



Nanotechnology Applications: Meeting Basic Needs and Making India Globally Competent

Dr. Swati Mishra

Assistant Professor,
Department of Physics,
Government College Patharia, Dist. - Damoh (MP), India.

Abstract: Nanotechnology has indeed emerged as a critical research area with a multidisciplinary approach and the potential to address a wide range of challenges in various fields. In India, nanotechnology has been playing an essential role in providing innovative solutions to issues related to water, energy, food, health, cosmetics, manufacturing, defense, and materials engineering. With the support of the government, the country has been able to establish a robust framework for research and development (R&D) in nanotechnology. One of the significant advantages of nanotechnology is its ability to address problems in developing countries like India, where the demand for efficient and cost-effective solutions is high. For instance, in the field of water, nanotechnology-based solutions can help in providing safe and clean drinking water to the rural population, which is still struggling with the problem of contaminated water. Similarly, in the energy sector, nanotechnology-based solutions can help in improving the efficiency of solar cells, which can reduce the dependence on fossil fuels and provide clean energy. The Government of India has been actively promoting nanotechnology and technology-related R&D in the country. Several initiatives have been taken to attract young talent to this interdisciplinary field, and various ministries are supporting researchers with basic and advanced infrastructure facilities, manpower development, scholarships, and awareness activities. These efforts have led to several breakthroughs in the field of nanotechnology in India, making the country a significant player on the global research map. In conclusion, nanotechnology has the potential to set new benchmarks in research and development in India in all areas. Its applications in critical sectors can provide innovative solutions to problems faced by the country, making it globally competitive. With the support of the government and the involvement of young talent, India can continue to make significant strides in this field and establish itself as a leader in nanotechnology research. This paper explains the research activities in nanotechnology to meet the basic needs.

Index Terms - Nanotechnology, Globally Competent, Applications, Basic needs.

1. INTRODUCTION: Along with India, the whole world is also making rapid progress in the field of science and technology, but the importance of science and technology is then that it benefits the common citizen of the country and makes his life easier. This is possible only when the use of science and technology is not only limited to space and research centers, but also when this technology covers all areas related to basic needs such as water, agriculture, food, health, and other areas. For this reason, many such research laboratories have been set up in India where nanotechnology is being used to work on all these things.[1] Nanotechnology is one of the many evolving technologies of the 21st century that has impacted many industrial sectors and played an important role in various industrial segments. The technology has proven its importance in today's competitive environment and has played an important role in maintaining India's image as a Vishwa Guru. [2]

2. APPLICATIONS OF NANOTECHNOLOGY: One of the best ways to bridge the gap between India's rich, diverse natural resources and the country's ever-increasing demands, such as pure water, food, and low-cost diagnostic machines, is using nanotechnology. [4] Today, there is a large body of facts and evidence that illustrate that modern science and technology have set many milestones in creating India's identity in the world. [3] Many branches of science are growing equally in India, but in this paper only studies related to nanotechnology have been considered. Nanotechnology is a revolutionary field of science that encompasses a wide range of tools, techniques, and applications that manipulate materials at the nanoscale to create novel properties that do not exist at larger scales. These solutions include sufficient, effective, and low-cost water purification devices, medical diagnostic tests and drug delivery systems, energy sources, durable building materials, and other products for developing countries. [1] As I discussed earlier, nanotechnology has touched almost every aspect of our lives, but this paper will highlight some specific areas, that show how Nanotechnology is making India globally competent through its use. [5]

2.1. Water - The use of nanotechnology in water treatment has great potential to provide clean and safe drinking water to millions of people in India. With the increasing demand for water and the growing concern over water pollution, the application of nanotechnology in water treatment is becoming more important. The use of nanotechnology-based products for water treatment can effectively remove a wide range of contaminants from water, including bacteria, viruses, heavy metals, and organic pollutants. These products offer several advantages over conventional water treatment methods, such as improved efficiency, cost-

effectiveness, and reduced energy consumption. Several water treatment devices incorporating nanotechnology are already on the market and others are at an advanced stage of development. These nanotechnology-based products include nano-filtration membranes, zeolites, polymer filters, nano-ceramics, clay, magnetic nanoparticles, polymer filters, catalysts, and nano-sensors. Research and development related with nanotechnology in the water sector is mainly at the laboratory stage in India. There are several centers working in this area. Hyderabad has developed a coating technology that has been transferred to SBP Aquatech Private Limited Hyderabad, which will mass produce and market the candle filters. The nano-silver activated carbon block was developed in collaboration with the Indian Institute of Technology, Chennai, and will be marketed by Eureka Forbes as part of its new Aqua guard Total Gold Nova water purifier. The Indian Institute of Chemical Technology, Hyderabad, has developed a nano silver-coated alumina catalyst using an electrochemical process. These catalysts have been shown to be effective in controlling microorganisms in water. Rensselaer Polytechnic Institute in the U.S. and Banaras Hindu College Varanasi have developed a simple method for making carbon nano-tube filters that efficiently remove micro- to nanoscale contaminants from water and heavy hydrocarbons from petroleum. Indian Institute of Technology (IIT) Kharagpur has developed synthesized iron oxide particles using chemical methods to remove arsenic from water. [1] [3]

2.2. Energy - Nanotechnology also holds promise for improving the efficiency and safety of nuclear energy production. For example, researchers are exploring the use of nanomaterials to improve the durability and safety of nuclear fuel rods, as well as developing advanced sensors and monitoring systems that use nanotechnology to improve the detection of radiation leaks and other safety hazards. Additionally, nanotechnology can play a role in improving the efficiency of fossil fuel extraction and processing, as well as reducing the environmental impact of these activities by developing more effective carbon capture and storage technologies. Overall, nanotechnology has the potential to make a significant contribution to the development of both conventional and renewable energy sources, as well as improving the safety and sustainability of energy production and use. Various centers such as Anna College Chennai, Jawaharlal Nehru Center for Advanced Scientific Research (JNCASR) Bangalore, Central Glass and Ceramic Research Institute (CGCRI) Kolkata and Indian Association for the Cultivation of Science (IACS) Kolkata are working in this area.[7]

2.3. Food and Agriculture - Furthermore, nanotechnology is also being explored for use in the packaging and preservation of food. Nanoparticle-based films can prevent the growth of bacteria and fungi, extending the shelf life of food products. In addition, nano sensors are being developed to detect food pathogens and contaminants, improving food safety, and reducing the risk of foodborne illnesses. Delhi University is working to develop nano particulate controlled-release formulations for pesticides and insecticides. The Indian Statistical Institute (ISI) Kolkata development of entomologic nanoparticles is working on studies of insecticidal efficacy and biosafety, metabolomics, and machine learning tools. The University of Allahabad Uttar Pradesh is working on the potential role of nanoparticles in early-stage plant pathogen detection and waste management.[8]

2.4. Health - Nanotechnology has a significant impact on the healthcare and medicine industry in India. The targeted drug delivery systems have been developed that deliver drugs directly to the affected area, minimizing side effects. Nanotechnology-based cancer therapies, including nanoparticle-based drug delivery and imaging systems, are currently being developed and tested in India. The Indian Institute of Technology Bombay has developed a gold nanoparticle-based drug delivery system that targets cancer cells specifically. Additionally, research is being conducted to create nanotechnology-based sensors that can detect diseases in their early stages, and diagnostic imaging technologies that provide more detailed information about the human body's internal structures. Furthermore, antimicrobial coatings have been developed that can prevent the growth of bacteria on medical devices, reducing the risk of infections. Several centers working in this area, such as the Defense Research & Development Establishment (DRDE) Gwalior have developed a typhoid detection kit that uses a nano sensor. The Chemistry Department of Delhi University has developed eleven patentable technologies for improved drug delivery systems using nanoparticles. U.S. patents have been issued for four of these processes. One of the major achievements in the early stages of drug delivery research was the development of an inverted micelle-based method for the synthesis of hydrogels and smart hydrogel nanoparticles for the encapsulation of water-soluble drugs. This method enabled the synthesis of hydrogel nanoparticles with a size of less than 100 nm in diameter. This technology was sold to the Dabur Research Foundation in 1999 (Press Information Bureau, 2006). The Central Scientific Instruments Organization of India has developed a nanotechnology-based diagnostic kit TB that is currently undergoing clinical trials. This could reduce both the cost and time required for TB testing and requires a smaller amount of blood for testing. The Centre for Research in Nanotechnology & Science (CRNTS) at the Indian Institute of Technology, Bombay, specializes in the use of nanomagnetic materials in the form of magnetic fluids for hyperthermia treatment of cancer. [6]

3. CONCLUSION: Nanotechnology and technological development are currently in a growth phase in India. Nanotechnology has the potential to revolutionize India's global competitiveness by providing new opportunities for economic growth, job creation, and improved quality of life. Nanotechnology can enable India to become a leader in the field of advanced materials and technologies and can help India to develop better products at lower costs. It can also be used to improve existing products, such as medical devices and electronics. Additionally, nanotechnology can be used to create energy efficient materials, improve water purification systems, and develop new methods of food production. Finally, nanotechnology can help India become more competitive in global markets by providing access to cutting-edge research and development capabilities.[9] [10]

The Government of India has encouraged the growth of the sector by funding projects under various programs of DBT, DST, DSIR, ICMR, MNRE, and ICAR. [3]. Finally, nanotechnology education and training programs are critical for building a workforce capable of addressing the complex challenges facing society today. Indian institutions such as the Indian Institute of Technology, the Indian Institute of Science, and the Jawaharlal Nehru Centre for Advanced Scientific Research are actively engaged in nanotechnology research and education, providing training and expertise for future generations of scientists and engineers.

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