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Cover Page Footnote

We sincerely acknowledge International atomic energy agency (IAEA); WINS, Vienna, Austria; Civilian Research and Development Foundation Global (CRDF-Global) and Defence Threat Reduction Agency (DTRA), USA for their support in attending and organizing various events related to nuclear security.

Women in Nuclear Science & Technology in India: Challenges & Opportunities

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Abstract

Women have been actively contributing toward frontline research and development of various advanced technologies in the nuclear domain and playing a crucial role in key positions. However, proportional representation of women in various decision-making positions at higher levels in politics, diplomacy, military affairs, science, and technology remains low, and most of these positions remain male-dominated. We see that women often find it difficult to achieve leadership roles for several reasons, but often from an implicit bias in society. The stereotypical image of women in society is still propagated very discreetly. In recent times, Indian women have made big strides in several frontline sectors like Information Technology (IT), Biotechnology, and on corporate levels. More recently, organizations, including the Indian government, have been promoting an awareness of gender equality in various fields including nuclear technology. Amity University has also been motivating women academicians to take a lead in various fields including nuclear technology and nuclear security. This paper describes various initiatives that the Government of India has taken, along with many Indian organizations, including Amity University, to promote women in various fields especially in nuclear technology. This paper also discusses the opportunities for Indian women, their contributions, and challenges.

Keywords: nuclear science, nuclear security, Indian women, challenges, opportunities

I. Introduction

Globally, nuclear science and technology significantly contributes to improving human lives in terms of electricity generation, industry, healthcare, agriculture, biology, and research. Women should be a vital part of the essential workforce needed to develop the nuclear industry. Various studies have been conducted on the involvement of women in industry, legal frameworks, academia, and nuclear security. However, only 20-25% of the nuclear workforce are women, and the number is still smaller in the case of nuclear security and cybersecurity workforces [1–5]. This could be due to gender disparity in the workplace or lack of awareness about nuclear related technologies. Therefore, it is necessary to attract

and keep talented women engineers, scientists, academicians, and policy makers in the nuclear industry to support diversity in the workforce and to strengthen the trust of the general public in nuclear technologies. Many international organizations have recognized the importance of diversity in the workplace in terms of increasing representation of women and have taken a lead role to create awareness about gender equality and to empower women in the workplace [6–8]. The present study will discuss initiatives taken to promote gender equality in the nuclear field at international and national levels, including the initiatives of Amity University Uttar Pradesh (AUUP), Noida campus.

II. International Organizations Supporting Women in Nuclear Fields

The International Atomic Energy Agency (IAEA), in Vienna, Austria is the umbrella organization of the United Nations (UN) and is playing a key role in increasing the representation of women in various positions, including high-level positions at IAEA. They are also committed to equal participation of women and men in the secretariat through a number of measures and improving the life of female employees and their families [9]. Director General (IAEA), Mr. Rafael Mariano Grossi, voiced his concerns in these words: “Women play a vital role throughout the Agency, but they are still not adequately represented. For me, gender parity means 50 percent women and 50 percent men – and that is the goal I set for myself” [10]. Technical cooperation programs at IAEA include fellowships and scientific visits in the field of nuclear science and technology and in the field of nuclear security. Recently, IAEA introduced a fellowship program called the Marie Skłodowska-Curie Fellowship Programme to support young women who would like to pursue their career in nuclear science and technology. The reason for introducing this fellowship program is to increase the number of women scientists in nuclear science and technology fields, as well as in non-proliferation [9]. During the International Nuclear Security Education Network (INSEN) annual meeting in 2019, officials from IAEA emphasized that they are giving weightage in their recruitment process for women and making it mandatory to have women take part in every event [11].

In 1978, the Women in International Security (WIIS) organization was established and is dedicated to providing professional and leadership quality development for women by organizing leadership training, mentoring, and networking programs in the fields of international peace and security [12].

World Institute for Nuclear Security (WINS), a non-governmental organization in Vienna, Austria, has undertaken many initiatives through the WINS Academy [13], such as knowledge exchange, training, and professional certification in nuclear security to increase the participation of women in nuclear security. The commitments of WINS include increasing female participation and female subject-matter experts at various WINS events and increasing female enrolment at WINS Academy, thereby increasing the number of female Certified Nuclear Security Professionals (CNSP) [13].

The U.S. Civilian Research and Development Foundation Global (CRDF-Global) is not only a facilitator for innovation, chemical, biological, and nuclear fields, but also works toward the advancement of women in nuclear science and security [14]. Recently, CRDF-Global collaborated with various international agencies, conducted a series of online webinars to further explore issues, and provided solutions to persisting inequality issues in science, technology, engineering, mathematics, and medicine (STEMM) fields and national security work. The Institute of Nuclear Materials Management (INMM) developed *Respectful Behavior Policy* for providing safe, welcoming, and productive environments to female employees [15]. Women in Nuclear Global (WiN Global), another association of women working in various fields of nuclear energy and radiation applications, was established to exchange information and raise awareness of the benefits of utilizing nuclear and radiation technology [16]. The objectives of WiN Global are also to sensitize gender equality, increase mentorship, and support women in the field of nuclear technology. Gender Champions in Nuclear Policy (GCNP), launched in November 2018, is a

leadership network aiming to bring heads of various organizations together to work in nuclear policy [17]. They are committed to breaking the gender barriers and establishing gender equity in the field of nuclear non-proliferation, nuclear weapons policy, nuclear disarmament, nuclear security, nuclear deterrence, and nuclear energy [17]. The Women of Color Advance Peace and Security (WCAPS) program is another initiative, established to empower the next generation of young women. The vision of WCAPS is to provide a platform to encourage young women of color to pursue their interests in the fields of international peace, security, and conflict transformation through various programs such as mentorship programs, blogs, podcasts, webinars, and joint programming so that WCAPS can connect young women of color, across the world, to develop their experiences and passions in global leadership among global community [18].

III. National Perspective

Developing gender equality and women-empowerment in India in health, education, economics, and political fields is one of the biggest goals and has a long history. Gender disparity affects many aspects of women's lives including education, health, and career development. It often leads to a deterioration in mental health and can cause other disorders. However, over time, the mind-set of the male-dominated society is changing. Recently, the Government of India has taken many initiatives to strengthen women's education, safeguarding their career, and health. Indian government has been developing a monumental program with the slogan of "Beti bachao, Beti padhao" (i.e., protect the girl-child and educate the girl-child). The Support to Training and Employment Program (STEP) scheme was set up to train women in various skills for gainful employment and to supply the right competencies and training for women to become entrepreneurs [19]. Central and State governments have also launched many digital programs and platforms, such as the Girl Child Education Group on the MyGov digital application. Also digitizing is Digital Gender Atlas for Advancing Girl's Education, Udaan, E-pathshala, E-Balbharti, and various initiatives like Working Women's Hostel, National Scheme of Incentive to Girls for Secondary Education, Scheme by All India Council for Technical Education (AICTE), and University Grant Commission (UGC) for promoting education for girls in India [20].

Recently, Indian Armed Forces is commissioning women for combat duties. Women also chair at several Indian banks, government organizations, as well as in corporate sectors. The law requires a female role in every organization, which in turn, is becoming beneficial in reducing workplace harassment. This is helping women to flourish and work more confidently. Many research schemes have been discussed by the Government of India, under various funding agencies for women only (e.g., DST-SERB women scientist schemes) to promote women, and to contribute to more research in various science and engineering fields, including nuclear science and technology [21]. The primary aim of this initiative is to provide opportunities for women scientists and technologists, between the ages of 27-57 years old, who had a break in their career but desired to return to an active research position [21]. Indian Youth Nuclear Society (IYNS) is a non-profit organization established under the Indian Nuclear Society to spread awareness to the general public about the benefits of nuclear energy and to encourage youth to learn and contribute to nuclear energy programs [22]. Under this society, all youth, regardless of gender, are contributing immensely to promoting peaceful uses of nuclear energy. They are participating in activities including guest lectures, where many women speakers are delivering lectures related to nuclear energy [23]. Recently, the Women in Nuclear (WiN) India chapter was launched on 15th August 2020, the Independence Day of India, to mark the independence of Women in Nuclear. Many eminent Indian women scientists joined in the inaugural program of WiN India Chapter. This organization is for all of the Indian women working in the field of nuclear science and technology such as radiation, radiotherapy, and research. Objectives of this organization are to acknowledge and promote Indian women contributing to nuclear science and technology. They have also taken initiatives to encourage young females to choose nuclear science as their preferred career. Several Indian organizations are taking initiatives to promote women in nuclear science and technology. One such organization is Amity University (AUUP, Noida

campus), which boasts of 25,000+ students on its Noida campus alone and lead by a woman Vice-Chancellor. Many Indian female academicians have authored books on Indian nuclear strategy [24], nuclear deterrence and diplomacy [25], global nuclear challenges [26], and *Nuclear Power: In the Wake of Fukushima* [27], and they have also been participating in discussions at global online round-table meetings on various topics like how women might have greater influence on nuclear policy, and how their empowerment might positively affect the disarmament and non-proliferation efforts [28].

IV. Amity University's Perspective

Amity Institute of Nuclear Science and Technology (AINST) is a unique institution under Amity University Uttar Pradesh (AUUP), Noida campus. It is the first institute in India under a private university which offers an undergraduate program in nuclear science and technology [29]. In addition, AINST also offers postgraduate and Ph.D. programs. AINST has been motivating women academicians to take a lead in nuclear technology fields, including nuclear safety and security studies. It has been conducting national and international meetings, workshops, and training schools in nuclear security technology on a regular basis. A woman academician holds the position of director at AINST since its start in 2009, and the ratio of women to men faculty members is 1:1.

It is encouraging to note that other institutes under Amity University have also been empowering women in their respective fields to promote gender equality across their various campuses nationally. Several female employees of Amity University are occupying senior leadership positions like vice chancellor, director, and head of various institutions. Amity University celebrates the International Women's Day every year, which is marked as a global day, recognizing the social, economic, cultural, and political achievements of women.

One important initiative of AINST is to enhance the representation of women in the Indian nuclear program, and to encourage participation of women academicians in various nuclear and radiation technology related activities, and nuclear safety, and security in India, as well as overseas. As a result, faculty members are attending seminars, workshops, and training programs, as well as presenting papers [15, 29, 30], delivering lectures, and contributing in panel discussion globally (Pictures 1-2).

Women research scholars and faculty member of AINST have attended the Joint- ICTP-IAEA International School on Nuclear Security at the International Centre for Theoretical Physics (ICTP), Trieste, Italy (Picture 3), and the 24th annual meeting of Women in Nuclear Security (WiN) at Abu Dhabi, UAE in 2016. Director and Head of AINST is a WINS Academy alumnus, WINS Ambassador, and an active participant in the IAEA-INSEN programs. She has also been working in prestigious positions at INSEN, IAEA. Initially she was a member, then vice chair, and then the chair of working groups under INSEN. In 2017, she was invited for a lecture and a panel discussion on the topic of the role of women in nuclear security, during the INSEN annual meeting. In the panel discussion, women academicians and researchers from various institutions were encouraged to engage more in the field of nuclear security and to embody leadership qualities. As a result, another woman academician of AINST participated in a panel discussion on the Best Practices in Nuclear Security during the INSEN-IAEA annual meeting in 2018.



Picture 1: Women faculty members and research scholars of AINST participated in the workshop on “Incorporating Both Technical and Human Elements to Reduce Hazards and Vulnerabilities in Industries of National Importance”, PDPU Gandhinagar, India, 2019



Picture 2: Women academicians of AINST participated in Discussion Meeting on “Human Reliability Program in Industries of National Importance” National Institute of Advanced Studies (NIAS), Bengaluru, India, 2019.



Picture 3: Research associates of AINST at Joint ICTP-IAEA international school on nuclear security at Miramare, Trieste-Italy, 2016

One of the women academicians of AINST presented a paper called “Evaluation of the Effectiveness of Physical Protection System for Nuclear/Radioactive Materials Used in Research Institutes” during the IAEA International Conference on Nuclear Security (ICONS) in February 2020 [31]. Recently, two of the women academicians of AINST presented papers in the 61st INNМ annual meeting with the financial support from the Defense Threat Reduction Agency (DTRA), USA [30, 31]. Another AINST female faculty member is pursuing her Ph.D. in the field of nuclear security.

AINST has conducted numerous events in collaboration with many national and international organizations [29]. Several events are organized and coordinated by women academicians (Picture 4). Most events encourage women scientists, researchers, and academicians to deliver lectures and maximize their participation. A few women academicians have also received funds for their research projects in nuclear technology and nuclear security from national and international funding agencies.



Picture 4. National and international women organizers during WINS Academy training course, 2019.

AINST's goal is to encourage girls to study nuclear science and technology. Female students who are studying in B.Tech, B.Tech + M.Tech, and M.Tech are encouraged to participate in various activities, like quiz competitions, essay writing, debates, seminar, training, and workshops in nuclear technology, and they are also recommended for various fellowship programs in the field of nuclear science and technology. Some female students and a research scholar of AINST are alumni of WINS Academy, and one of them attended the first WINS Academy Alumni event at Vienna, Austria in 2019 (Picture 5). WINS Academy held this meeting for its alumni from countries around the globe. Participants include 12 women and 11 men who hold the status of Certified Nuclear Security Professional (CNSP). The purpose was to explore how the WINS Academy program can help nuclear security professionals achieve diversity, professional competency, lessons learned, and knowledge exchange.



Picture 5: Dr. Kawalpreet Kalra, AINST Alumni, WINS Academy, attended first WINS Academy Alumni event at Vienna, Austria in the year of 2019.

AUUP established a student chapter of INMM in 2015, which organizes various events such as guest lectures, poster competitions, quiz competitions, seminars, and workshops at the university campus collaborating with international and national agencies [31, 32]. In INMM Amity University students' chapter, many important positions are held by girl students of AINST. Under the chapter, they take part in various activities on campus and have educational programs in schools, teaching about the benefits of utilizing nuclear technology.

V. Challenges

Many female professionals face challenges during their journey, in most professional fields, and even more so in nuclear sciences, as this is a very specialized and technical field. Key challenges faced by women are:

- The nuclear field is particularly challenging as it requires extra dedication, devotion, and time management. Women are often limited to working during the day (for example, in India, night duty work with nuclear reactors is generally not given to women). Similarly, most nuclear experiments run day and night, often for weeks and sometimes for months, making it challenging for women to work in such situations
- Difficulties sustaining nuclear-related programs in universities and institutions from lack of public education and poor public perception, and confidentiality guidelines from government institutions often makes the public opinion of nuclear technology worse
- Motivation for women to work in nuclear fields, specifically in nuclear security, is low from lack of future professional prospects in this field. The career opportunities for nuclear engineering students, specifically in the field of nuclear security are mostly in government agencies, like the Department of Atomic Energy, which includes Bhaba Atomic Research Centre (BARC), Indira Gandhi Centre for Atomic Research (IGCAR), Nuclear Fuel Corporation (NFC), and Nuclear Power Corporation of India Limited (NPCIL), where students should qualify notational level tests to enter the system. There are very few high-level positions, which may influence women's interest in this field compared to the other fields [citation]
- It is not easy to keep equality in recruitment, promotion, and retention of women. The turnover rate is high among women, as they prefer to settle down with their families. They have work limitations to be able to take care of their family, specifically caring for their children, making

them reluctant to apply for leadership positions. Sometimes, family members are not supportive of their professional choices

- Unequal access to training and professional development for women is still an issue due to society's beliefs that women are too weak for leadership positions. However, in each sector, women are contributing immensely, and now is the time to break the barrier. It is like a glass ceiling, which needs to be broken

VI. Opportunities

Though there are challenges, there are several opportunities available for women, and they should take advantage of them. Key opportunities are:

- Men and women are at the same, or even better horizon in professional aspects of life. A study shows that women are better than men at multi-tasking capabilities because they have genetically evolved that way by nature and can perform their responsibilities very efficiently [33, 34].
- Presently, the Indian government is also taking many of initiatives to introducing and supporting women in each level of their career [33, 34].

VII. Conclusion

We have summarized the status of professional women in nuclear science and technology in India. We have also summarized the efforts various agencies are making to support women in nuclear technologies. We only have a few women scientists and academicians in the field of nuclear science and technology, who may become the role models to motivate other women to join the nuclear sector. However, role models are not created overnight. We should increase program awareness at the early school level to educate girls about opportunities, so when they grow up, they can fearlessly contribute toward the progress of society and gain the quality of leadership in sensitive areas like nuclear security and other sectors. There is an African Proverb that says, "If you educate a man, you educate an individual but if you educate a woman, you educate families, societies and nations."

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