



# An Analysis of Scientific Literature Production Related to Radiation Protection and Strategic Environmental Assessment

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## 1. Introduction

Radiation protection is a term applied to concepts, requirements, technologies and operations related to protection of people (radiation workers, members of the public, and patients undergoing radiation diagnosis and therapy) against the harmful effects of ionizing radiation [1]. It is under development since the beginning of the last century [2]. Currently, the process of scientific evolution of radiation protection is well established and is carried out by a group of international institutions, such as the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), the International Commission on Radiological Protection (ICRP) and the International Atomic Energy Agency (IAEA), working together and in harmony.

For many decades the scientific and technological development of knowledge related to nuclear energy has been avant-garde and contributes to the development of other human activities [3]. However, other lines of scientific development have been improved and have now established a number of innovations and perhaps these innovations may have some use for the development of nuclear science.

One possibility of an environmentally sustainable advance in the development of the use of nuclear energy is perhaps the adoption of a tool developed in environmental science, the Strategic Environmental Assessment (SEA).

Strategic Environmental Assessment is “a decision making support instrument for the formulation of sustainable spatial and sector policies, plans and programs, aiming to ensure an appropriate consideration of the environment” [4]. SEA is an appropriate environmental impact assessment instrument to establish whether or not a policy, plan or program can be developed and under which conditions. Once it has been decided whether or not certain economic activity will be accepted by society and under what general conditions, the implementation of related projects will be facilitated since the environmental impact assessment to be developed via a specific environmental impact study for each of the projects already has the established development decision and under what general conditions [5], [6].

Public acceptance of almost every use related to nuclear radioactivity is a problem because people, in general, do not think ionizing radiation is safe [7],[8].

Development of projects in nuclear area, such as construction of nuclear reactors for supply of electricity, or the construction of a place to use it as a repository for management of radioactive waste, etc. These projects may face strong opposition from public, especially from people living close to these projects [9], [10].

The SEA is a decision support tool that aims to assist in the preparation of environmentally sustainable policies, plans and programmes by public authorities. It thereby targets strategic levels and is meant to guide the subsequent development of projects [11].

Currently, SEAs are formally required in some 60 countries [12] and there are experiences with their application in many other countries around the world. To carry out our bibliographic research we decided to use a source of information related to nuclear energy and ionizing radiation, the International Nuclear Information System (INIS) database.

## 2. Methodology

The method of analysis for conducting the research is quantitative. The bibliographic review was carried out in the INIS database and the search strategy was done using as Boolean logic parameters the exact phrase for strategic environmental assessment and the exact phrase for radiological protection. It was tried to map the main concepts that support determined area of knowledge, examine the extent, the scope and nature of the research, to summarize and research data and identify existing research gaps.

INIS, which is a “decentralized information system operated by the IAEA in Vienna, Austria in co-operation with its Member States and co-operating international organizations. It is the world’s leading information system on the peaceful uses of nuclear science and technology. INIS maintains a database of over 3 million bibliographic references and announces the availability of scientific literature published world-wide on the peaceful uses of nuclear energy. INIS covers all aspects of the peaceful uses of nuclear science and technology. There are central areas to the scope such as nuclear reactors, reactor safety, nuclear fusion, applications of radiation and radioisotopes in medicine, agriculture, industry and pest control as well as related fields such as nuclear chemistry, nuclear physics and materials science. Special emphasis is placed on the environmental, economic and health effects of nuclear energy. Legal and social aspects associated with nuclear energy are also covered. And, from 1992, the economic and environmental aspects of all non-nuclear energy sources are included in the scope” [13].

INIS stores different types of scientific documents and is an advantage of INIS compared to other databases that normally store only scientific journal articles. In this way, it is possible to verify how their production varies over time.

## 3. Results and Discussion

The total results for a bibliographic search in the INIS database for the expression Strategic Environmental Assessment was 397 documents. For a search in the INIS base for the expression Radiation Protection the result was 200359 documents. In both searches the Exact Phrase filter was used. Using Boolean logic we have as a result of the intersection of these two searches, on December 14, 2018, the total of 110 documents recovered. That is, of a universe of 397 SEA-related documents, approximately 25% cite some form of radiation protection.

The documents were studied in relation to the year of publication, country and language, besides type of publication.

The English language is the most used in the texts on SEA and Radiation Protection. Then we can see

that French is the second most used language. However, the countries where the English language is the native language are not the main document providers.

In addition to the contribution of France, two other major generators of texts for the theme on display are the Scandinavian countries, especially Sweden and a surprise is Slovakia, which has a similar production to the USA.

Among the countries that are absent in terms of scientific production, we can highlight Germany, which has reiterated its willingness to abandon the use of nuclear energy in its energy matrix. And the United Kingdom, which also has a remarkable scientific and institutional production in SEA, but that this result does not extend to Radiation Protection issue.

International institutions such as NEA and IAEA are major contributors to documents stored in the INIS database on the subject of this article.

This demonstrates a decision to support and encourage the implementation of the SEA in the nuclear area by these international institutions.

According to research published in 2010 [14] the number of SEAs conducted worldwide is around 1000 per year nowadays. However, the deposit of SEAs in the INIS database is substantially lower. According to the figure 1, which reflects the number of documents per year, the values are much more modest.

One of the results of our research is the discovery of the discrepancy between the number of SEAs performed in the world per year and the number of SEAs related to radiation protection.

An article that studied the frequency of publications in three scientific journals related to the focus on SEAs [15], which is described by the author: “The first one was in 2000 and was mainly triggered by authors from Europe. This is most likely connected with work revolving around the then forthcoming SEA Directive. A second peak was established, lasting from 2004 to 2007. This is interpreted as a follow-up to the SEA Directive taking effect. Finally, a third peak has just occurred in 2011. This comes with increased activities around Sino-Asian related papers, as well as a renewed interest into issues of SEA effectiveness and outcomes internationally” [15].

European Sea Directive is related with certain public plans and programs, but not related with policies. It demands that certain plans and programs must be checked in the field of environmental protection to evaluate all those harmful effects they may cause and how to deal with them. It started in 2001 [16].

On this issue the SEA Directive follows the general approach taken by the Sea Protocol to the UNECE Convention on Environmental Impact Assessment in a Transboundary Context.

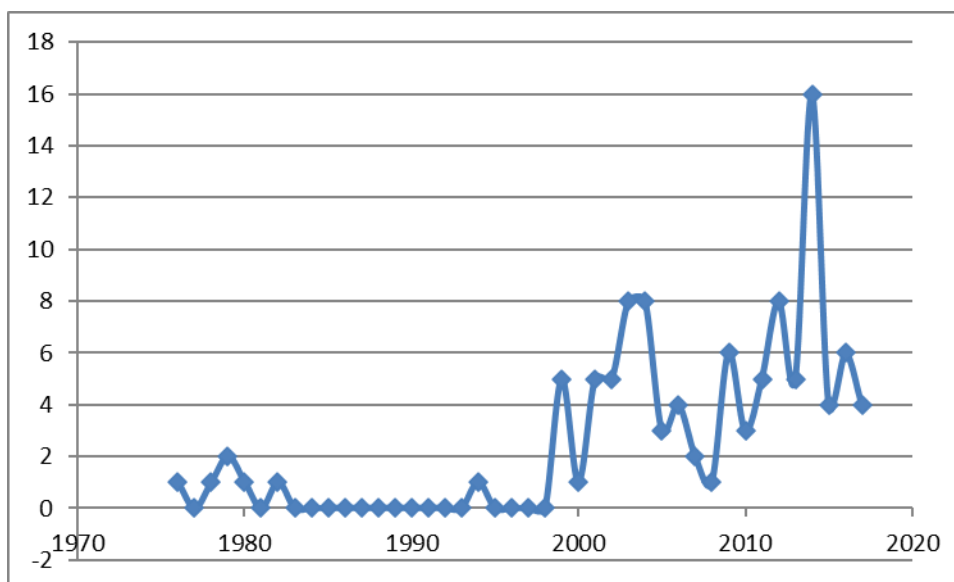


Figure 1: Number of documents per year

As we can see in figure 2, most of the documents stored in the INIS database are reports. And it is impressive that the percentage of articles is so low, the Boolean analysis used in this research has only recovered seven citations, in fact only two of them are articles and the others are translations into the official languages of the IAEA.

The first article is titled "Legal Aspects of Radioactive Waste Management: Relevant International Legal Instruments" and was written in the year 2014 and the second is entitled "Multilateral agreements" and published in 2012. Both documents originated from international institutions and are referenced in this paper in the item references of this paper.

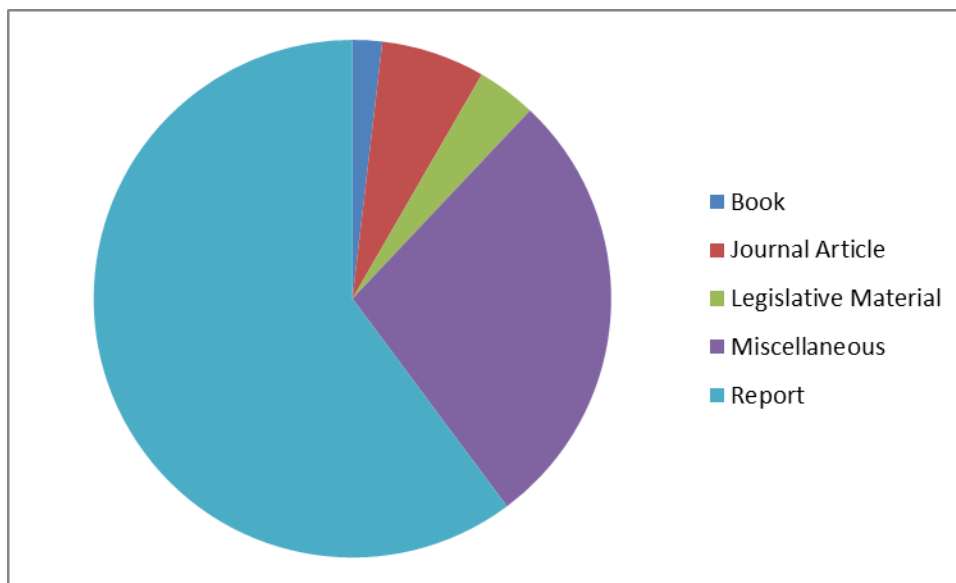


Figure 2: Scientific Production Related to Document Type.

As shown in the chart above, most documents consist of two types: reports and miscellaneous. Thus, we infer to which subjects these two types of documents point using the NVivo program.

NVivo computer software is used for qualitative data analysis.

We group all the documents classified as miscellaneous obtained in the bibliographic search in the INIS database and we inserted in the NVivo program to perform the frequency analysis of words and later we generate a visualization of this analysis. We proceed in the same way with respect to the documents of the type obtained in INIS.

Using the criterion of frequency of words in the texts of the documents cataloged as miscellaneous and that were retrieved from the INIS database we have as the five most frequent words: nuclear, management, waste, power and reactor. Thus, in this type of document the emphasis is on nuclear systems, the management of nuclear power generation issues and the tailings generated by this energy source. However, we can infer that other topic related to ionizing radiation, such as radiopharmaceuticals, are not priorities in this type of document. In figure 3 we present the result of this analysis.



Figure 3 Visualization of miscellaneous type documents.

For report documents the NVivo program selected as the most frequent words: nuclear, management, waste, radioactive and safety. The reports agreed on miscellaneous type documents with respect to the first most frequent words, however, appeared the words radioactive and safety as a topic of interest. We can infer that this is because reports are often produced by virtue of some legal provision and that the authors of these reports have one of their safety concerns.

#### 4. Conclusions

The scientific community linked to the nuclear sector has had access to enormous resources since the Second Great War. Due to this enormous interest on the part of the world powers the generation of knowledge and technology was also massive. However, in the last decades the nuclear area has lost part of its importance in the global context and other areas of knowledge have emerged and / or become more prominent. Thus, our article proposes to verify how SEA has been used by the scientific community related to the nuclear sector, in the aspect of radiation protection.

The first result of our research was that the number of documents stored in the repository of all knowledge in the nuclear area, the AEIA INIS database, is small relative to the number of SEA produced annually in the world, this can be attributed to the decrease in the importance of the nuclear area in the studied period. The primordial process by which researchers obtain information about the work of their peers is through articles and as this number is small, we conclude that the dissemination of knowledge is low.

One of the results pointed out in this research is that the production of articles for scientific journals is much smaller than the reports produced for the themes Strategic Environmental Assessment and radioprotection in the world. Conclusions pointed out in this research is that it is not possible to relate the production of articles to scientific journals with the production of no other type of scientific or technical literature at the moment. Future studies can check whether the number of reports produced may turn out to be relevant articles or not.

Another result of our research was the prominence of languages other than the traditional ones. Our conclusion was that this is due to the participation of several countries in international treaties that require the use of SEA in the nuclear area, generating some interest in the subject. This is in line with another finding in our research those international agencies like NEA and IAEA have encouraged the use of SEA by their associated countries.

We also have as a result of using NVivo software that documents published as miscellaneous does not have radiation protection or anything related as one of the main interests of these documents. However, we have the word safety in the case of documents of the type report. This is due to the fact that all the documents, including those of the report type that served as a basis for this research were selected according to the term's radiation protection and SEA. Thus, the report-type documents studied in this research only exist because they have some interest in safety. And although miscellaneous documents

studied in this research have the same origin, they had different motivation to be produced.

The term nuclear was the most cited word, according to the software NVivo, in the two types of documents analyzed.

We conclude that the scientific community linked to the area of radiation protection can explore and thus contribute more to the development of the SEA, especially with scientific articles, if it deals with all other aspects related to the nuclear and radiological area.

## References

- [1] Shapiro J, *Radiation Protection: a Guide for Scientists and Physicians*. 4th edition, Harvard University Press, Cambridge, MA, (2002).
- [2] Inkret W C, Meinhold CB, Taschner JC, “A brief history of radiation protection standards,” *Los Alamos Sci.* 23, 116–123 (1995).
- [3] Lorenz A, Schmidt J J, "Nuclear Data: Serving Basic Needs of Science and Technology," *IAEA Bulletin*, Vol. 28, No. 4 (1986).
- [4] Fischer T B, “Strategic environmental assessment in post-modern times,” *Environmental Impact Assessment Review.* 23 155–170 (2003).
- [5] Théritel R, *Strategic environmental assessment in action*, 1st ed., London: Earthscan (2004).
- [6] Partidário M R, *Strategic environmental assessment better practice guide*. Agência Portuguesa do Ambiente e Redes Energéticas Nacionais, Lisboa (2012).
- [7] Cuttler JM, “Remedy for radiation fear—discard the politicized science,” *Dose Response* 12: 170–184, (2014).
- [8] Ropeik, David., “The consequences of fear,” *EMBO reports*, 5 Spec No. S56-60, 10.1038/sj.embor.7400228 (2004).
- [9] Welsh I, “The NIMBY Syndrome: Its Significance in the History of the Nuclear Debate in Britain,” *British Journal for the History of Science* 26: 15-32 (1991).
- [10] Vittes M E, Pollock P H III and Lillie S A, “Factors contributing to NIMBY attitudes,” *Waste Management*, 13: 125–129 (1993).
- [11] Fischer T B, *The theory and practice of strategic environmental assessment towards a more systematic Approach*, Earthscan (2007).
- [12] Tetlow M F, Hanusch M, “Strategic environmental assessment: the state of the art,” *Impact Assessment and Project Appraisal*, v. 30, n. 1, p. 15-24 (2012).
- [13] “INIS & NKM Section, International Atomic Energy Agency,” <https://www.iaea.org/newscenter/news/frequently-asked-questions-inis> (2018)
- [14] Fischer T B, “Reviewing the quality of strategic environmental assessment reports for English spatial plan core strategies”, *Environ Impact Assess Rev*, 30(1):62–69 (2010).
- [15] Fischer T B, Onyango V, “Strategic environmental assessment-related research projects and journal

articles: an overview of the past 20 years,” *Impact Assess Proj Apprais*, 30 (4). pp. 253-263 (2012).

[16] “European Commission”, <http://ec.europa.eu/environment/eia/sea-legalcontext.htm>,(2018).