Philippines from 1956 to 2020 are categorized

under ‘General Information and Annual Reports’. This implies that the flow of general information about nuclear research is the top most priority of researchers. Further, the table reports that ‘Applied Life Sciences’ ranked 2nd. (665 of 4, 620 publications, 14.39%). This implies that researchers aim to apply nuclear research to make life better, for what else is the purpose of research but to generate products and services to make lives better. On the same note, the table reveals that Environmental Science ranked 3rd (324 of 4, 620 publications, 7.01%). This could be regarded to mean that nuclear research is being assessed as it could potentially impact the environment. While it is true that research aims to make life better, it does not necessarily result to destroying the environment.

Further, the table reports that research on ‘Specific Nuclear Reactors and Associated Plants’ ranked 4th (287 of 4, 620 publications, 6.21). This should provide us an idea that researchers wanted to publish the most available data about nuclear facilities and nuclear plants – these are not kept secret, but are freely accessible to the public. Related to these are researchers under ‘General Studies of Nuclear Reactors’ which ranked 8th (164 of 4, 620 publications, 3.55%) and ‘Instrumentation Related to Nuclear Science and Technology’ which ranked 10th (141 of 4, 620 publications, 3.05%). That publications related to nuclear facilities and its instrumentation should provide us an idea that nuclear science and technology in the Philippines have been developing in this area for 64 years already and still counting (1956 to 2020). This could mean that nuclear facilities and their operation remains the focus of researchers in the Philippines.

Furthermore, the table shows that energy generation appears to be the main concern for the development of nuclear science and technology in the Philippines with ‘Energy Planning, Policy and Economy’ ranking 5th (285 of 4, 620 publications, 6.17%), while providing safe use and human protection with ‘Management of Radioactive Wastes and Non-radioactive Wastes from Nuclear Facilities’ ranking 6th (241 of 4, 620 articles, 5.22%) and ‘Radiation Protection and Dosimetry’ ranking 7th (195 of 4, 620 publications). Finally, it is worthy to take note that a link between nuclear science and technology and ‘Geosciences’ is built with the latter ranking 9th (143 of 4, 620 publications, 3.10%).

Record Type of Publications and Implications

Table 3 Frequency and Percentage of Philippine Nuclear Science and Technology Publications
Record Type Published

Record Type	f	%
Report	2, 260	48.92
Miscellaneous	1, 346	29.13
Book	686	14.85
Journal Article	150	3.25
Thesis/Dissertation	148	3.20
Legislative Material	17	0.37
Standard	6	0.13
Book	4	0.09
Software	2	0.04
Multimedia	1	0.02
Total	4, 620	100.00

Findings on Type of Publications as shown in Table 2 clearly show that majority and almost half of 4, 620 publications (2, 260 publications, 48.92%) of the publications in nuclear science and technology in the Philippines from 1956 to 2020 are merely ‘Reports’. This finding is supported by the findings revealed in Table 1 with publications under ‘General Information and Annual Reports’ being ranked 1. Further, several publications are ‘Miscellaneous’ publications which ranked 2nd (1, 346 publications, 29.13%) and a number of the publications are ‘Books’ (686 of 4, 620 publications, 14.85%).

Further, Table 2 reveals that of the 4, 620 publications on NST in the country, there are only and actually 150 which are journal articles, or empirical studies on NST. This is a very small number when taken against the

potential contribution of research to the field of nuclear science and technology. Several publications are theses and dissertations (3.20%), legislative material (<1%), standard (<1%), Book (<1%), Software (<1%), and Multimedia (<1%).

Year of Publication and Implications

Findings on Year of Publications as shown in Table 3 displays the years where publication exceeded 100. The year 2013 topped all the other 63 years of analysis of NST in the Philippines with 133 publications (2.88%). The year 1999 had 132 publications (2.86%), and the year 1997 had 122 publications (2.64%). During there year range – 1995 to 2000 – several related events took place in the Philippines including, but not limited to the following: the successful trial of the Sterile Insect Technique in Guimaras, Philippines was held in 1995, the ascent to presidency in 1996 to the 40th General Conference of the International Atomic Energy Agency IAEA, of the then DOST Secretary Dr. William G. Padolina, and the successful conduct in 1997 of the second Philippine Nuclear Congress which was held in Manila, in celebration of the centennial discovery of radioactivity. All these factors could have strongly influenced the increase in number of publications on Philippine’s NST during those periods.

Similarly, major events in the Philippines in NST occurred during these periods 2000 – 2015. During these periods, (1) the Philippines was recognized as one of only three countries to launch Project IWAVE which aimed to help member countries to improve long-term access to freshwater using science-based, comprehensive assessments of national water resources, (2) the National Nuclear Safety Plan, which, as the term suggests ensures safety with the use of nuclear-based materials among others, (3) the formal engagement of member states to study the disaster impact of nuclear activities on the marine environment, (4) the tripartite cooperation of the Philippines, South Africa, and the IAEA for the conditioning and storage of Spent High Activity Radioactive Sources (SHARS), and (5) finally, in 2014, the PNRI Electron Beam Facility was inaugurated and the PNRI successfully conducted its first ‘full’ exhibit of Filipino applications of nuclear science and technology in Vienna, Austria.

From the data collected, as shown in italics in Table 3, there were already eleven (11, 0.24%) publications about the Philippine’s Nuclear Science and Technology, this is even before the passage of Science Acts of 1958 – this fact is so vital to the study’s analysis that such is included in Table 3 along other years with 100+ publications. Descriptive statistics performed among the data (not shown in Table) would show that, on average, 72.18 publications (4, 620 in 64 years) are published each year in the Philippines which translates to 6 publications per month (4, 620 publications in 768 months of 64 years). This is considerably plenty, but when compared against Table 2, this is only 2.34% per year and 0.20% publication per month of journal articles – this is very low, in fact almost non-existent.

Figure 1 displays a graph on the publications of the Philippines’ NST since 1956 using a 5-year interval. The figure clearly shows that the publication behavior is increasing, with some stagnation during 1981 to 1990 and 2000 to 2010, with a decline during 1996 to 2005, but eventually skyrocketing from 2010 onwards, in fact reaching its peak during this period. If this trend continues, we could expect a steady increase of publications in NST of the Philippines, and hope that this time would have its increase in journal articles or empirical studies.

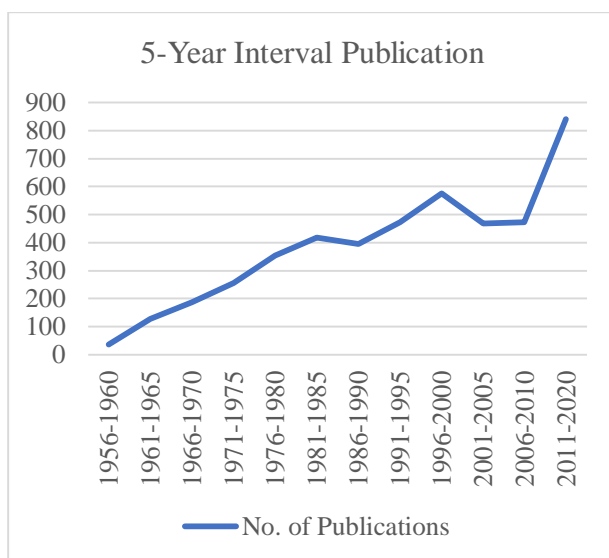


Figure 1. Increasing Graph of Publication on Nuclear

S & T in the Philippines since 1956

Worldwide NST Publications and Implications

Table 4. Frequency and Percentage of Philippine Nuclear Science and Technology Publications Published Worldwide with 1%+ Publications

Origin of Publication	f	%
International Atomic Energy Agency (IAEA)	2, 610	56.49
United States	470	10.17
France	276	5.97
Philippines	245	5.30
Japan	193	4.18
Korea, Republic of	75	1.62
Nuclear Energy Agency of the OECD (NEA)	75	1.62
Netherlands	71	1.54
Australia (68)	68	1.47
Malaysia (50)	50	1.08

Findings as shown in Table 4 reveals that more than half (2, 610 publications of 4, 620 publications, 56.49%) of the publications of the Philippines on NST are authored by the International Atomic Energy Agency, or IAEA. This is not surprising because IAEA is tasked for this purpose, what is surprising is that the Philippines only ranked 3rd (245 of 4, 620 publications, 5.30%) with United States topping all other countries with 470 publications (10.17%), next to France with 276 publications (5.97%). Japan ranked 4th among countries with 193 publications about the Philippines’ NST. Korea (1.62%), Netherlands (1.54%), Australia (1.47%), and Malaysia (1.08%) also are major contributors to the INIS Database on the Philippines’ NST. Other countries and organizations with less than 1% publications are not included in Table 4.

Philippines Modern Response to NST

The Department of Science and Technology – Philippine Nuclear Research Institute (DOST-PNRI) under its Research and Development (R&D) Projects now focuses on four foci for researches on nuclear science and technology, to wit, (1) Food and Agriculture, (2) Human Health and Medicine, (3) Environmental Protection and Management, and (4) Applications of High Technology Materials. The PNRI now maintains its own journal, titled ‘Philippine Nuclear Journal’, PNJ to publish accounts of researches, studies and activities on nuclear energy and related fields carried out in the Philippines, or by Filipinos in investigations done outside the country. The PNRI website states that the journal was on its 14th volume, as written in an article published on its website dated January 26, 2005. The PNJ could not be found online as of this writing, and the PNRI website claims that the PNJ is distributed to various school libraries and other government agencies.

On the other hand, the Philippine Journal of Science, or PJS, has published a special issue – the 2nd Special Issue of the journal next to ‘Genomics’ – solely dedicated to nuclear science and technology in its 149th volume in 2019. Similarly, the foreword of the PNRI President Dr. Dela Rosa has presented research outputs that belong to the above-mentioned foci of research in nuclear science and technology as shown in the PNRI Website.

V. CONCLUSIONS

With all these findings, the researcher concludes that the publications of the Philippines in Nuclear Science and Technology is still young. With the country's general information and annual reports as its most publications and reports as mostly published record type and not journal articles, nuclear science and technology deserves considerable attention now more than ever. That the Philippines only ranked 4th among the most number of research contributions to its own NST may not be alarming but is surprising, and therefore have strong implications to policies on R&D Projects of the government – we may not be doing enough. However, the response of the DOST-PNRI through the publication of research outputs through its Philippine Nuclear Journal deserves recognition, and the publication of a special issue solely devoted to the Philippines' NST by the Philippine Journal of Science is commendable. The Philippines, a once active in nuclear activity, is surely responding to the need to make nuclear science and technology a potential choice for energy once again. The researcher recommends the analysis of its training courses to be aligned to the STEM curriculum for future engineering students in SUCs or non-SUCs in the Philippines (Camara, 2020a) to ensure that nuclear science and technology will have a formal venue for instruction and for the emerging Industrial Revolution 4.0 (Camara, 2020b). Further, emerging S & T techniques could be used to enhance the agricultural sector (Camara, 2020c).

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